Module Handbook
Mathematics Master 2016 (Master of Science (M.Sc.))

SPO 2016

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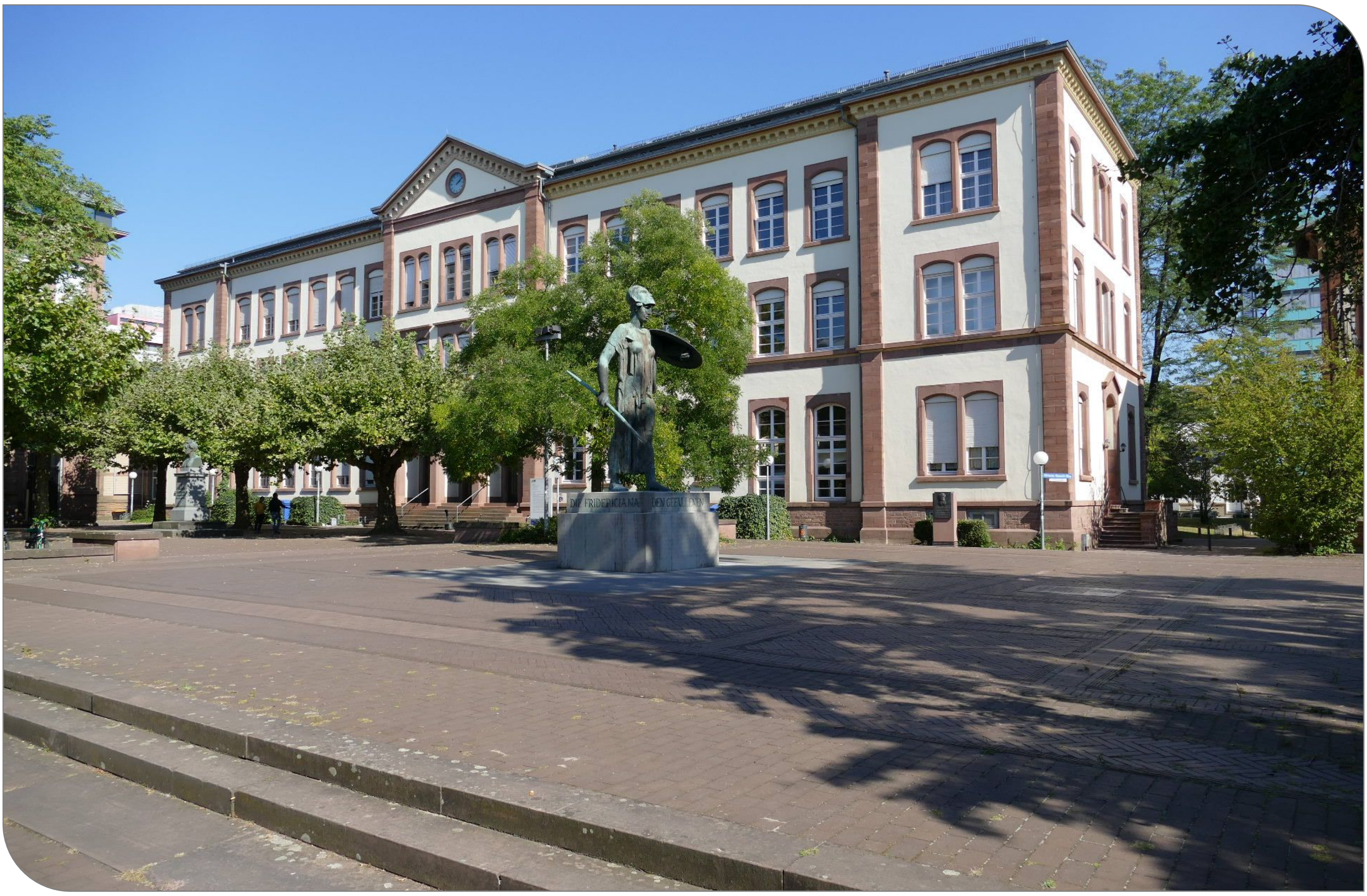
KIT DEPARTMENT OF MATHEMATICS



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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)

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: Funktionalanalysis (functional analysis))
- Harmonische Analysis (harmonic analysis) (4+2 SWS) (prerequisite: Funktionalanalysis (functional analysis))
- Integralgleichungen (integral equations) (4+2 SWS) (prerequisite: Funktionalanalysis (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 Optimierungsmethoden (numerical optimization methods) (4+2 SWS) (prerequisite: Optimierungstheorie aus dem Bachelorstudium (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))
- Statistical Learning (4+2 SWS, 8 credits, Ss)
- 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

- Master's thesis

###Example 4 (Start in the winter semester)

Semester 1: 30 credits, 3 examinations, 2 courseworks

- 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 courseworks

- 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 courseworks

- 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

Mandatory	
Master's Thesis	30 CR
Mathematical Methods 1	24 CR
Mathematical Methods 2	16 CR
Complementary Field	16-24 CR
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

Credits
30

Mandatory		
M-MATH-102917	Master's Thesis	30 CR

2.2 Mathematical Methods 1

Credits
24

Mathematical Methods 1 (Election: 1 item)	
Field Algebra and Geometry	24 CR
Field Analysis	24 CR
Field Applied and Numerical Mathematics	24 CR
Field Stochastics	24 CR

2.2.1 Field Algebra and Geometry

Part of: Mathematical Methods 1

Credits
24

Field Algebra and Geometry (Election: at least 24 credits)		
M-MATH-102865	Stochastic Geometry	8 CR
M-MATH-102866	Geometry of Schemes	8 CR
M-MATH-102868	Modular Forms	8 CR
M-MATH-102869	Geometric Group Theory II	8 CR
M-MATH-102912	Global Differential Geometry	8 CR
M-MATH-102940	Comparison Geometry	5 CR
M-MATH-102953	Algebraic Topology II	8 CR
M-MATH-102954	Group Actions in Riemannian Geometry	5 CR
M-MATH-101315	Algebra	8 CR
M-MATH-101317	Differential Geometry	8 CR
M-MATH-101336	Graph Theory	8 CR
M-MATH-101724	Algebraic Geometry	8 CR
M-MATH-101725	Algebraic Number Theory	8 CR
M-MATH-102864	Convex Geometry	8 CR
M-MATH-102867	Geometric Group Theory	8 CR
M-MATH-102948	Algebraic Topology	8 CR
M-MATH-102949	Introduction to Geometric Measure Theory	6 CR
M-MATH-102950	Combinatorics	8 CR
M-MATH-102952	L2-Invariants	5 CR
M-MATH-102959	Homotopy Theory	8 CR
M-MATH-102957	Extremal Graph Theory	4 CR
M-MATH-103251	Aspects of Geometric Analysis	4 CR
M-MATH-104057	Key Moments in Geometry	5 CR
M-MATH-104261	Lie Groups and Lie Algebras	8 CR
M-MATH-104349	Bott Periodicity	5 CR
M-MATH-105101	Introduction to Homogeneous Dynamics	6 CR
M-MATH-105331	Introduction to Aperiodic Order	3 CR
M-MATH-105463	Structural Graph Theory	4 CR
M-MATH-105487	Topological Data Analysis	6 CR
M-MATH-105649	Fractal Geometry	6 CR
M-MATH-105651	Applications of Topological Data Analysis	4 CR
M-MATH-105839	Lie-Algebras (Linear Algebra 3)	8 CR
M-MATH-105931	Metric Geometry	8 CR
M-MATH-105973	Translation Surfaces	8 CR
M-MATH-106064	Topological Genomics	3 CR
M-MATH-106466	Riemann Surfaces	8 CR
M-MATH-106473	Ergodic Theory	8 CR
M-MATH-106632	Curves on Surfaces	3 CR

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

Credits
24

Field Analysis (Election: at least 24 credits)		
M-MATH-101768	Spectral Theory	8 CR
M-MATH-102878	Complex Analysis	8 CR
M-MATH-102881	Stochastic Differential Equations	8 CR
M-MATH-101320	Functional Analysis	8 CR
M-MATH-102870	Classical Methods for Partial Differential Equations	8 CR
M-MATH-102871	Boundary and Eigenvalue Problems	8 CR
M-MATH-102872	Evolution Equations	8 CR
M-MATH-102874	Integral Equations	8 CR
M-MATH-102875	Models of Mathematical Physics	8 CR
M-MATH-102876	Boundary value problems for nonlinear differential equations	8 CR
M-MATH-102877	Nonlinear Evolution Equations	8 CR
M-MATH-102879	Potential Theory	8 CR
M-MATH-102880	Spectral Theory of Differential Operators	8 CR
M-MATH-102883	Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems	8 CR
M-MATH-102884	Scattering Theory	8 CR
M-MATH-102885	Maxwell's Equations	8 CR
M-MATH-102886	Nonlinear Functional Analysis	3 CR
M-MATH-102887	Monotonicity Methods in Analysis	3 CR
M-MATH-102890	Inverse Problems	8 CR
M-MATH-102913	Banach Algebras	3 CR
M-MATH-102918	Internet Seminar for Evolution Equations	8 CR
M-MATH-102923	Geometric Analysis	8 CR
M-MATH-102924	Optimization in Banach Spaces	5 CR
M-MATH-102927	Traveling Waves	6 CR
M-MATH-102941	Control Theory	6 CR
M-MATH-102952	L2-Invariants	5 CR
M-MATH-103080	Dynamical Systems	8 CR
M-MATH-103086	Nonlinear Schroedinger and Wave Equations	8 CR
M-MATH-102926	Sobolev Spaces	8 CR
M-MATH-103079	Mathematical Physics	8 CR
M-MATH-103259	Bifurcation Theory	5 CR
M-MATH-103251	Aspects of Geometric Analysis	4 CR
M-MATH-103262	Eigenvalue Problems in Complicated Domains	4 CR
M-MATH-103274	Mathematical Physics 2	8 CR
M-MATH-103539	Nonlinear Analysis	8 CR
M-MATH-104059	Mathematical Topics in Kinetic Theory	4 CR
M-MATH-104425	Dispersive Equations	6 CR
M-MATH-104435	Selected Topics in Harmonic Analysis	3 CR
M-MATH-104827	Fourier Analysis and its Applications to PDEs	6 CR
M-MATH-105066	Nonlinear Maxwell Equations	8 CR
M-MATH-105101	Introduction to Homogeneous Dynamics	6 CR
M-MATH-105093	Variational Methods	8 CR
M-MATH-105324	Harmonic Analysis	8 CR
M-MATH-105326	Nonlinear Wave Equations	4 CR
M-MATH-105432	Discrete Dynamical Systems	3 CR
M-MATH-105487	Topological Data Analysis	6 CR
M-MATH-105650	Introduction to Fluid Dynamics	3 CR
M-MATH-105651	Applications of Topological Data Analysis	4 CR
M-MATH-105837	Introduction to Kinetic Equations	3 CR

M-MATH-105838	Introduction to Microlocal Analysis	3 CR
M-MATH-105897	Selected Methods in Fluids and Kinetic Equations	3 CR
M-MATH-105964	Introduction to Convex Integration	3 CR
M-MATH-106401	Introduction to Fluid Mechanics	6 CR
M-MATH-106486	Harmonic Analysis 2	8 CR
M-MATH-106591	Introduction to Dynamical Systems	6 CR
M-MATH-106664	Scattering Theory for Time-dependent Waves neu	6 CR
M-MATH-106667	Geometric Variational Problems neu	8 CR
M-MATH-106666	Minimal Surfaces neu	3 CR
M-MATH-106663	Semigroup Theory for the Navier-Stokes Equations neu	6 CR
M-MATH-106696	Regularity for Elliptic Operators neu	6 CR

Modelled 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

Credits
24

Field Applied and Numerical Mathematics (Election: at least 24 credits)		
M-MATH-102928	Numerical Methods for Time-Dependent Partial Differential Equations	8 CR
M-MATH-102930	Numerical Methods for Integral Equations	8 CR
M-MATH-102955	Advanced Inverse Problems: Nonlinearity and Banach Spaces	5 CR
M-MATH-101338	Parallel Computing	5 CR
M-MATH-102874	Integral Equations	8 CR
M-MATH-102879	Potential Theory	8 CR
M-MATH-102884	Scattering Theory	8 CR
M-MATH-102885	Maxwell's Equations	8 CR
M-MATH-102888	Numerical Methods for Differential Equations	8 CR
M-MATH-102889	Introduction to Scientific Computing	8 CR
M-MATH-102890	Inverse Problems	8 CR
M-MATH-102891	Finite Element Methods	8 CR
M-MATH-102892	Numerical Optimisation Methods	8 CR
M-MATH-102894	Numerical Methods in Computational Electrodynamics	6 CR
M-MATH-102895	Wavelets	8 CR
M-MATH-102897	Mathematical Methods in Signal and Image Processing	8 CR
M-MATH-102898	Multigrid and Domain Decomposition Methods	4 CR
M-MATH-102899	Optimisation and Optimal Control for Differential Equations	4 CR
M-MATH-102900	Adaptive Finite Elemente Methods	6 CR
M-MATH-102901	Numerical Methods in Mathematical Finance	8 CR
M-MATH-102915	Numerical Methods for Hyperbolic Equations	6 CR
M-MATH-102920	Special Topics of Numerical Linear Algebra	8 CR
M-MATH-102921	Geometric Numerical Integration	6 CR
M-MATH-102924	Optimization in Banach Spaces	5 CR
M-MATH-102929	Mathematical Modelling and Simulation in Practise	4 CR
M-MATH-102931	Numerical Methods for Maxwell's Equations	6 CR
M-MATH-102932	Numerical Methods in Fluid Mechanics	4 CR
M-MATH-102935	Compressive Sensing	5 CR
M-MATH-102936	Functions of Operators	6 CR
M-MATH-102937	Functions of Matrices	8 CR
M-MATH-106634	Computational Fluid Dynamics and Simulation Lab neu	4 CR
M-MATH-102943	Introduction into Particulate Flows	3 CR
M-MATH-102926	Sobolev Spaces	8 CR
M-MATH-103260	Mathematical Methods of Imaging	5 CR
M-MATH-103527	Foundations of Continuum Mechanics	3 CR
M-MATH-103700	Exponential Integrators	6 CR
M-MATH-103709	Numerical Linear Algebra for Scientific High Performance Computing	5 CR
M-MATH-103919	Introduction to Kinetic Theory	4 CR
M-MATH-104054	Uncertainty Quantification	4 CR
M-MATH-104058	Numerical Linear Algebra in Image Processing	6 CR
M-MATH-103540	Boundary Element Methods	8 CR
M-MATH-105325	Splitting Methods for Evolution Equations	6 CR
M-MATH-105327	Numerical Simulation in Molecular Dynamics	8 CR
M-MATH-105636	Analytical and Numerical Homogenization	6 CR
M-MATH-105764	Numerical Analysis of Helmholtz Problems	3 CR
M-MATH-105966	Space and Time Discretization of Nonlinear Wave Equations	6 CR
M-MATH-106053	Stochastic Simulation	5 CR
M-MATH-106063	Numerical Complex Analysis	6 CR
M-MATH-106064	Topological Genomics	3 CR

M-MATH-106328	Bayesian Inverse Problems with Connections to Machine Learning	4 CR
M-MATH-106640	Modelling and Simulation of Lithium-Ion Batteries neu	4 CR
M-MATH-106664	Scattering Theory for Time-dependent Waves neu	6 CR
M-MATH-106695	Numerical Analysis of Neural Networks neu	6 CR
M-MATH-106682	Numerical Methods for Oscillatory Differential Equations neu	8 CR

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

Credits
24

Field Stochastics (Election: at least 24 credits)		
M-MATH-102865	Stochastic Geometry	8 CR
M-MATH-102860	Continuous Time Finance	8 CR
M-MATH-102903	Spatial Stochastics	8 CR
M-MATH-102904	Brownian Motion	4 CR
M-MATH-102905	Percolation	5 CR
M-MATH-102906	Generalized Regression Models	4 CR
M-MATH-102907	Markov Decision Processes	5 CR
M-MATH-102908	Stochastic Control	4 CR
M-MATH-102909	Mathematical Statistics	8 CR
M-MATH-102910	Nonparametric Statistics	4 CR
M-MATH-102911	Time Series Analysis	4 CR
M-MATH-102919	Discrete Time Finance	8 CR
M-MATH-102922	Poisson Processes	5 CR
M-MATH-102939	Extreme Value Theory	4 CR
M-MATH-102947	Probability Theory and Combinatorial Optimization	8 CR
M-MATH-102956	Forecasting: Theory and Practice	8 CR
M-MATH-103087	Designtheory with Applications in Statistics	8 CR
M-MATH-104055	Ruin Theory	4 CR
M-MATH-102881	Stochastic Differential Equations	8 CR
M-MATH-105101	Introduction to Homogeneous Dynamics	6 CR
M-MATH-105487	Topological Data Analysis	6 CR
M-MATH-105579	Steins Method with Applications in Statistics	4 CR
M-MATH-105649	Fractal Geometry	6 CR
M-MATH-105651	Applications of Topological Data Analysis	4 CR
M-MATH-102864	Convex Geometry	8 CR
M-MATH-105840	Statistical Learning	8 CR
M-MATH-106045	Introduction to Stochastic Differential Equations	4 CR
M-MATH-106052	Random Graphs and Networks	8 CR
M-MATH-106064	Topological Genomics	3 CR
M-MATH-106485	Functional Data Analysis	4 CR
M-MATH-106473	Ergodic Theory	8 CR

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

Credits
16

Mathematical Methods 2 (Election: 1 item)	
Field Algebra and Geometry	16 CR
Field Analysis	16 CR
Field Applied and Numerical Mathematics	16 CR
Field Stochastics	16 CR

2.3.1 Field Algebra and Geometry

Part of: Mathematical Methods 2

Credits 16

Field Algebra and Geometry (Election: at least 16 credits)		
M-MATH-102865	Stochastic Geometry	8 CR
M-MATH-102866	Geometry of Schemes	8 CR
M-MATH-102868	Modular Forms	8 CR
M-MATH-102869	Geometric Group Theory II	8 CR
M-MATH-102912	Global Differential Geometry	8 CR
M-MATH-102940	Comparison Geometry	5 CR
M-MATH-102953	Algebraic Topology II	8 CR
M-MATH-102954	Group Actions in Riemannian Geometry	5 CR
M-MATH-101315	Algebra	8 CR
M-MATH-101317	Differential Geometry	8 CR
M-MATH-101336	Graph Theory	8 CR
M-MATH-101724	Algebraic Geometry	8 CR
M-MATH-101725	Algebraic Number Theory	8 CR
M-MATH-102864	Convex Geometry	8 CR
M-MATH-102867	Geometric Group Theory	8 CR
M-MATH-102948	Algebraic Topology	8 CR
M-MATH-102949	Introduction to Geometric Measure Theory	6 CR
M-MATH-102950	Combinatorics	8 CR
M-MATH-102952	L2-Invariants	5 CR
M-MATH-102959	Homotopy Theory	8 CR
M-MATH-102957	Extremal Graph Theory	4 CR
M-MATH-103251	Aspects of Geometric Analysis	4 CR
M-MATH-104057	Key Moments in Geometry	5 CR
M-MATH-104261	Lie Groups and Lie Algebras	8 CR
M-MATH-104349	Bott Periodicity	5 CR
M-MATH-105101	Introduction to Homogeneous Dynamics	6 CR
M-MATH-105331	Introduction to Aperiodic Order	3 CR
M-MATH-105463	Structural Graph Theory	4 CR
M-MATH-105487	Topological Data Analysis	6 CR
M-MATH-105649	Fractal Geometry	6 CR
M-MATH-105651	Applications of Topological Data Analysis	4 CR
M-MATH-105839	Lie-Algebras (Linear Algebra 3)	8 CR
M-MATH-105931	Metric Geometry	8 CR
M-MATH-105973	Translation Surfaces	8 CR
M-MATH-106064	Topological Genomics	3 CR
M-MATH-106466	Riemann Surfaces	8 CR
M-MATH-106473	Ergodic Theory	8 CR
M-MATH-106632	Curves on Surfaces	3 CR

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

Field Analysis (Election: at least 16 credits)		
M-MATH-101768	Spectral Theory	8 CR
M-MATH-102878	Complex Analysis	8 CR
M-MATH-102881	Stochastic Differential Equations	8 CR
M-MATH-101320	Functional Analysis	8 CR
M-MATH-102870	Classical Methods for Partial Differential Equations	8 CR
M-MATH-102871	Boundary and Eigenvalue Problems	8 CR
M-MATH-102872	Evolution Equations	8 CR
M-MATH-102874	Integral Equations	8 CR
M-MATH-102875	Models of Mathematical Physics	8 CR
M-MATH-102876	Boundary value problems for nonlinear differential equations	8 CR
M-MATH-102877	Nonlinear Evolution Equations	8 CR
M-MATH-102879	Potential Theory	8 CR
M-MATH-102880	Spectral Theory of Differential Operators	8 CR
M-MATH-102883	Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems	8 CR
M-MATH-102884	Scattering Theory	8 CR
M-MATH-102885	Maxwell's Equations	8 CR
M-MATH-102886	Nonlinear Functional Analysis	3 CR
M-MATH-102887	Monotonicity Methods in Analysis	3 CR
M-MATH-102890	Inverse Problems	8 CR
M-MATH-102913	Banach Algebras	3 CR
M-MATH-102918	Internet Seminar for Evolution Equations	8 CR
M-MATH-102923	Geometric Analysis	8 CR
M-MATH-102924	Optimization in Banach Spaces	5 CR
M-MATH-102927	Traveling Waves	6 CR
M-MATH-102941	Control Theory	6 CR
M-MATH-102952	L2-Invariants	5 CR
M-MATH-103080	Dynamical Systems	8 CR
M-MATH-103086	Nonlinear Schroedinger and Wave Equations	8 CR
M-MATH-102926	Sobolev Spaces	8 CR
M-MATH-103079	Mathematical Physics	8 CR
M-MATH-103259	Bifurcation Theory	5 CR
M-MATH-103251	Aspects of Geometric Analysis	4 CR
M-MATH-103262	Eigenvalue Problems in Complicated Domains	4 CR
M-MATH-103274	Mathematical Physics 2	8 CR
M-MATH-103539	Nonlinear Analysis	8 CR
M-MATH-104059	Mathematical Topics in Kinetic Theory	4 CR
M-MATH-104425	Dispersive Equations	6 CR
M-MATH-104435	Selected Topics in Harmonic Analysis	3 CR
M-MATH-104827	Fourier Analysis and its Applications to PDEs	6 CR
M-MATH-105066	Nonlinear Maxwell Equations	8 CR
M-MATH-105101	Introduction to Homogeneous Dynamics	6 CR
M-MATH-105093	Variational Methods	8 CR
M-MATH-105324	Harmonic Analysis	8 CR
M-MATH-105326	Nonlinear Wave Equations	4 CR
M-MATH-105432	Discrete Dynamical Systems	3 CR
M-MATH-105487	Topological Data Analysis	6 CR
M-MATH-105650	Introduction to Fluid Dynamics	3 CR
M-MATH-105651	Applications of Topological Data Analysis	4 CR
M-MATH-105837	Introduction to Kinetic Equations	3 CR

M-MATH-105838	Introduction to Microlocal Analysis	3 CR
M-MATH-105897	Selected Methods in Fluids and Kinetic Equations	3 CR
M-MATH-105964	Introduction to Convex Integration	3 CR
M-MATH-106401	Introduction to Fluid Mechanics	6 CR
M-MATH-106486	Harmonic Analysis 2	8 CR
M-MATH-106591	Introduction to Dynamical Systems	6 CR
M-MATH-106664	Scattering Theory for Time-dependent Waves neu	6 CR
M-MATH-106667	Geometric Variational Problems neu	8 CR
M-MATH-106666	Minimal Surfaces neu	3 CR
M-MATH-106663	Semigroup Theory for the Navier-Stokes Equations neu	6 CR
M-MATH-106696	Regularity for Elliptic Operators neu	6 CR

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

Part of: Mathematical Methods 2

Credits
16

Field Applied and Numerical Mathematics (Election: at least 16 credits)		
M-MATH-102928	Numerical Methods for Time-Dependent Partial Differential Equations	8 CR
M-MATH-102930	Numerical Methods for Integral Equations	8 CR
M-MATH-102955	Advanced Inverse Problems: Nonlinearity and Banach Spaces	5 CR
M-MATH-101338	Parallel Computing	5 CR
M-MATH-102874	Integral Equations	8 CR
M-MATH-102879	Potential Theory	8 CR
M-MATH-102884	Scattering Theory	8 CR
M-MATH-102885	Maxwell's Equations	8 CR
M-MATH-102888	Numerical Methods for Differential Equations	8 CR
M-MATH-102889	Introduction to Scientific Computing	8 CR
M-MATH-102890	Inverse Problems	8 CR
M-MATH-102891	Finite Element Methods	8 CR
M-MATH-102892	Numerical Optimisation Methods	8 CR
M-MATH-102894	Numerical Methods in Computational Electrodynamics	6 CR
M-MATH-102895	Wavelets	8 CR
M-MATH-102897	Mathematical Methods in Signal and Image Processing	8 CR
M-MATH-102898	Multigrid and Domain Decomposition Methods	4 CR
M-MATH-102899	Optimisation and Optimal Control for Differential Equations	4 CR
M-MATH-102900	Adaptive Finite Elemente Methods	6 CR
M-MATH-102901	Numerical Methods in Mathematical Finance	8 CR
M-MATH-102915	Numerical Methods for Hyperbolic Equations	6 CR
M-MATH-102920	Special Topics of Numerical Linear Algebra	8 CR
M-MATH-102921	Geometric Numerical Integration	6 CR
M-MATH-102924	Optimization in Banach Spaces	5 CR
M-MATH-102929	Mathematical Modelling and Simulation in Practise	4 CR
M-MATH-102931	Numerical Methods for Maxwell's Equations	6 CR
M-MATH-102932	Numerical Methods in Fluid Mechanics	4 CR
M-MATH-102935	Compressive Sensing	5 CR
M-MATH-102936	Functions of Operators	6 CR
M-MATH-102937	Functions of Matrices	8 CR
M-MATH-106634	Computational Fluid Dynamics and Simulation Lab neu	4 CR
M-MATH-102943	Introduction into Particulate Flows	3 CR
M-MATH-102926	Sobolev Spaces	8 CR
M-MATH-103260	Mathematical Methods of Imaging	5 CR
M-MATH-103527	Foundations of Continuum Mechanics	3 CR
M-MATH-103700	Exponential Integrators	6 CR
M-MATH-103709	Numerical Linear Algebra for Scientific High Performance Computing	5 CR
M-MATH-103919	Introduction to Kinetic Theory	4 CR
M-MATH-104054	Uncertainty Quantification	4 CR
M-MATH-104058	Numerical Linear Algebra in Image Processing	6 CR
M-MATH-103540	Boundary Element Methods	8 CR
M-MATH-105325	Splitting Methods for Evolution Equations	6 CR
M-MATH-105327	Numerical Simulation in Molecular Dynamics	8 CR
M-MATH-105636	Analytical and Numerical Homogenization	6 CR
M-MATH-105764	Numerical Analysis of Helmholtz Problems	3 CR
M-MATH-105966	Space and Time Discretization of Nonlinear Wave Equations	6 CR
M-MATH-106053	Stochastic Simulation	5 CR
M-MATH-106063	Numerical Complex Analysis	6 CR
M-MATH-106064	Topological Genomics	3 CR

M-MATH-106328	Bayesian Inverse Problems with Connections to Machine Learning	4 CR
M-MATH-106640	Modelling and Simulation of Lithium-Ion Batteries neu	4 CR
M-MATH-106664	Scattering Theory for Time-dependent Waves neu	6 CR
M-MATH-106695	Numerical Analysis of Neural Networks neu	6 CR
M-MATH-106682	Numerical Methods for Oscillatory Differential Equations neu	8 CR

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

Credits
16

Field Stochastics (Election: at least 16 credits)		
M-MATH-102865	Stochastic Geometry	8 CR
M-MATH-102860	Continuous Time Finance	8 CR
M-MATH-102903	Spatial Stochastics	8 CR
M-MATH-102904	Brownian Motion	4 CR
M-MATH-102905	Percolation	5 CR
M-MATH-102906	Generalized Regression Models	4 CR
M-MATH-102907	Markov Decision Processes	5 CR
M-MATH-102908	Stochastic Control	4 CR
M-MATH-102909	Mathematical Statistics	8 CR
M-MATH-102910	Nonparametric Statistics	4 CR
M-MATH-102911	Time Series Analysis	4 CR
M-MATH-102919	Discrete Time Finance	8 CR
M-MATH-102922	Poisson Processes	5 CR
M-MATH-102939	Extreme Value Theory	4 CR
M-MATH-102947	Probability Theory and Combinatorial Optimization	8 CR
M-MATH-102956	Forecasting: Theory and Practice	8 CR
M-MATH-103087	Designtheory with Applications in Statistics	8 CR
M-MATH-104055	Ruin Theory	4 CR
M-MATH-102881	Stochastic Differential Equations	8 CR
M-MATH-105101	Introduction to Homogeneous Dynamics	6 CR
M-MATH-105487	Topological Data Analysis	6 CR
M-MATH-105579	Steins Method with Applications in Statistics	4 CR
M-MATH-105649	Fractal Geometry	6 CR
M-MATH-105651	Applications of Topological Data Analysis	4 CR
M-MATH-102864	Convex Geometry	8 CR
M-MATH-105840	Statistical Learning	8 CR
M-MATH-106045	Introduction to Stochastic Differential Equations	4 CR
M-MATH-106052	Random Graphs and Networks	8 CR
M-MATH-106064	Topological Genomics	3 CR
M-MATH-106485	Functional Data Analysis	4 CR
M-MATH-106473	Ergodic Theory	8 CR

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

Credits
16-24

Complementary Field (Election: 1 item)	
Field Algebra and Geometry	16-24 CR
Field Analysis	16-24 CR
Field Applied and Numerical Mathematics	16-24 CR
Field Stochastics	16-24 CR
Subject Computer Science	16-24 CR
Subject Physics	16-24 CR
Subject Economics	16-24 CR
Subject Mechanical Engineering	16-24 CR
Subject Electrical Engineering	16-24 CR

2.4.1 Field Algebra and Geometry

Part of: Complementary Field

Credits
16-24

Field Algebra and Geometry (Election: at least 1 item as well as between 16 and 24 credits)		
M-MATH-102866	Geometry of Schemes	8 CR
M-MATH-102867	Geometric Group Theory	8 CR
M-MATH-102868	Modular Forms	8 CR
M-MATH-102869	Geometric Group Theory II	8 CR
M-MATH-102912	Global Differential Geometry	8 CR
M-MATH-102940	Comparison Geometry	5 CR
M-MATH-102948	Algebraic Topology	8 CR
M-MATH-102954	Group Actions in Riemannian Geometry	5 CR
M-MATH-102865	Stochastic Geometry	8 CR
M-MATH-102953	Algebraic Topology II	8 CR
M-MATH-101315	Algebra	8 CR
M-MATH-101317	Differential Geometry	8 CR
M-MATH-101336	Graph Theory	8 CR
M-MATH-101724	Algebraic Geometry	8 CR
M-MATH-101725	Algebraic Number Theory	8 CR
M-MATH-102864	Convex Geometry	8 CR
M-MATH-102949	Introduction to Geometric Measure Theory	6 CR
M-MATH-102950	Combinatorics	8 CR
M-MATH-102952	L2-Invariants	5 CR
M-MATH-102959	Homotopy Theory	8 CR
M-MATH-102957	Extremal Graph Theory	4 CR
M-MATH-103251	Aspects of Geometric Analysis	4 CR
M-MATH-104057	Key Moments in Geometry	5 CR
M-MATH-104261	Lie Groups and Lie Algebras	8 CR
M-MATH-104349	Bott Periodicity	5 CR
M-MATH-105101	Introduction to Homogeneous Dynamics	6 CR
M-MATH-105331	Introduction to Aperiodic Order	3 CR
M-MATH-105463	Structural Graph Theory	4 CR
M-MATH-105487	Topological Data Analysis	6 CR
M-MATH-105649	Fractal Geometry	6 CR
M-MATH-105651	Applications of Topological Data Analysis	4 CR
M-MATH-105839	Lie-Algebras (Linear Algebra 3)	8 CR
M-MATH-105931	Metric Geometry	8 CR
M-MATH-105973	Translation Surfaces	8 CR
M-MATH-106064	Topological Genomics	3 CR
M-MATH-106466	Riemann Surfaces	8 CR
M-MATH-106473	Ergodic Theory	8 CR
M-MATH-106632	Curves on Surfaces	3 CR

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.

