UNIVERSITY OF GREIFSWALD
FACULTY OF MATHEMATICS AND NATURAL SCIENCES
Institute of Mathematics and Computer Sciences

Catalogue of Modules

Master of Science

Biomathematik (Biomathematics)

Contents

The module examinations are done as a 30 min oral exam, a 60 min or 90 min written exam, or as a 60 min oral presentation (seminar). In the seminar module B, a written version of the presentation needs to be created. The criteria for receiving a tutorial certificate are specified by the lecturer in the first lecture week. If no specific criteria are set, it is required to solve 50% of the exercises successfully. Tutorial certificates, seminar certificates and protocols of tutorials or internships are examinations without a mark.

Analysis / optimization

Module Approximation	
Responsible professor	Professorship of applied mathematics, professorship of numerical mathematics and optimization
Teaching methods	Lecture (3 credit hours) and tutorial (1 credit hour)
Duration/cycle	1 sem., biennially in summer semester even years (F)

Contents

- Approximation in normed spaces
- Continuous and discrete approximation
- Interpolation and splines
- Parameter identification

Qualification aims

- Knowledge of the fundamental tasks in approximation theory
- Knowledge of the most important results in Hilbert spaces
- Ability to apply methods to determine best approximations
- Ability to determine the approximation quality
- Competence in applying suitable methods in practice

Prior knowledge	Analysis I, II
Language	German
Examination	The module examination consists of a 30 min oral exam. An active participation in the tutorial is expected. Both contents of lecture and tutorial are examined.
Mark	Mark of the module examination
Workload in h	180 (lecture: 45, tutorial: 15, self-study: 120)
Course credits	6

Degree courses

M.Sc. Mathematik - analysis/optimization
M.Sc. Biomathematik - analysis/optimization

Module Image and signal analysis	
Teaching methods	Lecture (4 credit hours)
Duration/cycle	1 sem., annually in summer semester (B)
Contents	
• Fast Fourier transformation • Fourier series • Fourier transformation • Wavelets • Mathematical morphology	
Qualification aims	
• Profound knowledge of the basic mathematical properties of the different transformations • Competent choice of the different transformations according to their application fields • Competence in the basic mathematical structures for the numeric implementation of the tranformations	
Prior knowledge	Analysis I, II, ordinary differential equations, linear algebra I, II
Examination	The module examination consists of an oral exam.
Mark	Mark of the module examination
Workload in h	180 (lecture: 60, self-study: 120)
Course credits	6
Degree courses	
M.Sc. Mathematik - analysis/optimization M.Sc. Biomathematik - analysis/optimization	

Module Differential equations in biology	
Responsible professor	Professorship of biomathematics
Teaching methods	Lecture (3 credit hours) and tutorial (1 credit hour)
Duration/cycle	1 sem., annually in winter semester (A)
Contents	
• Stability of ordinary differential equations • Bifurcation theory of ordinary differential equations • Examples of bifurcations • Delayed differential equations • Reaction-diffusion equations	
Qualification aims	
• Profound application of different stability criterias • Distinction of basic bifurcation types of ordinary differential equations as well as their classification according to their importance in modelling • Implementation of complex stability and bifurcation analysis for ordinary, delayed and partial differential equations, also in groups	
Prior knowledge	Analysis I, II, ordinary differential equations, linear algebra I, II
Language	German
Examination	The module examination consists of a 30 min oral exam. An active participation in the tutorial is expected. Both contents of lecture and tutorial are examined.
Mark	Mark of the module examination
Workload in h	180 (lecture: 45, tutorial: 15, self-study: 120)
Course credits	6
Degree courses	
M.Sc. Mathematik - analysis/optimization M.Sc. Biomathematik - analysis/optimization	

Module Dynamical systems	
Responsible professor	Professorship of stochastics
Teaching methods	Lecture (3 credit hours) and tutorial (1 credit hour)
Duration/cycle	1 sem., biennially in summer semester odd years (D)

Contents

Basics of dynamic systems:

- Iteration of real and complex functions, pathways, periodic points, behaviour in infinity
- Functions on metric spaces, fixed-point theorem, attractors
- Measure-preserving functions, recurrence, ergodic theorems
- Linear and non-linear differential equations
- Behaviour at critical points, bifurcations
- Chaotic systems and their characteristics

