Excerpt from Module Descriptions

Master of Education Mathematics

Examination Regulations in the Version of: 2018

Sub-Section: Elective Modules Applied Mathematics and Mathematical Technology
## Index

### Elective Modules Applied Mathematics and Mathematical Technology

<table>
<thead>
<tr>
<th>Module</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial Mathematics I</td>
<td>1</td>
</tr>
<tr>
<td>Graph Theory</td>
<td>3</td>
</tr>
<tr>
<td>Mathematics of Games</td>
<td>5</td>
</tr>
<tr>
<td>Numerical Analysis</td>
<td>7</td>
</tr>
<tr>
<td>Numerical Practice</td>
<td>9</td>
</tr>
<tr>
<td>Numerical Linear Algebra</td>
<td>11</td>
</tr>
<tr>
<td>Optimization and OR I</td>
<td>13</td>
</tr>
<tr>
<td>Stochastic I - Statistics</td>
<td>15</td>
</tr>
</tbody>
</table>
Financial Mathematics I
Modules referring to Elective Modules Applied Mathematics and Mathematical Technology

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<td>Cycle</td>
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<tr>
<td>Coordinator</td>
<td>Prof. Dr. Robert Stelzer</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Instructors of financial mathematics</td>
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Allocation of study programmes
- Wirtschaftsmathematik BSc, Studienbeginn WiSe, Wahlpflicht Stochastik/Optimierung/Finanzmathematik
- Wirtschaftsmathematik BSc, Studienbeginn SoSe, Wahlpflicht Stochastik/Optimierung/Finanzmathematik
- Mathematische Biometrie BSc, Studienbeginn WiSe, Wahlpflicht Mathematik
- Mathematik BSc, Studienbeginn WiSe, Wahlpflicht Angewandte Mathematik
- Mathematik BSc, Studienbeginn SoSe, Wahlpflicht Angewandte Mathematik
- Mathematik MSc, Studienbeginn WiSe, Wahlpflicht
- Mathematik MSc, Studienbeginn SoSe, Wahlpflicht
- Wirtschaftsmathematik MSc, Studienbeginn WiSe, Wahlpflicht Stochastik/Optimierung/Finanzmathematik
- Wirtschaftsmathematik MSc, Studienbeginn SoSe, Wahlpflicht Stochastik/Optimierung/Finanzmathematik
- Mathematische Biometrie MSc, Wahlpflicht Mathematik
- Finance MSc, Studienbeginn WiSe, Pflichtmodul
- Wirtschaftswissenschaften MSc, Wahlpflicht Mathematik/Informatik

Recommended prerequisites
Analysis I,II; Linear Algebra I,II; Stochastics I; Elementary Probability and Statistics; Measure Theory, or: Bachelor

Learning objectives
The students are to
- understand and master fundamental principles and techniques of financial mathematics
- gain or deepen, respectively, the underlying probabilistic techniques
- be able to work on and solve elementary (practical) questions in financial mathematics
- see and understand relations to other areas of mathematics, especially probability, statistics, numerics and analysis
Syllabus

• Financial market models in discrete time: arbitrage freeness and completeness
• Valuation of European, American and path-dependent options
• Foundations of continuous time market models and of the Black-Scholes model
• Interest rate models and derivatives
• Risk measures
• Portfolio optimisation and CAPM

Literature


Teaching and learning methods

• Lecture, 4 hrs/week
• Exercises, 2 hrs/week

Workload

Präsenzzeit: 84 h; Eigenstudium: Nacharbeitung (64 h), Übungsaufgaben (90 h), Prüfung und Vorbereitung (32 h); **Summe: 270 Stunden**

Assessment

No english version available yet.

Grading procedure

No english version available yet.