2.4.2 Field Analysis

Part of: Complementary Field

Credits
16-24

Field Analysis (Election: at least 1 item as well as between 16 and 24 credits)		
M-MATH-101320	Functional Analysis	8 CR
M-MATH-101768	Spectral Theory	8 CR
M-MATH-102881	Stochastic Differential Equations	8 CR
M-MATH-102870	Classical Methods for Partial Differential Equations	8 CR
M-MATH-102871	Boundary and Eigenvalue Problems	8 CR
M-MATH-102872	Evolution Equations	8 CR
M-MATH-102874	Integral Equations	8 CR
M-MATH-102875	Models of Mathematical Physics	8 CR
M-MATH-102876	Boundary value problems for nonlinear differential equations	8 CR
M-MATH-102877	Nonlinear Evolution Equations	8 CR
M-MATH-102878	Complex Analysis	8 CR
M-MATH-102879	Potential Theory	8 CR
M-MATH-102880	Spectral Theory of Differential Operators	8 CR
M-MATH-102883	Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems	8 CR
M-MATH-102884	Scattering Theory	8 CR
M-MATH-102885	Maxwell's Equations	8 CR
M-MATH-102886	Nonlinear Functional Analysis	3 CR
M-MATH-102887	Monotonicity Methods in Analysis	3 CR
M-MATH-102890	Inverse Problems	8 CR
M-MATH-102913	Banach Algebras	3 CR
M-MATH-102918	Internet Seminar for Evolution Equations	8 CR
M-MATH-102923	Geometric Analysis	8 CR
M-MATH-102924	Optimization in Banach Spaces	5 CR
M-MATH-102927	Traveling Waves	6 CR
M-MATH-102941	Control Theory	6 CR
M-MATH-102952	L2-Invariants	5 CR
M-MATH-103080	Dynamical Systems	8 CR
M-MATH-103086	Nonlinear Schroedinger and Wave Equations	8 CR
M-MATH-102926	Sobolev Spaces	8 CR
M-MATH-103079	Mathematical Physics	8 CR
M-MATH-103259	Bifurcation Theory	5 CR
M-MATH-103251	Aspects of Geometric Analysis	4 CR
M-MATH-103262	Eigenvalue Problems in Complicated Domains	4 CR
M-MATH-103274	Mathematical Physics 2	8 CR
M-MATH-103539	Nonlinear Analysis	8 CR
M-MATH-104059	Mathematical Topics in Kinetic Theory	4 CR
M-MATH-104425	Dispersive Equations	6 CR
M-MATH-104435	Selected Topics in Harmonic Analysis	3 CR
M-MATH-104827	Fourier Analysis and its Applications to PDEs	6 CR
M-MATH-105066	Nonlinear Maxwell Equations	8 CR
M-MATH-105101	Introduction to Homogeneous Dynamics	6 CR
M-MATH-105093	Variational Methods	8 CR
M-MATH-105324	Harmonic Analysis	8 CR
M-MATH-105326	Nonlinear Wave Equations	4 CR
M-MATH-105432	Discrete Dynamical Systems	3 CR
M-MATH-105487	Topological Data Analysis	6 CR
M-MATH-105650	Introduction to Fluid Dynamics	3 CR
M-MATH-105651	Applications of Topological Data Analysis	4 CR
M-MATH-105837	Introduction to Kinetic Equations	3 CR

M-MATH-105838	Introduction to Microlocal Analysis	3 CR
M-MATH-105897	Selected Methods in Fluids and Kinetic Equations	3 CR
M-MATH-105964	Introduction to Convex Integration	3 CR
M-MATH-106401	Introduction to Fluid Mechanics	6 CR
M-MATH-106486	Harmonic Analysis 2	8 CR
M-MATH-106591	Introduction to Dynamical Systems	6 CR
M-MATH-106664	Scattering Theory for Time-dependent Waves neu	6 CR
M-MATH-106667	Geometric Variational Problems neu	8 CR
M-MATH-106666	Minimal Surfaces neu	3 CR
M-MATH-106663	Semigroup Theory for the Navier-Stokes Equations neu	6 CR
M-MATH-106696	Regularity for Elliptic Operators neu	6 CR

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.

2.4.3 Field Applied and Numerical Mathematics

Part of: Complementary Field

Credits
16-24

Field Applied and Numerical Mathematics (Election: at least 1 item as well as between 16 and 24 credits)		
M-MATH-102928	Numerical Methods for Time-Dependent Partial Differential Equations	8 CR
M-MATH-102930	Numerical Methods for Integral Equations	8 CR
M-MATH-102955	Advanced Inverse Problems: Nonlinearity and Banach Spaces	5 CR
M-MATH-101338	Parallel Computing	5 CR
M-MATH-102874	Integral Equations	8 CR
M-MATH-102879	Potential Theory	8 CR
M-MATH-102884	Scattering Theory	8 CR
M-MATH-102885	Maxwell's Equations	8 CR
M-MATH-102888	Numerical Methods for Differential Equations	8 CR
M-MATH-102889	Introduction to Scientific Computing	8 CR
M-MATH-102890	Inverse Problems	8 CR
M-MATH-102891	Finite Element Methods	8 CR
M-MATH-102892	Numerical Optimisation Methods	8 CR
M-MATH-102894	Numerical Methods in Computational Electrodynamics	6 CR
M-MATH-102895	Wavelets	8 CR
M-MATH-102897	Mathematical Methods in Signal and Image Processing	8 CR
M-MATH-102898	Multigrid and Domain Decomposition Methods	4 CR
M-MATH-102899	Optimisation and Optimal Control for Differential Equations	4 CR
M-MATH-102900	Adaptive Finite Elemente Methods	6 CR
M-MATH-102901	Numerical Methods in Mathematical Finance	8 CR
M-MATH-102915	Numerical Methods for Hyperbolic Equations	6 CR
M-MATH-102920	Special Topics of Numerical Linear Algebra	8 CR
M-MATH-102921	Geometric Numerical Integration	6 CR
M-MATH-102924	Optimization in Banach Spaces	5 CR
M-MATH-102929	Mathematical Modelling and Simulation in Practise	4 CR
M-MATH-102931	Numerical Methods for Maxwell's Equations	6 CR
M-MATH-102932	Numerical Methods in Fluid Mechanics	4 CR
M-MATH-102935	Compressive Sensing	5 CR
M-MATH-102936	Functions of Operators	6 CR
M-MATH-102937	Functions of Matrices	8 CR
M-MATH-106634	Computational Fluid Dynamics and Simulation Lab neu	4 CR
M-MATH-102943	Introduction into Particulate Flows	3 CR
M-MATH-102926	Sobolev Spaces	8 CR
M-MATH-103260	Mathematical Methods of Imaging	5 CR
M-MATH-103527	Foundations of Continuum Mechanics	3 CR
M-MATH-103700	Exponential Integrators	6 CR
M-MATH-103709	Numerical Linear Algebra for Scientific High Performance Computing	5 CR
M-MATH-103919	Introduction to Kinetic Theory	4 CR
M-MATH-104054	Uncertainty Quantification	4 CR
M-MATH-104058	Numerical Linear Algebra in Image Processing	6 CR
M-MATH-103540	Boundary Element Methods	8 CR
M-MATH-105325	Splitting Methods for Evolution Equations	6 CR
M-MATH-105327	Numerical Simulation in Molecular Dynamics	8 CR
M-MATH-105636	Analytical and Numerical Homogenization	6 CR
M-MATH-105764	Numerical Analysis of Helmholtz Problems	3 CR
M-MATH-105966	Space and Time Discretization of Nonlinear Wave Equations	6 CR
M-MATH-106053	Stochastic Simulation	5 CR
M-MATH-106063	Numerical Complex Analysis	6 CR
M-MATH-106064	Topological Genomics	3 CR

M-MATH-106328	Bayesian Inverse Problems with Connections to Machine Learning	4 CR
M-MATH-106640	Modelling and Simulation of Lithium-Ion Batteries neu	4 CR
M-MATH-106664	Scattering Theory for Time-dependent Waves neu	6 CR
M-MATH-106695	Numerical Analysis of Neural Networks neu	6 CR
M-MATH-106682	Numerical Methods for Oscillatory Differential Equations neu	8 CR

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

Credits 16-24

Field Stochastics (Election: at least 1 item as well as between 16 and 24 credits)		
M-MATH-102865	Stochastic Geometry	8 CR
M-MATH-102860	Continuous Time Finance	8 CR
M-MATH-102903	Spatial Stochastics	8 CR
M-MATH-102904	Brownian Motion	4 CR
M-MATH-102905	Percolation	5 CR
M-MATH-102906	Generalized Regression Models	4 CR
M-MATH-102907	Markov Decision Processes	5 CR
M-MATH-102908	Stochastic Control	4 CR
M-MATH-102909	Mathematical Statistics	8 CR
M-MATH-102910	Nonparametric Statistics	4 CR
M-MATH-102911	Time Series Analysis	4 CR
M-MATH-102919	Discrete Time Finance	8 CR
M-MATH-102922	Poisson Processes	5 CR
M-MATH-102939	Extreme Value Theory	4 CR
M-MATH-102947	Probability Theory and Combinatorial Optimization	8 CR
M-MATH-102956	Forecasting: Theory and Practice	8 CR
M-MATH-103087	Designtheory with Applications in Statistics	8 CR
M-MATH-104055	Ruin Theory	4 CR
M-MATH-102881	Stochastic Differential Equations	8 CR
M-MATH-105101	Introduction to Homogeneous Dynamics	6 CR
M-MATH-105487	Topological Data Analysis	6 CR
M-MATH-105579	Steins Method with Applications in Statistics	4 CR
M-MATH-105649	Fractal Geometry	6 CR
M-MATH-105651	Applications of Topological Data Analysis	4 CR
M-MATH-102864	Convex Geometry	8 CR
M-MATH-105840	Statistical Learning	8 CR
M-MATH-106045	Introduction to Stochastic Differential Equations	4 CR
M-MATH-106052	Random Graphs and Networks	8 CR
M-MATH-106064	Topological Genomics	3 CR
M-MATH-106485	Functional Data Analysis	4 CR
M-MATH-106473	Ergodic Theory	8 CR

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

Part of: Complementary Field

Credits
16-24

Subject Computer Science (Election: at least 1 item as well as between 16 and 24 credits)		
M-INFO-100723	Asymmetric Encryption Schemes	3 CR
M-INFO-100725	Human Brain and Central Nervous System: Anatomy, Information Transfer, Signal Processing, Neurophysiology and Therapy	3 CR
M-INFO-100731	Photorealistic Rendering	5 CR
M-INFO-100743	Digital Signatures	3 CR
M-INFO-100782	Network Security: Architectures and Protocols	4 CR
M-INFO-100795	Algorithm Engineering	5 CR
M-INFO-100799	Formal Systems	6 CR
M-INFO-100823	Signals and Codes	3 CR
M-INFO-100824	Human-Machine-Interaction in Anthropomatics: Basics	3 CR
M-INFO-100836	Selected Topics in Cryptography	3 CR
M-INFO-100853	Symmetric Encryption	3 CR
M-INFO-100893	Robotics I - Introduction to Robotics	6 CR
M-INFO-102110	Computational Geometry	6 CR
M-INFO-100840	Localization of Mobile Agents	6 CR
M-INFO-100839	Fuzzy Sets	6 CR
M-INFO-101887	Seminar Advanced Topics in Parallel Programming	3 CR
M-INFO-100829	Stochastic Information Processing	6 CR
M-INFO-106014	Introduction to Artificial Intelligence	5 CR
M-INFO-106015	Information Security	5 CR
M-INFO-106315	IT Security	6 CR

2.4.6 Subject Physics

Part of: Complementary Field

Credits
16-24

Subject Physics (Election: at least 1 item as well as between 16 and 24 credits)		
M-PHYS-106331	Modern Experimental Physics I, Atoms, Nuclei and Molecules	8 CR
M-PHYS-106332	Modern Experimental Physics II, Structure of Matter	8 CR
M-PHYS-106334	Modern Theoretical Physics I, Foundations of Quantum Mechanics	8 CR
M-PHYS-106335	Modern Theoretical Physics II, Advanced Quantum Mechanics and Statistical Physics	8 CR
M-PHYS-102033	Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises	12 CR
M-PHYS-102035	Theoretical Particle Physics I, Fundamentals and Advanced Topics, without Exercises	8 CR
M-PHYS-102046	Theoretical Particle Physics II, with Exercises	12 CR
M-PHYS-102048	Theoretical Particle Physics II, without Exercises	8 CR

2.4.7 Subject Economics

Part of: Complementary Field

Credits 16-24

Subject Economics (Election: at least 1 item as well as between 16 and 24 credits)		
M-WIWI-101413	Applications of Operations Research	9 CR
M-WIWI-101414	Methodical Foundations of OR	9 CR
M-WIWI-101452	Energy Economics and Technology	9 CR
M-WIWI-101472	Informatics	9 CR
M-WIWI-101473	Mathematical Programming	9 CR
M-WIWI-101480	Finance 3	9 CR
M-WIWI-101482	Finance 1	9 CR
M-WIWI-101483	Finance 2	9 CR
M-WIWI-101496	Growth and Agglomeration	9 CR
M-WIWI-101500	Microeconomic Theory	9 CR
M-WIWI-101502	Economic Theory and its Application in Finance	9 CR
M-WIWI-102832	Operations Research in Supply Chain Management	9 CR
M-WIWI-102970	Decision and Game Theory	9 CR

2.4.8 Subject Mechanical Engineering

Part of: Complementary Field

Credits 16-24

Subject Mechanical Engineering (Election: at least 1 item as well as between 16 and 24 credits)		
M-MATH-103198	Wildcard	6 CR

2.4.9 Subject Electrical Engineering

Part of: Complementary Field

Credits 16-24

Subject Electrical Engineering (Election: at least 1 item as well as between 16 and 24 credits)		
M-ETIT-100361	Distributed Discrete Event Systems	4 CR
M-ETIT-100371	Nonlinear Control Systems	3 CR
M-ETIT-106449	Medical Imaging Technology I	3 CR
M-ETIT-106670	Medical Imaging Technology II neu	3 CR
M-ETIT-100386	Electromagnetics and Numerical Calculation of Fields	4 CR
M-ETIT-100390	Physiology and Anatomy for Engineers I	3 CR
M-ETIT-100444	Applied Information Theory	6 CR
M-ETIT-100506	Optical Waveguides and Fibers	4 CR
M-ETIT-100531	Optimization of Dynamic Systems	5 CR
M-ETIT-100532	Batteries and Fuel Cells	5 CR
M-ETIT-100538	Technical Optics	5 CR
M-ETIT-100540	Methods of Signal Processing	6 CR
M-ETIT-101845	Linear Electronic Networks	7 CR
M-ETIT-102102	Digital Technology	6 CR
M-ETIT-102103	Communications Engineering I	6 CR
M-ETIT-102310	Optimal Control and Estimation	3 CR
M-ETIT-105274	Communications Engineering II	4 CR
M-ETIT-106336	Information and Automation Technology	7 CR
M-ETIT-106675	Signal Processing with Nonlinear Fourier Transforms and Koopman Operators neu	6 CR

2.5 Mathematical Seminar

Credits
6

Mandatory		
M-MATH-102730	Seminar	3 CR
M-MATH-103925	Seminar 2	3 CR

2.6 Mathematical Specialization

Credits
14-22

Mathematical Specialization (Election: at least 1 item as well as between 14 and 22 credits)		
M-MATH-101768	Spectral Theory	8 CR
M-MATH-102865	Stochastic Geometry	8 CR
M-MATH-102866	Geometry of Schemes	8 CR
M-MATH-102868	Modular Forms	8 CR
M-MATH-102869	Geometric Group Theory II	8 CR
M-MATH-102878	Complex Analysis	8 CR
M-MATH-102881	Stochastic Differential Equations	8 CR
M-MATH-102912	Global Differential Geometry	8 CR
M-MATH-102928	Numerical Methods for Time-Dependent Partial Differential Equations	8 CR
M-MATH-102930	Numerical Methods for Integral Equations	8 CR
M-MATH-102940	Comparison Geometry	5 CR
M-MATH-102953	Algebraic Topology II	8 CR
M-MATH-102954	Group Actions in Riemannian Geometry	5 CR
M-MATH-102955	Advanced Inverse Problems: Nonlinearity and Banach Spaces	5 CR
M-MATH-101315	Algebra	8 CR
M-MATH-101317	Differential Geometry	8 CR
M-MATH-101320	Functional Analysis	8 CR
M-MATH-101336	Graph Theory	8 CR
M-MATH-101338	Parallel Computing	5 CR
M-MATH-101724	Algebraic Geometry	8 CR
M-MATH-101725	Algebraic Number Theory	8 CR
M-MATH-102860	Continuous Time Finance	8 CR
M-MATH-102864	Convex Geometry	8 CR
M-MATH-102867	Geometric Group Theory	8 CR
M-MATH-102870	Classical Methods for Partial Differential Equations	8 CR
M-MATH-102871	Boundary and Eigenvalue Problems	8 CR
M-MATH-102872	Evolution Equations	8 CR
M-MATH-102874	Integral Equations	8 CR
M-MATH-102875	Models of Mathematical Physics	8 CR
M-MATH-102876	Boundary value problems for nonlinear differential equations	8 CR
M-MATH-102877	Nonlinear Evolution Equations	8 CR
M-MATH-102879	Potential Theory	8 CR
M-MATH-102880	Spectral Theory of Differential Operators	8 CR
M-MATH-102883	Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems	8 CR
M-MATH-102884	Scattering Theory	8 CR
M-MATH-102885	Maxwell's Equations	8 CR
M-MATH-102886	Nonlinear Functional Analysis	3 CR
M-MATH-102887	Monotonicity Methods in Analysis	3 CR
M-MATH-102888	Numerical Methods for Differential Equations	8 CR
M-MATH-102889	Introduction to Scientific Computing	8 CR
M-MATH-102890	Inverse Problems	8 CR
M-MATH-102891	Finite Element Methods	8 CR
M-MATH-102892	Numerical Optimisation Methods	8 CR
M-MATH-102894	Numerical Methods in Computational Electrodynamics	6 CR
M-MATH-102895	Wavelets	8 CR
M-MATH-102897	Mathematical Methods in Signal and Image Processing	8 CR
M-MATH-102898	Multigrid and Domain Decomposition Methods	4 CR
M-MATH-102899	Optimisation and Optimal Control for Differential Equations	4 CR
M-MATH-102900	Adaptive Finite Elemente Methods	6 CR

M-MATH-102901	Numerical Methods in Mathematical Finance	8 CR
M-MATH-102903	Spatial Stochastics	8 CR
M-MATH-102904	Brownian Motion	4 CR
M-MATH-102905	Percolation	5 CR
M-MATH-102906	Generalized Regression Models	4 CR
M-MATH-102907	Markov Decision Processes	5 CR
M-MATH-102908	Stochastic Control	4 CR
M-MATH-102909	Mathematical Statistics	8 CR
M-MATH-102910	Nonparametric Statistics	4 CR
M-MATH-102911	Time Series Analysis	4 CR
M-MATH-102913	Banach Algebras	3 CR
M-MATH-102915	Numerical Methods for Hyperbolic Equations	6 CR
M-MATH-102918	Internet Seminar for Evolution Equations	8 CR
M-MATH-102919	Discrete Time Finance	8 CR
M-MATH-102920	Special Topics of Numerical Linear Algebra	8 CR
M-MATH-102921	Geometric Numerical Integration	6 CR
M-MATH-102922	Poisson Processes	5 CR
M-MATH-102923	Geometric Analysis	8 CR
M-MATH-102924	Optimization in Banach Spaces	5 CR
M-MATH-102927	Traveling Waves	6 CR
M-MATH-102929	Mathematical Modelling and Simulation in Practise	4 CR
M-MATH-102931	Numerical Methods for Maxwell's Equations	6 CR
M-MATH-102932	Numerical Methods in Fluid Mechanics	4 CR
M-MATH-102935	Compressive Sensing	5 CR
M-MATH-102936	Functions of Operators	6 CR
M-MATH-102937	Functions of Matrices	8 CR
M-MATH-106634	Computational Fluid Dynamics and Simulation Lab neu	4 CR
M-MATH-102939	Extreme Value Theory	4 CR
M-MATH-102941	Control Theory	6 CR
M-MATH-102943	Introduction into Particulate Flows	3 CR
M-MATH-102947	Probability Theory and Combinatorial Optimization	8 CR
M-MATH-102948	Algebraic Topology	8 CR
M-MATH-102949	Introduction to Geometric Measure Theory	6 CR
M-MATH-102950	Combinatorics	8 CR
M-MATH-102952	L2-Invariants	5 CR
M-MATH-102956	Forecasting: Theory and Practice	8 CR
M-MATH-102959	Homotopy Theory	8 CR
M-MATH-103080	Dynamical Systems	8 CR
M-MATH-103086	Nonlinear Schroedinger and Wave Equations	8 CR
M-MATH-103087	Designtheory with Applications in Statistics	8 CR
M-MATH-102926	Sobolev Spaces	8 CR
M-MATH-102957	Extremal Graph Theory	4 CR
M-MATH-103079	Mathematical Physics	8 CR
M-MATH-103259	Bifurcation Theory	5 CR
M-MATH-103260	Mathematical Methods of Imaging	5 CR
M-MATH-103251	Aspects of Geometric Analysis	4 CR
M-MATH-103262	Eigenvalue Problems in Complicated Domains	4 CR
M-MATH-103274	Mathematical Physics 2	8 CR
M-MATH-103276	Seminar	3 CR
M-MATH-103527	Foundations of Continuum Mechanics	3 CR

M-MATH-103539	Nonlinear Analysis	8 CR
M-MATH-103700	Exponential Integrators	6 CR
M-MATH-103709	Numerical Linear Algebra for Scientific High Performance Computing	5 CR
M-MATH-103919	Introduction to Kinetic Theory	4 CR
M-MATH-104054	Uncertainty Quantification	4 CR
M-MATH-104055	Ruin Theory	4 CR
M-MATH-104057	Key Moments in Geometry	5 CR
M-MATH-104058	Numerical Linear Algebra in Image Processing	6 CR
M-MATH-104059	Mathematical Topics in Kinetic Theory	4 CR
M-MATH-104261	Lie Groups and Lie Algebras	8 CR
M-MATH-104349	Bott Periodicity	5 CR
M-MATH-104425	Dispersive Equations	6 CR
M-MATH-104435	Selected Topics in Harmonic Analysis	3 CR
M-MATH-104827	Fourier Analysis and its Applications to PDEs	6 CR
M-MATH-103540	Boundary Element Methods	8 CR
M-MATH-105066	Nonlinear Maxwell Equations	8 CR
M-MATH-105101	Introduction to Homogeneous Dynamics	6 CR
M-MATH-105093	Variational Methods	8 CR
M-MATH-105324	Harmonic Analysis	8 CR
M-MATH-105325	Splitting Methods for Evolution Equations	6 CR
M-MATH-105326	Nonlinear Wave Equations	4 CR
M-MATH-105327	Numerical Simulation in Molecular Dynamics	8 CR
M-MATH-105331	Introduction to Aperiodic Order	3 CR
M-MATH-105432	Discrete Dynamical Systems	3 CR
M-MATH-105463	Structural Graph Theory	4 CR
M-MATH-105487	Topological Data Analysis	6 CR
M-MATH-105579	Steins Method with Applications in Statistics	4 CR
M-MATH-105636	Analytical and Numerical Homogenization	6 CR
M-MATH-105649	Fractal Geometry	6 CR
M-MATH-105650	Introduction to Fluid Dynamics	3 CR
M-MATH-105651	Applications of Topological Data Analysis	4 CR
M-MATH-105764	Numerical Analysis of Helmholtz Problems	3 CR
M-MATH-105837	Introduction to Kinetic Equations	3 CR
M-MATH-105838	Introduction to Microlocal Analysis	3 CR
M-MATH-105839	Lie-Algebras (Linear Algebra 3)	8 CR
M-MATH-105840	Statistical Learning	8 CR
M-MATH-105897	Selected Methods in Fluids and Kinetic Equations	3 CR
M-MATH-105931	Metric Geometry	8 CR
M-MATH-105964	Introduction to Convex Integration	3 CR
M-MATH-105966	Space and Time Discretization of Nonlinear Wave Equations	6 CR
M-MATH-105973	Translation Surfaces	8 CR
M-MATH-106045	Introduction to Stochastic Differential Equations	4 CR
M-MATH-106052	Random Graphs and Networks	8 CR
M-MATH-106053	Stochastic Simulation	5 CR
M-MATH-106063	Numerical Complex Analysis	6 CR
M-MATH-106064	Topological Genomics	3 CR
M-MATH-106328	Bayesian Inverse Problems with Connections to Machine Learning	4 CR
M-MATH-106401	Introduction to Fluid Mechanics	6 CR
M-MATH-106466	Riemann Surfaces	8 CR
M-MATH-106473	Ergodic Theory	8 CR

M-MATH-106485	Functional Data Analysis	4 CR
M-MATH-106486	Harmonic Analysis 2	8 CR
M-MATH-106591	Introduction to Dynamical Systems	6 CR
M-MATH-106632	Curves on Surfaces	3 CR
M-MATH-106640	Modelling and Simulation of Lithium-Ion Batteries neu	4 CR
M-MATH-106664	Scattering Theory for Time-dependent Waves neu	6 CR
M-MATH-106667	Geometric Variational Problems neu	8 CR
M-MATH-106666	Minimal Surfaces neu	3 CR
M-MATH-106663	Semigroup Theory for the Navier-Stokes Equations neu	6 CR
M-MATH-106696	Regularity for Elliptic Operators neu	6 CR
M-MATH-106695	Numerical Analysis of Neural Networks neu	6 CR
M-MATH-106682	Numerical Methods for Oscillatory Differential Equations neu	8 CR

2.7 Interdisciplinary Qualifications

Credits
6

Überfachliche Qualifikation (Election: at least 6 credits)		
M-MATH-103053	Key Competences	6 CR

2.8 Additional Examinations

Additional Examinations (Election: at most 30 credits)		
M-MATH-101315	Algebra	8 CR
M-MATH-101317	Differential Geometry	8 CR
M-MATH-101320	Functional Analysis	8 CR
M-MATH-101336	Graph Theory	8 CR
M-MATH-101338	Parallel Computing	5 CR
M-MATH-101724	Algebraic Geometry	8 CR
M-MATH-101725	Algebraic Number Theory	8 CR
M-MATH-101768	Spectral Theory	8 CR
M-MATH-102860	Continuous Time Finance	8 CR
M-MATH-102864	Convex Geometry	8 CR
M-MATH-102865	Stochastic Geometry	8 CR
M-MATH-102866	Geometry of Schemes	8 CR
M-MATH-102867	Geometric Group Theory	8 CR
M-MATH-102868	Modular Forms	8 CR
M-MATH-102869	Geometric Group Theory II	8 CR
M-MATH-102870	Classical Methods for Partial Differential Equations	8 CR
M-MATH-102871	Boundary and Eigenvalue Problems	8 CR
M-MATH-102872	Evolution Equations	8 CR
M-MATH-102874	Integral Equations	8 CR
M-MATH-102875	Models of Mathematical Physics	8 CR
M-MATH-102876	Boundary value problems for nonlinear differential equations	8 CR
M-MATH-102877	Nonlinear Evolution Equations	8 CR
M-MATH-102878	Complex Analysis	8 CR
M-MATH-102879	Potential Theory	8 CR
M-MATH-102880	Spectral Theory of Differential Operators	8 CR
M-MATH-102881	Stochastic Differential Equations	8 CR
M-MATH-102883	Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems	8 CR
M-MATH-102884	Scattering Theory	8 CR
M-MATH-102885	Maxwell's Equations	8 CR
M-MATH-102886	Nonlinear Functional Analysis	3 CR
M-MATH-102887	Monotonicity Methods in Analysis	3 CR
M-MATH-102888	Numerical Methods for Differential Equations	8 CR
M-MATH-102889	Introduction to Scientific Computing	8 CR
M-MATH-102890	Inverse Problems	8 CR
M-MATH-102891	Finite Element Methods	8 CR
M-MATH-102892	Numerical Optimisation Methods	8 CR
M-MATH-102894	Numerical Methods in Computational Electrodynamics	6 CR
M-MATH-102895	Wavelets	8 CR
M-MATH-102897	Mathematical Methods in Signal and Image Processing	8 CR
M-MATH-102898	Multigrid and Domain Decomposition Methods	4 CR
M-MATH-102899	Optimisation and Optimal Control for Differential Equations	4 CR
M-MATH-102900	Adaptive Finite Elemente Methods	6 CR
M-MATH-102901	Numerical Methods in Mathematical Finance	8 CR
M-MATH-102903	Spatial Stochastics	8 CR
M-MATH-102904	Brownian Motion	4 CR
M-MATH-102905	Percolation	5 CR
M-MATH-102906	Generalized Regression Models	4 CR
M-MATH-102907	Markov Decision Processes	5 CR
M-MATH-102908	Stochastic Control	4 CR

M-MATH-102909	Mathematical Statistics	8 CR
M-MATH-102910	Nonparametric Statistics	4 CR
M-MATH-102911	Time Series Analysis	4 CR
M-MATH-102912	Global Differential Geometry	8 CR
M-MATH-102913	Banach Algebras	3 CR
M-MATH-102915	Numerical Methods for Hyperbolic Equations	6 CR
M-MATH-102918	Internet Seminar for Evolution Equations	8 CR
M-MATH-102919	Discrete Time Finance	8 CR
M-MATH-102920	Special Topics of Numerical Linear Algebra	8 CR
M-MATH-102921	Geometric Numerical Integration	6 CR
M-MATH-102922	Poisson Processes	5 CR
M-MATH-102923	Geometric Analysis	8 CR
M-MATH-102924	Optimization in Banach Spaces	5 CR
M-MATH-102926	Sobolev Spaces	8 CR
M-MATH-102927	Traveling Waves	6 CR
M-MATH-102928	Numerical Methods for Time-Dependent Partial Differential Equations	8 CR
M-MATH-102929	Mathematical Modelling and Simulation in Practise	4 CR
M-MATH-102930	Numerical Methods for Integral Equations	8 CR
M-MATH-102931	Numerical Methods for Maxwell's Equations	6 CR
M-MATH-102932	Numerical Methods in Fluid Mechanics	4 CR
M-MATH-102935	Compressive Sensing	5 CR
M-MATH-102936	Functions of Operators	6 CR
M-MATH-102937	Functions of Matrices	8 CR
M-MATH-106634	Computational Fluid Dynamics and Simulation Lab neu	4 CR
M-MATH-102939	Extreme Value Theory	4 CR
M-MATH-102940	Comparison Geometry	5 CR
M-MATH-102941	Control Theory	6 CR
M-MATH-102943	Introduction into Particulate Flows	3 CR
M-MATH-102947	Probability Theory and Combinatorial Optimization	8 CR
M-MATH-102948	Algebraic Topology	8 CR
M-MATH-102949	Introduction to Geometric Measure Theory	6 CR
M-MATH-102950	Combinatorics	8 CR
M-MATH-102952	L2-Invariants	5 CR
M-MATH-102953	Algebraic Topology II	8 CR
M-MATH-102954	Group Actions in Riemannian Geometry	5 CR
M-MATH-102955	Advanced Inverse Problems: Nonlinearity and Banach Spaces	5 CR
M-MATH-102956	Forecasting: Theory and Practice	8 CR
M-MATH-102957	Extremal Graph Theory	4 CR
M-MATH-102959	Homotopy Theory	8 CR
M-MATH-103079	Mathematical Physics	8 CR
M-MATH-103080	Dynamical Systems	8 CR
M-MATH-103086	Nonlinear Schroedinger and Wave Equations	8 CR
M-MATH-103087	Designtheory with Applications in Statistics	8 CR
M-MATH-103259	Bifurcation Theory	5 CR
M-MATH-103260	Mathematical Methods of Imaging	5 CR
M-MATH-103251	Aspects of Geometric Analysis	4 CR
M-MATH-103262	Eigenvalue Problems in Complicated Domains	4 CR
M-MATH-103274	Mathematical Physics 2	8 CR
M-MATH-103919	Introduction to Kinetic Theory	4 CR
M-MATH-103539	Nonlinear Analysis	8 CR

M-MATH-103527	Foundations of Continuum Mechanics	3 CR
M-MATH-104058	Numerical Linear Algebra in Image Processing	6 CR
M-MATH-103700	Exponential Integrators	6 CR
M-MATH-103709	Numerical Linear Algebra for Scientific High Performance Computing	5 CR
M-MATH-104054	Uncertainty Quantification	4 CR
M-MATH-104055	Ruin Theory	4 CR
M-MATH-104057	Key Moments in Geometry	5 CR
M-MATH-104059	Mathematical Topics in Kinetic Theory	4 CR
M-MATH-104261	Lie Groups and Lie Algebras	8 CR
M-MATH-104349	Bott Periodicity	5 CR
M-MATH-104425	Dispersive Equations	6 CR
M-MATH-104435	Selected Topics in Harmonic Analysis	3 CR
M-MATH-104827	Fourier Analysis and its Applications to PDEs	6 CR
M-MATH-103540	Boundary Element Methods	8 CR
M-MATH-105066	Nonlinear Maxwell Equations	8 CR
M-MATH-105101	Introduction to Homogeneous Dynamics	6 CR
M-MATH-105093	Variational Methods	8 CR
M-MATH-105324	Harmonic Analysis	8 CR
M-MATH-105325	Splitting Methods for Evolution Equations	6 CR
M-MATH-105326	Nonlinear Wave Equations	4 CR
M-MATH-105327	Numerical Simulation in Molecular Dynamics	8 CR
M-MATH-105331	Introduction to Aperiodic Order	3 CR
M-MATH-105432	Discrete Dynamical Systems	3 CR
M-MATH-105463	Structural Graph Theory	4 CR
M-MATH-105487	Topological Data Analysis	6 CR
M-MATH-105579	Steins Method with Applications in Statistics	4 CR
M-MATH-105636	Analytical and Numerical Homogenization	6 CR
M-MATH-105649	Fractal Geometry	6 CR
M-MATH-105650	Introduction to Fluid Dynamics	3 CR
M-MATH-105651	Applications of Topological Data Analysis	4 CR
M-MATH-105837	Introduction to Kinetic Equations	3 CR
M-MATH-105838	Introduction to Microlocal Analysis	3 CR
M-MATH-105839	Lie-Algebras (Linear Algebra 3)	8 CR
M-MATH-105764	Numerical Analysis of Helmholtz Problems	3 CR
M-MATH-105840	Statistical Learning	8 CR
M-MATH-105897	Selected Methods in Fluids and Kinetic Equations	3 CR
M-MATH-105931	Metric Geometry	8 CR
M-MATH-105964	Introduction to Convex Integration	3 CR
M-MATH-105966	Space and Time Discretization of Nonlinear Wave Equations	6 CR
M-MATH-105973	Translation Surfaces	8 CR
M-MATH-106045	Introduction to Stochastic Differential Equations	4 CR
M-MATH-106052	Random Graphs and Networks	8 CR
M-MATH-106053	Stochastic Simulation	5 CR
M-MATH-106063	Numerical Complex Analysis	6 CR
M-MATH-106064	Topological Genomics	3 CR
M-ZAK-106099	Supplementary Studies on Sustainable Development	19 CR
M-ZAK-106235	Supplementary Studies on Culture and Society	22 CR
M-MATH-106328	Bayesian Inverse Problems with Connections to Machine Learning	4 CR
M-MATH-106401	Introduction to Fluid Mechanics	6 CR
M-MATH-106466	Riemann Surfaces	8 CR

M-MATH-106473	Ergodic Theory	8 CR
M-MATH-106485	Functional Data Analysis	4 CR
M-MATH-106486	Harmonic Analysis 2	8 CR
M-MATH-106591	Introduction to Dynamical Systems	6 CR
M-MATH-106632	Curves on Surfaces	3 CR
M-MATH-106640	Modelling and Simulation of Lithium-Ion Batteries neu	4 CR
M-MATH-106664	Scattering Theory for Time-dependent Waves neu	6 CR
M-MATH-106667	Geometric Variational Problems neu	8 CR
M-MATH-106666	Minimal Surfaces neu	3 CR
M-MATH-106663	Semigroup Theory for the Navier-Stokes Equations neu	6 CR
M-MATH-106696	Regularity for Elliptic Operators neu	6 CR
M-MATH-106695	Numerical Analysis of Neural Networks neu	6 CR
M-MATH-106682	Numerical Methods for Oscillatory Differential Equations neu	8 CR

3 Modules

M 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

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

Mandatory			
T-MATH-105898	Adaptive Finite Element Methods	6 CR	Dörfler

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 implementions
- 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

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

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

M 3.3 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

Credits	Grading scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each winter term	1 term	4	2

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 worklaod : 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 benefitial.