Qualification aims

- Knowledge of a comprehensive theory, which connects different fields of stochastics and analysis
- Advanced knowledge in analysis, linear algebra, stochastics and differential equations, as well as knowledge of their cross connections
- Basic knowledge for potentially additional modules such as stochastic processes and time series analysis, as well as competence in different approaches
- Competence using the abstract geometric language and way of thinking, which reduces complex systems to their substantial properties
- Ability to evaluate the practical and social relevance of dynamic processes
- Ability to explore complex systems through computer experiments in the tutorial

Prior knowledge	Analysis I, II, stochastics, ordinary differential equations, mathematical biology
Language	German
Examination	The module examination consists of a 30 min oral exam. An active participation in the tutorial is expected. Both contents of lecture and tutorial are examined.
Mark	Mark of the module examination
Workload in h	180 (lecture: 45, tutorial: 15, self-study: 120)
Course credits	6

Degree courses

M.Sc. Mathematik - analysis/optimization
M.Sc. Biomathematik - analysis/optimization

Module Fourier analysis / theory of generalised functions	
Responsible professor	Professorship of analysis
Teaching methods	Lecture (4 credit hours)
Duration/cycle	1 sem., biennially in summer semester even years (F)

Contents

- Convergence of Fourier series
- Convolution products
- Fourier inversion formula, Plancherel's theorem
- Test function spaces and distributions
- Schwartz space, tempered distributions and their Fourier transformation
- Sobolev spaces, the concept of weak derivation, embedding theorems, Hilbert space methods
- Application of the theory of partial differential equations, especially those from mathematical physics, fundamental solutions
- Applications in variational calculus, formulation of boundary value problems

Qualification aims

- Advanced knowledge about the Fourier transformation and the handling of the distribution calculus
- Competence in the main proof techniques and solution strategies of Fourier analysis
- Ability to abstract and apply mathematical methods like the translation from mathematical intuition into formal explanations and the mathematical modelling of physical problems
- Ability to study research literatur about partial differential equations and harmonical analysis
- Knowledge about connections and the success of the interplay of methods from different fields (like analysis, theory of functions and functional analysis)

Prior knowledge	Analysis I, II, theory of measure and integration
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam.
Mark	Mark of the module examination
Workload in h	180 (lecture: 60, self-study: 120)
Course credits	6

Degree courses

B.Sc. Mathematik mit Informatik - elective - rec. in 6th sem.
M.Sc. Mathematik - analysis/optimization
M.Sc. Biomathematik - analysis/optimization

Module Functional analysis	
Responsible professor	Professorship of algebra and functional analytical applications
Teaching methods	Lecture (4 credit hours) and tutorial (2 credit hours)
Duration/cycle	1 sem., biennially in summer semester even years (F)

Contents

- Banach spaces, sequence spaces, dual spaces, Hilbert spaces
- Principles of functional analysis
- Compact operators
- Spectral theory of bounded operators
- Resolvents
- Symmetric operators
- Functional calculus
- Unbounded operators

Qualification aims

- Profound knowledge about typical problems of infinite dimensional theory and its applications
- Knowledge about the close relation of abstract and applied mathematics (mathematical physics, signal theory)
- Ability to work mathematically (cultivation of mathematical intuition and its formal explanation, training of the faculty of abstraction, argumentation)
- Ability to communicate through free speech and discussions (tutorial)

Prior knowledge	Analysis I, II, linear algebra and analytical geometry I, II
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam. The criteria for receiving a tutorial certificate are specified by the lecturer in the first lecture week.If no specific criteria are set, it is required to solve 50% of the exercises successfully.
Mark	Mark of the module examination
Workload in h	270 (lecture: 60, tutorial: 30, self-study: 180)
Course credits	9

Degree courses

B.Sc. Mathematik mit Informatik - elective - rec. in 6th sem.
M.Sc. Mathematik - analysis/optimization
M.Sc. Biomathematik - analysis/optimization