Basis for

Financial Mathematics II
## Graph Theory

Modules referring to Elective Modules Applied Mathematics and Mathematical Technology

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<tr>
<td>Coordinator</td>
<td>Prof. Dr. Dieter Rautenbach</td>
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<tr>
<td>Instructor(s)</td>
<td>Lecturers of optimization</td>
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| Allocation of study programmes | B.Sc. Mathematics  
B.Sc. Mathematics and Management  
B.Sc. Mathematical Biometry  
B.Sc. Informatics  
M.Sc. Informatics  
M.Ed. Mathematics |
| Recommended prerequisites | Analysis 1+2, Linear Algebra 1+2 |
| Learning objectives | The students should understand the basic graph theoretical concepts. They should acquire insight and intuition about the structural and the algorithmic approaches within graph theory. |
| Syllabus | Fundamental concepts, paths and cycles, matchings and flows, connectivity, planar graphs, colorings, independent sets, dominating sets, extremal problems and substructures |
| Literature |  
| **Teaching and learning methods** | Lecture 4SWS  
Exercise 2SWS |
|-------------------------------|-----------------|
| **Workload**                  | Classroom hours: 84 h;  
Individual study time/ preparation and postprocessing (64 h), Exercise (90 h),  
Revision and exam (32 h);  
Total: 270h |
| **Assessment**                | The grade of the module will be the grade of the oral or written (depending on the number of participants) exam. Prerequisite for exam registration is passing the pre-course (to be defined by the examiner). |
| **Grading procedure**         | The grade of the module will be the grade of the exam. |
| **Basis for**                 | Advanced lectures in Optimization / Operations Research |
Mathematics of Games
Modules referring to Elective Modules Applied Mathematics and Mathematical Technology

Code 6410572103

ECTS credits 9

Attendance time 6

Language of instruction English

Duration 1 Semester

Cycle <a href= "http://www.uni-ulm.de/index.php?id=43318">long-term range of teaching Master WiWi</a>

Coordinator Dr. Lucia Draque Penso

Instructor(s) Dr. Lucia Draque Penso

Allocation of study programmes
- M.Sc. Mathematics
- M.Sc. Mathematics and Management
- M.Sc. Mathematical Biometry
- M.Sc. Computational Science and Engineering
- M.Ed. Mathematics
- M.Sc. Management and Economics

Recommended prerequisites -

Learning objectives
This course provides the students with some modern game-theoretical mathematical tools, with which situations from the business and economical world can be mapped in order to find among the game participants an equilibrium solution. The idea is to forster in the students initiative, creativity, confidence, and independence of problem-solving thinking when encountering diverse business and economical situations requiring mathematical analysis.

Syllabus
In this course, the students learn how to model miscellaneous themes stemming from the economics field in a game-theoretical fashion. A variety of game-theoretical models mathematically defined and supported, as well as diverse problem example solutions with a strong link to economical (micro- or -macro) applications are presented. Both models with a finite or infinite number of rounds are considered. Some models entail complete information on the aspects of the game (such as the players' types and payoff functions), while others not. Concepts from algorithms, probability theory, calculus, linear algebra, discrete
mathematics and optimization are used. Problems inspired by the economical and business world such as market competition, oligopoly formation, auctions, bargaining, trading, voting, public good design, monetary policy, tariff handling, and incentive measures are studied. A glimpse on more advanced topics such as reputation and mechanism design might be given at the end.

**Literature**

Game Theory, Drew Fundenberg and Jean Tirole, 2005

**Teaching and learning methods**

lecture: 4SWS

exercise 2SWS

**Workload**

- classroom hours: 120 h
- individual study time/ preparation and postprocessing: 130 h
- total: 250 h

**Assessment**

The grade of the module will be the grade of the oral or written (depending on the number of participants) exam. Prerequisite for exam registration is passing the pre-course (to be defined by the examiner).

**Grading procedure**

The grade of the module will be the grade of the exam.