3.4 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
Additional Examinations

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

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.

M 3.5 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

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

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.

M 3.6 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

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

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

Prerequisites
none

3.7 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

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

Mandatory			
T-MATH-105926	Algebraic Topology II	8 CR	Sauer

Prerequisites
none

M 3.8 Module: Algorithm Engineering [M-INFO-100795]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each summer term	1 term	German/English	4	3

Mandatory			
T-INFO-101332	Algorithm Engineering	4 CR	Sanders
T-INFO-111856	Algorithm Engineering Pass	1 CR	Sanders

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
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

M 3.9 Module: Analytical and Numerical Homogenization [M-MATH-105636]

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

Mandatory			
T-MATH-111272	Analytical and Numerical Homogenization	6 CR	Hochbruck, Maier

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 the solution of multiscale problems and from homogenization theory. In addition, they know methods for the numerical approximation of multiscale and the homogenized solution. They are able to analyze the convergence of these methods and asses the pros and cons 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. local orthogonal decomposition)

Annotation
Upon request the lecture will be held in english.

3.10 Module: Applications of Operations Research [M-WIWI-101413]

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

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

Compulsory Elective Courses (Election: between 1 and 2 items)			
T-WIWI-102704	Facility Location and Strategic Supply Chain Management	4,5 CR	Nickel
T-WIWI-102714	Tactical and Operational Supply Chain Management	4,5 CR	Nickel
Supplementary Courses (Election: at most 1 item)			
T-WIWI-102726	Global Optimization I	4,5 CR	Stein
T-WIWI-106199	Modeling and OR-Software: Introduction	4,5 CR	Nickel
T-WIWI-106545	Optimization under Uncertainty	4,5 CR	Rebennack

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 seperately.

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 Suppy 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.

M 3.11 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

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

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

Prerequisites
None

M 3.12 Module: Applied Information Theory [M-ETIT-100444]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100748	Applied Information Theory	6 CR	Jäkel

Prerequisites
none

3.13 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

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

Mandatory			
T-MATH-106461	Aspects of Geometric Analysis	4 CR	Lamm

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

M 3.14 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-INFO-101260	Asymmetric Encryption Schemes	3 CR	Müller-Quade

3.15 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

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

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. 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.

M 3.16 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	German	4	2

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

Prerequisites
none

3.17 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

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

Mandatory			
T-MATH-112842	Bayesian Inverse Problems with Connections to Machine Learning	4 CR	Krumscheid

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.

M 3.18 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

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

Mandatory			
T-MATH-106487	Bifurcation Theory	5 CR	Mandel

Prerequisites
None

Annotation
Course is held in English

M 3.19 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	Grading scale	Recurrence	Duration	Level	Version
5	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-108905	Bott Periodicity	5 CR	Tuschmann

Prerequisites
None

M 3.20 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	Grading scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each summer term	1 term	4	1

Mandatory			
T-MATH-105833	Boundary and Eigenvalue Problems	8 CR	Frey, Hundertmark, Lamm, Plum, Reichel, Schnaubelt

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

M 3.21 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
Additional Examinations

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

M 3.22 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

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

Mandatory			
T-MATH-105847	Boundary Value Problems for Nonlinear Differential Equations	8 CR	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.

3.23 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
Additional Examinations

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

Mandatory			
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: zz 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.

M 3.24 Module: Classical Methods for Partial Differential Equations [M-MATH-102870]

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

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

Mandatory			
T-MATH-105832	Classical Methods for Partial Differential Equations	8 CR	Frey, Hundertmark, Lamm, Plum, Reichel, Schnaubelt

M 3.25 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
Additional Examinations

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	see Annotations	1 term	English	4	3

Mandatory			
T-MATH-105916	Combinatorics	8 CR	Aksenovich

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 ist 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.

3.26 Module: Communications Engineering I [M-ETIT-102103]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	2	2

Mandatory			
T-ETIT-101936	Communications Engineering I	6 CR	Schmalen

Competence Certificate
Type of examination: written exam. Duration of Examination: approx. 180 minutes.

Prerequisites
none

M 3.27 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

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

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
The module can be started for the first time in summer term2020. Please note: The German course "Nachrichtentechnik II" takes place every summer term(starting summer term 2020) and the English version "Communications Engineering II" takes place every winter term (starting winter term 2020/2021).

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.

M 3.28 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

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

Mandatory			
T-MATH-105917	Comparison Geometry	5 CR	Tuschmann

Prerequisites
none

M 3.29 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

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

Mandatory			
T-MATH-105849	Complex Analysis	8 CR	Herzog, Plum, Reichel, Schnaubelt, Tolksdorf

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.

M 3.30 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

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

Mandatory			
T-MATH-105894	Compressive Sensing	5 CR	Rieder

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.

M 3.31 Module: Computational Fluid Dynamics and Simulation Lab [M-MATH-106634]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German/English	4	2

Mandatory			
T-MATH-113373	Computational Fluid Dynamics and Simulation Lab	4 CR	Krause, Thäter

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 recommened.

M 3.32 Module: Computational Geometry [M-INFO-102110]

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

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

Mandatory			
T-INFO-104429	Computational Geometry	6 CR	Bläsius

M 3.33 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

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

Mandatory			
T-MATH-105854	Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems	8 CR	Plum

M 3.34 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	Grading scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each summer term	1 term	4	1

Mandatory			
T-MATH-105930	Continuous Time Finance	8 CR	Bäuerle, Fasen-Hartmann, Trabs

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-Doeblin 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.

M 3.35 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	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	German/English	4	1

Mandatory			
T-MATH-105909	Control Theory	6 CR	Schnaubelt

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

- controllabilty and observabilty of systems of linear ordinary differential equations
- stabilizability and detectability
- transfer functions
- realization theory,
- quadratic optimal control, feedback synthesis
- nonlinear controll 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 und Lineare Algebra 1-2 are strongly recommended. Further knowledge of ordinary differential equations (as in Analysis 4) is useful.

Literature
J. Zabczyk, Mathematical Control Theory. An Introduction.

M 3.36 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

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

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
D. Hug, W. Weil: Lectures on Convex Geometry. Graduate Texts in Mathematics, Vol. 286, Springer, Cham, 2020.

M 3.37 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

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

Mandatory			
T-MATH-113364	Curves on Surfaces	3 CR	Fioravanti

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 faciliate a deeper understanding of the course contents.

3.38 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
9	Grade to a tenth	Each winter term	1 term	German	4	1

Wahlpflichtangebot (Election: 9 credits)			
T-WIWI-102613	Auction Theory	4,5 CR	Ehrhart
T-WIWI-102614	Experimental Economics	4,5 CR	Weinhardt
T-WIWI-102861	Advanced Game Theory	4,5 CR	Ehrhart, Puppe, Reiß

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 seperately.

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.

M 3.39 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

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

Mandatory			
T-MATH-106122	Designtheory with Applications in Statistics	8 CR	Ebner, Folkers

M 3.40 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

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

Mandatory			
T-MATH-102275	Differential Geometry	8 CR	Tuschmann

Prerequisites
None

3.41 Module: Digital Signatures [M-INFO-100743]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

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

M 3.42 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	1	1

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

M 3.43 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

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

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.

M 3.44 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

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

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.

3.45 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	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-109001	Dispersive Equations	6 CR	Reichel

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.

M 3.46 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

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

Mandatory			
T-ETIT-100960	Distributed Discrete Event Systems	4 CR	Heizmann

Prerequisites
none

M 3.47 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

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

Mandatory			
T-MATH-106114	Dynamical Systems	8 CR	Reichel

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.

M 3.48 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

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

Compulsory Elective Courses (Election: 1 item)			
T-WIWI-102609	Advanced Topics in Economic Theory	4,5 CR	Mitusch
T-WIWI-102861	Advanced Game Theory	4,5 CR	Ehrhart, Puppe, Reiß
Supplementary Courses (Election:)			
T-WIWI-113469	Advanced Corporate Finance	4,5 CR	Ruckes
T-WIWI-102647	Asset Pricing	4,5 CR	Ruckes, Uhrig-Homburg
T-WIWI-109050	Corporate Risk Management	4,5 CR	Ruckes
T-WIWI-102623	Financial Intermediation	4,5 CR	Ruckes

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 compulsary.

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
The total workload for this module is approximately 270 hours. For further information see German version.

3.49 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

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

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.
- Eigenvalue problems in thin domains. Dumbbell-shape domains. Quantum graphs.

M 3.50 Module: Electromagnetics and Numerical Calculation of Fields [M-ETIT-100386]

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

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

Mandatory			
T-ETIT-100640	Electromagnetics and Numerical Calculation of Fields	4 CR	Zwick

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
Allen Taflove and Susan Hagness (2000), Computational electrodynamics: the finite-difference time-domain method.
Artech House, Boston, 1-58053-076-1
Nathan Ida and Joao Bastos (1997), Electromagnetics and calculation of fields.
Springer Verlag, New York, 0-387-94877-5
Z. Haznadar and Z. Stih (2000), Electromagnetic Fields, Waves and Numerical Methods.
IOS Press, Ohmsha, 1 58603 064 7
M.V.K. Chari and S.J. Salon (2000), Numerical Methods in Electromagnetism, Academic Press, 0 12 615760 X

3.51 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

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

Compulsory Elective Courses (Election: at least 9 credits)			
T-WIWI-102793	Efficient Energy Systems and Electric Mobility	3,5 CR	Jochem
T-WIWI-102650	Energy and Environment	3,5 CR	Karl
T-WIWI-113073	Machine Learning and Optimization in Energy Systems	4 CR	Fichtner
T-WIWI-107464	Smart Energy Infrastructure	5,5 CR	Ardone, Pustisek
T-WIWI-102695	Heat Economy	3,5 CR	Fichtner

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 seperately.

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 approximately 270 hours. For further information see German version.

M 3.52 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	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	German	4	1

Mandatory			
T-MATH-113086	Ergodic Theory	8 CR	Link

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.

M 3.53 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	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	see Annotations	1 term	German/English	4	1

Mandatory			
T-MATH-105844	Evolution Equations	8 CR	Frey, Kunstmann, Schnaubelt

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.

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

Mandatory			
T-MATH-107475	Exponential Integrators	6 CR	Hochbruck, Jahnke

Competence Certificate
Oral exam of approximately 20 minutes

Prerequisites
None

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.

M 3.55 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

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

Mandatory			
T-MATH-105931	Extremal Graph Theory	4 CR	Aksenovich

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.

M 3.56 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	Grading scale	Recurrence	Duration	Level	Version
4	Grade to a tenth	Irregular	1 term	4	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.

M 3.57 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

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

Compulsory Elective Courses (Election: 9 credits)			
T-WIWI-102643	Derivatives	4,5 CR	Uhrig-Homburg
T-WIWI-102621	Valuation	4,5 CR	Ruckes
T-WIWI-102647	Asset Pricing	4,5 CR	Ruckes, Uhrig-Homburg

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 seperately.

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 approximately 270 hours. For further information see German version.

3.58 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

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

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.

++

Compulsory Elective Courses (Election: at least 9 credits)			
T-WIWI-113469	Advanced Corporate Finance	4,5 CR	Ruckes
T-WIWI-110513	Advanced Empirical Asset Pricing	4,5 CR	Thimme
T-WIWI-102647	Asset Pricing	4,5 CR	Ruckes, Uhrig-Homburg
T-WIWI-110995	Bond Markets	4,5 CR	Uhrig-Homburg
T-WIWI-110997	Bond Markets - Models & Derivatives	3 CR	Uhrig-Homburg
T-WIWI-110996	Bond Markets - Tools & Applications	1,5 CR	Uhrig-Homburg
T-WIWI-109050	Corporate Risk Management	4,5 CR	Ruckes
T-WIWI-102643	Derivatives	4,5 CR	Uhrig-Homburg
T-WIWI-110797	eFinance: Information Systems for Securities Trading	4,5 CR	Weinhardt
T-WIWI-102900	Financial Analysis	4,5 CR	Luedecke
T-WIWI-102623	Financial Intermediation	4,5 CR	Ruckes
T-WIWI-102626	Business Strategies of Banks	3 CR	Müller
T-WIWI-102646	International Finance	3 CR	Uhrig-Homburg
T-WIWI-102621	Valuation	4,5 CR	Ruckes

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 seperately.

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.

3.59 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	Grading scale	Recurrence	Duration	Language	Level	Version
9	Grade to a tenth	Each term	1 term	German/English	4	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.

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Compulsory Elective Courses (Election: at least 9 credits)			
T-WIWI-113469	Advanced Corporate Finance	4,5 CR	Ruckes
T-WIWI-110513	Advanced Empirical Asset Pricing	4,5 CR	Thimme
T-WIWI-102647	Asset Pricing	4,5 CR	Ruckes, Uhrig-Homburg
T-WIWI-110995	Bond Markets	4,5 CR	Uhrig-Homburg
T-WIWI-110997	Bond Markets - Models & Derivatives	3 CR	Uhrig-Homburg
T-WIWI-110996	Bond Markets - Tools & Applications	1,5 CR	Uhrig-Homburg
T-WIWI-109050	Corporate Risk Management	4,5 CR	Ruckes
T-WIWI-102643	Derivatives	4,5 CR	Uhrig-Homburg
T-WIWI-110797	eFinance: Information Systems for Securities Trading	4,5 CR	Weinhardt
T-WIWI-102900	Financial Analysis	4,5 CR	Luedecke
T-WIWI-102623	Financial Intermediation	4,5 CR	Ruckes
T-WIWI-102626	Business Strategies of Banks	3 CR	Müller
T-WIWI-102646	International Finance	3 CR	Uhrig-Homburg
T-WIWI-102621	Valuation	4,5 CR	Ruckes
T-WIWI-110933	Web App Programming for Finance	4,5 CR	Thimme

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 seperately.

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.

M 3.60 Module: Finite Element Methods [M-MATH-102891]

Responsible: Prof. Dr. Willy Dörfler
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

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

Mandatory			
T-MATH-105857	Finite Element Methods	8 CR	Dörfler, Hochbruck, Jahnke, Rieder, Wieners

M 3.61 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	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	2 terms	English	4	2

Mandatory			
T-MATH-105928	Forecasting: Theory and Practice	8 CR	Gneiting

Prerequisites
None

Annotation

- Regular cycle: every 2nd year, starting winter semester 16/17
- Course is held in English

M 3.62 Module: Formal Systems [M-INFO-100799]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-INFO-101336	Formal Systems	6 CR	Beckert

M 3.63 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

Credits	Grading scale	Recurrence	Duration	Level	Version
3	Grade to a tenth	Once	1 term	4	1

Mandatory			
T-MATH-107044	Foundations of Continuum Mechanics	3 CR	Wieners

Prerequisites
none

3.64 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

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

Mandatory			
T-MATH-109850	Fourier Analysis and its Applications to PDEs	6 CR	Liao

Prerequisites
None

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

Mandatory			
T-MATH-111296	Fractal Geometry	6 CR	Winter

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.

M 3.66 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

Credits	Grading scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each winter term	1 term	4	2

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

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

Mandatory			
T-MATH-113102	Functional Data Analysis	4 CR	Ebner, Klar, Trabs

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.

3.68 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

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

Mandatory			
T-MATH-105906	Functions of Matrices	8 CR	Grimm

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.

3.69 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

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

Mandatory			
T-MATH-105905	Functions of Operators	6 CR	

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.

3.70 Module: Fuzzy Sets [M-INFO-100839]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-INFO-101376	Fuzzy Sets	6 CR	Hanebeck

3.71 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

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

Mandatory			
T-MATH-105870	Generalized Regression Models	4 CR	Ebner, Fasen-Hartmann, Klar, Trabs

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

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 "Statistics" are strongly recommended.

M 3.72 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

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

Mandatory			
T-MATH-105892	Geometric Analysis	8 CR	Lamm

Prerequisites
none

3.73 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

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

Mandatory			
T-MATH-105842	Geometric Group Theory	8 CR	Herrlich, Link, Llosa Isenrich, Sauer, Tuschmann

3.74 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

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

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

Prerequisites
none

3.75 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

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

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.

3.76 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

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

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.

M 3.77 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

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

Mandatory			
T-MATH-105841	Geometry of Schemes	8 CR	Herrlich, Kühnlein

Competence Certificate
The modules 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.

M 3.78 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

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

Mandatory			
T-MATH-105885	Global Differential Geometry	8 CR	Tuschmann

Prerequisites
none

3.79 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

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

Mandatory			
T-MATH-102273	Graph Theory	8 CR	Aksenovich

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

M 3.80 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	Grading scale	Recurrence	Duration	Level	Version
5	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105925	Group Actions in Riemannian Geometry	5 CR	Tuschmann

Prerequisites
none

M 3.81 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	Grading scale	Recurrence	Duration	Language	Level	Version
9	Grade to a tenth	Each term	1 term	German/English	4	5

Compulsory Elective Courses (Election: 9 credits)			
T-WIWI-109194	Dynamic Macroeconomics	4,5 CR	Brumm
T-WIWI-112816	Growth and Development	4,5 CR	Ott
T-WIWI-103107	Spatial Economics	4,5 CR	Ott

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
The total workload for this module is approximately 270 hours. For further information see German version.

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.

M 3.82 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

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

Mandatory			
T-MATH-111289	Harmonic Analysis	8 CR	Frey, Kunstmann, Schnaubelt, Tolksdorf

Content

- Fourier series
- Fourier transform on L1 and L2
- Tempered distributions and their Fourier transform
- Explizit 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

3.83 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

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

Mandatory			
T-MATH-113103	Harmonic Analysis 2	8 CR	Frey, Kunstmann, Tolksdorf

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".

M 3.84 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

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

Mandatory			
T-MATH-105933	Homotopy Theory	8 CR	Sauer

3.85 Module: Human Brain and Central Nervous System: Anatomy, Information Transfer, Signal Processing, Neurophysiology and Therapy [M-INFO-100725]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each term	1 term	German	4	1

Mandatory			
T-INFO-101262	Human Brain and Central Nervous System: Anatomy, Information Transfer, Signal Processing, Neurophysiology and Therapy	3 CR	Asfour, Spetzger

M 3.86 Module: Human-Machine-Interaction in Anthropomatics: Basics [M-INFO-100824]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-INFO-101361	Human-Machine-Interaction in Anthropomatics: Basics	3 CR	Beyerer, van de Camp

M 3.87 Module: Informatics [M-WIWI-101472]

Responsible: Dr.-Ing. Michael Färber
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	Grading scale	Recurrence	Duration	Level	Version
9	Grade to a tenth	Each term	1 term	4	18

Compulsory Elective Area (Election:)			
T-WIWI-110339	Applied Informatics – Principles of Internet Computing: Foundations for Emerging Technologies and Future Services	4,5 CR	Sunyaev
T-WIWI-102680	Computational Economics	4,5 CR	Shukla
T-WIWI-112690	Cooperative Autonomous Vehicles	4,5 CR	Vinel
T-WIWI-113363	Collective Perception in Autonomous Driving	4,5 CR	Vinel
T-WIWI-109248	Critical Information Infrastructures	4,5 CR	Sunyaev
T-WIWI-109246	Digital Health	4,5 CR	Sunyaev
T-WIWI-113059	Human Factors in Autonomous Driving	4,5 CR	Vinel
T-WIWI-109270	Human Factors in Security and Privacy	4,5 CR	Volkamer
T-WIWI-102661	Database Systems and XML	4,5 CR	Oberweis
T-WIWI-110346	Supplement Enterprise Information Systems	4,5 CR	Oberweis
T-WIWI-110372	Supplement Software- and Systemsengineering	4,5 CR	Oberweis
T-WIWI-106423	Information Service Engineering	4,5 CR	Sack
T-WIWI-102666	Knowledge Discovery	4,5 CR	Färber
T-WIWI-112599	Management of IT-Projects	4,5 CR	Schätzle
T-WIWI-106340	Machine Learning 1 - Basic Methods	5 CR	Zöllner
T-WIWI-106341	Machine Learning 2 – Advanced Methods	5 CR	Zöllner
T-WIWI-112685	Modeling and Simulation	4,5 CR	Lazarova-Molnar
T-WIWI-102697	Business Process Modelling	4,5 CR	Oberweis
T-WIWI-102679	Nature-Inspired Optimization Methods	4,5 CR	Shukla
T-WIWI-109799	Process Mining	4,5 CR	Oberweis
T-WIWI-110848	Semantic Web Technologies	4,5 CR	Käfer
T-WIWI-102895	Software Quality Management	4,5 CR	Oberweis
Seminars and Advanced Labs (Election: between 0 and 1 items)			
T-WIWI-110144	Emerging Trends in Digital Health	4,5 CR	Sunyaev
T-WIWI-110143	Emerging Trends in Internet Technologies	4,5 CR	Sunyaev
T-WIWI-109249	Sociotechnical Information Systems Development	4,5 CR	Sunyaev
T-WIWI-111126	Advanced Lab Blockchain Hackathon (Master)	4,5 CR	Sunyaev
T-WIWI-111125	Advanced Lab Sociotechnical Information Systems Development (Master)	4,5 CR	Sunyaev
T-WIWI-110548	Advanced Lab Informatics (Master)	4,5 CR	Professorenschaft des Instituts AIFB
T-WIWI-112914	Advanced Lab Realization of Innovative Services (Master)	4,5 CR	Oberweis
T-WIWI-108439	Advanced Lab Security, Usability and Society	4,5 CR	Volkamer
T-WIWI-109786	Advanced Lab Security	4,5 CR	Volkamer

T-WIWI-109985	Project Lab Cognitive Automobiles and Robots	5 CR	Zöllner
T-WIWI-109983	Project Lab Machine Learning	5 CR	Zöllner
T-WIWI-113026	Trustworthy Emerging Technologies	4,5 CR	Sunyaev

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.

3.88 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
7	Grade to a tenth	Each summer term	1 term	German	4	2

Mandatory			
T-ETIT-112878	Information and Automation Technology	5 CR	Barth
T-ETIT-112879	Information and Automation Technology - Lab Course	2 CR	Sax

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.

3.89 Module: Information Security [M-INFO-106015]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each summer term	1 term	German	4	2

Mandatory			
T-INFO-112195	Information Security	5 CR	Müller-Quade

M 3.90 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

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

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

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

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 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

3.91 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	German/English	4	1

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

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.

3.92 Module: Introduction into Particulate Flows [M-MATH-102943]

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

Credits	Grading scale	Recurrence	Duration	Level	Version
3	Grade to a tenth	Once	1 term	4	1

Mandatory			
T-MATH-105911	Introduction into Particulate Flows	3 CR	Dörfler

Prerequisites
none

M 3.93 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	Grading scale	Recurrence	Duration	Level	Version
3	Grade to a tenth	Irregular	1 term	4	1

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

Prerequisites
None

M 3.94 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-INFO-112194	Introduction to Artificial Intelligence	5 CR	Friederich, Neumann

M 3.95 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

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

Mandatory			
T-MATH-112119	Introduction to Convex Integration	3 CR	Zillinger

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.

M 3.96 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

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

Mandatory			
T-MATH-113263	Introduction to Dynamical Systems	6 CR	de Rijk, Reichel

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.

M 3.97 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

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

Mandatory			
T-MATH-111297	Introduction to Fluid Dynamics	3 CR	Reichel

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.

M 3.98 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	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-MATH-112927	Introduction to Fluid Mechanics	6 CR	Liao

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.

M 3.99 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	Grading scale	Recurrence	Duration	Level	Version
6	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105918	Introduction to Geometric Measure Theory	6 CR	Winter

Prerequisites
none

M 3.100 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

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

Mandatory			
T-MATH-110323	Introduction to Homogeneous Dynamics	6 CR	Hartnick

Prerequisites
None

3.101 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	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Irregular	1 term	English	4	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
Totel 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.

M 3.102 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-MATH-108013	Introduction to Kinetic Theory	4 CR	Frank

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 asypmtotic 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

M 3.103 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

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

Mandatory			
T-MATH-111722	Introduction to Microlocal Analysis	3 CR	Liao

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
Totel 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".

3.104 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

Credits	Grading scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each summer term	1 term	4	2

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".

3.105 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

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

Mandatory			
T-MATH-112234	Introduction to Stochastic Differential Equations	4 CR	Janák, Trabs

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.

M 3.106 Module: Inverse Problems [M-MATH-102890]

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

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

Mandatory			
T-MATH-105835	Inverse Problems	8 CR	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.

3.107 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

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

Mandatory			
T-INFO-112818	IT Security	6 CR	Hartenstein, Müller-Quade, Strufe, Wressnegger

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 effectivity

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: Netzsicherheit (dpunkt)
- Anderson: Security Engineering (Wiley, and online)
- Stallings/Brown: Computer Security (Pearson)
- Pfleeger, Pfleeger, Margulies: Security in Computing (Prentice Hall)

M 3.108 Module: Key Competences [M-MATH-103053]

Organisation: KIT Department of Mathematics

Part of: Interdisciplinary Qualifications

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Each term	1 term	German	4	3

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)			
T-MATH-106119	Introduction to Python	3 CR	Weiß
T-MATH-111515	Self-Booking-HOC-SPZ-ZAK-1-Graded	2 CR	
T-MATH-111517	Self-Booking-HOC-SPZ-ZAK-2-Graded	2 CR	
T-MATH-111518	Self-Booking-HOC-SPZ-ZAK-Graded	2 CR	
T-MATH-111519	Self-Booking-HOC-SPZ-ZAK-4-Graded	2 CR	
T-MATH-111516	Self-Booking-HOC-SPZ-ZAK-5-Ungraded	2 CR	
T-MATH-111520	Self-Booking-HOC-SPZ-ZAK-6-Ungraded	2 CR	
T-MATH-111521	Self-Booking-HOC-SPZ-ZAK-7-Ungraded	2 CR	
T-MATH-111522	Self-Booking-HOC-SPZ-ZAK-8-Ungraded	2 CR	
T-MATH-111851	Introduction to Python - Programming Project	1 CR	Weiß

Prerequisites

None

3.109 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

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

Mandatory			
T-MATH-108401	Key Moments in Geometry	5 CR	Tuschmann

Prerequisites
None

M 3.110 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	Grading scale	Recurrence	Duration	Level	Version
5	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105924	L2-Invariants	5 CR	Kammeyer, Sauer

Prerequisites
none

M 3.111 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

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

Mandatory			
T-MATH-108799	Lie Groups and Lie Algebras	8 CR	Hartnick

M 3.112 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

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

Mandatory			
T-MATH-111723	Lie-Algebras (Linear Algebra 3)	8 CR	

3.113 Module: Linear Electronic Networks [M-ETIT-101845]

Responsible: Prof. Dr. Olaf Dössel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Complementary Field / Subject Electrical Engineering

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
7	Grade to a tenth	Each winter term	1 term	German	1	1

Mandatory			
T-ETIT-101917	Linear Electronic Networks	7 CR	Dössel

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.

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.

M 3.114 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-INFO-101377	Localization of Mobile Agents	6 CR	Hanebeck

M 3.115 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

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

Mandatory			
T-MATH-105921	Markov Decision Processes	5 CR	Bäuerle

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.

M 3.116 Module: Master's Thesis [M-MATH-102917]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: Master's Thesis

Credits	Grading scale	Recurrence	Duration	Level	Version
30	Grade to a tenth	Each term	1 term	4	1

Mandatory			
T-MATH-105878	Master's Thesis	30 CR	Kühnlein

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.

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

M 3.117 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	Grading scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	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.

3.118 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
5	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-106488	Mathematical Methods of Imaging	5 CR	Rieder

Competence 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.

3.119 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

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

Mandatory			
T-MATH-105889	Mathematical Modelling and Simulation in Practise	4 CR	Thäter

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
Hans-Joachim Bungartz e.a.: Modeling and Simulation: An Application-Oriented Introduction, Springer, 2013

3.120 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

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

Mandatory			
T-MATH-106113	Mathematical Physics	8 CR	Hundertmark

Prerequisites
None

M 3.121 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

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

Mandatory			
T-MATH-106526	Mathematical Physics 2	8 CR	Hundertmark

Prerequisites
None

3.122 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	Grading scale	Recurrence	Duration	Language	Level	Version
9	Grade to a tenth	Each term	1 term	German/English	4	7

Compulsory Elective Courses (Election: at most 2 items)			
T-WIWI-102719	Mixed Integer Programming I	4,5 CR	Stein
T-WIWI-102726	Global Optimization I	4,5 CR	Stein
T-WIWI-103638	Global Optimization I and II	9 CR	Stein
T-WIWI-102856	Convex Analysis	4,5 CR	Stein
T-WIWI-111587	Multicriteria Optimization	4,5 CR	Stein
T-WIWI-102724	Nonlinear Optimization I	4,5 CR	Stein
T-WIWI-103637	Nonlinear Optimization I and II	9 CR	Stein
T-WIWI-102855	Parametric Optimization	4,5 CR	Stein
Supplementary Courses (Election: at most 2 items)			
T-WIWI-106548	Advanced Stochastic Optimization	4,5 CR	Rebennack
T-WIWI-102720	Mixed Integer Programming II	4,5 CR	Stein
T-WIWI-102727	Global Optimization II	4,5 CR	Stein
T-WIWI-102723	Graph Theory and Advanced Location Models	4,5 CR	Nickel
T-WIWI-106549	Large-scale Optimization	4,5 CR	Rebennack
T-WIWI-111247	Mathematics for High Dimensional Statistics	4,5 CR	Grothe
T-WIWI-103124	Multivariate Statistical Methods	4,5 CR	Grothe
T-WIWI-102725	Nonlinear Optimization II	4,5 CR	Stein
T-WIWI-102715	Operations Research in Supply Chain Management	4,5 CR	Nickel
T-WIWI-110162	Optimization Models and Applications	4,5 CR	Sudermann-Merx
T-WIWI-112109	Topics in Stochastic Optimization	4,5 CR	Rebennack

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 seperately.

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 modul 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.

M 3.123 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

Credits	Grading scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each winter term	1 term	4	2

Mandatory			
T-MATH-105872	Mathematical Statistics	8 CR	Ebner, Fasen-Hartmann, Klar, Trabs

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.

M 3.124 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

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

Mandatory			
T-MATH-108403	Mathematical Topics in Kinetic Theory	4 CR	Hundertmark

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

M 3.125 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

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

Mandatory			
T-MATH-105856	Maxwell's Equations	8 CR	Arens, Griesmaier, Hettlich

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

Attendace: 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

M 3.126 Module: Medical Imaging Technology I [M-ETIT-106449]

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

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

Mandatory			
T-ETIT-113048	Medical Imaging Technology I	3 CR	Spadea

Competence Certificate
The examination takes place in form of a written examination lasting 60 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 students will be able to communicate in technical and clinical English languange.

Content
The module Medical Imaging Technology I provides knowledge on

- the basic knowledge of mathematical and physical principles of medical imaging formation, including X-ray based modalities, nuclear medicine imaging, magnetic resonance imaging and ultrasound
- 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

1. attendance in lectures an exercises: 2SWS = 30 h
2. preparation / follow-up: 15*2 h = 30 h
3. preparation of and attendance in examination: 30 h

A total of 90 h = 3 CR

Recommendation
Basic knowledge in the field of physics and signal processing is helpful.

3.127 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

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

Mandatory			
T-ETIT-113421	Medical Imaging Technology II	3 CR	Spadea

Competence Certificate
The examination takes place in form of a written examination lasting 60 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.

M 3.128 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

Credits	Grading scale	Recurrence	Duration	Level	Version
9	Grade to a tenth	Each term	1 term	4	10

Compulsory Elective Courses (Election: at least 1 item as well as between 4,5 and 9 credits)			
T-WIWI-102726	Global Optimization I	4,5 CR	Stein
T-WIWI-103638	Global Optimization I and II	9 CR	Stein
T-WIWI-102724	Nonlinear Optimization I	4,5 CR	Stein
T-WIWI-103637	Nonlinear Optimization I and II	9 CR	Stein
Supplementary Courses (Election:)			
T-WIWI-106546	Introduction to Stochastic Optimization	4,5 CR	Rebennack
T-WIWI-102727	Global Optimization II	4,5 CR	Stein
T-WIWI-102725	Nonlinear Optimization II	4,5 CR	Stein
T-WIWI-102704	Facility Location and Strategic Supply Chain Management	4,5 CR	Nickel

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 seperately.