Module Complex analysis	
Responsible professor	Professorship of algebra and functional analytical applications
Teaching methods	Lecture (3 credit hours) and tutorial (1 credit hour)
Duration/cycle	1 sem., biennially in winter semester even years (C)

Contents

- Complex differentiability, Cauchy-Riemann differential equations, holomorphic functions
- Power series, analytic functions
- Complex line integral, Cauchy integral theorem, Cauchy integral formula
- Power series expansion, singularities, Laurent's expansion, meromorphic functions
- Residue theorem and its applications
- Weierstraß's factor theorem, Mittag-Leffler theorem
- Elliptical functions

Qualification aims

- Knowledge about an elegant mathematical theory
- Knowledge about the application of complex analytical methods to solve problems in real analysis
- Profound understanding of the elementary functions through the view of complex analysis
- Andvanced understanding of the structure and the methodology of mathematics, based on the historical development of this mathematical field
- Ability to work mathematically (cultivation of mathematical intuition and its formal explanation, training of the faculty of abstraction, argumentation)
- Competence in communication and scientific discussion

Prior knowledge	Analysis I, II, linear algebra and analytical geometry I, II
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam. An active participation in the tutorial is expected. Both contents of lecture and tutorial are examined.
Mark	Mark of the module examination
Workload in h	180 (lecture: 45, tutorial: 15, self-study: 120)
Course credits	6

Degree courses

B.Sc. Mathematik mit Informatik - elective - rec. in 5th sem.
M.Sc. Mathematik - analysis/optimization
M.Sc. Biomathematik - analysis/optimization

Module Measure theory and integration	
Responsible professor	Professorship of analysis, professorship of biomathematics
Teaching methods	Lecture (4 credit hours) and tutorial (2 credit hours)
Duration/cycle	1 sem., annually in winter semester (A)

Contents

Fundamental principles of measure theory and integration:

- Design of measures
- Lebesgue's integration theory
- Product measure, Fubini's theorem
- Representation theorem (Riesz, Radon-Nikodym)
- L_p spaces

Additional topics, e.g.

- Lebesgue integral on submanifolds of $\mathbb{R}^n$, differential forms and Stokes' theorem
- Disintegration and conditional expected values

Qualification aims

- Knowledge about the advantages and applications of an abstract notion of measure and integration as basis for an advanced study of stochastics and analysis
- Competence in applying the typical analytical and stochastic concepts and understanding their relations
- Competence in advanced proof methods
- Abbility to communicate through free speech and discussion (tutorial)

Prior knowledge	Analysis I, II
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam. The criteria for receiving a tutorial certificate are specified by the lecturer in the first lecture week. If no specific criteria are set, it is required to solve 50% of the exercises successfully.
Mark	Mark of the module examination
Workload in h	270 (lecture: 60, tutorial: 30, self-study: 180)
Course credits	9

Degree courses

B.Sc. Mathematik mit Informatik - elective - rec. in 5th sem.
M.Sc. Mathematik - analysis/optimization
M.Sc. Biomathematik - analysis/optimization

Module Non-linear optimization	
Responsible professor	Professorship of applied mahematics, professorship of numerical mathematic and optimization
Teaching methods	Lecture (4 credit hours)
Duration/cycle	1 sem., annually in winter semester (A)
Contents	
• Necessary and sufficient conditions for solving unconstrainted and constrainted, non-linear optimization problems (Karush-Kuhn-Tucker theory) • Numerical methods for solving corresponding smooth problems • Descent method • Trust-Region method • Penalty method • Active set strategy and SQP method	
Qualification aims	
• Basic knowledge in optimization theory • Ability to numerically solve optimization problems • Understanding the importance of optimization in numerous practical problems • Competence in classifying specific tasks and choosing adequate methods	
Prior knowledge	Analysis I, II, linear algebra I, II, optimization
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam.
Mark	Mark of the module examination
Workload in h	180 (lecture: 60, self-study: 120)
Course credits	6
Degree courses	
B.Sc. Mathematik mit Informatik - elective - rec. in 5th sem. M.Sc. Mathematik - analysis/optimization M.Sc. Biomathematik - analysis/optimization	