**Basis for**

-
Numerical Analysis
Modules referring to Elective Modules Applied Mathematics and Mathematical Technology

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<td>each Summer Semester</td>
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<td>Coordinator</td>
<td>Prof. Dr. Karsten Urban</td>
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Instructor(s)
- Prof. Dr. Karsten Urban
- Prof. Dr. Dirk Lebiedz
- Prof. Dr. Stefan Funken
- as well as all lecturers of mathematics

Allocation of study programmes
- B.Sc. Mathematics
- B.Sc. Mathematics and Management
- B.Sc. Mathematical Biometry
- B.Ed. Mathematics
- B.Sc. Computer Science
- M.Ed. Mathematics

Recommended prerequisites
Analysis I, II; Linear algebra I, II; (or alternatively: higher mathematics for physics and CSE I, II; higher mathematics for economics and CSE III); General Computer Science I, II

Learning objectives
Students shall
- Develop understanding for the basic principles of Numerical Mathematics
- Master basic methods from Numerical Analysis
- Develop extended insight and intuition for the numerical treatment of problems and sensitivity for numerical challenges such as finite-precision arithmetic and error control
- Be able to apply the introduces numerical methods in a competent manner. In particular, they shall be able to realize numerical methods in software and to select appropriate schemes from existing standard software.
- Realize the various connections to other fields of mathematics such as Linear Algebra, Analysis, Geomety etc.
- Obtain basic knowledge for advanced courses
Syllabus
• Numerical integration: quadrature and cubature
• Nonlinear systems of equations, fixpoint iteration, Newton’s scheme
• Interpolation by polynomials, trigonometric interpolation, FFT
• Splines

Literature

Teaching and learning methods
Lecture 2SWS
Exercise 2SWS

Workload
Classroom hours (56 h)
Individual study time/ preparation and postprocessing (28 h), exercises (76 h), revision and exam (20 h)
Total: 180 h

Assessment
No english version available yet.

Grading procedure
No english version available yet.

Basis for
Possible specializations in Numerical Methods for Ordinary Differential Equations, Numerical Optimization
Numerical Practice
Modules referring to Elective Modules Applied Mathematics and Mathematical Technology

Code 6410575070

ECTS credits 2

Attendance time 2

Language of instruction German

Duration 1 Semester

Cycle each Winter Semester

Coordinator Prof. Dr. Karsten Urban

Instructor(s) Prof. Dr. Karsten Urban
Prof. Dr. Stefan Funken
Prof. Dr. Dirk Lebiedz

Allocation of study programmes • MEd Mathematik

Recommended prerequisites • Analysis 1/2
• Linear Algebra or comparable

Learning objectives Students shall
• master the realization of the methods from Numerical Linear Algebra (Numerical Analysis) in term of standard software tools
• validate the written computer code in terms of correctness, runtime and exactness
• be able to visualize the results of numerical experiments
• can design and realize test problems for the validation

Syllabus • numerical algorithms in Matlab
• convergence plots
• visualization

Literature • Deuflhard, P; Hohmann, A.: NUmerische Mathematik 1, 2, de Gruyter
• Quarteroni A.; Sacco R.; Saleri F.: Numerische Mathematik 1,2, Springer
• integrated help in Matlab
<table>
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<tr>
<th><strong>Teaching and learning methods</strong></th>
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<tbody>
<tr>
<td><strong>Workload</strong></td>
<td>classroom hours: 28h</td>
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<td></td>
<td>individual study time: 32h</td>
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<td><strong>Assessment</strong></td>
<td>The award of the credit points for this ungraded module is based on successful completion of the programming tasks. Prerequisites are necessary for exam registration: one of the exams Numerical Linear Algebra or Numerical Analysis has to be passed.</td>
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<td><strong>Grading procedure</strong></td>
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<td><strong>Basis for</strong></td>
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Numerical Linear Algebra
Modules referring to Elective Modules Applied Mathematics and Mathematical Technology

Code 6410570011
ECTS credits 6
Attendance time 4
Language of instruction German
Duration 1 Semester
Cycle each Winter Semester
Coordinator Prof. Dr. Karsten Urban