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 modul 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 approximately 270 hours. For further information see German version.

Recommendation
The courses Introduction to Operations Research I and II are helpful.

M 3.129 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100694	Methods of Signal Processing	6 CR	Heizmann

Prerequisites
none

M 3.130 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

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

Mandatory			
T-MATH-111933	Metric Geometry	8 CR	Lytchak, Nepechiy

Competence Certificate
oral examination of circa 20 minutes

Prerequisites
None

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

M 3.131 Module: Microeconomic Theory [M-WIWI-101500]

Responsible: Prof. Dr. Clemens Puppe
Organisation: KIT Department of Economics and Management
Part of: Complementary Field / Subject Economics

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

Compulsory Elective Courses (Election: at least 9 credits)			
T-WIWI-102609	Advanced Topics in Economic Theory	4,5 CR	Mitusch
T-WIWI-102861	Advanced Game Theory	4,5 CR	Ehrhart, Puppe, Reiß
T-WIWI-102613	Auction Theory	4,5 CR	Ehrhart
T-WIWI-105781	Incentives in Organizations	4,5 CR	Nieken
T-WIWI-113264	Matching Theory	4,5 CR	Puppe
T-WIWI-102859	Social Choice Theory	4,5 CR	Puppe

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 seperately.

The overall grade of the 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 microoeconomic 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
The total workload for this module is approximately 270 hours. For further information see German version.

3.132 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	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Irregular	1 term	German	4	1

Mandatory			
T-MATH-113417	Minimal Surfaces	3 CR	Lewintan

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 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.

M 3.133 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

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

Mandatory			
T-MATH-113382	Modelling and Simulation of Lithium-Ion Batteries	4 CR	Dörfler

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 fiite 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.

M 3.134 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	Grading scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	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

M 3.135 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

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

Mandatory			
T-PHYS-112846	Modern Experimental Physics I, Atoms, Nuclei and Molecules	8 CR	Studiendekan Physik

Competence Certificate
See components of this module

Prerequisites
none

3.136 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-PHYS-112847	Modern Experimental Physics II, Structure of Matter	8 CR	Studiendekan Physik

Competence Certificate
See components of this module

Prerequisites
none

M 3.137 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

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

Mandatory			
T-PHYS-112848	Modern Theoretical Physics I, Foundations of Quantum Mechanics	8 CR	Studiendekan Physik

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
- Rotational symmetry and spin, degeneracy, irreducible representations of rotations: Addition of angular momenta, product representations of the angular group, Clebsch-Gordan coefficients, irreducible tensor operators, Wigner-Eckart theorem.
- 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

M 3.138 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	German	4	1

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

3.139 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

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

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.

M 3.140 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			
T-MATH-105877	Monotonicity Methods in Analysis	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 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.

M 3.141 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

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

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

M 3.142 Module: Network Security: Architectures and Protocols [M-INFO-100782]

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

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

Mandatory			
T-INFO-101319	Network Security: Architectures and Protocols	4 CR	Zitterbart

M 3.143 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

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

Mandatory			
T-MATH-107065	Nonlinear Analysis	8 CR	Lamm

Prerequisites
None

M 3.144 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	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100980	Nonlinear Control Systems	3 CR	Kluwe

Prerequisites
none

M 3.145 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	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	German/English	4	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 behaviour 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.

M 3.146 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

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

Mandatory			
T-MATH-105876	Nonlinear Functional Analysis	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 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

M 3.147 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

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

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.

3.148 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

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

Mandatory			
T-MATH-106121	Nonlinear Schroedinger and Wave Equations	8 CR	Weis

M 3.149 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

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

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.

M 3.150 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

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

Mandatory			
T-MATH-105873	Nonparametric Statistics	4 CR	Ebner, Fasen-Hartmann, Klar, Trabs

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.

M 3.151 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

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

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.

M 3.152 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	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	German/English	4	1

Mandatory			
T-MATH-113470	Numerical Analysis of Neural Networks	6 CR	Maier

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 in the context of partial differential equations (such as physics-informed neural networks).

Content

- Neural networks
- Approximation results
- Connections to finite element methods
- Numerical methods for the efficient learning
- Physics-informed neural networks

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
A solid background in numerical mathematics is strongly recommended. Basic knowledge of functional analysis and finite element methods is helpful, but not required.

3.153 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

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

Mandatory			
T-MATH-112280	Numerical Complex Analysis	6 CR	Hochbruck

Competence Certificate
oral exam of ca. 20 minutes

Prerequisites
none

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

Workload
total workload: 180 h

3.154 Module: Numerical Linear Algebra for Scientific High Performance Computing [M-MATH-103709]

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

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

Mandatory			
T-MATH-107497	Numerical Linear Algebra for Scientific High Performance Computing	5 CR	Anzt

Prerequisites
None

M 3.155 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
Additional Examinations

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

3.156 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	Grading scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each winter term	1 term	4	1

Mandatory			
T-MATH-105836	Numerical Methods for Differential Equations	8 CR	Dörfler, Hochbruck, Jahnke, Rieder, Wieners

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".

3.157 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

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

Mandatory			
T-MATH-105900	Numerical Methods for Hyperbolic Equations	6 CR	Dörfler

Prerequisites
none

Competence Goal
.

M 3.158 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

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

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 degenerate kernel approximation, 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
- Quadrature formulae
- Approximation by degenerate kernel functions
- Nyström methods
- Projection 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

M 3.159 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	Grading scale	Recurrence	Duration	Level	Version
6	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105920	Numerical Methods for Maxwell's Equations	6 CR	Hochbruck, Jahnke

M 3.160 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	see Annotations	1 term	German/English	4	1

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 oscillatons.
- 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.).

3.161 Module: Numerical Methods for Time-Dependent Partial Differential Equations [M-MATH-102928]

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

Mandatory			
T-MATH-105899	Numerical Methods for Time-Dependent Partial Differential Equations	8 CR	Hochbruck, Jahnke

3.162 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

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

Mandatory			
T-MATH-105860	Numerical Methods in Computational Electrodynamics	6 CR	Dörfler, Hochbruck, Jahnke, Rieder, Wieners

Prerequisites
none

M 3.163 Module: Numerical Methods in Fluid Mechanics [M-MATH-102932]

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

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

Mandatory			
T-MATH-105902	Numerical Methods in Fluid Mechanics	4 CR	Dörfler, Thäter

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 especiallly 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.

3.164 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	see Annotations	1 term	German/English	4	1

Mandatory			
T-MATH-105865	Numerical Methods in Mathematical Finance	8 CR	Jahnke

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.

M 3.165 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

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

Mandatory			
T-MATH-105858	Numerical Optimisation Methods	8 CR	Dörfler, Hochbruck, Jahnke, Rieder, Wieners

M 3.166 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

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

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.

3.167 Module: Operations Research in Supply Chain Management [M-WIWI-102832]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
9	Grade to a tenth	Each term	2 terms	German	4	8

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)			
T-WIWI-102723	Graph Theory and Advanced Location Models	4,5 CR	Nickel
T-WIWI-106200	Modeling and OR-Software: Advanced Topics	4,5 CR	Nickel
T-WIWI-102715	Operations Research in Supply Chain Management	4,5 CR	Nickel
Supplementary Courses (Election: at most 1 item)			
T-MACH-112213	Applied material flow simulation	4,5 CR	Baumann
T-WIWI-106546	Introduction to Stochastic Optimization	4,5 CR	Rebennack
T-WIWI-102718	Discrete-Event Simulation in Production and Logistics	4,5 CR	Spieckermann
T-WIWI-102719	Mixed Integer Programming I	4,5 CR	Stein
T-WIWI-102720	Mixed Integer Programming II	4,5 CR	Stein
T-WIWI-110162	Optimization Models and Applications	4,5 CR	Sudermann-Merx
T-WIWI-106549	Large-scale Optimization	4,5 CR	Rebennack
T-WIWI-111587	Multicriteria Optimization	4,5 CR	Stein
T-WIWI-112109	Topics in Stochastic Optimization	4,5 CR	Rebennack

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 seperately.

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 Suppy Chain Mangement, 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.

3.168 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

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 relatons, 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

3.169 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	1	1

Mandatory			
T-ETIT-104594	Optimal Control and Estimation	3 CR	Hohmann

Prerequisites
none

M 3.170 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

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

Mandatory			
T-MATH-105864	Optimisation and Optimal Control for Differential Equations	4 CR	

Prerequisites
none

M 3.171 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

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

Mandatory			
T-MATH-105893	Optimization in Banach Spaces	5 CR	Griesmaier, Hettlich

Competence 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.

3.172 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	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	English	4	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)

M 3.173 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

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

Mandatory			
T-MATH-102271	Parallel Computing	5 CR	Krause, Wieners

Prerequisites
None

M 3.174 Module: Percolation [M-MATH-102905]

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

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

Mandatory			
T-MATH-105869	Percolation	5 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 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.

M 3.175 Module: Photorealistic Rendering [M-INFO-100731]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	German/English	4	2

Mandatory			
T-INFO-101268	Photorealistic Rendering	5 CR	Dachsbacher

M 3.176 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	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	3

Mandatory			
T-ETIT-101932	Physiology and Anatomy for Engineers I	3 CR	Nahm

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
  - Nuleic 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

3.177 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

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

Mandatory			
T-MATH-105922	Poisson Processes	5 CR	Fasen-Hartmann, Hug, Last, Nestmann, Winter

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.

M 3.178 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

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

Mandatory			
T-MATH-105850	Potential Theory	8 CR	Arens, Griesmaier, Hettlich, Reichel

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 solver 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

3.179 Module: Probability Theory and Combinatorial Optimization [M-MATH-102947]

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

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

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 modul 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.

M 3.180 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

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

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:

- Erdös--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.

3.181 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

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

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 exmaples,
- have mastered the important techniques of proofs for regulariy 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.

3.182 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

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

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*".

M 3.183 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German/English	4	3

Mandatory			
T-INFO-108014	Robotics I - Introduction to Robotics	6 CR	Asfour

Competence Certificate
See partial achivements (Teilleistung)

Prerequisites
See partial achivements (Teilleistung)

Competence Goal
The student is 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 student masters the kinematic and dynamic modeling of robot systems, as well as the modeling and design of simple controllers. The student knows the algorithmic basics of motion and grasp planning and can apply these algorithms to problems in robotics. He/she knows algorithms from the field of image processing and is able to apply them to problems in robotics. He/she is able to model and solve tasks as a symbolic planning problem. The student has knowledge about intuitive programming procedures for robots and knows 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

M 3.184 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

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

Mandatory			
T-MATH-108400	Ruin 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 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.

3.185 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

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

Mandatory			
T-MATH-105855	Scattering Theory	8 CR	Arens, Griesmaier, Hettlich

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 soultions
- 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

3.186 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

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

Mandatory			
T-MATH-113416	Scattering Theory for Time-dependent Waves	6 CR	Griesmaier

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 depence 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.

M 3.187 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

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

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 eqautions.
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
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.

M 3.188 Module: Selected Topics in Cryptography [M-INFO-100836]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-INFO-101373	Selected Topics in Cryptography	3 CR	Müller-Quade

3.189 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

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

Mandatory			
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

3.190 Module: Semigroup Theory for the Navier-Stokes Equations [M-MATH-106663]

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

Mandatory			
T-MATH-113415	Semigroup Theory for the Navier-Stokes Equations	6 CR	Tolksdorf

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.*

M 3.191 Module: Seminar [M-MATH-102730]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: Mathematical Seminar

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	pass/fail	Each term	1 term	German/English	4	3

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

3.192 Module: Seminar [M-MATH-103276]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: Mathematical Specialization

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	pass/fail	Each term	1 term	German	4	1

Mandatory			
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

3.193 Module: Seminar 2 [M-MATH-103925]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: Mathematical Seminar

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	pass/fail	Each term	1 term	German	3	1

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

M 3.194 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German/English	4	1

Mandatory			
T-INFO-103584	Seminar Advanced Topics in Parallel Programming	3 CR	Streit

3.195 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-113428	Signal Processing with Nonlinear Fourier Transforms and Koopman Operators	6 CR	Wahls

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 interesting of 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.

M 3.196 Module: Signals and Codes [M-INFO-100823]

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

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

Mandatory			
T-INFO-101360	Signals and Codes	3 CR	Müller-Quade

M 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

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

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.

M 3.198 Module: Space and Time Discretization of Nonlinear Wave Equations [M-MATH-105966]

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

Mandatory			
T-MATH-112120	Space and Time Discretization of Nonlinear Wave Equations	6 CR	Hochbruck

M 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

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

Mandatory			
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.

M 3.200 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	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	see Annotations	1 term	English	4	1

Mandatory			
T-MATH-105891	Special Topics of Numerical Linear Algebra	8 CR	Grimm, Hochbruck, Neher

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 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 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
Numerical analysis 1 and 2

3.201 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

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

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.

M 3.202 Module: Spectral Theory of Differential Operators [M-MATH-102880]

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

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

Mandatory			
T-MATH-105851	Spectral Theory of Differential Operators	8 CR	Plum

3.203 Module: Splitting Methods for Evolution Equations [M-MATH-105325]

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

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

Mandatory			
T-MATH-110805	Splitting Methods for Evolution Equations	6 CR	Jahnke

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.

M 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

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

Mandatory			
T-MATH-111726	Statistical Learning	8 CR	Trabs

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.

M 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

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

Mandatory			
T-MATH-111187	Steins Method with Applications in Statistics	4 CR	Ebner, Hug

Prerequisites
None

M 3.206 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	Grading scale	Recurrence	Duration	Level	Version
4	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105871	Stochastic Control	4 CR	Bäuerle

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.

M 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

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

Mandatory			
T-MATH-105852	Stochastic Differential Equations	8 CR	Frey, Schnaubelt

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

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

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 modul 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.

M 3.209 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-INFO-101366	Stochastic Information Processing	6 CR	Hanebeck

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-MATH-112242	Stochastic Simulation	5 CR	Krumscheid

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.

M 3.211 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	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-MATH-111004	Structural Graph Theory	4 CR	Aksenovich

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.

3.212 Module: Supplementary Studies on Culture and Society [M-ZAK-106235]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: Additional Examinations

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
22	Grade to a tenth	Each term	3 terms	German	4	1

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/ and on the ZAK homepage at 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 examantion grades, not as the average of the module grades.

Mandatory			
T-ZAK-112653	Basics Module - Self Assignment BAK	3 CR	Mielke, Myglas
In-depth Module (Election: 3 items)			
T-ZAK-112654	In-depth Module - Technology & Responsibility - Self Assignment BAK	3 CR	Mielke, Myglas
T-ZAK-112655	In-depth Module - Doing Culture - Self Assignment BAK	3 CR	Mielke, Myglas
T-ZAK-112656	In-depth Module - Media & Aesthetics - Self Assignment BAK	3 CR	Mielke, Myglas
T-ZAK-112657	In-depth Module - Spheres of Life - Self Assignment BAK	3 CR	Mielke, Myglas
T-ZAK-112658	In-depth Module - Global Cultures - Self Assignment BAK	3 CR	Mielke, Myglas
Mandatory			
T-ZAK-112660	Practice Module	4 CR	Mielke, Myglas
T-ZAK-112659	Oral Exam - Supplementary Studies on Culture and Society	4 CR	Mielke, Myglas

Competence Certificate

The monitoring is explained in the respective partial achievement.

They are composed of:

- minutes
- presentations
- a seminar paper
- an internship report
- an oral examination

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.

M 3.213 Module: Supplementary Studies on Sustainable Development [M-ZAK-106099]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: Additional Examinations

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
19	Grade to a tenth	Each term	3 terms	German	4	1

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 "ÜQ/SQ-Leistungen". Further instructions on self-recording of achievements can be found in the FAQ at https://campus.studium.kit.edu/ and on the ZAK homepage at 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 examantion grades, not as the average of the module grades.

Mandatory			
T-ZAK-112345	Basics Module - Self Assignment BeNe	3 CR	Myglas
Elective Module (Election: 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 thematic 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.

M 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-INFO-101390	Symmetric Encryption	3 CR	Müller-Quade

M 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100804	Technical Optics	5 CR	Neumann

Prerequisites
none

M 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	Grading scale	Recurrence	Duration	Language	Level	Version
12	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102544	Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises	12 CR	Heinrich, Melnikov, Mühlleitner, Nierste, Steinhauser

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 FField Theory
- L. Ryder, Quantum Field Theory

M 3.217 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102546	Theoretical Particle Physics I, Fundamentals and Advanced Topics, without Exercises	8 CR	Heinrich, Melnikov, Mühlleitner, Nierste, Steinhauser

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 FField Theory.
- L. Ryder, Quantum Field Theory

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	Grade to a tenth	Each summer term	1 term	German	4	1

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

3.219 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

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

Mandatory			
T-PHYS-102554	Theoretical Particle Physics II, without Exercises	8 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-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

Credits	Grading scale	Recurrence	Duration	Level	Version
4	Grade to a tenth	Each summer term	1 term	4	2

Mandatory			
T-MATH-105874	Time Series Analysis	4 CR	Ebner, Fasen-Hartmann, Gneiting, Klar, Trabs

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.

M 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

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

Mandatory			
T-MATH-111031	Topological Data Analysis	6 CR	Hartnick, Sauer

M 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

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

Mandatory			
T-MATH-112281	Topological Genomics	3 CR	Ott

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

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

- Chararcterization 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.

M 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
Additional Examinations

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

Mandatory			
T-MATH-105897	Traveling Waves	6 CR	de Rijk, Reichel

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 reommended: Analysis 1-4.

Literature
Kapitula, Todd; Promislow, Keith. Spectral and dynamical stability of nonlinear waves. Applied Mathematical Sciences, 185. Springer, New York, 2013.

M 3.225 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

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

Mandatory			
T-MATH-108399	Uncertainty Quantification	4 CR	Frank

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

M 3.226 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	Grading scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-110302	Variational Methods	8 CR	Reichel

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.

M 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

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

Mandatory			
T-MATH-105838	Wavelets	8 CR	Rieder

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.

M 3.228 Module: Wildcard [M-MATH-103198]

Organisation: University

Part of: Complementary Field / Subject Mechanical Engineering

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each term	1 term	German	4	1

Wildcard (Election: at least 1 item)			
T-MATH-106331	Wildcard 1	6 CR	

Prerequisites

None

4 Courses

T 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

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Events					
ST 2024	0160610	Tutorial for 0160600 (Numerical Methods in Fluidmechanics)	1 SWS	Practice	Dörfler

Prerequisites
none

T 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	1

Events					
ST 2024	2530214	Advanced Corporate Finance	2 SWS	Lecture / 🗣	Ruckes

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

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:

V Advanced Corporate Finance

2530214, SS 2024, 2 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

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-conceptional 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

Verschiedene Literaturquellen, u.a. Brealey/Myers/Allen/Edmans: Principles of Corporate Finance; Thomson/Conyon: Corporate Governance: Mechanisms and Systems; Larcker/Tayan: Corporate Governance Matters. Weitere Literatur wird in der Lehrveranstaltung bekannt gegeben.

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.

T 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	1

Events					
WT 23/24	2530601	Übung zu Advanced Empirical Asset Pricing	1 SWS	Practice / 🗣🖥	Thimme
WT 23/24	2530602	Advanced Empirical Asset Pricing	2 SWS	Lecture / 🗣🖥	Thimme
Exams					
WT 23/24	7900319	Advanced Empirical Asset Pricing			Thimme

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

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.

Below you will find excerpts from events related to this course:

V Advanced Empirical Asset Pricing
2530602, WS 23/24, 2 SWS, Language: English, Open in study portal

Lecture (V)
Blended (On-Site/Online)

Content
In this course we will discuss the fundamentals of Asset Pricing and how to test them. Although this is an Empirical Asset Pricing course, we deal with some concepts from Asset Pricing Theory that we can test afterwards (CAPM, ICAPM, CCAPM, recursive utility). Besides, the course will cover the most important empirical methods to do so. For that purpose, we will discuss the overarching tool *Generalized Method of Moments*, and the special cases of OLS and FMB regressions. Every second week, we will meet for a programing session, in which we will look at the data to draw our own conclusions. An introduction to the software MATLAB will be given at the beginning of the course. Students should bring a laptop to these sessions. Programing skills are not required but helpful.

We start with a review of the Stochastic Discount Factor, which is already known from the course „Asset Pricing". We then derive the CAPM and the Consumption-CAPM as special cases from the general consumption-savings optimization problem of the rational investor. In the first part of the course we discuss the CAPM and, as natural extensions, models with multiple factors. Prominent phenomena such as the value premium and momentum are discussed. In the second part of the lecture we will study extensions of Consumption-CAPM and study the implications of exotic preferences.

Organizational issues
Die Veranstaltung findet mittwochs um 8:00-09:30 im Raum 001 im Geb. 40.28) statt und endet nach ersten Semesterhälfte.

Literature

Basisliteratur

Asset pricing / Cochrane, J.H. - Rev. ed., Princeton Univ. Press, 2005.

zur Vertiefung/ Wiederholung

Investments and Portfolio Management / Bodie, Z., Kane, A., Marcus, A.J. - 9. ed., McGraw-Hill, 2011.

The econometrics of financial markets / Campbell, J.Y., Lo, A.W., MacKinlay, A.C. - 2. printing, with corrections, Princeton Univ. Press, 1997.

T 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	1

Events					
WT 23/24	2521533	Advanced Game Theory	2 SWS	Lecture / 🗣	Reiß
WT 23/24	2521534	Übung zu Advanced Game Theory	1 SWS	Practice / 🗣	Reiß, Peters
Exams					
WT 23/24	7910001	Advanced Game Theory			Reiß

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

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:

V Advanced Game Theory — **Lecture (V) On-Site**
2521533, WS 23/24, 2 SWS, Language: English, Open in study portal

T 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

Type	Credits	Grading scale	Version
Oral examination	5	Grade to a third	1

Prerequisites
none

T 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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4,5	Grade to a third	Each term	1

Events					
WT 23/24	2512403	Advanced Lab Blockchain Hackathon (Bachelor)		Practical course / 🖥	Sunyaev, Kannengießer, Sturm, Beyene
Exams					
WT 23/24	7900141	Advanced Lab Blockchain Hackathon (Master)			Sunyaev
ST 2024	7900172	Lab Blockchain Hackathon (Master)			Sunyaev

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

T 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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4,5	Grade to a third	Each term	1

Events					
WT 23/24	2512205	Lab Realisation of innovative services (Master)	3 SWS	Practical course /	Oberweis, Toussaint, Schiefer, Schüler
WT 23/24	2512401	Practical Course Sociotechnical Information Systems Development (Master)	3 SWS	Practical course /	Sunyaev, Goram, Leiser
WT 23/24	2512403	Advanced Lab Blockchain Hackathon (Bachelor)		Practical course /	Sunyaev, Kannengießer, Sturm, Beyene
WT 23/24	2512501	Practical Course Cognitive automobiles and robots (Master)	3 SWS	Practical course /	Zöllner, Daaboul
WT 23/24	2512600	Project lab Information Service Engineering (Master)	3 SWS	Practical course /	Sack
ST 2024	2512205	Lab Realisation of innovative services (Master)	3 SWS	Practical course /	Schiefer, Schüler, Toussaint
ST 2024	2512207	Lab Automation in Everyday Life (Master)	3 SWS	Practical course /	Oberweis, Forell, Frister, Rybinski, Schiefer
ST 2024	2512401	Advanced Lab Development of Sociotechnical Information Systems (Master)	3 SWS	Practical course /	Sunyaev, Leiser
ST 2024	2512403	Advanced Lab Blockchain Hackathon (Master)		Practical course /	Sunyaev, Sturm, Kannengießer, Beyene
ST 2024	2512500	Project Lab Machine Learning	3 SWS	Practical course /	Daaboul, Zöllner, Schneider
ST 2024	2512555	Praktikum Security, Usability and Society (Master)	3 SWS	Practical course /	Volkamer, Strufe, Mayer, Berens, Mossano, Hennig, Veit, Länge

Exams			
WT 23/24	7900102	Advanced Lab Information Service Engineering (Master)	Sack
WT 23/24	7900107	Advanced Lab Cognitive Automobile and Robots (Master)	Zöllner
WT 23/24	7900141	Advanced Lab Blockchain Hackathon (Master)	Sunyaev
WT 23/24	7900143	Advanced Lab Development of Sociotechnical Information Systems (Master)	Sunyaev
WT 23/24	7900306	Advanced Lab Realization of Innovative Services (Master)	Oberweis
WT 23/24	7900307	Advanced Lab Security, Usability and Society (Master)	Volkamer
ST 2024	7900020	Lab Automation in Everyday Life (Master)	Oberweis
ST 2024	7900086	Project Lab Machine Learning	Zöllner
ST 2024	7900148	Advanced Lab Realization of innovative services (Master)	Oberweis
ST 2024	7900172	Lab Blockchain Hackathon (Master)	Sunyaev
ST 2024	7900173	Advanced Lab Development of Sociotechnical Information Systems (Master)	Sunyaev
ST 2024	7900178	Practical Lab Security, Usability and Society (Master)	Volkamer

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:

V	**Lab Realisation of innovative services (Master)** 2512205, WS 23/24, 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).

Further information can be found on the ILIAS page of the lab.

Organizational issues
Die genauen Termine und Informationen zur Anmeldung werden auf der Veranstaltungsseite bekannt gegeben.

V	**Practical Course Cognitive automobiles and robots (Master)** 2512501, WS 23/24, 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 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.

V **Project lab Information Service Engineering (Master)**
2512600, WS 23/24, 3 SWS, Language: English, Open in study portal

Practical course (P)
On-Site

Content
The ISE project lab is based on the summer semester lecture "Information Service Engineering". Goal of the course is to work on a given research problem in small groups (3-4 students) related to the ISE lecture topics, i.e. Natural Language Processing, Knowledge Graphs, and Machine Learning. The solution of the given research problem requires the development of a software implementation.

The project will be worked on in teams of 3-4 students each, guided by a tutor from the teaching staff.

Required coursework includes:

- Mid term presentation (5-10 min)
- Final presentation (10-15 min)
- Course report (c. 20 pages)
- Participation and contribution of the students during the course
- Software development and delivery

Notes:

The ISE project lab can also be credited as a **seminar** (if necessary).

The project will be worked on in teams of 3-4 students each, guided by a tutor from the teaching staff.

Participation will be restricted to 16 students.

Participation in the lecture "Information Service Engineering" (summer semester) is required. There are video recordings on our youtube channel.

ISE Tutor Team:

- Dr. Genet Asefa Gesese
- M. Sc. Mirza Mohtasim Alam
- M. Sc. Oleksandra Bruns
- M. Sc. Ebrahim Norouzi
- M. Sc. Mary Ann Tan
- B. Sc. Tabea Tietz
- M. Sc. Mahsa Vafaie

WS 2023/24 Tasks List:

- **Task 1: Zero-shot Ultrafine Typing of Named Entities.** Use Pre-trained Language Models to assign predefined labels to entity mentions in a given context. Evaluate approaches which require no training data on a standard benchmark, i.e. UFET
- **Task 2: Object Detection on Historical Theatre Photographs**. Use Pre-trained DL models to detect and identify objects in historical theatre photographs and integrate the results into an existing Knowledge Graph.
- **Task 3: Automatically Generate Ontologies from Competency Questions using Language Models**. Competency questions (CQs) define the scope of knowledge represented in an ontology and are used to evaluate an ontology based on its ability to answer each question. In this task, we are investigating the benefit of Large Language Models to generate and evaluate ontologies from a set of competency questions.
- **Task 4: Boosting the Performance of Large Language Models for Question Answering with Knowledge Graph Integration**. Often, large language models hallucinate users with wrong or confusing answers. In order to generate relevant answers, knowledge graphs can help in many ways. The goal of this task is to utilize a knowledge graph to provide context and factual information to a language model, thereby improving the relevance and accuracy of its responses.
- **Task 5:Information Extraction and Knowledge Graph Engineering on the Use Case of Historical Political Flyers**
Information extraction and Knowledge Graph construction from digitized political leaflets of the Weimar Republic.
- **Task 6: Sentiment Analysis on Multilingual Wikipedia.** Analyse how different language Versions of Wikipedia differ in terms of Sentiment Bias.
- of a Knowledge Graph from 1.3 Mio Archival Objects from the German Digital Library

Literature
ISE video channel on youtube: https://www.youtube.com/channel/UCjkkhNSNuXrJpMYZoeSBw6Q/

V **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).

Further information can be found on the ILIAS page of the lab.

Organizational issues
Die genauen Termine und Informationen zur Anmeldung werden auf der Veranstaltungsseite bekannt gegeben.

V	**Lab Automation in Everyday Life (Master)** 2512207, SS 2024, 3 SWS, Language: German, Open in study portal	**Practical course (P)** **On-Site**

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.

Further information can be found on the ILIAS page of the lab.

Organizational issues
Die genauen Termine und Informationen zur Anmeldung werden auf der Veranstaltungsseite bekannt gegeben.

V	**Advanced Lab Development of Sociotechnical Information Systems (Master)** 2512401, SS 2024, 3 SWS, Language: German/English, Open in study portal	**Practical course (P)** **Blended (On-Site/Online)**

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.

V	**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.

V **Praktikum Security, Usability and Society (Master)**
2512555, SS 2024, 3 SWS, Language: German/English, Open in study portal

Practical course (P)
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 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 Authetication 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 student: 1 Ma
Description:

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**) .

T 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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4,5	Grade to a third	Each term	1

Events					
WT 23/24	2512205	Lab Realisation of innovative services (Master)	3 SWS	Practical course /	Oberweis, Toussaint, Schiefer, Schüler
ST 2024	2512205	Lab Realisation of innovative services (Master)	3 SWS	Practical course /	Schiefer, Schüler, Toussaint
Exams					
WT 23/24	7900306	Advanced Lab Realization of Innovative Services (Master)			Oberweis
ST 2024	7900148	Advanced Lab Realization of innovative services (Master)			Oberweis

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:

V Lab Realisation of innovative services (Master)
2512205, WS 23/24, 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).

Further information can be found on the ILIAS page of the lab.

Organizational issues
Die genauen Termine und Informationen zur Anmeldung werden auf der Veranstaltungsseite bekannt gegeben.

V 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).

Further information can be found on the ILIAS page of the lab.

Organizational issues
Die genauen Termine und Informationen zur Anmeldung werden auf der Veranstaltungsseite bekannt gegeben.

T 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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4,5	Grade to a third	Each winter term	2

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.

T 4.10 Course: Advanced Lab Security, Usability and Society [T-WIWI-108439]

Responsible: Prof. Dr. Melanie Volkamer
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101472 - Informatics

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4,5	Grade to a third	see Annotations	2

Events					
WT 23/24	2512554	Praktikum Security, Usability and Society (Bachelor)	3 SWS	Practical course / 🖥	Volkamer, Strufe, Berens, Länge, Mossano, Hennig, Hilt, Veit
WT 23/24	2512555	Praktikum Security, Usability and Society (Master)	3 SWS	Practical course / 🖥	Volkamer, Strufe, Berens, Länge, Mossano, Hennig, Hilt, Veit
ST 2024	2512554	Practical lab Security, Usability and Society (Bachelor)	3 SWS	Practical course / 🖥	Volkamer, Strufe, Mayer, Berens, Mossano, Hennig, Veit, Länge
Exams					
WT 23/24	7900116	Advanced Lab Security, Usability and Society (Bachelor)			Volkamer
WT 23/24	7900307	Advanced Lab Security, Usability and Society (Master)			Volkamer
ST 2024	7900029	Practical lab Security, Usability and Society (Bachelor)			Volkamer

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:

V Praktikum Security, Usability and Society (Bachelor)
2512554, WS 23/24, 3 SWS, Language: German/English, Open in study portal

Practical course (P)
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://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: *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 be 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**) .

V **Praktikum Security, Usability and Society (Master)**
2512555, WS 23/24, 3 SWS, Language: German/English, **Open in study portal**

Practical course (P)
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 been already assigned.

There are two deadlines:

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:

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 advices
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.

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) .

V	**Practical lab Security, Usability and Society (Bachelor)** 2512554, SS 2024, 3 SWS, Language: German/English, Open in study portal	**Practical course (P)** **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.

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, 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 Authetication 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) .

T 4.11 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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4,5	Grade to a third	Each term	1

Events					
WT 23/24	2512401	Practical Course Sociotechnical Information Systems Development (Master)	3 SWS	Practical course / 🖥	Sunyaev, Goram, Leiser
Exams					
WT 23/24	7900143	Advanced Lab Development of Sociotechnical Information Systems (Master)			Sunyaev
ST 2024	7900173	Advanced Lab Development of Sociotechnical Information Systems (Master)			Sunyaev

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

T 4.12 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4,5	Grade to a third	Irregular	2

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.

T 4.13 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Irregular	1

Events					
ST 2024	2520527	Advanced Topics in Economic Theory	2 SWS	Lecture / 🗣	Mitusch, Brumm
ST 2024	2520528	Übung zu Advanced Topics in Economic Theory	1 SWS	Practice / 🗣	Pegorari, Corbo

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment consists of a written exam (60min) (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:

V Advanced Topics in Economic Theory
2520527, SS 2024, 2 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

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.

4.14 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	2

Events					
WT 23/24	0102200	Algebra	4 SWS	Lecture / 🗣	Sauer
WT 23/24	0102210	Tutorial for 0102200 (Algebra)	2 SWS	Practice / 🗣	Sauer
Exams					
WT 23/24	7700136	Algebra			Sauer

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 4.15 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2024	0152000	Algebraische Geometrie	4 SWS	Lecture	Herrlich
ST 2024	0152010	Übungen zu 0152000 (Algebraische Geometrie)	2 SWS	Practice	Herrlich

4.16 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Exams			
WT 23/24	7700099	Algebraic Number Theory	Herrlich

Competence Certificate
oral examination of ca. 30 minutes

Prerequisites
none

T 4.17 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	Credits	Grading scale	Recurrence	Version
Written examination	8	Grade to a third	Irregular	1

Prerequisites
none

T 4.18 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	8	Grade to a third	Irregular	1

Prerequisites
none

T 4.19 Course: Algorithm Engineering [T-INFO-101332]

Responsible: Prof. Dr. Peter Sanders
Organisation: KIT Department of Informatics
Part of: M-INFO-100795 - Algorithm Engineering

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each summer term	4

Events					
WT 23/24	2400021	Algorithm Engineering	2/1 SWS	Lecture / 🗣	Sanders, Seemaier
Exams					
WT 23/24	75514	Algorithm Engineering			Sanders

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

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.