Module Numerical mathematics II	
Teaching methods	Lecture (4 credit hours) and tutorial (2 credit hours)
Duration/cycle	1 sem., annually in winter semester (A)
Contents	
• Numerical analysis of partial differential equations • Methods for elliptic, parabolic and hyperbolic problems • Interactive solution of large systems of equations • Numerical analysis of eigenvalue problems	
Qualification aims	
• Competence in the basic methods for solving partial differential equations numerically • Competence in choosing adequate methods for specific problems • Knowledge about the convergence theory and methods of error control • Competence in implementing numerical methods with efficient software (large systems of equations) • Knowledge of cross connections to other fields like analysis, algebra, geometry, etc. • Competence in the most important methods for calculating eigenvalues • Ability to communicate through free speech and scientific discussion (tutorial)	
Prior knowledge	Numerical mathematics I
Language	German
Examination	The module examination consists of a written or oral exam. The criteria for receiving a tutorial certificate are specified by the lecturer in the first lecture week.If no specific criteria are set, it is required to solve 50% of the exercises successfully.
Mark	Mark of the module examination
Workload in h	270 (lecture: 60, tutorial: 30, self-study: 180)
Course credits	9
Degree courses	
B.Sc. Mathematik mit Informatik - elective - rec. in 5th sem. M.Sc. Mathematik - analysis/optimization M.Sc. Biomathematik - advanced course analysis/optimization	

Module Numerical lab course	
Responsible professor	Professorship of applied mathematics, professorship of numerical mathematics and optimization
Teaching methods	Lecture (2 credit hours) and tutorial (2 credit hours)
Duration/cycle	1 sem., annually in winter semester (A)
Contents	
• Methods for solving initial value problems of ordinary differential equations numerically • Efficient one-step methods (Runge-Kutta method) with step size control • Efficient multi-step methods with step size control and order control • Convergence theory • Implicite methods for stiff problems	
Qualification aims	
• Knowledge about the application field of ordinary differential equations • Ability to critically evaluate numerical results • Competence in choosing adequate numerical methods • Competence in developing numerical software for initial value problems • Competence in tranferring and discussing scientific results	
Prior knowledge	Analysis I, II, linear algebra I, II, numerical mathematics I
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam. The criteria for receiving a tutorial certificate are specified by the lecturer in the first lecture week.If no specific criteria are set, it is required to solve 50% of the exercises successfully.
Mark	Mark of the module examination
Workload in h	180 (lecture: 30, tutorial: 30, self-study: 120)
Course credits	6
Degree courses	
B.Sc. Mathematik mit Informatik - compulsory module - rec. in 5th sem. M.Sc. Biomathematik - analysis/optimization	

Module Optimal control / calculus of variations	
Responsible professor	Professorship of applied mathematics, professorship of numerical mathematics and optimization
Teaching methods	Lecture (3 credit hours) and tutorial (1 credit hour)
Duration/cycle	1 sem., biennially in summer semester odd years (D)

Contents

- Variational problems without constraints - necessary conditions of 1st order
- Constraints in the form of integrals, differential equations and inequalities
- Optimal control problems and solution of multipoint boundary value problems
- Necessary conditions of 2nd order
- Weierstraß's sufficient condition

Qualification aims

- Competence in the basic methods of variational calculus in a systematic structure
- Knowledge of the necessary conditions in the case of constraints
- Competence in the numerical methods for solving the resulting boundary value problems
- Understanding the analogy with and differences to optimization problems in the finite-dimensional space
- Ability to handle application-oriented questions with appropriate software
- Ability to communicate and discuss scientifically

Prior knowledge	Analysis I, II
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam. An active participation in the tutorial is expected. Both contents of lecture and tutorial are examined.
Mark	Mark of the module examination
Workload in h	180 (lecture: 45, tutorial: 15, self-study: 120)
Course credits	6

Degree courses

M.Sc. Mathematik - analysis/optimization
M.Sc. Biomathematik - analysis/optimization

Module Partial differential equations	
Responsible professor	Professorship of analysis
Teaching methods	Lecture (3 credit hours) and tutorial (1 credit hour)
Duration/cycle	1 sem., annually in winter semester (A)

Contents

Partial differential equations of 1st order:

- Method of characteristics
- Complete integral
- Hamilton-Jacobi theory

Partial differential equations of 2nd order:

- Laplace's equation (fundamental solution, representation formulas, Green's function, Dirichlet problem for the sphere, maximum principle)
- Heat equation (fundamental solution, Cauchy boundary value problem, maximum principle)
- Wave equation (initial value problem, Duhamel's principle)
- Hilbert space methods for elliptical boundary value problems (introduction)

Qualification aims

- Knowledge about the fundamental types of differential equations (Laplace's equation, Heat equation, Wave equation)
- Ability to formulate problems mathematically using partial differential equations
- Competence in analytical solution methods
- Ability to communicate through free speech and discussion (tutorial)

Prior knowledge	Analysis, ordinary differential equations
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam. An active participation in the tutorial is expected. Both contents of lecture and tutorial are examined.
Mark	Mark of the module examination
Workload in h	180 (lecture: 45, tutorial: 15, self-study: 120)
Course credits	6

Degree courses

B.Sc. Mathematik mit Informatik - elective - rec. in 5th sem.
M.Sc. Mathematik - analysis/optimization
M.Sc. Biomathematik - analysis/optimization

Module Special course I analysis/optimisation	
Responsible professor	Professorship of analysis, professorship of numerical mathematics and optimization, professorship of applied mathematics, professorship of algebraic methods of analysis
Teaching methods	Lecture (2 credit hours)
Duration/cycle	1 sem., on demand
Contents	
• Special topics from analysis/optimization	
Qualification aims	
Advanced knowledge and enhanced competence in a selected special field.	
Prior knowledge	Analysis, linear algebra and analytical geometry
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam.
Mark	Mark of the module examination
Workload in h	90 (lecture: 30, self-study: 60)
Course credits	3
Degree courses	
M.Sc. Mathematik - analysis/optimization M.Sc. Biomathematik - analysis/optimization	

Module Special course II analysis/optimisation	
Responsible professor	Professorship of analysis, professorship of numerical mathematics and optimization, professorship of applied mathematics, professorship of algebraic methods of analysis
Teaching methods	Lecture (2 credit hours) and tutorial (2 credit hours)
Duration/cycle	1 sem., on demand
Contents	
• Special topics from analysis/optimization	
Qualification aims	
Advanced knowledge and enhanced competence in a selected special field.	
Prior knowledge	Analysis, linear algebra and analytical geometry
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam.
Mark	Mark of the module examination
Workload in h	180 (lecture: 30, tutorial: 30, self-study: 120)
Course credits	6
Degree courses	
M.Sc. Mathematik - analysis/optimization M.Sc. Biomathematik - analysis/optimization	

Module Theoretical ecology	
Responsible professor	Professorship of biomathematics
Teaching methods	Lecture (4 credit hours)
Duration/cycle	1 sem., biennially in summer semester even years (F)
Contents	
• Modelling principles, expansion rates • Model types and their application fields • Increase of a population, logistic increase, fishing and harvesting scenarios as optimization problems • Competition, preditor-prey and symbiosis models • Meta populations	
Qualification aims	
• Profound knowledge about models of population ecology • Advances abilities in the analysis of differential equation models and stochastic models • Competence in independently selecting suitable models and ability to interpret their results	
Prior knowledge	Mathematical biology, differential equations in biology, stochastic models in biology
Language	German
Examination	90 min written exam or 30 min oral exam, at the lecturers discretion.
Mark	Mark of the module examination
Workload in h	180 (lecture: 60, self-study:120)
Course credits	6
Degree courses	
M.Sc. Biomathematik - analysis/optimization	