Instructor(s)
• Prof. Dr. Stefan Funken
• Prof. Dr. Dirk Lebiedz
• Prof. Dr. Karsten Urban
• as well as all lecturers of mathematics

Allocation of study programmes
B.Sc. Physics and Management
B.Sc. Mathematical Biometry
M.Ed. Mathematics
B.Sc. Computer Science
B.Sc. Physics

Recommended prerequisites
Analysis I, II; Linear algebra I, II; (or alternatively: Higher Mathematics for Physics and CSE I, II; Higher Mathematics for Economic Physics and CSE III) General Computer Science I, II

Learning objectives
Students shall
• Develop understanding for the basic principles of Numerical Mathematics
• Master basic methods from Numerical Linear Algebra
• Develop extended insight and intuition for the numerical treatment of problems and sensitivity for numerical challenges such as finite-precision arithmetic and error control
• Be able to apply the introduces numerical methods in a competent manner. In particular, they shall be able to realize numerical methods in software and to select appropriate schemes from existing standard software.
• Realize the various connections to other fields of mathematics such as Linear Algebra, Analysis, Geometry etc.
• Obtain basic knowledge for advanced courses
| Syllabus | • Finite arithmetics, numerical realization of (real) numbers, condition, stability  
• Direct methods for solving linear systems of equations  
• Linear least squares problems, orthogonalization  
• Iterative methods for linear systems of equations  
• Eigenvalue problems |
| --- | --- |
| Literature | • Deuflhard, P.; Hohmann, A.: Numerische Mathematik I, de Gruyter Lehrbuch  
• Quarteroni, A.; Sacco, R.; Saleri, F.: Numerische Mathematik 1,2, Springer  
• Bollhöfer, M., Mehrmann, V.: Numerische Mathematik, Vieweg Studium  
• Hanke-Bourgeois, M.: Grundlagen der Numerischen Mathematik und des Wissenschaftlichen Rechnens, Teubner |
| Teaching and learning methods | Lecture 2SWS  
Exercise 2SWS |
| Workload | Classroom hours (56 h)  
Individual study time/ preparation and postprocessing (28 h), exercises (76 h), revision and exam (20 h)  
Total: 180 h |
| Assessment | No english version available yet. |
| Grading procedure | No english version available yet. |
| Basis for | Possible specializations in Numerical Methods for Ordinary Differential Equations, Numerical Optimization |
# Optimization and OR I

Modules referring to Elective Modules Applied Mathematics and Mathematical Technology

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<td>M.Ed. Mathematics</td>
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</table>

**Recommended prerequisites**

Analysis I,II; Linear Algebra I,II

**Learning objectives**

The students should learn and master the fundamental principles and solution approaches for optimization problems. They should be able to mathematically formalize and solve practical operations research problems. In connection with large instances standard software should be employed. Connections to other mathematical areas such as numeric analysis, analysis, and stochastics should become apparent and be exploited.

**Syllabus**

- Linear optimization: systems of linear inequalities, polyhedra, duality, simplex method, polynomial time algorithms, ellipsoid method, Kamarkar’s interior point method
- Integer linear optimization: integral polyhedra, integer linear programs, heuristics, cutting plane methods
- Discrete Optimization: connectivity, minimum spanning tree, shortest paths, network flows, network simplex

**Literature**

• Schrijver, A.: Theory of Linear and Integer Programming, Wiley
• Schrijver, A.: Combinatorial Optimization, Wiley

<table>
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<tr>
<th>Teaching and learning methods</th>
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</table>

| Workload                      | Classroom hours: 84 h; |
|                               | Individual study time/ preparation and postprocessing (64 h), Exercise (90 h), Revision and exam (32 h); |
|                               | Total: 270h |

| Assessment                    | No english version available yet. |
| Grading procedure             | No english version available yet. |

| Basis for                     | Optimization II, Advanced Lectures in Optimization / Operations Research |
### Stochastic I - Statistics
Modules referring to Elective Modules Applied Mathematics and Mathematical Technology

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Basis for

No english version available yet.