T 4.20 Course: Algorithm Engineering Pass [T-INFO-111856]

Responsible: Prof. Dr. Peter Sanders
Organisation: KIT Department of Informatics
Part of: M-INFO-100795 - Algorithm Engineering

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	1	Grade to a third	Each summer term	1

Exams			
WT 23/24	7500187	Algorithm Engineering Pass	Sanders

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.

T 4.21 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Events					
WT 23/24	0100046	Analytical and numerical homogenization	3 SWS	Lecture	Maier
Exams					
WT 23/24	7700139	Analytical and Numerical Homogenization			Maier

Prerequisites
none

4.22 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Prerequisites
none

T 4.23 Course: Applied Informatics – Principles of Internet Computing: Foundations for Emerging Technologies and Future Services [T-WIWI-110339]

Responsible: Prof. Dr. Ali Sunyaev
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101472 - Informatics

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	2

Events					
ST 2024	2511032	Applied Informatics - Internet Computing	2 SWS	Lecture / 🗣	Sunyaev
ST 2024	2511033	Übungen zu Angewandte Informatik - Internet Computing	1 SWS	Practice / ✲	Sunyaev, Rank, Guse
Exams					
WT 23/24	79AIFB_AI-IC_B4	Applied Informatics – Principles of Internet Computing: Foundations for Emerging Technologies and Future Services			Sunyaev
ST 2024	79AIFB_AI2_A2	Applied Informatics - Internet Computing (Registration until 15 July 2024)			Sunyaev

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 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

Annotation

Replaces from winter semester 2019/2020 T-WIWI-109445 "Applied Informatics - Internet Computing".

Below you will find excerpts from events related to this course:

V Applied Informatics - Internet Computing

Lecture (V)
On-Site

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.

Literature

Wird in der Vorlesung bekannt gegeben

T 4.24 Course: Applied Information Theory [T-ETIT-100748]

Responsible: Dr.-Ing. Holger Jäkel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100444 - Applied Information Theory

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each winter term	1

Events					
WT 23/24	2310537	Applied Information Theory	3 SWS	Lecture /	Jäkel
WT 23/24	2310539	Tutorial for 2310537 Applied Information Theory	1 SWS	Practice /	Jäkel
Exams					
WT 23/24	7310537-1	Applied Information Theory			Jäkel
ST 2024	7310537-1	Applied Information Theory			Jäkel

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Prerequisites
none

4.25 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4,5	Grade to a third	Each winter term	1

Events					
WT 23/24	2117054	Applied material flow simulation	3 SWS	Lecture / Practice (/	Baumann
Exams					
WT 23/24	76-T-MACH-112213	Applied material flow simulation			Baumann, Furmans

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 23/24, 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 2023/2024 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 01.09.2023 bis zum 30.09.2023 möglich.**

Literature

Borshev, A. (2022): The Big Book of Simulation Modeling - Multimethod Modeling with AnyLogic 8, https://www.anylogic.de/resources/books/big-book-of-simulation-modeling/.

Grigoryev, I. (2021): AnyLogic8 in Three Days, 5. Aufl., https://www.anylogic.de/resources/books/free-simulation-book-and-modeling-tutorials/.

Gutenschwager, K. et. al. (2017): Simulation in Produktion und Logistik, Springer Vieweg, Berlin.

VDI (2014): Simulation von Logistik-, Materialfluss- und Produktionssystemen - Grundlagen. VDI Richtlinie 3633, Blatt 1, VDI-Verlag, Düsseldorf.

VDI (2016): Simulation von Logistik-, Materialfluss- und Produktionssystemen - Simulation und Optimierung. VDI Richtlinie 3633, Blatt 12, VDI-Verlag, Düsseldorf

T 4.26 Course: Aspects of Geometric Analysis [T-MATH-106461]

Responsible: Prof. Dr. Tobias Lamm
Organisation: KIT Department of Mathematics
Part of: M-MATH-103251 - Aspects of Geometric Analysis

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Events					
ST 2024	0176600	AG Geometrische Analysis	2 SWS	Seminar	Lamm

Prerequisites
Keine

T 4.27 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	2

Events					
ST 2024	2530555	Asset Pricing	2 SWS	Lecture / 🗣	Uhrig-Homburg, Müller
ST 2024	2530556	Asset Pricing	1 SWS	Practice / 🗣	Böll, Uhrig-Homburg, Müller
Exams					
WT 23/24	7900056	Asset Pricing			Uhrig-Homburg

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:

V Asset Pricing
2530556, SS 2024, 1 SWS, Language: German, Open in study portal

Practice (Ü)
On-Site

T 4.28 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

T 4.29 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	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	1

Events					
WT 23/24	2520408	Auktionstheorie	2 SWS	Lecture	Ehrhart
WT 23/24	2520409	Übungen zu Auktionstheorie	1 SWS	Practice	Ehrhart
Exams					
WT 23/24	7900039	Auction Theory			Ehrhart
ST 2024	7900255	Auction Theory			Ehrhart

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 Auktionstheorie
2520408, WS 23/24, 2 SWS, Open in study portal

Lecture (V)

Literature

- Ehrhart , K.-M. und S. Seifert: Auktionstheorie, Skript zur Vorlesung, KIT, 2011
- Krishna, V.: Auction Theory, Academic Press, Second Edition, 2010
- Milgrom, P.: Putting Auction Theory to Work, Cambridge University Press, 2004
- Ausubel, L.M. und P. Cramton: Demand Reduction and Inefficiency in Multi-Unit Auctions, University of Maryland, 1999

T 4.30 Course: Banach Algebras [T-MATH-105886]

Responsible: PD Dr. Gerd Herzog
Organisation: KIT Department of Mathematics
Part of: M-MATH-102913 - Banach Algebras

Type	Credits	Grading scale	Version
Oral examination	3	Grade to a third	1

Prerequisites
none

T 4.31 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

Type	Credits	Grading scale	Version
Completed coursework	3	pass/fail	1

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 stdues
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
Fjordevik, Anneli und Jörg Roche: Angewandte Kulturwissenschaften. Vol. 10. Narr Francke Attempto Verlag, 2019.

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.

T 4.32 Course: Basics Module - Self Assignment BeNe [T-ZAK-112345]

Responsible: Christine Myglas
Organisation:
Part of: M-ZAK-106099 - Supplementary Studies on Sustainable Development

Type	Credits	Grading scale	Version
Completed coursework	3	pass/fail	1

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 stdues
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
Kropp, Ariane: Grundlagen der Nachhaltigen Entwicklung: Handlungsmöglichkeiten und Strategien zur Umsetzung. Springer-Verlag, 2018.

Pufé, Iris: Nachhaltigkeit. 3. überarb. Edition, UTB, 2017.

Roorda, Niko, et al.: Grundlagen der nachhaltigen Entwicklung. Springer-Verlag, 2021.

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 an 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.

T 4.33 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	3

Events					
WT 23/24	2304207	Batteries and Fuel Cells	2 SWS	Lecture / Blended (On-Site/Online)	Krewer
WT 23/24	2304213	Batteries and Fuel Cells (Exercise to 2304207)	1 SWS	Practice / On-Site	Krewer, Lindner
Exams					
WT 23/24	7304207	Batteries and Fuel Cells			Krewer
ST 2024	7300006	Batteries and Fuel Cells			Krewer

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Prerequisites
none

Below you will find excerpts from events related to this course:

V Batteries and Fuel Cells
2304207, WS 23/24, 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
https://ilias.studium.kit.edu/goto.php?target=crs_2193746&client_id=produktiv

T 4.34 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

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	4	Grade to a third	Each summer term	1 terms	1

Competence Certificate
oral exam of ca. 30 min

Prerequisites
none

T 4.35 Course: Bifurcation Theory [T-MATH-106487]

Responsible: Dr. Rainer Mandel
Organisation: KIT Department of Mathematics
Part of: M-MATH-103259 - Bifurcation Theory

Type	Credits	Grading scale	Recurrence	Version
Oral examination	5	Grade to a third	Irregular	1

Prerequisites
None

T 4.36 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	1

Events					
WT 23/24	2530560	Bond Markets	3 SWS	Lecture / Practice (/ 🗣	Uhrig-Homburg, Molnar
Exams					
WT 23/24	7900311	Bond Markets			Uhrig-Homburg

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:

V Bond Markets

2530560, WS 23/24, 3 SWS, Language: English, Open in study portal

Lecture / Practice (VÜ)
On-Site

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 exercices. 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.

4.37 Course: Bond Markets - Models & Derivatives [T-WIWI-110997]

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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	3	Grade to a third	Each winter term	1

Events					
WT 23/24	2530565	Bond Markets - Models & Derivatives	2 SWS	Block / 🗣	Grauer, Uhrig-Homburg
Exams					
WT 23/24	7900318	Bond Markets - Models & Derivatives			Uhrig-Homburg

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:

V Bond Markets - Models & Derivatives
2530565, WS 23/24, 2 SWS, Language: English, Open in study portal

Block (B)
On-Site

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 (Kickoff am 08.12.23) und hat Seminarcharakter - mit dem Ziel, ein selbstgewähltes Themenfeld in Form einer schriftlichen Ausarbeitung eigenständig zu erarbeiten.

T 4.38 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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	1,5	Grade to a third	Each winter term	1

Events					
WT 23/24	2530562	Bond Markets - Tools & Applications	1 SWS	Block / 🗣	Uhrig-Homburg, Grauer
Exams					
WT 23/24	7900317	Bond Markets - Tools & Applications			Uhrig-Homburg

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:

V Bond Markets - Tools & Applications
2530562, WS 23/24, 1 SWS, Language: English, Open in study portal

Block (B)
On-Site

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
Die Veranstaltung findet in der ersten Semesterhälfte statt (Kickoff am 10.11.23) und beinhaltet eine eigenständige Projektarbeit im Umgang mit realen Bond Daten. Die Erfolgskontrolle erfolgt anhand einer schriftlichen Ausarbeitung und einer kurzen Präsentation.

T 4.39 Course: Bott Periodicity [T-MATH-108905]

Responsible: Prof. Dr. Wilderich Tuschmann
Organisation: KIT Department of Mathematics
Part of: M-MATH-104349 - Bott Periodicity

Type	Credits	Grading scale	Recurrence	Version
Oral examination	5	Grade to a third	Irregular	1

Prerequisites
none

T 4.40 Course: Boundary and Eigenvalue Problems [T-MATH-105833]

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-102871 - Boundary and Eigenvalue Problems

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2024	0157500	Boundary and Eigenvalue Problems	4 SWS	Lecture	Lewintan
ST 2024	0157510	Tutorial for 0157500 (Boundary and Eigenvalue Problems)	2 SWS	Practice	Lewintan
Exams					
WT 23/24	0100032	Boundary and Eigenvalue Problems			Anapolitanos, Lamm, Hundertmark, Liao, Lewintan

Below you will find excerpts from events related to this course:

V 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.

T 4.41 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Prerequisites
none

T 4.42 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	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

4.43 Course: Brownian Motion [T-MATH-105868]

Responsible: 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

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	1

Exams			
WT 23/24	7700029	Brownian Motion	Bäuerle

Prerequisites
none

T 4.44 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	2

Events					
WT 23/24	2511210	Business Process Modelling	2 SWS	Lecture / 🗣	Oberweis
WT 23/24	2511211	Exercise Business Process Modelling	1 SWS	Practice / 🗣	Oberweis, Schüler
Exams					
WT 23/24	79AIFB_MvG_C2	Business Process Modelling			Oberweis
ST 2024	79AIFB_MvG_B4	Business Process Modelling (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:

V Business Process Modelling
2511210, WS 23/24, 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 aplly 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 modells 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

- M. Weske: Business Process Management: Concepts, Languages, Architectures. Springer 2012.
- F. Schönthaler, G.Vossen, A. Oberweis, T. Karl: Business Processes for Business Communities: Modeling Languages, Methods, Tools. Springer 2012.

Weitere Literatur wird in der Vorlesung bekannt gegeben.

T 4.45 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	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	see Annotations	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.

T 4.46 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	Credits	Grading scale	Version
Written examination	8	Grade to a third	1

Events					
WT 23/24	0105300	Classical Methods for Partial Differential Equations	4 SWS	Lecture	Lewintan, Henninger
WT 23/24	0105310	Tutorial for 0105300 (Classical Methods for Partial Differential Equations)	2 SWS	Practice	Lewintan, Henninger
Exams					
WT 23/24	7700045	Classical Methods for Partial Differential Equations			Reichel, Anapolitanos, Lamm, Hundertmark, Lewintan

T 4.47 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	1

Events					
ST 2024	2511456	Collective Perception in Autonomous Driving	2 SWS	Lecture / Blended	Bied, Zhao , Vinel
ST 2024	2511457	Exercise Collective Perception in Autonomous Driving	1 SWS	Practice / Blended	Bied, Zhao , Lucena
Exams					
ST 2024	79AIFB_CPAD_C3	Collective Perception in Autonomous Driving (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.

T 4.48 Course: Combinatorics [T-MATH-105916]

Responsible: Prof. Dr. Maria Aksenovich
Organisation: KIT Department of Mathematics
Part of: M-MATH-102950 - Combinatorics

Type	Credits	Grading scale	Recurrence	Version
Written examination	8	Grade to a third	see Annotations	3

Events					
ST 2024	0150300	Combinatorics	4 SWS	Lecture	Aksenovich
ST 2024	0150310	Tutorial for 0150300 (Combinatorics)	2 SWS	Practice	Liu

Prerequisites
none

Annotation
The course is offered every second year.

Below you will find excerpts from events related to this course:

V Combinatorics

0150300, SS 2024, 4 SWS, Open in study portal

Lecture (V)

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.

T 4.49 Course: Communications Engineering I [T-ETIT-101936]

Responsible: Prof. Dr.-Ing. Laurent Schmalen
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-102103 - Communications Engineering I

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	2

Events					
WT 23/24	2310506	Communication Engineering I	3 SWS	Lecture /	Schmalen
WT 23/24	2310508	Übungen zu 2310506 Nachrichtentechnik I	1 SWS	Practice /	Schmalen, Edelmann
Exams					
WT 23/24	7310506	Communication Engineering I			Schmalen
ST 2024	7310506	Communication Engineering I			Schmalen

Legend: Online, Blended (On-Site/Online), On-Site, × Cancelled

Prerequisites
none

T 4.50 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

Type	Credits	Grading scale	Recurrence	Expansion	Version
Written examination	4	Grade to a third	Each term	1 terms	1

Events					
WT 23/24	2310509	Communications Engineering II	2 SWS	Lecture /	Jäkel
WT 23/24	2310510	Übung zu 2310509 Communications Engineering II	1 SWS	Practice /	Jäkel
ST 2024	2310511	Communications Engineering II	2 SWS	Lecture /	Jäkel
ST 2024	2310513	Tutorial for 2310511 Communications Engineering II	1 SWS	Practice /	Jäkel
Exams					
WT 23/24	7310511	Communications Engineering II			Jäkel
ST 2024	7310511	Communications Engineering II			Jäkel

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.

T 4.51 Course: Comparison Geometry [T-MATH-105917]

Responsible: Prof. Dr. Wilderich Tuschmann
Organisation: KIT Department of Mathematics
Part of: M-MATH-102940 - Comparison Geometry

Type	Credits	Grading scale	Recurrence	Version
Oral examination	5	Grade to a third	Irregular	1

Prerequisites
Keine

T 4.52 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

T 4.53 Course: Compressive Sensing [T-MATH-105894]

Responsible: Prof. Dr. Andreas Rieder
Organisation: KIT Department of Mathematics
Part of: M-MATH-102935 - Compressive Sensing

Type	Credits	Grading scale	Recurrence	Version
Oral examination	5	Grade to a third	Irregular	1

T 4.54 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	see Annotations	3

Events					
WT 23/24	2590458	Computational Economics (canceled)	2 SWS	Lecture /	Shukla
WT 23/24	2590459	Excercises to Computational Economics (canceled)	1 SWS	Practice /	Shukla
Exams					
ST 2024	79AIFB_CE_C6	Computational Economics (Registration until 15 July 2024)			Shukla

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

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:

V Computational Economics (canceled)
2590458, WS 23/24, 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

- R. Axelrod: "Advancing the art of simulation in social sciences". R. Conte u.a., Simulating Social Phenomena, Springer, S. 21-40, 1997.
- R. Axtel: "Why agents? On the varied motivations for agent computing in the social sciences". CSED Working Paper No. 17, The Brookings Institution, 2000.
- K. Judd: "Numerical Methods in Economics". MIT Press, 1998, Kapitel 6-7.
- A. M. Law and W. D. Kelton: "Simulation Modeling and Analysis", McGraw-Hill, 2000.
- R. Sargent: "Simulation model verification and validation". Winter Simulation Conference, 1991.
- L. Tesfation: "Notes on Learning", Technical Report, 2004.
- L. Tesfatsion: "Agent-based computational economics". ISU Technical Report, 2003.

Weiterführende Literatur:

- Amman, H., Kendrick, D., Rust, J.: "Handbook of Computational Economics". Volume 1, Elsevier North-Holland, 1996.
- Tesfatsion, L., Judd, K.L.: "Handbook of Computational Economics". Volume 2: Agent-Based Computational Economics, Elsevier North-Holland, 2006.
- Marimon, R., Scott, A.: "Computational Methods for the Study of Dynamic Economies". Oxford University Press, 1999.
- Gilbert, N., Troitzsch, K.: "Simulation for the Social Scientist". Open University Press, 1999.

T 4.55 Course: Computational Fluid Dynamics and Simulation Lab [T-MATH-113373]

Responsible:	PD Dr. Mathias Krause PD Dr. Gudrun Thäter
Organisation:	KIT Department of Mathematics
Part of:	M-MATH-106634 - Computational Fluid Dynamics and Simulation Lab

Type	Credits	Grading scale	Version
Examination of another type	4	Grade to a third	1

Events					
ST 2024	0161700	Computational Fluid Dynamics and Simulation Lab	4 SWS	Practical course	Thäter, Krause, Simonis
Exams					
ST 2024	7700108	Computational Fluid Dynamics and Simulation Lab			Thäter

Prerequisites
none

Below you will find excerpts from events related to this course:

V Computational Fluid Dynamics and Simulation Lab

0161700, SS 2024, 4 SWS, Language: German/English, Open in study portal

Practical course (P)

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 recommened.

T 4.56 Course: Computational Geometry [T-INFO-104429]

Responsible: TT-Prof. Dr. Thomas Bläsius
Organisation: KIT Department of Informatics
Part of: M-INFO-102110 - Computational Geometry

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	2

Events					
WT 23/24	2400083	Computational Geometry	4 SWS	Lecture / Practice (/ 🗣	Bläsius, Yi
Exams					
WT 23/24	7500283	Computational Geometry			Bläsius
ST 2024	7500192	Computational Geometry			Bläsius

Legend: Online, Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Below you will find excerpts from events related to this course:

V Computational Geometry

2400083, WS 23/24, 4 SWS, Language: German, Open in study portal

Lecture / Practice (VÜ)
On-Site

Organizational issues
nur Masterstudiengang Informatik

T 4.57 Course: Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems [T-MATH-105854]

Responsible: Prof. Dr. Michael Plum
Organisation: KIT Department of Mathematics
Part of: M-MATH-102883 - Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

T 4.58 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2024	0159400	Continuous Time Finance	4 SWS	Lecture	Fasen-Hartmann
ST 2024	0159410	Tutorial for 0159400 (Continuous Time Finance)	2 SWS	Practice	Fasen-Hartmann
Exams					
WT 23/24	77220	Continuous Time Finance			Bäuerle
ST 2024	7700092	Continuous Time Finance			Fasen-Hartmann

Competence Certificate
oral exam of ca. 30 minutes

Prerequisites
none

Below you will find excerpts from events related to this course:

V Continuous Time Finance

0159400, SS 2024, 4 SWS, Open in study portal

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

T 4.59 Course: Control Theory [T-MATH-105909]

Responsible: Prof. Dr. Roland Schnaubelt
Organisation: KIT Department of Mathematics
Part of: M-MATH-102941 - Control Theory

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Prerequisites
none

T 4.60 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Irregular	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).

T 4.61 Course: Convex Geometry [T-MATH-105831]

Responsible: Prof. Dr. Daniel Hug
Organisation: KIT Department of Mathematics
Part of: M-MATH-102864 - Convex Geometry

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

T 4.62 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	1

Events					
ST 2024	2511450	Cooperative Autonomous Vehicles	2 SWS	Lecture /	Vinel
ST 2024	2511451	Exercise Cooperative Autonomous Vehicles	1 SWS	Practice /	Vinel
Exams					
WT 23/24	79AIFB_CAV_A3	Cooperative Autonomous Vehicles			Vinel
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.

4.63 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	2

Exams			
WT 23/24	7900136	Corporate Risk Management	Ruckes

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.

T 4.64 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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4,5	Grade to a third	Each winter term	4

Events					
WT 23/24	2511400	Critical Information Infrastructures	2 SWS	Lecture / 🗣	Sunyaev, Dehling, Jin
WT 23/24	2511401	Exercises to Critical Information Infrastructures	1 SWS	Practice / 🗣	Sunyaev, Dehling, Jin
Exams					
WT 23/24	7900067	Critical Information Infrastructures			Sunyaev

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

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
New lecture from winter semester 2018/2019.

T 4.65 Course: Curves on Surfaces [T-MATH-113364]

Responsible: Dr. Elia Fioravanti
Organisation: KIT Department of Mathematics
Part of: M-MATH-106632 - Curves on Surfaces

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Irregular	1

Competence Certificate
oral exam (ca. 20-30 min)

Prerequisites
none

T 4.66 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	2

Events					
WT 23/24	2511202	Database Systems and XML	2 SWS	Lecture / 🧩	Oberweis
WT 23/24	2511203	Exercises Database Systems and XML	1 SWS	Practice / 🗣	Oberweis, Fritsch
Exams					
WT 23/24	79AIFB_DBX_A4	Database Systems and XML			Oberweis
ST 2024	79AIFB_DBX_A3	Database Systems and XML (Registration until 15 July 2024)			Oberweis

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:

V **Database Systems and XML**
2511202, WS 23/24, 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

- M. Klettke, H. Meyer: XML & Datenbanken: Konzepte, Sprachen und Systeme. dpunkt.verlag 2003
- H. Schöning: XML und Datenbanken: Konzepte und Systeme. Carl Hanser Verlag 2003
- W. Kazakos, A. Schmidt, P. Tomchyk: Datenbanken und XML. Springer-Verlag 2002
- R. Elmasri, S. B. Navathe: Grundlagen der Datenbanksysteme. 2009
- G. Vossen: Datenbankmodelle, Datenbanksprachen und Datenbankmanagementsysteme. Oldenbourg 2008

Weitere Literatur wird in der Vorlesung bekannt gegeben.

T 4.67 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	1

Events					
ST 2024	2530550	Derivatives	2 SWS	Lecture / 🗣	Uhrig-Homburg
ST 2024	2530551	Übung zu Derivate	1 SWS	Practice / 🗣	Dinger, Uhrig-Homburg
Exams					
WT 23/24	7900051	Derivatives			Uhrig-Homburg

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:

V Derivatives

2530550, SS 2024, 2 SWS, Language: German, Open in study portal

Lecture (V)
On-Site

Literature

- Hull (2012): Options, Futures, & Other Derivatives, Prentice Hall, 8th Edition

Weiterführende Literatur:

Cox/Rubinstein (1985): Option Markets, Prentice Hall

T 4.68 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

4.69 Course: Differential Geometry [T-MATH-102275]

Responsible: Prof. Dr. Wilderich Tuschmann
Organisation: KIT Department of Mathematics
Part of: M-MATH-101317 - Differential Geometry

Type	Credits	Grading scale	Recurrence	Version
Written examination	8	Grade to a third	Each summer term	1

Events					
ST 2024	0100300	Differential Geometry	4 SWS	Lecture	Sorcar
ST 2024	0100310	Tutorial for 0100300 (Differential Geometry)	2 SWS	Practice	Kupper, Sorcar

Below you will find excerpts from events related to this course:

Differential Geometry

0100300, SS 2024, 4 SWS, Language: English, Open in study portal

Lecture (V)

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.

T 4.70 Course: Digital Health [T-WIWI-109246]

Responsible: Prof. Dr. Ali Sunyaev
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101472 - Informatics

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4,5	Grade to a third	Each winter term	3

Events					
WT 23/24	2511402	Digital Health	2 SWS	Lecture / Blended	Sunyaev, Thiebes, Schmidt-Kraepelin
Exams					
WT 23/24	7900068	Digital Health			Sunyaev

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.

T 4.71 Course: Digital Signatures [T-INFO-101280]

Responsible: Prof. Dr. Dennis Hofheinz
Organisation: KIT Department of Informatics
Part of: M-INFO-100743 - Digital Signatures

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

T 4.72 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Events					
WT 23/24	2311613	Accompanying group tutorial for 2311615 Digital Technology / Fundamentals of Digital Technology		Tutorial (/	Höfer
WT 23/24	2311615	Digital Technology / Fundamentals of Digital Technology	3 SWS	Lecture /	Becker
WT 23/24	2311617	Tutorial for 2311615 Digital Technology / Fundamentals of Digital Technology	1 SWS	Practice /	Höfer
Exams					
WT 23/24	7311615	Digital Technology			Becker
WT 23/24	73116151	Digital Technology			Becker
ST 2024	7311615	Digital Technology			Becker

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Prerequisites
none

T 4.73 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Irregular	1

Prerequisites
none

T 4.74 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	8	Grade to a third	Each winter term	1

Events					
WT 23/24	0108400	Finanzmathematik in diskreter Zeit	4 SWS	Lecture / 🗣	Bäuerle
WT 23/24	0108500	Übungen zu 0108400 (Finanzmathematik in Diksreter Zeit)	2 SWS	Practice / 🗣	Bäuerle
Exams					
WT 23/24	0100025	Discrete Time Finance			Bäuerle
WT 23/24	6700054	Discrete Time Finance			Bäuerle

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.

T 4.75 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	Credits	Grading scale	Recurrence	Version
Examination of another type	4,5	Grade to a third	Each summer term	2

Events					
ST 2024	2550488	Ereignisdiskrete Simulation in Produktion und Logistik	3 SWS	Lecture / 🗣	Spieckermann
Exams					
ST 2024	7900244	Discrete-Event Simulation in Production and Logistics			Spieckermann

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:

V Ereignisdiskrete Simulation in Produktion und Logistik

2550488, SS 2024, 3 SWS, Language: German, Open in study portal

Lecture (V)
On-Site

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 dol.ior.kit.edu

Literature

- Gutenschwager K., Rabe M., Spieckermann S. und S. Wenzel (2017): Simulation in Produktion und Logistik, Springer, Berlin.
- Banks J., Carson II J. S., Nelson B. L., Nicol D. M. (2010) Discrete-event system simulation, 5.Aufl., Pearson, Upper Saddle River.
- Eley, M. (2012): Simulation in der Logistik - Einführung in die Erstellung ereignisdiskreter Modelle unter Verwendung des Werkzeuges "Plant Simulation“, Springer, Berlin und Heidelberg
- Kosturiak, J. und M. Gregor (1995): Simulation von Produktionssystemen. Springer, Wien und New York.
- Law, A. M. (2015): Simulation Modeling and Analysis. 5th Edition, McGraw-Hill, New York usw.
- Liebl, F. (1995): Simulation. 2. Auflage, Oldenbourg, München.
- Noche, B. und S. Wenzel (1991): Marktspiegel Simulationstechnik. In: Produktion und Logistik. TÜV Rheinland, Köln.
- Pidd, M. (2004): Computer Simulation in Management Science. 5th Edition, Wiley, Chichester.
- Robinson S (2004) Simulation: the practice of model development and use. John Wiley & Sons, Chichester
- VDI (2014): Simulation von Logistik-, Materialfluß- und Produktionssystemen. VDI Richtlinie 3633, Blatt 1, VDI-Verlag, Düsseldorf.

T 4.76 Course: Dispersive Equations [T-MATH-109001]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: M-MATH-104425 - Dispersive Equations

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Prerequisites
none

T 4.77 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each summer term	1

Events					
ST 2024	2302106	Verteilte ereignisdiskrete Systeme	2 SWS	Lecture /	Heizmann
ST 2024	2302108	Übungen zu 2302106 Verteilte ereignisdiskrete Systeme	1 SWS	Practice /	Hoffmann
Exams					
WT 23/24	7302106	Distributed Discrete Event Systems			Heizmann

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Prerequisites
none

T 4.78 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	4

Events					
WT 23/24	2560402	Dynamic Macroeconomics	2 SWS	Lecture /	Brumm
WT 23/24	2560403	Übung zu Dynamic Macroeconomics	1 SWS	Practice /	Hußmann
Exams					
WT 23/24	7900261	Dynamic Macroeconomics			Brumm

Legend: Online, Blended (On-Site/Online), On-Site, × Cancelled

Competence Certificate
The assessment is a written exam (60 min.).

Prerequisites
None.

Below you will find excerpts from events related to this course:

V Dynamic Macroeconomics

2560402, WS 23/24, 2 SWS, Language: English, Open in study portal

Lecture (V)
Blended (On-Site/Online)

Content
This course addresses macroeconomic questions on an advanced level. The main focus of this course is on dynamic programming and its fundamental role in modern macroeconomics. In the first part of the course, the necessary mathematical tools are introduced as well as basic applications in labor economics, economic growth and business cycle analysis. In the second part of the course, these basic models are expanded to incorporate household heterogeneity in various forms: Models of economic inequality to analyze the distributional impact of tax policies and models of overlapping generations to analyze the impact of social security reforms or changes in government debt. Finally, advanced methods based on sparse grids or neural nets are introduced to solve high-dimensional models. The course pursues a hands-on approach so that students not only gain theoretical insights but also learn numerical tools to solve dynamic economic models using the programming language Python.

Literature
Literatur und Skripte werden in der Veranstaltung angegeben.

T 4.79 Course: Dynamical Systems [T-MATH-106114]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: M-MATH-103080 - Dynamical Systems

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Prerequisites
none

4.80 Course: Efficient Energy Systems and Electric Mobility [T-WIWI-102793]

Responsible: PD Dr. Patrick Jochem
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101452 - Energy Economics and Technology

Type	Credits	Grading scale	Recurrence	Version
Written examination	3,5	Grade to a third	Each summer term	1

Events					
ST 2024	2581006	Efficient Energy Systems and Electric Mobility	2 SWS	Lecture / 🗣	Jochem
Exams					
WT 23/24	7981006	Efficient Energy Systems and Electric Mobility			Fichtner
ST 2024	7981006	Efficient Energy Systems and Electric Mobility			Fichtner

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

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. Institutsaushang

Literature
Wird in der Vorlesung bekanntgegeben.

T 4.81 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	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	1

Events					
WT 23/24	2540454	eFinance: Information Systems for Securities Trading	2 SWS	Lecture / 🗣	Weinhardt, Jaquart
WT 23/24	2540455	Übungen zu eFinance: Information Systems for Securities Trading	1 SWS	Practice / 🗣	Motz
Exams					
WT 23/24	7900182	eFinance: Information Engineering and Management for Securities Trading			Weinhardt
ST 2024	7900269	eFinance: Information Systems for Securities Trading			Weinhardt

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:

V eFinance: Information Systems for Securities Trading

2540454, WS 23/24, 2 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

Literature

- Picot, Arnold, Christine Bortenlänger, Heiner Röhrl (1996): "Börsen im Wandel". Knapp, Frankfurt
- Harris, Larry (2003): "Trading and Exchanges - Market Microstructure for Practitioners"". Oxford University Press, New York

Weiterführende Literatur:

- Gomber, Peter (2000): "Elektronische Handelssysteme - Innovative Konzepte und Technologien". Physika Verlag, Heidelberg
- Schwartz, Robert A., Reto Francioni (2004): "Equity Markets in Action - The Fundamentals of Liquidity, Market Structure and Trading". Wiley, Hoboken, NJ

T 4.82 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Once	1

Prerequisites
Keine

T 4.83 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	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	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 stdues
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
The content of the Basics Module is helpful.

T 4.84 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	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	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 stdues
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
The content of the Basics Module is helpful.

T 4.85 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

Type	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	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 stdues
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
The content of the Basics Module is helpful.

T 4.86 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

Type	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	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 stdues
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
The content of the Basics Module is helpful.

T 4.87 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each winter term	1

Events					
WT 23/24	2308263	Electromagnetics and Numerical Calculation of Fields	2 SWS	Lecture / 🗣	Pauli
WT 23/24	2308265	Exercise for 2308263 Electromagnetics and Numerical Calculation of Fields	1 SWS	Practice / 🗣	Pauli, Giroto de Oliveira
Exams					
WT 23/24	7308263	Electromagnetics and Numerical Calculation of Fields			Pauli
ST 2024	7308263	Electromagnetics and Numerical Calculation of Fields			Pauli

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.

T 4.88 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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4,5	Grade to a third	Each summer term	2

Events					
ST 2024	2513404	Seminar Emerging Trends in Digital Health (Bachelor)	2 SWS	Seminar /	Sunyaev, Toussaint, Brecker, Danylak
ST 2024	2513405	Seminar Emerging Trends in Digital Health (Master)	2 SWS	Seminar /	Sunyaev, Toussaint, Brecker, Danylak

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.

T 4.89 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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4,5	Grade to a third	Each summer term	2

Events					
ST 2024	2513402	Seminar Emerging Trends in Internet Technologies (Bachelor)	2 SWS	Seminar /	Sunyaev, Toussaint, Brecker, Danylak
ST 2024	2513403	Seminar Emerging Trends in Internet Technologies (Master)	2 SWS	Seminar /	Sunyaev, Toussaint, Brecker, Danylak

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.

T 4.90 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	3,5	Grade to a third	Each summer term	2

Events					
ST 2024	2581003	Energy and Environment	2 SWS	Lecture / 🗣	Karl
Exams					
WT 23/24	7981003	Energy and Environment			Fichtner
ST 2024	7900294	Energy and Environment NEW			Karl
ST 2024	7981003	Energy and Environment			Karl

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:

V Energy and Environment
2581003, SS 2024, 2 SWS, Language: German, Open in study portal

Lecture (V)
On-Site

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)

T 4.91 Course: Ergodic Theory [T-MATH-113086]

Responsible: Dr. Gabriele Link
Organisation: KIT Department of Mathematics
Part of: M-MATH-106473 - Ergodic Theory

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	8	Grade to a third	Irregular	1 terms	1

Exams			
WT 23/24	7700114	Ergodic Theory	Link
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.

T 4.92 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	0105900	Evolution equations	4 SWS	Lecture	Schnaubelt
WT 23/24	0105910	Tutorial for 0105900 (Evolution Equations)	2 SWS	Practice	Schnaubelt
Exams					
WT 23/24	7700132	Evolution Equations			Schnaubelt
ST 2024	7700118	Evolution Equations			Schnaubelt

T 4.93 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	1

Events					
WT 23/24	2540489	Experimental Economics	2 SWS	Lecture / 🗣	Knierim
WT 23/24	2540493	Übung zu Experimental Economics	1 SWS	Practice / 🗣	Greif-Winzrieth, Knierim, del Puppo
Exams					
WT 23/24	7900096	Experimental Economics			Weinhardt
ST 2024	7900258	Experimental Economics			Weinhardt

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment consists of a written exam (60 min).

By successful completion of 70% of the maximum number of points in the exercise(s) a bonus can be obtained.

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). The exact criteria for the award of a bonus will be announced at the beginning of the lecture.

Prerequisites
None

Below you will find excerpts from events related to this course:

V Experimental Economics

Lecture (V)
On-Site

2540489, WS 23/24, 2 SWS, Language: German, Open in study portal

Literature

- Strategische Spiele; S. Berninghaus, K.-M. Ehrhart, W. Güth; Springer Verlag, 2. Aufl. 2006.
- Handbook of Experimental Economics; J. Kagel, A. Roth; Princeton University Press, 1995.
- Experiments in Economics; J.D. Hey; Blackwell Publishers, 1991.
- Experimental Economics; D.D. Davis, C.A. Holt; Princeton University Press, 1993.
- Experimental Methods: A Primer for Economists; D. Friedman, S. Sunder; Cambridge University Press, 1994.

T 4.94 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Prerequisites
none

T 4.95 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	2

Prerequisites
none

T 4.96 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

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	2

Events					
ST 2024	0155600	Extremwerttheorie	2 SWS	Lecture	Fasen-Hartmann
ST 2024	0155610	Übungen zu 0155600 (Extremwerttheorie)	1 SWS	Practice	Fasen-Hartmann
Exams					
ST 2024	7700100	Extreme Value Theory			Fasen-Hartmann

T 4.97 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	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	4

Events					
WT 23/24	2550486	Facility Location and Strategic Supply Chain Management	2 SWS	Lecture / 🗣	Nickel
WT 23/24	2550487	Übungen zu Standortplanung und strategisches SCM	1 SWS	Practice / 🗣	Hoffmann
Exams					
WT 23/24	7900091	Facility Location and Strategic Supply Chain Management			Nickel
ST 2024	7900027	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 succesful completion of the online assessments.

Prerequisites
Prerequisite for admission to examination is the succesful 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

Lecture (V)
On-Site

2550486, WS 23/24, 2 SWS, Language: German, Open in study portal

Organizational issues
Für die Klausurzulassung müssen 4 von 5 Online-Tests bestanden sein.

Die Zulassung ist ein Jahr gültig, außer es handelt sich um einen Zweitversuch. In diesem Falle müssen die Online-Tests nicht erneut absolviert werden.

Literature
Weiterführende Literatur:

- Daskin: Network and Discrete Location: Models, Algorithms, and Applications, Wiley, 1995
- Domschke, Drexl: Logistik: Standorte, 4. Auflage, Oldenbourg, 1996
- Francis, McGinnis, White: Facility Layout and Location: An Analytical Approach, 2nd Edition, Prentice Hall, 1992
- Love, Morris, Wesolowsky: Facilities Location: Models and Methods, North Holland, 1988
- Thonemann: Operations Management - Konzepte, Methoden und Anwendungen, Pearson Studium, 2005

T 4.98 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	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	1

Events					
ST 2024	2530205	Financial Analysis	2 SWS	Lecture / 🗣	Luedecke
ST 2024	2530206	Übungen zu Financial Analysis	2 SWS	Practice / 🗣	Luedecke
Exams					
WT 23/24	7900059	Financial Analysis			Ruckes, Luedecke

Legend: 🖥 Online, Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

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:

V Financial Analysis
2530205, SS 2024, 2 SWS, Language: German, Open in study portal

Lecture (V)
On-Site

Literature

- Alexander, D. and C. Nobes (2017): Financial Accounting – An International Introduction, 6th ed., Pearson.
- Penman, S.H. (2013): Financial Statement Analysis and Security Valuation, 5th ed., McGraw Hill.

T 4.99 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	1

Events					
WT 23/24	2530232	Financial Intermediation	2 SWS	Lecture / 🗣	Ruckes
WT 23/24	2530233	Übung zu Finanzintermediation	1 SWS	Practice	Ruckes, Benz
Exams					
WT 23/24	7900063	Financial Intermediation			Ruckes

Legend: 🖥 Online, ❂ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

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:

V Financial Intermediation

2530232, WS 23/24, 2 SWS, Language: German, Open in study portal

Lecture (V)
On-Site

Organizational issues
Terminankündigungen des Instituts beachten

Literature
Weiterführende Literatur:

- Hartmann-Wendels/Pfingsten/Weber (2014): Bankbetriebslehre, 6. Auflage, Springer Verlag.
- Freixas/Rochet (2008): Microeconomics of Banking, 2. Auflage, MIT Press.

T 4.100 Course: Finite Element Methods [T-MATH-105857]

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-102891 - Finite Element Methods

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	0110300	Finite Element Methods	4 SWS	Lecture	Rieder
WT 23/24	0110310	Tutorial for 0110300 (Finite Element Methods)	2 SWS	Practice	Rieder
Exams					
WT 23/24	7700089	Finite Element Methods			Rieder

T 4.101 Course: Forecasting: Theory and Practice [T-MATH-105928]

Responsible: Prof. Dr. Tilmann Gneiting
Organisation: KIT Department of Mathematics
Part of: M-MATH-102956 - Forecasting: Theory and Practice

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	2

T 4.102 Course: Formal Systems [T-INFO-101336]

Responsible: Prof. Dr. Bernhard Beckert
Organisation: KIT Department of Informatics
Part of: M-INFO-100799 - Formal Systems

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Events					
WT 23/24	24086	Formale Systeme	4 SWS	Lecture / Practice (	Beckert, Ulbrich, Weigl
Exams					
WT 23/24	7500036	Formal Systems			Beckert
ST 2024	7500009	Formal Systems			Beckert

T 4.103 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Once	1

Prerequisites
none

T 4.104 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	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	3

Prerequisites
none

4.105 Course: Fractal Geometry [T-MATH-111296]

Responsible: PD Dr. Steffen Winter
Organisation: KIT Department of Mathematics
Part of: M-MATH-105649 - Fractal Geometry

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Exams			
WT 23/24	7700135	Fractal Geometry	Winter

Prerequisites
none

4.106 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	8	Grade to a third	Each winter term	3

Events					
WT 23/24	0104800	Functional Analysis	4 SWS	Lecture / 🗣	Frey
WT 23/24	0104810	Tutorial for 0104800 (Functional Analysis)	2 SWS	Practice / 🗣	Frey
Exams					
WT 23/24	0100047	Functional Analysis			Lamm, Hundertmark, Kunstmann, Schnaubelt, Frey, Liao

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Written examination of 120 minutes.

Prerequisites
none

4.107 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Exams			
WT 23/24	7700117	Functional Data Analysis	Ebner

Competence Certificate
Oral examination of ca. 25 minutes.

Prerequisites
none

Recommendation
The contents of the modules "Probability Theory" and "Mathematical Statistics" are strongly recommended.

T 4.108 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Prerequisites
none

T 4.109 Course: Functions of Operators [T-MATH-105905]

Organisation: KIT Department of Mathematics
Part of: M-MATH-102936 - Functions of Operators

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

T 4.110 Course: Fuzzy Sets [T-INFO-101376]

Responsible: Prof. Dr.-Ing. Uwe Hanebeck
Organisation: KIT Department of Informatics
Part of: M-INFO-100839 - Fuzzy Sets

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	1

Exams			
WT 23/24	7500011	Fuzzy Sets	Pfaff

4.111 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

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	3

Events					
ST 2024	0161400	Generalisierte Regressionsmodelle	2 SWS	Lecture	Klar
ST 2024	0161410	Übungen zu 0161400 (generalisierte Regressionsmodelle)	1 SWS	Practice	Klar

T 4.112 Course: Geometric Analysis [T-MATH-105892]

Responsible: Prof. Dr. Tobias Lamm
Organisation: KIT Department of Mathematics
Part of: M-MATH-102923 - Geometric Analysis

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Exams			
WT 23/24	7700140	Geometric Analysis	Lamm

Prerequisites
none

T 4.113 Course: Geometric Group Theory [T-MATH-105842]

Responsible: Prof. Dr. Frank Herrlich
Dr. Gabriele Link
Jun.-Prof. Dr. Claudio Llosa Isenrich
Prof. Dr. Roman Sauer
Prof. Dr. Wilderich Tuschmann

Organisation: KIT Department of Mathematics

Part of: M-MATH-102867 - Geometric Group Theory

Type	Credits	Grading scale	Recurrence	Version
Written examination	8	Grade to a third	Irregular	1

Events					
ST 2024	0153300	Geometric Group Theory	4 SWS	Lecture	Link
ST 2024	0153310	Tutorial for 0153300 (Geometric Group Theory)	2 SWS	Practice	Link
Exams					
WT 23/24	7700028	Geometric Group Theory			Llosa Isenrich

Below you will find excerpts from events related to this course:

V 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.

4.114 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	0102900	Geometric Group Theory II	4 SWS	Lecture	Llosa Isenrich
WT 23/24	0102910	Tutorial for 0102900 (Geometric Group Theory II)	2 SWS	Practice	Llosa Isenrich
Exams					
WT 23/24	7700133	Geometric Group Theory II			Llosa Isenrich

T 4.115 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

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Prerequisites
none

T 4.116 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Competence Certificate
oral exam of ca. 30 min

Prerequisites
none

T 4.117 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

T 4.118 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Prerequisites
none

T 4.119 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	1

Events					
ST 2024	2550134	Global Optimization I	2 SWS	Lecture / 🗣	Stein
Exams					
WT 23/24	7900004_WS2324_NK	Global Optimization I			Stein
ST 2024	7900205_SS2024_HK	Global Optimization I			Stein

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

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:

V **Global Optimization I** — **Lecture (V) On-Site**
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

O. Stein, Grundzüge der Globalen Optimierung, SpringerSpektrum, 2018.

Weiterführende Literatur:

- W. Alt, Numerische Verfahren der konvexen, nichtglatten Optimierung, Teubner, 2004
- C.A. Floudas, Deterministic Global Optimization, Kluwer, 2000
- R. Horst, H. Tuy, Global Optimization, Springer, 1996
- A. Neumaier, Interval Methods for Systems of Equations, Cambridge University Press, 1990

T 4.120 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	9	Grade to a third	Each summer term	1

Events					
ST 2024	2550134	Global Optimization I	2 SWS	Lecture / 🗣	Stein
ST 2024	2550135	Exercise to Global Optimization I and II	2 SWS	Practice / 🗣	Stein, Beck
ST 2024	2550136	Global Optimization II	2 SWS	Lecture / 🗣	Stein
Exams					
WT 23/24	7900006_WS2324_NK	Global Optimization I and II			Stein
ST 2024	7900207_SS2024_HK	Global Optimization I and II			Stein

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:

V Global Optimization I

Lecture (V)
On-Site

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

O. Stein, Grundzüge der Globalen Optimierung, SpringerSpektrum, 2018.

Weiterführende Literatur:

- W. Alt, Numerische Verfahren der konvexen, nichtglatten Optimierung, Teubner, 2004
- C.A. Floudas, Deterministic Global Optimization, Kluwer, 2000
- R. Horst, H. Tuy, Global Optimization, Springer, 1996
- A. Neumaier, Interval Methods for Systems of Equations, Cambridge University Press, 1990

V	**Global Optimization II** 2550136, SS 2024, 2 SWS, Language: German, Open in study portal	**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 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
O. Stein, Grundzüge der Globalen Optimierung, SpringerSpektrum, 2018.

Weiterführende Literatur:

- W. Alt, Numerische Verfahren der konvexen, nichtglatten Optimierung, Teubner, 2004
- C.A. Floudas, Deterministic Global Optimization, Kluwer, 2000
- R. Horst, H. Tuy, Global Optimization, Springer, 1996
- A. Neumaier, Interval Methods for Systems of Equations, Cambridge University Press, 1990

T 4.121 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	2

Events					
ST 2024	2550136	Global Optimization II	2 SWS	Lecture / 🗣	Stein
Exams					
WT 23/24	7900005_WS2324_NK	Global Optimization II			Stein
ST 2024	7900206_SS2024_HK	Global Optimization II			Stein

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:

V Global Optimization II — **Lecture (V) On-Site**
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

O. Stein, Grundzüge der Globalen Optimierung, SpringerSpektrum, 2018.

Weiterführende Literatur:

- W. Alt, Numerische Verfahren der konvexen, nichtglatten Optimierung, Teubner, 2004
- C.A. Floudas, Deterministic Global Optimization, Kluwer, 2000
- R. Horst, H. Tuy, Global Optimization, Springer, 1996
- A. Neumaier, Interval Methods for Systems of Equations, Cambridge University Press, 1990

4.122 Course: Graph Theory [T-MATH-102273]

Responsible: Prof. Dr. Maria Aksenovich
Organisation: KIT Department of Mathematics
Part of: M-MATH-101336 - Graph Theory

Type	Credits	Grading scale	Recurrence	Version
Written examination	8	Grade to a third	Irregular	2

Events					
WT 23/24	0104500	Graph Theory	4 SWS	Lecture	Aksenovich, Clemen, Winter
WT 23/24	0104510	Tutorial for 0104500 (Graph Theory)	2 SWS	Practice	Aksenovich, Clemen
Exams					
WT 23/24	7700038	Graph Theory			Aksenovich

Prerequisites
None

Below you will find excerpts from events related to this course:

Graph Theory

Lecture (V)

0104500, WS 23/24, 4 SWS, Language: English, Open in study portal

Content
Graphs are structures in discrete mathematics that in particular model various networks. The course starts with basic concepts in graph theory such as trees, cycles, matchings, factors, connectivity, and their interconnections. Further topics include properties of graphs with forbidden subgraphs, planar graphs, graph colorings, random graphs, Ramsey theory, and graph minors. Not only classical, but very recent results in the field will be discussed. The class is oriented towards problem solving. Particular attention to proof writing techniques will be paid in the problem class. The final grade will be based on the written exam. Bonus points will be given for weekly or biweekly homework assignments.

T 4.123 Course: Graph Theory and Advanced Location Models [T-WIWI-102723]

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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Irregular	2

Events					
WT 23/24	2500007		1,5 SWS	Practice /	Bakker
WT 23/24	2550484	Graph Theory and Advanced Location Models	3 SWS	Lecture /	Nickel
Exams					
WT 23/24	7900033	Graph Theory and Advanced Location Models			Nickel
ST 2024	7900283	Graph Theory and Advanced Location Models			Nickel

Legend: Online, Blended (On-Site/Online), On-Site, × Cancelled

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://dol.ior.kit.edu/english/Courses.php.

Below you will find excerpts from events related to this course:

V Graph Theory and Advanced Location Models
2550484, WS 23/24, 3 SWS, Language: English, Open in study portal

Lecture (V)
Blended (On-Site/Online)

Content
Graph Theory is an important part of Discrete Mathematics. A special attraction is in its clearness and variety of proof techniques. Topic of the first part “Graph Theory” is the mediation of basic graph theoretical concepts and algorithms, which are deployed in many areas of operations research. In focus is the modeling of different problems with graph theoretical methods und their solutions with efficient algorithms. Significant focal points are shortest paths, flows, matchings, colorings and matroids. A variety of application areas of location theory has attracted increasing research interest within the last decades, because location decisions are a critical factor in strategic planning. In the second part “Advanced Location Models”, some current research questions of modern industrial location theory are discussed after a short introduction. Thereby, practical models and suitable solution methods for location problems in general networks are presented. The lecture goes into details about pareto solutions in networks, ordered median problems, covering problems and allocation problems.

Literature
- Jungnickel: Graphs, Networks and Algorithms, 2nd edition, Springer, 2005
- Diestel: Graph Theory, 3rd edition, Springer, 2006
- Bondy, Murty: Graph Theory, Springer, 2008
- Nickel, Puerto: Location Theory, Springer, 2005
- Drezner: Facility Location – Applications and Theory, 2nd edition, Springer, 2005

T 4.124 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

Type	Credits	Grading scale	Version
Oral examination	5	Grade to a third	1

Prerequisites
none

4.125 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	1

Events					
WT 23/24	2561503	Growth and Development	2 SWS	Lecture / 🗣	Ott
WT 23/24	2561504	Exercise for Growth and Development	1 SWS	Practice / 🗣	Ott, Zoroglu
Exams					
WT 23/24	7900078	Growth and Development			Ott
ST 2024	7900105	Growth and Development			Ott

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:

V Growth and Development
2561503, WS 23/24, 2 SWS, Language: German/English, Open in study portal

Lecture (V)
On-Site

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:

- Acemoglu, D. (2009): Introduction to modern economic growth. Princeton University Press, New Jersey.
- Aghion, P., Howitt, P. (2009): Economics of growth, MIT-Press, Cambridge/MA.
- Barro, R.J., Sala-I-Martin, X. (2003): Economic Growth. MIT-Press, Cambridge/MA.
- Sydsaeter, K., Hammond, P. (2008): Essential mathematics for economic analysis. Prentice Hall International, Harlow.
- Sydsæter, K., Hammond, P., Seierstad, A., Strom, A., (2008): Further Mathematics for Economic Analysis, Second Edition, Pearson Education Limited, Essex.

4.126 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Exams			
WT 23/24	7700115	Harmonic Analysis	Frey, Tolksdorf

T 4.127 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Exams			
WT 23/24	7700120	Harmonic Analysis 2	Kunstmann
ST 2024	7700115	Harmonic Analysis 2	Kunstmann

Competence Certificate
oral examination of ca. 30 minutes.

Prerequisites
none

Recommendation
The following modules are strongly recommended: "Harmonic Analysis", "Functional Analysis".

T 4.128 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	3,5	Grade to a third	Each summer term	2

Events					
ST 2024	2581001	Heat Economy	2 SWS	Lecture / 🗣	Fichtner
Exams					
WT 23/24	7981001	Heat Economy			Fichtner
ST 2024	7981001	Heat Economy			Fichtner

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:

V Heat Economy
2581001, SS 2024, 2 SWS, Language: German, Open in study portal

Lecture (V)
On-Site

Organizational issues
Block, Seminarraum Standort West - siehe Institutsaushang

T 4.129 Course: Homotopy Theory [T-MATH-105933]

Responsible: Prof. Dr. Roman Sauer
Organisation: KIT Department of Mathematics
Part of: M-MATH-102959 - Homotopy Theory

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

T 4.130 Course: Human Brain and Central Nervous System: Anatomy, Information Transfer, Signal Processing, Neurophysiology and Therapy [T-INFO-101262]

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

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each term	2

Events					
WT 23/24	24139	Human Brain and Central Nervous System: Anatomy, Information Transfer, Signal Processing, Neurophysiology and Therapy	2 SWS	Lecture / 🗣	Spetzger
ST 2024	24678	Human Brain and Central Nervous System: Anatomy, Information Transfer, Signal Processing, Neurophysiology and Therapy	2 SWS	Lecture / 🗣	Spetzger
Exams					
WT 23/24	7500118	Human Brain and Central Nervous System: Snatomy, Information Transfer, Signal Processing, Neurophysiology and Therapy			Spetzger
ST 2024	7500145	Human Brain and Central Nervous System: Anatomy, Information Transfer, Signal Processing, Neurophysiology and Therapy			Spetzger

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

4.131 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	1

Events					
WT 23/24	2511452	Human Factors in Autonomous Driving	2 SWS	Lecture / 🗣	Vinel, Bied, Schrapel
WT 23/24	2511453	Exercises Human Factors in Autonomous Driving	1 SWS	Practice / 🗣	Vinel, Bied, Schrapel
Exams					
WT 23/24	79AIFB_HFAD_C6	Human Factors in Autonomous Driving			Vinel
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.

T 4.132 Course: Human Factors in Security and Privacy [T-WIWI-109270]

Responsible: Prof. Dr. Melanie Volkamer
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101472 - Informatics

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Irregular	3

Events					
WT 23/24	2511554	Human Factors in Security and Privacy	2 SWS	Lecture / 🗣	Volkamer

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 (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.

Below you will find excerpts from events related to this course:

V Human Factors in Security and Privacy — **Lecture (V) On-Site**
2511554, WS 23/24, 2 SWS, Language: German/English, Open in study portal

Content

Please take a look at all the information provided before the first event (e.g. first slides)!

The event will be conducted with 3G. Accordingly, either a one-time proof of vaccination or an official proof of a negative test is required for each event.

Some lectures are in English, some in German.

To participate in the quizzes at the beginning of the event a charged device is needed e.g. laptop or cell phone.

To successfully pass the course, the following requirements must be met:

Both need to be done:

- Reading Paper, Active Participation & 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
- Reading Paper, Active Participation & Pass Quiz “Users are not the enemy”Active participation exercise 1 – Part 2
- Reading Paper, Active Participation & Pass Quiz “Why Johnny can't encrypt”
- Reading Paper, Active Participation & Pass Quiz “Put Your Warning Where Your Link Is: Improving and Evaluating Email Phishing Warnings”
- Active participation exercise 1 – Part 3
- Active participation exercise 1 – Part 4 Results
- Reading Paper, Active Participation & Pass Quiz “User-centered security”Active participation exercise 2 – Part 1

Here is a first preview of the topics planned for the lecture:

1. General Introduction
2. Self-Study: Knowlege of Information Security Lecture
3. Terminology + Basics
4. Evaluation and analyses methods
5. Risk Communication
6. Security Awareness
7. Security Indicators
8. Graphical Authentication
9. Shoulder Surfing Authentication
10. Usable Verifiable Electronic Voting
11. Q&A + Exam preparation

Literature

- Usable Security: History, Themes, and Challenges (Synthesis Lectures on Information Security, Privacy, and Trust): Simson Garfinkel und Heather Richter Lipford. 2014
- Security and Usability: Designing Secure Systems that People Can Use von Lorrie Faith Cranor und Simson Garfinkel. 2005
- Melanie Volkamer, Karen Renaud: Mental Models - General Introduction and Review of Their Application to Human-Centred Security. In Number Theory and Cryptography (2013): 255-280: **https://link.springer.com/chapter/10.1007/978-3-642-42001-6_18**
- Paul Gerber, Marco Ghiglierie, Birgit Henhapl, Oksana Kulyk, Karola Marky, Peter Mayer, Benjamin Reinheimer, Melanie Volkamer: Human Factors in Security. In: Reuter C. (eds) Sicherheitskritische Mensch-Computer-Interaktion. Springer (2018) **https://link.springer.com/chapter/10.1007/978-3-658-19523-6_5**
- Bruce Schneier: Psychology of Security (2018): **https://www.schneier.com/essays/archives/2008/01/the_psychology_of_se.html**
- Ross Anderson: security /usability and psychology. In Security Engineering. **http://www.cl.cam.ac.uk/~rja14/Papers/SEv2-c02.pdf**
- Andrew Odlyzko: Economics, Psychology and Sociology of Security: **http://www.dtc.umn.edu/~odlyzko/doc/econ.psych.security.pdf**

T 4.133 Course: Human-Machine-Interaction in Anthropomatics: Basics [T-INFO-101361]

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

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each winter term	2

Events					
WT 23/24	24100	Human-Machine-Interaction in Anthropomatics: Basics	2 SWS	Lecture / 🧩	van de Camp
Exams					
WT 23/24	7500017	Human-Machine-Interaction in Anthropomatics: Basics			Beyerer, van de Camp

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 4.134 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	1

Events					
ST 2024	2573003	Incentives in Organizations	2 SWS	Lecture / 🗣	Nieken
ST 2024	2573004	Übung zu Incentives in Organizations	2 SWS	Practice / 🗣	Nieken, Mitarbeiter, Walther, Gorny
Exams					
WT 23/24	7900201	Incentives in Organizations			Nieken
ST 2024	7900132	Incentives in Organizations			Nieken

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment of this course is a written examination (60 min). The exam takesplace in every semester. Re-examinations are offered at every ordinaryexamination 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:

V **Incentives in Organizations** **Lecture (V)**
2573003, SS 2024, 2 SWS, Language: English, Open in study portal **On-Site**

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):

Managerial Economics and Organizantional Architecture, Brickley / Smith / Zimmerman, McGraw-Hill Education, 2015

Behavioral Game Theory, Camerer, Russel Sage Foundation, 2003

Personnel Economics in Practice, Lazear / Gibbs, Wiley, 2014

Introduction to Econometrics, Wooldridge, Andover, 2014

Econometric Analysis of Cross Section and Panel Data, Wooldridge, MIT Press, 2010

T 4.135 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

Type	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	1

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 aquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

Annotation
The content of the Basic Modul is helpful.

T 4.136 Course: In-depth Module - Global Cultures - Self Assignment BAK [T-ZAK-112658]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: M-ZAK-106235 - Supplementary Studies on Culture and Society

Type	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	1

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 aquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

Annotation
The content of the Basic Modul is helpful.

T 4.137 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

Type	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	1

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 aquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

Annotation

The content of the Basic Modul is helpful.

T 4.138 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

Type	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	1

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 aquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

Annotation

The content of the Basic Modul is helpful.

T 4.139 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

Type	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	1

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 aquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

Annotation
The content of the Basic Modul is helpful.

T 4.140 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

Type	Credits	Grading scale	Recurrence	Expansion	Version
Written examination	5	Grade to a third	Each summer term	1 terms	1

Events					
ST 2024	2303185	Informationstechnik und Automatisierungstechnik	3 SWS	Lecture / 🗣	Barth
ST 2024	2303186	Übung zu Informationstechnik und Automatisierungstechnik	1 SWS	Practice / 🗣	Madsen
Exams					
ST 2024	7300024	Information and Automation Technology			Barth

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

T 4.141 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

Type	Credits	Grading scale	Recurrence	Expansion	Version
Completed coursework	2	pass/fail	Each summer term	1 terms	1

Events					
ST 2024	2311653	Laboratory on Information Technology I	1 SWS	Practical course / 🧩	Sax

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

T 4.142 Course: Information Security [T-INFO-112195]

Responsible: Prof. Dr. Jörn Müller-Quade
Organisation: KIT Department of Informatics
Part of: M-INFO-106015 - Information Security

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each summer term	2

Events					
ST 2024	2400199	Informationssicherheit	3 SWS	Lecture / Practice (	Müller-Quade, Strufe, Hartenstein, Wressnegger
Exams					
WT 23/24	7500003	Information Security			Wressnegger, Müller-Quade, Strufe
ST 2024	7500028	Information Security			Müller-Quade, Wressnegger, Strufe

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-INFO-101371 - Security must not have been started.

T 4.143 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	2

Events					
ST 2024	2511606	Information Service Engineering	2 SWS	Lecture / 🗣	Sack
ST 2024	2511607	Exercises to Information Service Engineering	1 SWS	Practice / 🗣	Sack
Exams					
WT 23/24	79AIFB_ISE_B2	Information Service Engineering			Sack
ST 2024	79AIFB_ISE_B3	Information Service Engineering (Registration until 15 July 2024)			Sack

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:

V Information Service Engineering
2511606, SS 2024, 2 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

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

- D. Jurafsky, J.H. Martin, Speech and Language Processing, 2nd ed. Pearson Int., 2009.
- A. Hogan, The Web of Data, Springer, 2020.
- G. Rebala, A. Ravi, S. Churiwala, An Introduction to Machine Learning, Springer, 2019.

T 4.144 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Events					
ST 2024	0160510	Übungen zu 0160500 (Integralgleichungen)	2 SWS	Practice	Hettlich

T 4.145 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	see Annotations	1

Events					
ST 2024	2530570	International Finance	2 SWS	Lecture / 🗣	Walter, Uhrig-Homburg
Exams					
WT 23/24	7900052	International Finance			Uhrig-Homburg

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:

V 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:

- Eiteman, D. et al., Multinational Business Finance, 13. Auflage, 2012.
- Solnik, B. und D. McLeavey, Global Investments, 6. Auflage, 2008.

T 4.146 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	Credits	Grading scale	Version
Written examination	8	Grade to a third	1

Events					
WT 23/24	0105000	Internetseminar für Evolutionsgleichungen	2 SWS	Lecture / 🗣	Schnaubelt, Kunstmann, Frey, Tolksdorf
Exams					
WT 23/24	7700134	Internet Seminar for Evolution Equations			Tolksdorf, Frey, Kunstmann, Schnaubelt

Legend: 🖥 Online, ❀ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate

oral examination of ca. 30 minutes

Prerequisites

none

T 4.147 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

Type	Credits	Grading scale	Version
Oral examination	3	Grade to a third	1

Prerequisites
none

T 4.148 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Irregular	1

Prerequisites
none

T 4.149 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	6

Events					
WT 23/24	2400158	Introduction to Artificial Intelligence	3 SWS	Lecture / Practice (/ 🗣	Neumann, Friederich
Exams					
WT 23/24	7500136	Introduction to Artificial Intelligence			Friederich, Neumann
ST 2024	7500058	Introduction to Artificial Intelligence			Neumann, Friederich

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 4.150 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

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Irregular	1 terms	1

Events					
WT 23/24	0100024	Introduction to Convex Integration	2 SWS	Lecture	Zillinger
Exams					
WT 23/24	7700113	Introduction to Convex Integration			Zillinger

Competence Certificate
oral examination of approx. 30 minutes

Prerequisites
none

Recommendation
The courses "Classical Methods for Partial Differential Equations" and "Functional Analysis" are recommended.

T 4.151 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Exams			
WT 23/24	7700119	Introduction to Dynamical Systems	de Rijk

Competence Certificate
oral exam of ca. 30 min

Prerequisites
none

T 4.152 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Irregular	1

Prerequisites
none

T 4.153 Course: Introduction to Fluid Mechanics [T-MATH-112927]

Responsible: TT-Prof. Dr. Xian Liao
Organisation: KIT Department of Mathematics
Part of: M-MATH-106401 - Introduction to Fluid Mechanics

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	6	Grade to a third	Irregular	1 terms	1

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.

T 4.154 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

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Prerequisites
none

T 4.155 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Prerequisites
none

T 4.156 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

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Irregular	1 terms	1

Competence Certificate
oral examination of circa 30 minutes

Prerequisites
none

Recommendation
The course "Classical Methods for Partial Differential Equations" should be studied beforehand.

T 4.157 Course: Introduction to Kinetic Theory [T-MATH-108013]

Responsible: Prof. Dr. Martin Frank
Organisation: KIT Department of Mathematics
Part of: M-MATH-103919 - Introduction to Kinetic Theory

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 23/24	0155450	Introduction to Kinetic Theory	2 SWS	Lecture / 🔀	Frank
WT 23/24	0155460	Tutorial for 0155450 (Introduction to Kinetic Theory)	1 SWS	Practice	Frank
Exams					
WT 23/24	7700078	Introduction to Kinetic Theory			Frank

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

Below you will find excerpts from events related to this course:

V **Introduction to Kinetic Theory**
0155450, WS 23/24, 2 SWS, Language: English, Open in study portal

Lecture (V)
Blended (On-Site/Online)

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.

T 4.158 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

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Irregular	1 terms	1

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.

4.159 Course: Introduction to Python [T-MATH-106119]

Responsible: Dr. Daniel Weiß
Organisation: KIT Department of Mathematics
Part of: M-MATH-103053 - Key Competences

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	3	pass/fail	Each summer term	1

Events					
ST 2024	0169000	Einführung in Python	1 SWS	Lecture	Weiß

T 4.160 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

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	1	pass/fail	Each summer term	1

4.161 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	Credits	Grading scale	Version
Oral examination	8	Grade to a third	2

Events					
ST 2024	0165000	Einführung in das Wissenschaftliche Rechnen	3 SWS	Lecture	Wieners
ST 2024	0165010	Praktikum zu 0165000 (Einführung in das Wissenschaftliche Rechnen)	3 SWS	Practical course	Wieners

T 4.162 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

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.

T 4.163 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	3

Events					
ST 2024	2550470	Introduction to Stochastic Optimization	2 SWS	Lecture / 🖥	Rebennack
ST 2024	2550471	Übung zur Einführung in die Stochastische Optimierung	1 SWS	Practice / 🗣	Rebennack, Kandora
ST 2024	2550474	Rechnerübung zur Einführung in die Stochastische Optimierung	2 SWS	Others (sons	Rebennack, Kandora
Exams					
WT 23/24	7900242	Introduction to Stochastic Optimization			Rebennack
ST 2024	7900311	Introduction to Stochastic Optimization			Rebennack

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.

T 4.164 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	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	0105100	Inverse Problems	4 SWS	Lecture / 🗣	Griesmaier
WT 23/24	0105110	Tutorial for 0105100 (Inverse Problems)	2 SWS	Practice / 🗣	Griesmaier
Exams					
WT 23/24	7700131	Inverse Problems			Griesmaier

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 4.165 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	2

Events					
WT 23/24	2400010	IT Security	4 SWS	Lecture / Practice (/ 🗣	Müller-Quade, Strufe, Wressnegger, Hartenstein
Exams					
WT 23/24	7500038	IT Security			Müller-Quade, Strufe, Wressnegger, Hartenstein

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 90 minutes.

Prerequisites
None.

Recommendation
Students should be familiar with the content of the compulsory lecture "Informationssicherheit".

T 4.166 Course: Key Moments in Geometry [T-MATH-108401]

Responsible: Prof. Dr. Wilderich Tuschmann
Organisation: KIT Department of Mathematics
Part of: M-MATH-104057 - Key Moments in Geometry

Type	Credits	Grading scale	Recurrence	Version
Oral examination	5	Grade to a third	Irregular	1

Prerequisites
none

T 4.167 Course: Knowledge Discovery [T-WIWI-102666]

Responsible: Dr.-Ing. Michael Färber
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101472 - Informatics

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4,5	Grade to a third	Each winter term	3

Events					
WT 23/24	2511303	Knowledge Discovery and Graph Representation Learning	3 SWS	Lecture / Practice (/ 🗣	Färber, Saier, Shao
Exams					
WT 23/24	79AIFB_KD_B3	Knowledge Discovery			Färber

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate

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

Below you will find excerpts from events related to this course:

V Knowledge Discovery and Graph Representation Learning

Lecture / Practice (VÜ)
On-Site

2511303, WS 23/24, 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 obectives:

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 preperation and postprocessing: 60 hours
- Exam and exam preperation: 30 hours

Literature

- T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning: Data Mining, Inference, and Prediction (http://www-stat.stanford.edu/~tibs/ElemStatLearn/)
- T. Mitchell. Machine Learning. 1997
- M. Berhold, D. Hand (eds). Intelligent Data Analysis - An Introduction. 2003
- P. Tan, M. Steinbach, V. Kumar: Introduction to Data Mining, 2005, Addison Wesley

T 4.168 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	Credits	Grading scale	Version
Oral examination	5	Grade to a third	1

Prerequisites

none

T 4.169 Course: Large-scale Optimization [T-WIWI-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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	3

Events					
ST 2024	2550475	Large-Scale Optimization	2 SWS	Lecture / 🖥	Rebennack
ST 2024	2550476	Übung zu Large-Scale Optimization	1 SWS	Practice / 🗣	Bijiga, Rebennack
ST 2024	2550477	Rechnerübung zu Large-scale Optimization	2 SWS	Others (sons	Rebennack, Bijiga
Exams					
WT 23/24	7900244	Large-scale Optimization			Rebennack
ST 2024	7900291	Large-scale Optimization			Rebennack

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.

T 4.170 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	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

T 4.171 Course: Lie-Algebras (Linear Algebra 3) [T-MATH-111723]

Organisation: KIT Department of Mathematics
Part of: M-MATH-105839 - Lie-Algebras (Linear Algebra 3)

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	8	Grade to a third	Irregular	1 terms	1

Prerequisites
none

T 4.172 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	7	Grade to a third	Each winter term	2

Events					
WT 23/24	2305256	Linear Electric Circuits	4 SWS	Lecture / 🗣	Kempf, Jelonnek
WT 23/24	2305258	Linear Electric Circuits (Tutorial to 2305256)	1 SWS	Practice / 🗣	Wünsch
WT 23/24	2305581	Accompanying group tutorial to 2305256 Linear Electric Circuits		Practice / 🗣	Wünsch
Exams					
WT 23/24	7305256	Linear Electronic Networks			Kempf, Jelonnek
ST 2024	7312701	Linear Electronic Networks			Kempf, Jelonnek

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

T 4.173 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	1

Events					
ST 2024	24613	Localization of Mobile Agents	3 SWS	Lecture / 🗣	Hanebeck, Ernst
Exams					
WT 23/24	7500020	Localization of Mobile Agents			Zea Cobo

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Below you will find excerpts from events related to this course:

V Localization of Mobile Agents

24613, SS 2024, 3 SWS, Language: German, Open in study portal

Lecture (V)
On-Site

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.

T 4.174 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	4

Events					
WT 23/24	2511500	Machine Learning 1 - Fundamental Methods	2 SWS	Lecture / 🗣	Zöllner
WT 23/24	2511501	Exercises to Machine Learning 1 - Fundamental Methods	1 SWS	Practice / 🗣	Zöllner, Polley, Fechner, Daaboul
Exams					
WT 23/24	79AIFB_ML1_C5	Machine Learning 1 - Basic Methods			Zöllner
ST 2024	79AIFB_ML1_C4	Machine Learning 1 - Basic 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.

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:

V Machine Learning 1 - Fundamental Methods
2511500, WS 23/24, 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 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.

T 4.175 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each summer term	4

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					
WT 23/24	79AIFB_ML2_B8	Machine Learning 2 – Advanced Methods			Zöllner
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:

V Machine Learning 2 - Advanced methods
2511502, SS 2024, 2 SWS, Language: German, Open in study portal

Lecture (V)
On-Site

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.

T 4.176 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	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each winter term	3

Events					
WT 23/24	2581050	Machine Learning and Optimization in Energy Systems	3 SWS	Lecture / Practice (/ 🗣	Dengiz, Yilmaz, Perau
Exams					
WT 23/24	7900179	Machine Learning and Optimization in Energy Systems			Fichtner
ST 2024	7900207	Machine Learning and Optimization in Energy Systems			Fichtner

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 (30 min) depending on the number of participants.

Below you will find excerpts from events related to this course:

V Machine Learning and Optimization in Energy Systems
2581050, WS 23/24, 3 SWS, Language: English, Open in study portal

Lecture / Practice (VÜ)
On-Site

Content
Goals:
Participants should know about the most common optimization and machine learning approaches for the application in energy systems. They should understand the basic principles of the methods and should be able to apply them for solving important problems of future energy systems with high shares of renewable energy sources.

Content:
In the beginning, the essential transition of the energy system into a smart grid and the need for methods from the field of optimization and machine learning are explained. The course can be subdivided into an optimization part and a larger machine learning part. In the optimization part, the basics of optimization approaches that are used in energy systems are shown. Further, heuristic methods and approaches from the field of multiobjective optimization are introduced. In the machine learning part, the most important methods from the field of unsupervised learning, supervised learning and reinforcement learning are introduced and their application in future energy systems are investigated.

Amongst the considered applications are power plant dispatch, intelligent heating with heat pumps, charging strategies for electric vehicles, clustering of energy data for energy system models and electricity demand and renewable generation forecasting.

We also offer a voluntary computer exercise that deepens the understanding of the methods and applications covered in the lecture. The students will have the opportunity to solve problems from the energy domain by using optimization and machine learning approaches implemented in the programming language Python.

The course's general focus is on the application of the methods in the energy field and not on the mathematical details of the different approaches.

The total workload for this course is approximately 105 hours:

- Attendance: 30 hours
- Self-study: 30 hours
- Exam preparation: 45 hours

T 4.177 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	1

Events					
ST 2024	2511214	Management of IT-Projects	2 SWS	Lecture / 🗣	Schätzle
ST 2024	2511215	Übungen zu Management von IT-Projekten	1 SWS	Practice / 🗣	Schätzle
Exams					
WT 23/24	79AIFB_MvIP_C3	Management of IT-Projects			Oberweis
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 assessment takes place in the form of a written examination (exam) in the amount of 60 minutes. The examination is offered every semester and can be repeated at any regular examination date.

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.

Below you will find excerpts from events related to this course:

V Management of IT-Projects
Lecture (V)
On-Site

2511214, SS 2024, 2 SWS, Language: German, Open in study portal

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 infrastructur
- 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
- Project Management Institute Standards Committee. A Guide to the Project Management Body of Knowledge (PMBoK guide). Project Management Institute. Four Campus Boulevard. Newton Square. PA 190733299. U.S.A.

V **Übungen zu Management von IT-Projekten** **Practice (Ü)** **On-Site**
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.

T 4.178 Course: Markov Decision Processes [T-MATH-105921]

Responsible: Prof. Dr. Nicole Bäuerle
Organisation: KIT Department of Mathematics
Part of: M-MATH-102907 - Markov Decision Processes

Type	Credits	Grading scale	Version
Oral examination	5	Grade to a third	1

Prerequisites
none

T 4.179 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

Type	Credits	Grading scale	Version
Final Thesis	30	Grade to a third	1

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

T 4.180 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	1

Events					
WT 23/24	2500042	Matching Theory	3 SWS	Lecture / Practice (/ 🗣	Okulicz
Exams					
WT 23/24	7900347	Matching Theory			Puppe
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:

V Matching Theory
2500042, WS 23/24, 3 SWS, Language: English, Open in study portal

Lecture / Practice (VÜ)
On-Site

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

T 4.181 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Prerequisites
none

T 4.182 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	5	Grade to a third	Irregular	1

Events					
ST 2024	0102900	Mathematische Methoden der Bildgebung	2 SWS	Lecture	Rieder
ST 2024	0102910	Übungen zu 0102900 (mathematische Methoden der Bildgebung)	2 SWS	Practice	Rieder

Prerequisites
None

T 4.183 Course: Mathematical Modelling and Simulation in Practise [T-MATH-105889]

Responsible: PD Dr. Gudrun Thäter
Organisation: KIT Department of Mathematics
Part of: M-MATH-102929 - Mathematical Modelling and Simulation in Practise

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	2

Events					
WT 23/24	0109400	Mathematical Modelling and Simulation	2 SWS	Lecture	Thäter
WT 23/24	0109410	Tutorial for 0109400 (Mathematical modelling and simulation)	1 SWS	Practice	Thäter
Exams					
WT 23/24	7500115	Mathematical Modelling and Simulation in Practise			Thäter

Below you will find excerpts from events related to this course:

V Mathematical Modelling and Simulation

Lecture (V)

0109400, WS 23/24, 2 SWS, Language: English, Open in study portal

T 4.184 Course: Mathematical Physics [T-MATH-106113]

Responsible: Prof. Dr. Dirk Hundertmark
Organisation: KIT Department of Mathematics
Part of: M-MATH-103079 - Mathematical Physics

Type	Credits	Grading scale	Recurrence	Version
Written examination	8	Grade to a third	Irregular	1

Prerequisites
none

T 4.185 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	8	Grade to a third	Irregular	1

Prerequisites
none

T 4.186 Course: Mathematical Statistics [T-MATH-105872]

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-102909 - Mathematical Statistics

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	2

Exams			
WT 23/24	7700094	Mathematical Statistics	Fasen-Hartmann
ST 2024	7700112	Mathematical Statistics	Fasen-Hartmann

Prerequisites
none

T 4.187 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Prerequisites
none

T 4.188 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4,5	Grade to a third	Irregular	1

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.

T 4.189 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	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

T 4.190 Course: Medical Imaging Technology I [T-ETIT-113048]

Responsible: Prof. Dr.-Ing. Maria Francesca Spadea
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106449 - Medical Imaging Technology I

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each winter term	1

Events					
WT 23/24	2305261	Medical Imaging Technology I	2 SWS	Lecture	Spadea
Exams					
WT 23/24	7305012	Medical Imaging Technology I			Spadea
ST 2024	7305261	Medical Imaging Technology I			Spadea

Competence Certificate
The examination takes place in form of a written examination lasting 60 minutes. The course grade is the grade of the written exam.

Prerequisites
none

T 4.191 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	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each summer term	1

Events					
ST 2024	2305262	Medical Imaging Technology II	2 SWS	Lecture / 🗣	Spadea
Exams					
ST 2024	7305262	Medical Imaging Technology II			Spadea

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The examination takes place in form of a written examination lasting 60 minutes. The course grade is the grade of the written exam.

Prerequisites
none

T 4.192 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Events					
WT 23/24	2302113	Methods of Signal Processing	2 SWS	Lecture /	Wahls, Heizmann
WT 23/24	2302115	Methods of Signal Processing (Tutorial to 2302113)	1+1 SWS	Practice /	Wahls, Heizmann, Diaz Ocampo
Exams					
WT 23/24	7302113	Methods of Signal Processing			Wahls

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Prerequisites
none

4.193 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Competence Certificate
oral examination of circa 20 minutes

Prerequisites
none

4.194 Course: Minimal Surfaces [T-MATH-113417]

Responsible: Dr. Peter Lewintan
Organisation: KIT Department of Mathematics
Part of: M-MATH-106666 - Minimal Surfaces

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Irregular	1 terms	1

Prerequisites
None

T 4.195 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Irregular	1

Events					
WT 23/24	2550138	Mixed-integer Programming I	2 SWS	Lecture / 🗣	Stein
WT 23/24	2550139	Exercises Mixted Integer Programming I		Practice / 🗣	Stein, Beck
ST 2024	2550140	Mixed-integer Programming II	2 SWS	Lecture / 🗣	Stein
Exams					
WT 23/24	7900180_WS2324_HK	Mixed Integer Programming I			Stein
ST 2024	7900014_SS2024_NK	Mixed Integer Programming I			Stein

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:

V Mixed-integer Programming I
Lecture (V)
On-Site

2550138, WS 23/24, 2 SWS, Language: German, Open in study portal

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, and portfolio optimization with limitations on the number of securities. 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 *linear* optimization problems and is structured as follows:

- Introduction, solvability, and basic concepts
- LP relaxation and error bounds for roundings
- Branch-and-bound method
- Gomory's cutting plane method
- Benders decomposition

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 *nonlinear* optimization problems forms the contents of the lecture "Mixed-integer Programming II".

Learning objectives:

The student

- knows and understands the fundamentals of linear mixed integer programming,
- is able to choose, design and apply modern techniques of linear mixed integer programming in practice.

Literature

- C.A. Floudas, Nonlinear and Mixed-Integer Optimization: Fundamentals and Applications, Oxford University Press, 1995
- J. Kallrath: Gemischt-ganzzahlige Optimierung, Vieweg, 2002
- D. Li, X. Sun: Nonlinear Integer Programming, Springer, 2006
- G.L. Nemhauser, L.A. Wolsey, Integer and Combinatorial Optimization, Wiley, 1988
- M. Tawarmalani, N.V. Sahinidis, Convexification and Global Optimization in Continuous and Mixed-Integer Nonlinear Programming, Kluwer, 2002.

V **Mixed-integer Programming II**

2550140, SS 2024, 2 SWS, Language: German, Open in study portal

Lecture (V)
On-Site

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

- C.A. Floudas, Nonlinear and Mixed-Integer Optimization: Fundamentals and Applications, Oxford University Press, 1995
- J. Kallrath: Gemischt-ganzzahlige Optimierung, Vieweg, 2002
- D. Li, X. Sun: Nonlinear Integer Programming, Springer, 2006
- G.L. Nemhauser, L.A. Wolsey, Integer and Combinatorial Optimization, Wiley, 1988
- M. Tawarmalani, N.V. Sahinidis, Convexification and Global Optimization in Continuous and Mixed-Integer Nonlinear Programming, Kluwer, 2002.

T 4.196 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Irregular	1

Events					
ST 2024	2550140	Mixed-integer Programming II	2 SWS	Lecture / 🗣	Stein
ST 2024	2550141	Exercise to Mixed-integer Programming II	1 SWS	Practice / 🗣	Stein, Schwarze
Exams					
ST 2024	7900009_SS2024_HK	Mixed Integer Programming II			Stein

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:

V Mixed-integer Programming II
Lecture (V)
On-Site

2550140, SS 2024, 2 SWS, Language: German, Open in study portal

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

- C.A. Floudas, Nonlinear and Mixed-Integer Optimization: Fundamentals and Applications, Oxford University Press, 1995
- J. Kallrath: Gemischt-ganzzahlige Optimierung, Vieweg, 2002
- D. Li, X. Sun: Nonlinear Integer Programming, Springer, 2006
- G.L. Nemhauser, L.A. Wolsey, Integer and Combinatorial Optimization, Wiley, 1988
- M. Tawarmalani, N.V. Sahinidis, Convexification and Global Optimization in Continuous and Mixed-Integer Nonlinear Programming, Kluwer, 2002.

T 4.197 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	4

Events					
WT 23/24	2550490	Modellieren und OR-Software: Fortgeschrittene Themen	3 SWS	Practical course /	Pomes, Linner, Nickel
Exams					
WT 23/24	7900071	Modeling and OR-Software: Advanced Topics			Nickel
ST 2024	7900188	Modeling and OR-Software: Advanced Topics			Nickel

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:

V Modellieren und OR-Software: Fortgeschrittene Themen

2550490, WS 23/24, 3 SWS, Language: German, Open in study portal

Practical course (P)
Blended (On-Site/Online)

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 progamming languages are OPL and ILOG Script.

Organizational issues
Link zur Bewerbung:

http://go.wiwi.kit.edu/OR_Bewerbung

Bewerberzeitraum:

01.09.2023 00:00 - 12.10.2023 23:55

T 4.198 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	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	3

Events					
ST 2024	2550490	Modellieren und OR-Software: Einführung	3 SWS	Practical course /	Nickel, Linner, Pomes
Exams					
WT 23/24	7900073	Modeling and OR-Software: Introduction			Nickel
ST 2024	7900153	Modeling and OR-Software: Introduction			Nickel

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
Firm knowledge of the contents from the lecture *Introduction to Operations Research I* [2550040] of the module *Operations Research*.

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:

V Modellieren und OR-Software: Einführung

2550490, SS 2024, 3 SWS, Language: German, Open in study portal

Practical course (P)
Blended (On-Site/Online)

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.

T 4.199 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	1

Events					
ST 2024	2511100	Modeling and Simulation	2 SWS	Lecture	Lazarova-Molnar
ST 2024	2511101	Exercises Modeling and Simulation	1 SWS	Practice	Lazarova-Molnar
Exams					
WT 23/24	79AIFB_MaS_A6	Modeling and Simulation			Lazarova-Molnar
ST 2024	79AIFB_MaS_C6	Modeling and Simulation (Registration until 15 July 2024)			Lazarova-Molnar

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:

V Modeling and Simulation

Lecture (V)

2511100, 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

T 4.200 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

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	1

Competence Certificate
oral exam (ca. 20 min)

Prerequisites
None

4.201 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

T 4.202 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each summer term	1

Events					
ST 2024	4010041	Modern Experimental Physics I, Atoms, Nuclei and Molecules	4 SWS	Lecture / 🗣	Müller
ST 2024	4010042	Übungen zu Moderne Experimentalphysik I	2 SWS	Practice / 🗣	Müller, Hinz

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:

T 4.203 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each winter term	1

Events					
WT 23/24	4010051	Moderne Experimentalphysik II (Struktur der Materie)	4 SWS	Lecture / 🗣	Klute, Ustinov
WT 23/24	4010052	Übungen zu Moderne Experimentalphysik II	2 SWS	Practice / 🗣	Klute, Ustinov, Waßmer, Fischer

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:

T 4.204 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	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each summer term	1

Events					
ST 2024	4010141	Modern Theoretical Physics I, Foundations of Quantum Mechanics	4 SWS	Lecture / 🗣	Schmalian
ST 2024	4010142	Übungen zu Moderne Theoretische Physik I	2 SWS	Practice / 🗣	Schmalian, Jang, Palle

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Competence Certificate
Oral exam, approx. 45 min

Prerequisites
none

T 4.205 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each winter term	1

Events					
WT 23/24	4010151	Moderne Theoretische Physik II (Quantenmechanik II und Statistik)	4 SWS	Lecture / 🗣	Steinhauser
WT 23/24	4010152	Übungen zu Moderne Theoretische Physik II	2 SWS	Practice / 🗣	Steinhauser, Zhang, Egner
Exams					
WT 23/24	7800148	Modern Theoretical Physics II, Advanced Quantum Mechanics and Statistical Physics			Steinhauser

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Oral exam, approx. 45 min

Prerequisites
none

T 4.206 Course: Modular Forms [T-MATH-105843]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: M-MATH-102868 - Modular Forms

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

T 4.207 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

Type	Credits	Grading scale	Version
Oral examination	3	Grade to a third	1

T 4.208 Course: Multicriteria Optimization [T-WIWI-111587]

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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	see Annotations	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 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

4.209 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

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	1

Competence Certificate
Mündliche Prüfung im Umfang von ca. 20 Minuten.

Prerequisites
none

T 4.210 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Irregular	1

Competence Certificate
Witten 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 is offered irregularly. Detailed information can be found on the chair's website.

T 4.211 Course: Nature-Inspired Optimization Methods [T-WIWI-102679]

Responsible: Prof. Dr. Pradyumn Kumar Shukla
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101472 - Informatics

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	2

Events					
ST 2024	2511106	Nature-Inspired Optimization Methods	2 SWS	Lecture / Blended	Shukla
ST 2024	2511107	Übungen zu Nature-Inspired Optimization Methods	1 SWS	Practice / Blended	Shukla
Exams					
ST 2024	79AIFB_NOM_C1	Nature-Inspired Optimization Methods (Registration until 15 July 2024)			Shukla

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:

V 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. L. Aarts and J. K. Lenstra: 'Local Search in Combinatorial Optimization'. Wiley, 1997 * D. Corne and M. Dorigo and F. Glover: 'New Ideas in Optimization'. McGraw-Hill, 1999 * C. Reeves: 'Modern Heuristic Techniques for Combinatorial Optimization'. McGraw-Hill, 1995 * Z. Michalewicz, D. B. Fogel: How to solve it: Modern Heuristics. Springer, 1999 * E. Bonabeau, M. Dorigo, G. Theraulaz: 'Swarm Intelligence'. Oxford University Press, 1999 * A. E. Eiben, J. E. Smith: 'Introduction to Evolutionary Computation'. * M. Dorigo, T. Stützle: 'Ant Colony Optimization'. Bradford Book, 2004 Springer, 2003

T 4.212 Course: Network Security: Architectures and Protocols [T-INFO-101319]

Responsible: Prof. Dr. Martina Zitterbart
Organisation: KIT Department of Informatics
Part of: M-INFO-100782 - Network Security: Architectures and Protocols

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each summer term	1

Events					
ST 2024	24601	Netzsicherheit: Architekturen und Protokolle	2 SWS	Lecture / 🗣	Baumgart, Bless, Zitterbart
Exams					
WT 23/24	7500014	Network Security: Architectures and Protocols			Zitterbart
ST 2024	7500072	Network Security: Architectures and Protocols			Zitterbart, Bless, Baumgart

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 4.213 Course: Nonlinear Analysis [T-MATH-107065]

Responsible: Prof. Dr. Tobias Lamm
Organisation: KIT Department of Mathematics
Part of: M-MATH-103539 - Nonlinear Analysis

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Prerequisites
none

T 4.214 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each summer term	1

Events					
ST 2024	2303173	Nichtlineare Regelungssysteme	2 SWS	Lecture / 🗣	Kluwe
Exams					
WT 23/24	7303173	Nonlinear Control Systems			Kluwe

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 4.215 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2024	0156500	Nonlinear Evolution Equations	4 SWS	Lecture	Schnaubelt

Below you will find excerpts from events related to this course:

V 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.

T 4.216 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

Type	Credits	Grading scale	Version
Oral examination	3	Grade to a third	1

T 4.217 Course: Nonlinear Maxwell Equations [T-MATH-110283]

Responsible: Prof. Dr. Roland Schnaubelt
Organisation: KIT Department of Mathematics
Part of: M-MATH-105066 - Nonlinear Maxwell Equations

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Prerequisites
none

4.218 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	4

Events					
WT 23/24	2550111	Nonlinear Optimization I	2 SWS	Lecture / On-Site	Stein
WT 23/24	2550112	Exercises Nonlinear Optimization I + II		Practice / On-Site	Stein, Schwarze
Exams					
WT 23/24	7900001_WS2324_HK	Nonlinear Optimization I			Stein
ST 2024	7900202_SS2024_NK	Nonlinear Optimization I			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 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:

V Nonlinear Optimization I
2550111, WS 23/24, 2 SWS, Language: German, Open in study portal

Lecture (V)
On-Site

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 condtions
- 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

O. Stein, Grundzüge der Nichtlinearen Optimierung, 2. Aufl., SpringerSpektrum, 2021

Weiterführende Literatur:

- W. Alt, Nichtlineare Optimierung, Vieweg, 2002
- M.S. Bazaraa, H.D. Sherali, C.M. Shetty, Nonlinear Programming, Wiley, 1993
- O. Güler, Foundations of Optimization, Springer, 2010
- H.Th. Jongen, K. Meer, E. Triesch, Optimization Theory, Kluwer, 2004
- J. Nocedal, S. Wright, Numerical Optimization, Springer, 2000

T 4.219 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	9	Grade to a third	Each winter term	6

Events					
WT 23/24	2550111	Nonlinear Optimization I	2 SWS	Lecture / 🗣	Stein
WT 23/24	2550112	Exercises Nonlinear Optimization I + II		Practice / 🗣	Stein, Schwarze
WT 23/24	2550113	Nonlinear Optimization II	2 SWS	Lecture / 🗣	Stein
Exams					
WT 23/24	7900003_WS2324_HK	Nonlinear Optimization I and II			Stein
ST 2024	7900204_SS2024_NK	Nonlinear Optimization I and II			Stein

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment consits 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:

V Nonlinear Optimization I
2550111, WS 23/24, 2 SWS, Language: German, Open in study portal

Lecture (V)
On-Site

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 condtions
- 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

O. Stein, Grundzüge der Nichtlinearen Optimierung, 2. Aufl., SpringerSpektrum, 2021

Weiterführende Literatur:

- W. Alt, Nichtlineare Optimierung, Vieweg, 2002
- M.S. Bazaraa, H.D. Sherali, C.M. Shetty, Nonlinear Programming, Wiley, 1993
- O. Güler, Foundations of Optimization, Springer, 2010
- H.Th. Jongen, K. Meer, E. Triesch, Optimization Theory, Kluwer, 2004
- J. Nocedal, S. Wright, Numerical Optimization, Springer, 2000

V **Nonlinear Optimization II** — **Lecture (V) On-Site**

2550113, WS 23/24, 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

O. Stein, Grundzüge der Nichtlinearen Optimierung, 2. Aufl., SpringerSpektrum, 2021

Weiterführende Literatur:

- W. Alt, Nichtlineare Optimierung, Vieweg, 2002
- M.S. Bazaraa, H.D. Sherali, C.M. Shetty, Nonlinear Programming, Wiley, 1993
- O. Güler, Foundations of Optimization, Springer, 2010
- H.Th. Jongen, K. Meer, E. Triesch, Optimization Theory, Kluwer, 2004
- J. Nocedal, S. Wright, Numerical Optimization, Springer, 2000

T 4.220 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	3

Events					
WT 23/24	2550112	Exercises Nonlinear Optimization I + II		Practice / 🗣	Stein, Schwarze
WT 23/24	2550113	Nonlinear Optimization II	2 SWS	Lecture / 🗣	Stein
Exams					
WT 23/24	7900002_WS2324_HK	Nonlinear Optimization II			Stein
ST 2024	7900203_SS2024_NK	Nonlinear Optimization II			Stein

Legend: 🖥 Online, Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Competence Certificate
The assessment consits 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:

V Nonlinear Optimization II — **Lecture (V) On-Site**
2550113, WS 23/24, 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

O. Stein, Grundzüge der Nichtlinearen Optimierung, 2. Aufl., SpringerSpektrum, 2021

Weiterführende Literatur:

- W. Alt, Nichtlineare Optimierung, Vieweg, 2002
- M.S. Bazaraa, H.D. Sherali, C.M. Shetty, Nonlinear Programming, Wiley, 1993
- O. Güler, Foundations of Optimization, Springer, 2010
- H.Th. Jongen, K. Meer, E. Triesch, Optimization Theory, Kluwer, 2004
- J. Nocedal, S. Wright, Numerical Optimization, Springer, 2000

T 4.221 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

4.222 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Prerequisites
none

T 4.223 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

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	2

Events					
WT 23/24	0162300	Nichtparametrische Statistik	2 SWS	Lecture	Trabs
WT 23/24	0162310	Übungen zu 0162300 (Nichtparametrische Statistik)	1 SWS	Practice	Trabs
Exams					
WT 23/24	00090	Nonparametric Statistics			Trabs

Competence Certificate
oral exam of ca. 20 minutes

T 4.224 Course: Numerical Analysis of Helmholtz Problems [T-MATH-111514]

Responsible: TT-Prof. Dr. Barbara Verfürth
Organisation: KIT Department of Mathematics
Part of: M-MATH-105764 - Numerical Analysis of Helmholtz Problems

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Irregular	1 terms	1

T 4.225 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

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Competence Certificate
oral exam of ca. 30 minutes

Prerequisites
none

T 4.226 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

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	6	Grade to a third	Irregular	1 terms	1

Competence Certificate
oral exam of ca. 20 minutes

Prerequisites
none

Recommendation
Some basic knowledge of Complex Analysis is strongly recommended.

T 4.227 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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	5	Grade to a third	Irregular	2

Prerequisites
none

T 4.228 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Exams			
WT 23/24	7700137	Numerical Linear Algebra in Image Processing	Grimm
ST 2024	00024	Numerical Linear Algebra in Image Processing	Grimm

Prerequisites
none

T 4.229 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

Type	Credits	Grading scale	Version
Written examination	8	Grade to a third	3

Events					
WT 23/24	0110700	Numerische Methoden für Differentialgleichungen	4 SWS	Lecture / 🗣	Wieners
WT 23/24	0110800	Übungen zu 0110700 (numerische Methoden für Differentialgleichungen)	2 SWS	Practice / 🗣	Wieners
Exams					
WT 23/24	00049	Numerical Methods for Differential Equations			Wieners

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 4.230 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

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Prerequisites
none

T 4.231 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2024	0160500	Integralgleichungen	4 SWS	Lecture	Hettlich

T 4.232 Course: Numerical Methods for Maxwell's Equations [T-MATH-105920]

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

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

T 4.233 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Competence Certificate
oral exam of ca. 30 minutes

Prerequisites
none

T 4.234 Course: Numerical Methods for Time-Dependent Partial Differential Equations [T-MATH-105899]

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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

T 4.235 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

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Prerequisites
none

T 4.236 Course: Numerical Methods in Fluid Mechanics [T-MATH-105902]

Responsible: Prof. Dr. Willy Dörfler
PD Dr. Gudrun Thäter

Organisation: KIT Department of Mathematics

Part of: M-MATH-102932 - Numerical Methods in Fluid Mechanics

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	1

Events					
ST 2024	0161600	Numerical Methods in Fluidmechanics	2 SWS	Lecture	Dörfler

Below you will find excerpts from events related to this course:

V Numerical Methods in Fluidmechanics

0161600, SS 2024, 2 SWS, Language: English, Open in study portal

Lecture (V)

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.

T 4.237 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	0107800	Numerical methods in mathematical finance	4 SWS	Lecture	Jahnke
WT 23/24	0107900	Tutorial for 0107800 (numerical methods for mathematical finance)	2 SWS	Practice	Jahnke, Kirn
Exams					
WT 23/24	6700028	Numerical Methods in Mathematical Finance			Jahnke

Competence Certificate
oral exam of ca. 30 minutes

Prerequisites
none

T 4.238 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	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	0124000	Numerische Optimierungsmethoden	4 SWS	Lecture	Rieder
WT 23/24	0124010	Übungen zu 0124000 (numerische Optimierungsmethoden)	2 SWS	Practice	Rieder
Exams					
WT 23/24	7700126	Numerical Optimisation Methods			Rieder

T 4.239 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Prerequisites
none

T 4.240 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Irregular	2

Exams			
WT 23/24	7900076	Operations Research in Supply Chain Management	Nickel
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 SCMis 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.

4.241 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 23/24	2309464	Optical Waveguides and Fibers	2 SWS	Lecture / 🗣	Koos, N.N., Bao, Kelany
WT 23/24	2309465	Tutorial for 2309464 Optical Waveguides and Fibers	1 SWS	Practice / 🗣	Koos, N.N., Bao
Exams					
WT 23/24	7309464	Optical Waveguides and Fibers			Koos
ST 2024	7309464	Optical Waveguides and Fibers			Koos

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Prerequisites
none

T 4.242 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Events					
ST 2024	2303162	Optimale Regelung und Schätzung	2 SWS	Lecture / 🗣	Kluwe
Exams					
WT 23/24	7303162	Optimal Control and Estimation			Kluwe
ST 2024	7303162	Optimal Control and Estimation			Kluwe

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

4.243 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

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	1

Prerequisites

none

T 4.244 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

Type	Credits	Grading scale	Version
Oral examination	5	Grade to a third	2

Competence Certificate
oral examination of approximately 30 minutes

Prerequisites
none

Recommendation
Some basic knowledge of finite dimensional optimization theory and functional analysis is desirable.

T 4.245 Course: Optimization Models and Applications [T-WIWI-110162]

Responsible: Dr. Nathan Sudermann-Merx
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101473 - Mathematical Programming
M-WIWI-102832 - Operations Research in Supply Chain Management

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	see Annotations	1

Competence Certificate

The examination will take place for the last time in the winter semester 2020/2021.

The assessment consists of a written exam (60 min.) according to § 4 paragraph 2 Nr. 1 of the examination regulation.

The prerequisite for participation in the exam is the achievement of a minimum number of points in delivery sheets. Details will be announced at the beginning of the course.

Prerequisites

None.

Annotation

The course will take place for the last time in the winter semester 20/21.

T 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	1

Events					
WT 23/24	2303183	Optimization of Dynamic Systems	2 SWS	Lecture /	Hohmann
WT 23/24	2303185	Optimization of Dynamic Systems (Tutorial to 2303183)	1 SWS	Practice /	N.N.
WT 23/24	2303851	Accompanying group tutorial for 2303183 Optimization of Dynamic Systems	1 SWS	Tutorial (/	N.N.
Exams					
WT 23/24	7303183	Optimization of Dynamic Systems			Hohmann

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
The assessment consists of a written exam (120 min) taking place in the recess period.

Prerequisites
none

T 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	3

Events					
WT 23/24	2550464	Optimization Under Uncertainty	2 SWS	Lecture /	Rebennack
WT 23/24	2550465	Übungen zu Optimierungsansätze unter Unsicherheit	1 SWS	Practice /	Rebennack
WT 23/24	2550466		2 SWS	Others (sons	Rebennack
Exams					
WT 23/24	7900240	Optimization under Uncertainty			Rebennack
WT 23/24	7900355	Optimization under Uncertainty			Rebennack
ST 2024	7900309	Optimization under Uncertainty			Rebennack

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 exam takes place in every the semester.

Prerequisites
None.

T 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

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	1

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.

T 4.249 Course: Oral Exam - Supplementary Studies on Sustainable Development [T-ZAK-112351]

Organisation:

Part of: M-ZAK-106099 - Supplementary Studies on Sustainable Development

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	1

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.

T 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

Type	Credits	Grading scale	Version
Oral examination	5	Grade to a third	1

T 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	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Irregular	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).

T 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	Credits	Grading scale	Version
Oral examination	5	Grade to a third	2

Prerequisites
none

T 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	5	Grade to a third	Each summer term	1

Events					
WT 23/24	2400180	Fotorealistische Bildsynthese	2 SWS	Lecture / 🗣	Schudeiske
WT 23/24	2400185	Übung Fotorealistische Bildsynthese	2 SWS	Practice / 🗣	Schudeiske, Grauer
Exams					
WT 23/24	7500203	Fotorealistic Rendering			Dachsbacher

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each winter term	1

Events					
WT 23/24	2305281	Physiology and Anatomy for Engineers I	2 SWS	Lecture /	Nahm
Exams					
WT 23/24	7305281	Physiology and Anatomy for Engineers I			Nahm

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
Success control is carried out in the form of a written test of 60 minutes.

Prerequisites
none

T 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

Type	Credits	Grading scale	Version
Oral examination	5	Grade to a third	1

Events					
ST 2024	0152700	Der Poisson-Prozess	2 SWS	Lecture	Nestmann

Prerequisites
none

T 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

T 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

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

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.

T 4.258 Course: Probability Theory and Combinatorial Optimization [T-MATH-105923]

Responsible: Prof. Dr. Daniel Hug
Prof. Dr. Günter Last

Organisation: KIT Department of Mathematics

Part of: M-MATH-102947 - Probability Theory and Combinatorial Optimization

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Prerequisites
none

T 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	2

Events					
ST 2024	2511204	Process Mining	2 SWS	Lecture / 🗣	Oberweis
ST 2024	2511205	Exercise Process Mining	1 SWS	Practice / 🗣	Oberweis, Schreiber, Schüler, Rybinski
Exams					
WT 23/24	79AIFB_PM_A5	Process Mining			Oberweis
ST 2024	79AIFB_PM_C2	Process Mining (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

Annotation
Former name (up to winter semester 2018/1019) "Workflow Management".

Below you will find excerpts from events related to this course:

V Process Mining

Lecture (V)
On-Site

2511204, SS 2024, 2 SWS, Language: German, Open in study portal

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

- W. van der Aalst, H. van Kees: Workflow Management: Models, Methods and Systems, Cambridge, The MIT Press, 2002.
- W. van der Aalst: Process Mining: Data Science in Action. Springer, 2016.
- J. Carmona, B. van Dongen, A. Solti, M. Weidlich: Conformance Checking: Relating Processes and Models. Springer, 2018.
- A. Drescher, A. Koschmider, A. Oberweis: Modellierung und Analyse von Geschäftsprozessen: Grundlagen und Übungsaufgaben mit Lösungen. De Gruyter Studium, 2017.
- A. Oberweis: Modellierung und Ausführung von Workflows mit Petri-Netzen. Teubner-Reihe Wirtschaftsinformatik, B.G. Teubner Verlag, 1996.
- R. Peters, M. Nauroth: Process-Mining: Geschäftsprozesse: smart, schnell und einfach, Springer, 2019.
- F. Schönthaler, G.Vossen, A. Oberweis, T. Karle: Business Processes for Business Communities: Modeling Languages, Methods, Tools. Springer, 2012.
- M. Weske: Business Process Management: Concepts, Languages, Architectures. Springer, 2012.

Weitere Literatur wird in der Vorlesung bekannt gegeben.

T 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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	5	Grade to a third	Each winter term	3

Events					
WT 23/24	2512501	Practical Course Cognitive automobiles and robots (Master)	3 SWS	Practical course / Blended	Zöllner, Daaboul
Exams					
WT 23/24	7900107	Advanced Lab Cognitive Automobile and Robots (Master)			Zöllner

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:

V Practical Course Cognitive automobiles and robots (Master)
2512501, WS 23/24, 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 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.

T 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	Credits	Grading scale	Recurrence	Version
Examination of another type	5	Grade to a third	Each summer term	3

Events					
ST 2024	2512500	Project Lab Machine Learning	3 SWS	Practical course / Blended	Daaboul, Zöllner, Schneider
Exams					
ST 2024	7900086	Project Lab Machine Learning			Zöllner

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:

V 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.

T 4.262 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Competence Certificate
oral exam of ca. 30 min

Prerequisites
none

Recommendation
The contents of the module 'Probability Theory' are strongly recommended.

T 4.263 Course: Regularity for Elliptic Operators [T-MATH-113472]

Responsible: apl. Prof. Dr. Peer Kunstmann
Organisation: KIT Department of Mathematics
Part of: M-MATH-106696 - Regularity for Elliptic Operators

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Competence Certificate
oral exam of ca. 30 minutes

Prerequisites
none

T 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

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	8	Grade to a third	Irregular	1 terms	1

Exams			
WT 23/24	7700121	Riemann Surfaces	Herrlich

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

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Events					
WT 23/24	2424152	Robotics I - Introduction to Robotics	3/1 SWS	Lecture / 🗣	Asfour
Exams					
WT 23/24	7500106	Robotics I - Introduction to Robotics			Asfour
ST 2024	7500218	Robotik I - Einführung in die Robotik			Asfour

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 60 minutes.

Prerequisites
none.

T 4.266 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	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Prerequisites
none

T 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

T 4.268 Course: Scattering Theory for Time-dependent Waves [T-MATH-113416]

Responsible: Prof. Dr. Roland Griesmaier
Organisation: KIT Department of Mathematics
Part of: M-MATH-106664 - Scattering Theory for Time-dependent Waves

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Competence Certificate
oral exam of ca. 30 min

Prerequisites
none

T 4.269 Course: Selected Methods in Fluids and Kinetic Equations [T-MATH-111853]

Organisation: KIT Department of Mathematics

Part of: M-MATH-105897 - Selected Methods in Fluids and Kinetic Equations

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Irregular	1 terms	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.

T 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

T 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Irregular	1

Prerequisites
none

T 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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	2	Grade to a third	Each term	1

Self service assignment of supplementary stdues
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 "Sprachenzentrum" or the Center for Applied Cultural Studies and Studium Generale.

T 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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	2	Grade to a third	Each term	1

Self service assignment of supplementary stdues

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 "Sprachenzentrum" or the Center for Applied Cultural Studies and Studium Generale.

T 4.274 Course: Self-Booking-HOC-SPZ-ZAK-4-Graded [T-MATH-111519]

Organisation: KIT Department of Mathematics
Part of: M-MATH-103053 - Key Competences

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	2	Grade to a third	Each term	1

Self service assignment of supplementary stdues
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 "Sprachenzentrum" or the Center for Applied Cultural Studies and Studium Generale.

T 4.275 Course: Self-Booking-HOC-SPZ-ZAK-5-Ungraded [T-MATH-111516]

Organisation: KIT Department of Mathematics
Part of: M-MATH-103053 - Key Competences

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	2	pass/fail	Each term	1

Self service assignment of supplementary stdues
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 "Sprachenzentrum" or the Center for Applied Cultural Studies and Studium Generale.

T 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

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	2	pass/fail	Each term	1

Self service assignment of supplementary stdues

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 "Sprachenzentrum" or the Center for Applied Cultural Studies and Studium Generale.

T 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

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	2	pass/fail	Each term	1

Self service assignment of supplementary stdues
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 "Sprachenzentrum" or the Center for Applied Cultural Studies and Studium Generale.

T 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

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	2	pass/fail	Each term	1

Self service assignment of supplementary stdues

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 "Sprachenzentrum" or the Center for Applied Cultural Studies and Studium Generale.

T 4.279 Course: Self-Booking-HOC-SPZ-ZAK-Graded [T-MATH-111518]

Organisation: KIT Department of Mathematics
Part of: M-MATH-103053 - Key Competences

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	2	Grade to a third	Each term	1

Self service assignment of supplementary stdues
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 "Sprachenzentrum" or the Center for Applied Cultural Studies and Studium Generale.

T 4.280 Course: Semantic Web Technologies [T-WIWI-110848]

Responsible: Dr.-Ing. Tobias Christof Käfer
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101472 - Informatics

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	1

Events					
ST 2024	2511310	Semantic Web Technologies	2 SWS	Lecture / 🗣	Färber, Käfer, Braun
ST 2024	2511311	Exercises to Semantic Web Technologies	1 SWS	Practice / 🗣	Färber, Käfer, Braun
Exams					
WT 23/24	79AIFB_SWebT_A2	Semantic Web Technologies			Käfer
ST 2024	79AIFB_SWebT_A4	Semantic Web Technologies (Registration until 15 July 2024)			Färber

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:

V Semantic Web Technologies

2511310, SS 2024, 2 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

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 preperation and postprocessing: 60 hours
- Exam and exam preperation: 30 hours

Literature

- Pascal Hitzler, Markus Krötzsch, Sebastian Rudolph, York Sure: Semantic Web – Grundlagen. Springer, 2008.
- John Domingue, Dieter Fensel, James A. Hendler (Editors). Handbook of Semantic Web Technologies. Springer, 2011.

Weitere Literatur

- S. Staab, R. Studer (Editors). Handbook on Ontologies. International Handbooks in Information Systems. Springer, 2003.
- Tim Berners-Lee. Weaving the Web. Harper, 1999 geb. 2000 Taschenbuch.
- Ian Jacobs, Norman Walsh. Architecture of the World Wide Web, Volume One. W3C Recommendation 15 December 2004. http://www.w3.org/TR/webarch/
- Dean Allemang. Semantic Web for the Working Ontologist: Effective Modeling in RDFS and OWL. Morgan Kaufmann, 2008.
- Tom Heath and Chris Bizer. Linked Data: Evolving the Web into a Global Data Space. Synthesis Lectures on the Semantic Web: Theory and Technology, 2011.

V **Exercises to Semantic Web Technologies** **Practice (Ü)**
2511311, SS 2024, 1 SWS, Language: English, Open in study portal **On-Site**

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

- Pascal Hitzler, Markus Krötzsch, Sebastian Rudolph, York Sure: Semantic Web – Grundlagen. Springer, 2008.
- John Domingue, Dieter Fensel, James A. Hendler (Editors). Handbook of Semantic Web Technologies. Springer, 2011.

Weitere Literatur

- S. Staab, R. Studer (Editors). Handbook on Ontologies. International Handbooks in Information Systems. Springer, 2003.
- Tim Berners-Lee. Weaving the Web. Harper, 1999 geb. 2000 Taschenbuch.
- Ian Jacobs, Norman Walsh. Architecture of the World Wide Web, Volume One. W3C Recommendation 15 December 2004. http://www.w3.org/TR/webarch/
- Dean Allemang. Semantic Web for the Working Ontologist: Effective Modeling in RDFS and OWL. Morgan Kaufmann, 2008.
- Tom Heath and Chris Bizer. Linked Data: Evolving the Web into a Global Data Space. Synthesis Lectures on the Semantic Web: Theory and Technology, 2011.

T 4.281 Course: Semigroup Theory for the Navier-Stokes Equations [T-MATH-113415]

Responsible: Dr. rer. nat. Patrick Tolksdorf
Organisation: KIT Department of Mathematics
Part of: M-MATH-106663 - Semigroup Theory for the Navier-Stokes Equations

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Competence Certificate
oral exam of ca. 30 min

Prerequisites
none

T 4.282 Course: Seminar Advanced Topics in Parallel Programming [T-INFO-103584]

Responsible: Prof. Dr. Achim Streit
Organisation: KIT Department of Informatics
Part of: M-INFO-101887 - Seminar Advanced Topics in Parallel Programming

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	3	Grade to a third	Each summer term	1

T 4.283 Course: Seminar Mathematics [T-MATH-106541]

Organisation: KIT Department of Mathematics
Part of: M-MATH-103276 - Seminar

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	3	pass/fail	Each term	1

Exams			
WT 23/24	7700039	Seminar Mathematics	Kühnlein
ST 2024	7700026	Seminar Mathematics (Vert.)	Kühnlein

4.284 Course: Seminar Mathematics [T-MATH-105686]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: M-MATH-102730 - Seminar

Type	Credits	Grading scale	Version
Completed coursework	3	pass/fail	1

Exams			
WT 23/24	7700048	Seminar Mathematics	Kühnlein
ST 2024	7700025	Seminar Mathematics	Kühnlein

T 4.285 Course: Seminar Mathematics 2 [T-MATH-108020]

Organisation: KIT Department of Mathematics
Part of: M-MATH-103925 - Seminar 2

Type	Credits	Grading scale	Version
Completed coursework	3	pass/fail	1

Exams			
WT 23/24	7700020	Seminar Mathematics 2	Kühnlein
ST 2024	7700020	Seminar Mathematics 2	Kühnlein

T 4.286 Course: Signal Processing with Nonlinear Fourier Transforms and Koopman Operators [T-ETIT-113428]

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

Type	Credits	Grading scale	Version
Written examination	6	Grade to a third	1

Events					
ST 2024	2302135	Signal Processing with Nonlinear Fourier Transforms and Koopman Operators	2 SWS	Lecture / 🗣	Wahls
ST 2024	2302136	Practice to 2303135 Signal Processing with Nonlinear Fourier Transforms and Koopman Operators	2 SWS	Practice / 🗣	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

T 4.287 Course: Signals and Codes [T-INFO-101360]

Responsible: Prof. Dr. Jörn Müller-Quade
Organisation: KIT Department of Informatics
Part of: M-INFO-100823 - Signals and Codes

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Irregular	1

Events					
WT 23/24	24137	Signals and Codes	2 SWS	Lecture / 🗣	Geiselmann, Müller-Quade
Exams					
WT 23/24	7500090	Signals and Codes			Geiselmann, Müller-Quade

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Below you will find excerpts from events related to this course:

V Signals and Codes

24137, WS 23/24, 2 SWS, Language: German, Open in study portal

Lecture (V)
On-Site

Content

In this lecture, bounds for codes (Hamming, Gilbert-Varshamov, Singleton) are presented. Coding and decoding for classical algebraic codes (linear, cyclic, Reed Solomon-, Goppa- und Reed Muller-codes) will be presented as well as concatanated codes.

Literature

Shu Lin, Daniel Costello, 'Error Control Coding', 2nd Ed., Pearson Prentice Hall, 2004
Todd Moon, 'Error Correction Coding', Wiley, 2005
Weitere Literatur wird in der Vorlesung bekannt gegeben.

Weiterführende Literatur

Wird in der Vorlesung bekannt gegeben.

T 4.288 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	5,5	Grade to a third	Each winter term	2

Events					
WT 23/24	2581023	(Smart) Energy Infrastructure	4 SWS	Lecture / 🗣	Ardone, Pustisek
Exams					
WT 23/24	7900178	Smart Energy Infrastructure NEW			Fichtner
WT 23/24	7981023	Smart Energy Infrastructure			Fichtner
ST 2024	7900228	Smart Energy Infrastructure NEW			Fichtner
ST 2024	7981023	Smart Energy Infrastructure			Fichtner

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. Re-examinations are offered at every ordinary examination date.

Below you will find excerpts from events related to this course:

V (Smart) Energy Infrastructure
2581023, WS 23/24, 4 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

Content
The lecture provides a techno-economic overview of different infrastructures of the energy system and their importance regarding the future energy system ("Energiewende") – in particular

- for electricity:
  - the supply side (e.g. power plants)
  - the demand side (e.g. load structures of appliances, flexibilities) as well as
  - transport infrastructures (electricity grids)
- for fuel transportation:
  - pipeline infrastructures (focus on natural gas)
  - shipping of LNG
  - crude oil and oil product transportation
  - hydrogen transportation
  - comparison of potential energy carriers for global trade of renewable energy (e.g., hydrogen and its derivates, e-fuels, reactive metals)
- storage systems (e.g. batteries)

Additionally, the lecture provides a toolbox for energy system analysis such as an overview and classification of energy systems modelling approaches as well as the usage of scenario techniques for energy systems analysis.

The lecture also provides practical examples for the relevant methods presented.

Organizational issues
Blockveranstaltung

16.11., 17.11., 30.11., 01.12., 07.12., 08.12., 14.12., 15.12.

T 4.289 Course: Sobolev Spaces [T-MATH-105896]

Responsible: Prof. Dr. Roland Schnaubelt
Organisation: KIT Department of Mathematics
Part of: M-MATH-102926 - Sobolev Spaces

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	2

Recommendation
Some basic knowledge of (elementary) linear functional analysis is strongly recommended.

T 4.290 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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4,5	Grade to a third	Each summer term	2

Events					
ST 2024	2520537	Social Choice Theory	2 SWS	Lecture / 🗣	Puppe
ST 2024	2520539	Übung zu Social Choice Theory	1 SWS	Practice / 🗣	Puppe, Kretz

Legend: 🖥 Online, Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

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:

V 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 prooving the Gibbard-Satterthwaite theorem.

Literature
Main texts:

- Hervé Moulin: Axioms of Cooperative Decision Making, Cambridge University Press, 1988
- Christian List and Clemens Puppe: Judgement Aggregation. A survey, in: Handbook of rational & social choice, P.Anand,P.Pattanaik, C.Puppe (Eds.), Oxford University Press 2009.

Secondary texts:

- Amartya Sen: Collective Choice and Social Welfare, Holden-Day, 1970
- Wulf Gaertner: A Primer in Social Choice Theory, revised edition, Oxford University Press, 2009
- Wulf Gaertner: Domain Conditions in Social Choice Theory, Oxford University Press, 2001

T 4.291 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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4,5	Grade to a third	Each term	2

Events					
ST 2024	2512400	Advanced Lab Development of Sociotechnical Information Systems (Bachelor)	3 SWS	Practical course /	Sunyaev, Leiser
ST 2024	2512401	Advanced Lab Development of Sociotechnical Information Systems (Master)	3 SWS	Practical course /	Sunyaev, Leiser
Exams					
WT 23/24	7900080	Advanced Lab Development of Sociotechnical Information Systems (Bachelor)			Sunyaev
WT 23/24	7900143	Advanced Lab Development of Sociotechnical Information Systems (Master)			Sunyaev
ST 2024	7900173	Advanced Lab Development of Sociotechnical Information Systems (Master)			Sunyaev

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:

V Advanced Lab Development of Sociotechnical Information Systems (Bachelor)

2512400, SS 2024, 3 SWS, Language: German/English, Open in study portal

Practical course (P)
Blended (On-Site/Online)

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.

V Advanced Lab Development of Sociotechnical Information Systems (Master)

2512401, SS 2024, 3 SWS, Language: German/English, Open in study portal

Practical course (P)
Blended (On-Site/Online)

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.

T 4.292 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	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	2

Events					
ST 2024	2511208	Software Quality Management	2 SWS	Lecture / 🗣	Alpers
ST 2024	2511209	Übungen zu Software-Qualitätsmanagement	1 SWS	Practice / 🗣	Frister, Forell
Exams					
WT 23/24	79AIFB_STQM_C1	Software Quality Management			Oberweis
ST 2024	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:

V Software Quality Management
2511208, SS 2024, 2 SWS, Language: German, Open in study portal

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 sofware 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.

T 4.293 Course: Space and Time Discretization of Nonlinear Wave Equations [T-MATH-112120]

Responsible: Prof. Dr. Marlis Hochbruck
Organisation: KIT Department of Mathematics
Part of: M-MATH-105966 - Space and Time Discretization of Nonlinear Wave Equations

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	6	Grade to a third	Irregular	1 terms	1

Events					
WT 23/24	0100018	Space and time discretization of nonlinear wave equations	3 SWS	Lecture	Hochbruck, Dörich
Exams					
WT 23/24	7700138	Space and Time Discretization of Nonlinear Wave Equations			Hochbruck, Dörich

Prerequisites
none

T 4.294 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	1

Events					
WT 23/24	2561260	Spatial Economics	2 SWS	Lecture / 🗣	Ott
WT 23/24	2561261	Exercise for Spatial Economics	1 SWS	Practice / 🗣	Ott, Mirzoyan
Exams					
WT 23/24	7900075	Spatial Economics			Ott
WT 23/24	7900276	Spatial Economics			Ott

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 23/24, 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
Steven Brakman, Harry Garretsen, Charles van Marrewijk (2009): The New Introduction to Geographical Economics, 2nd ed, Cambridge University Press.

Weitere Literatur wird in der Vorlesung bekanntgegeben.
(Further literature will be announced in the lecture.)

T 4.295 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	0105600	Spatial Stochastics	4 SWS	Lecture	Hug
WT 23/24	0105610	Tutorial for 0105600 (Spatial Stochastics)	2 SWS	Practice	Hug
Exams					
WT 23/24	7700052	Spatial Stochastics			Last, Hug

Prerequisites
none

T 4.296 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Prerequisites
none

T 4.297 Course: Specialisation Module - Self Assignment BeNe [T-ZAK-112346]

Responsible: Christine Myglas
Organisation:
Part of: M-ZAK-106099 - Supplementary Studies on Sustainable Development

Type	Credits	Grading scale	Version
Examination of another type	6	Grade to a third	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 stdues
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
Knowledge from 'Basic Module ' and 'Elective Module ' is helpful.

T 4.298 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2024	0163700	Spectral Theory	4 SWS	Lecture	Frey
ST 2024	0163710	Tutorial for 0163700 (Spectral Theory)	2 SWS	Practice	Frey

Competence Certificate
Oral examination of approx. 30 minutes.

Prerequisites
none

Below you will find excerpts from events related to this course:

V Spectral Theory

0163700, SS 2024, 4 SWS, Open in study portal

Lecture (V)

Literature

- H.W. Alt: Lineare Funktionalanalysis.
- H. Brezis: Functional Analysis, Sobolev Spaces and Partial Differential Equations.
- J.B. Conway: A Course in Functional Analysis.
- N. Dunford, J.T. Schwartz: Linear Operators, Part I.
- T. Kato: Perturbation Theory of Linear Operators.
- B. Simon: Operator Theory. A Comprehensive Course in Analysis, Part 4.
- A.E. Taylor, D.C. Lay: Introduction to Functional Analysis.
- D. Werner: Funktionalanalysis.

T 4.299 Course: Spectral Theory of Differential Operators [T-MATH-105851]

Responsible: Prof. Dr. Michael Plum
Organisation: KIT Department of Mathematics
Part of: M-MATH-102880 - Spectral Theory of Differential Operators

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

4.300 Course: Splitting Methods for Evolution Equations [T-MATH-110805]

Responsible: Prof. Dr. Tobias Jahnke
Organisation: KIT Department of Mathematics
Part of: M-MATH-105325 - Splitting Methods for Evolution Equations

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Prerequisites
none

T 4.301 Course: Statistical Learning [T-MATH-111726]

Responsible: Prof. Dr. Mathias Trabs
Organisation: KIT Department of Mathematics
Part of: M-MATH-105840 - Statistical Learning

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

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.

T 4.302 Course: Steins Method with Applications in Statistics [T-MATH-111187]

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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Prerequisites

none

T 4.303 Course: Stochastic Control [T-MATH-105871]

Responsible: Prof. Dr. Nicole Bäuerle
Organisation: KIT Department of Mathematics
Part of: M-MATH-102908 - Stochastic Control

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	1

Prerequisites
none

T 4.304 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

T 4.305 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

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2024	0152600	Stochastic Geometry	4 SWS	Lecture	Winter
ST 2024	0152610	Tutorial for 0152600 (Stochastic Geometry)	2 SWS	Practice	Winter

Below you will find excerpts from events related to this course:

V Stochastic Geometry

0152600, SS 2024, 4 SWS, Open in study portal

Lecture (V)

Content

For some idea what this course is about see

https://www.math.kit.edu/stoch/seite/raeumstoch-lehre/en

T 4.306 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each winter term	1

Events					
WT 23/24	24113	Stochastic Information Processing	3 SWS	Lecture / 🗣	Hanebeck, Frisch
Exams					
WT 23/24	7500031	Stochastic Information Processing			Hanebeck

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Below you will find excerpts from events related to this course:

V Stochastic Information Processing

24113, WS 23/24, 3 SWS, Language: German, Open in study portal

Lecture (V)
On-Site

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 (gambichler@kit.edu) zu vereinbaren.

Literature

Weiterführende Literatur

Skript zur Vorlesung

T 4.307 Course: Stochastic Simulation [T-MATH-112242]

Responsible: TT-Prof. Dr. Sebastian Krumscheid
Organisation: KIT Department of Mathematics
Part of: M-MATH-106053 - Stochastic Simulation

Type	Credits	Grading scale	Recurrence	Version
Oral examination	5	Grade to a third	Each winter term	1

Events					
WT 23/24	0100027	Stochastic Simulation	2 SWS	Lecture	Krumscheid
Exams					
WT 23/24	7700109	Stochastic Simulation			Krumscheid

Competence Certificate
oral exam of ca. 30 min

Prerequisites
none

T 4.308 Course: Structural Graph Theory [T-MATH-111004]

Responsible: Prof. Dr. Maria Aksenovich
Organisation: KIT Department of Mathematics
Part of: M-MATH-105463 - Structural Graph Theory

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Prerequisites
none

T 4.309 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each term	1

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.

T 4.310 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each term	1

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.

T 4.311 Course: Symmetric Encryption [T-INFO-101390]

Responsible: Prof. Dr. Jörn Müller-Quade
Organisation: KIT Department of Informatics
Part of: M-INFO-100853 - Symmetric Encryption

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Exams			
WT 23/24	7500178	Symmetric Encryption	Geiselmann, Müller-Quade

Competence Certificate
Es wird empfohlen, das Modul Sicherheit zu belegen.

T 4.312 Course: Tactical and Operational Supply Chain Management [T-WIWI-102714]

Responsible: Prof. Dr. Stefan Nickel
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101413 - Applications of Operations Research

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each summer term	3

Events					
ST 2024	2550486	Tactical and operational SCM	3 SWS	Lecture / 🗣	Nickel
ST 2024	2550487	Übungen zu Taktisches und operatives SCM	1,5 SWS	Practice / 🗣	Pomes, Linner, Hoffmann
Exams					
WT 23/24	7900074	Tactical and Operational Supply Chain Management			Nickel
ST 2024	7900239	Tactical and Operational Supply Chain Management			Nickel

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 succesful 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:

V 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
- Domschke: Logistik: Rundreisen und Touren, 4. Auflage, Oldenbourg, 1997
- Ghiani, Laporte, Musmanno: Introduction to Logistics Systems Planning and Control, Wiley, 2004
- Gudehus: Logistik, 3. Auflage, Springer, 2005
- Simchi-Levi, Kaminsky, Simchi-Levi: Designing and Managing the Supply Chain, 3rd edition, McGraw-Hill, 2008
- Silver, Pyke, Peterson: Inventory management and production planning and scheduling, 3rd edition, Wiley, 1998

T 4.313 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	1

Events					
WT 23/24	2313720	Technical Optics	2 SWS	Lecture / 🗣	Neumann
WT 23/24	2313722	Technical Optics (Tutorial to 2313720)	1 SWS	Practice / 🗣	Neumann
Exams					
WT 23/24	7313720	Technical Optics			Neumann
ST 2024	7313720	Technical Optics			Neumann

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 4.314 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

Type	Credits	Grading scale	Version
Oral examination	12	Grade to a third	1

Events					
WT 23/24	4026111	Theoretical Particle Physics I	4 SWS	Lecture / 🗣	Mühlleitner
WT 23/24	4026112	Exercises to Theoretical Particle Physics I	2 SWS	Practice / 🗣	Mühlleitner, Borschensky

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 4.315 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	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	4026111	Theoretical Particle Physics I	4 SWS	Lecture / 🗣	Mühlleitner

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 4.316 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	12	Grade to a third	Each summer term	1

Events					
WT 23/24	4026011	Theoretical Particle Physics II	4 SWS	Lecture / 🗣	Melnikov
WT 23/24	4026012	Exercises to Theoretical Particle Physics II	2 SWS	Practice / 🗣	Melnikov, Pikelner
ST 2024	4025011	Theoretical Particle Physics II	4 SWS	Lecture / 🗣	Nierste
ST 2024	4025012	Exercises to Theoretical Particle Physics II	2 SWS	Practice / 🗣	Nierste, Kretz

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites

none

T 4.317 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each summer term	1

Events					
WT 23/24	4026011	Theoretical Particle Physics II	4 SWS	Lecture / 🗣	Melnikov
ST 2024	4025011	Theoretical Particle Physics II	4 SWS	Lecture / 🗣	Nierste

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 4.318 Course: Time Series Analysis [T-MATH-105874]

Responsible: Dr. rer. nat. Bruno Ebner
Prof. Dr. Vicky Fasen-Hartmann
Prof. Dr. Tilmann Gneiting
PD Dr. Bernhard Klar
Prof. Dr. Mathias Trabs

Organisation: KIT Department of Mathematics

Part of: M-MATH-102911 - Time Series Analysis

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	3

Events					
ST 2024	0161100	Time Series Analysis	2 SWS	Lecture	Gneiting
ST 2024	0161110	Tutorial for 0161100 (Time Series Analysis)	1 SWS	Practice	Gneiting

Below you will find excerpts from events related to this course:

V Time Series Analysis

0161100, SS 2024, 2 SWS, Language: English, Open in study portal

Lecture (V)

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.

T 4.319 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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4,5	Grade to a third	Each winter term	1

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.

T 4.320 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Prerequisites
none

T 4.321 Course: Topological Genomics [T-MATH-112281]

Responsible: Dr. Andreas Ott
Organisation: KIT Department of Mathematics
Part of: M-MATH-106064 - Topological Genomics

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Irregular	1 terms	1

Competence Certificate
oral exam of ca. 20 min

Prerequisites
none

4.322 Course: Translation Surfaces [T-MATH-112128]

Responsible: Prof. Dr. Frank Herrlich
Organisation: KIT Department of Mathematics
Part of: M-MATH-105973 - Translation Surfaces

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Prerequisites
none

T 4.323 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

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	2

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 4.324 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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4,5	Grade to a third	Each summer term	1

Events					
WT 23/24	2511404	Trustworthy Emerging Technologies		Lecture /	Sunyaev, Lins
ST 2024	2511404	Trustworthy Emerging Technologies		Lecture /	Sunyaev, Lins
Exams					
WT 23/24	7900280	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.

T 4.325 Course: Uncertainty Quantification [T-MATH-108399]

Responsible: Prof. Dr. Martin Frank
Organisation: KIT Department of Mathematics
Part of: M-MATH-104054 - Uncertainty Quantification

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Events					
ST 2024	0164400	Uncertainty Quantification	2 SWS	Lecture	Frank
ST 2024	0164410	Tutorial for 0164400 (Uncertainty quantification)	1 SWS	Practice	Frank
Exams					
ST 2024	7700045	Uncertainty Quantification			Frank

Prerequisites
none

Below you will find excerpts from events related to this course:

V 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 Un- certainty 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 un- certain 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

- R.C. Smith: Uncertainty Quantification: Theory, Implementation, and Applications, SIAM, 2014.
- T.J. Sullivan: Introduction to Uncertainty Quantification, Springer-Verlag, 2015.
- D. Xiu: Numerical Methods for Stochastic Computations, Princeton University Press, 2010.
- O.P. Le Maître, O.M. Knio: Spectral Methods for Uncertainty Quantification, Springer-Verlag, 2010.
- R. Ghanem, D. Higdon, H. Owhadi:Handbook of Uncertainty Quantification, Springer-Verlag, 2017.

4.326 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Each winter term	1

Events					
WT 23/24	2530212	Valuation	2 SWS	Lecture / 🗣	Ruckes
WT 23/24	2530213	Übungen zu Valuation	1 SWS	Practice / 🗣	Ruckes, Luedecke
Exams					
WT 23/24	7900057	Valuation			Ruckes

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:

V **Valuation**
2530212, WS 23/24, 2 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

Literature
Weiterführende Literatur

Titman/Martin (2013): *Valuation - The Art and Science of Corporate Investment Decisions*, 2nd. ed. Pearson International.

T 4.327 Course: Variational Methods [T-MATH-110302]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: M-MATH-105093 - Variational Methods

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

T 4.328 Course: Wavelets [T-MATH-105838]

Responsible: Prof. Dr. Andreas Rieder
Organisation: KIT Department of Mathematics
Part of: M-MATH-102895 - Wavelets

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Competence Certificate
Mündliche Prüfung im Umfang von ca. 30 Minuten.

Prerequisites
none

T 4.329 Course: Web App Programming for Finance [T-WIWI-110933]

Responsible: TT-Prof. Dr. Julian Thimme
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101480 - Finance 3

Type	Credits	Grading scale	Recurrence	Version
Written examination	4,5	Grade to a third	Once	1

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.

T 4.330 Course: Wildcard 1 [T-MATH-106331]

Organisation: University
Part of: M-MATH-103198 - Wildcard

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each term	1