Discrete mathematics / algorithmics

Module Algebra I	
Responsible professor	Professorship of algebra and functional analytical applications
Teaching methods	Lecture (4 credit hours) and tutorial (2 credit hours)
Duration/cycle	1 sem., annually in winter semester (A)
Contents	
• Groups: Lagrange's theorem, normal subgroups and factor groups, isomorphism theorems, cyclic groups, finite abelian groups, permutation groups, Sylow's theorems • Rings: ideals and factor rings, polynomial rings, Euclidean rings, principal rings, divisibility, quotient field, factorial rings • Fields: field extensions	
Qualification aims	
• Understanding of basic principles of algebraic structures • Understanding of applicability and advantages of algebraic structures in many mathematic fields • Advanced understanding and competence in using the algebraic structures groups, rings, fields and terms like factorisation and divisibility in an abstract context • Competence in using methods of the axiomatic approach • Ability to operate mathematically (developing a mathematical intuition and their formal reasoning, training the faculty of abstraction) • Competence in oral communication through free speech and discussions (tutorial)	
Prior knowledge	Linear algebra I, II
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam. The criteria for receiving a tutorial certificate are specified by the lecturer in the first lecture week.If no specific criteria are set, it is required to solve 50% of the exercises successfully.
Mark	Mark of the module examination
Workload in h	270 (lecture: 60, tutorial: 30, self-study: 180)
Course credits	9
Degree courses	
B.Sc. Mathematik mit Informatik - compulsory module - rec. in 3rd sem. M.Sc. Biomathematik - discrete mathematics/algorithmics	

Module Algebra II	
Responsible professor	Professorship of analysis, professorship of algebra and functional analytical applications
Teaching methods	Lecture (4 credit hours) and tutorial (2 credit hours)
Duration/cycle	1 sem., biennially in summer semester odd years (D)

Contents

- Lie algebras: nilpotent and solvable Lie algebras, Engel's theorem, Lie's theorem, Cartan's criteria, semisimple Lie group criterion for semisimplicity, classification and representation theory of semisimple Lie algebras
  or
- Representation theory: representation theory of finite groups, absolute reducibility; Schur's lemma, characters, irreducible representations of symmetric groups, Young tableaux, representation theory of classic matrix groups, classic groups, irreducible representations of classic groups

Qualification aims

- Knowledge of algebraisation of a fundamental notion of symmetry
- Knowledge about the collaboration of geometric and algebraic methods
- Knowledge of the basic notion of a representation and its applications in many fields of mathematics and natural sciences (algebra, operator algebras, physics, chemistry)
- Ability to independently develop complex mathematical models
- Advanced competence in operating mathematically (developing a mathematical intuition and its formal reasoning, improving abstract thinking, argumentation)
- Communication skills in scientific discussions (tutorial)

Prior knowledge	Analysis I, II, algebra I
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam. The criteria for receiving a tutorial certificate are specified by the lecturer in the first lecture week. If no specific criteria are set, it is required to solve 50% of the exercises successfully.
Mark	Mark of the module examination
Workload in h	270 (lecture: 60, tutorial: 30, self-study: 180)
Course credits	9

Degree courses

B.Sc. Mathematik mit Informatik - elective - rec. in 6th sem.
M.Sc. Mathematik - discrete mathematics/algorithmics/algebra
M.Sc. Biomathematik - discrete mathematics/algorithmics/algebra

Module Algorithmic and complexity theory	
Teaching methods	Lecture (4 credit hours)
Duration/cycle	1 sem., biennially in winter semester even years (C)
Contents	
• Motivation and practical relevance of the subject • Complexity classes, hierarchy and separation theorems • Non-deterministic machines and complexity classes • D-ND results concerning space complexity • Reducibility relations and complete problems • NP-complete problems and the P-NP problem • Complete problems in different complexity classes • Further topics of the structural complexity theory • Applications on optimization and problems of data processing	
Qualification aims	
• Knowledge of basic results of the structural complexity theory • Competence in basic techniques of the complexity theory • Competence in designing and analysing algorithms • Ability to apply concepts of the theoretical computer science to mathematical and informatical problems	
Prior knowledge	Theoretical computer science, data structures and efficient algorithms
Examination	The module examination consists of an oral exam.
Mark	Mark of the module examination
Workload in h	180 (lecture: 60, self-study: 120)
Course credits	6
Degree courses	
M.Sc. Mathematik - discrete mathematics/algorithmics/algebra M.Sc. Biomathematik - discrete mathematics/algorithmics/algebra	

Module Computability theory	
Teaching methods	Lecture (4 credit hours)
Duration/cycle	1 sem., biennially in summer semester odd years (D)

Contents

- Computability: basic properties and relations
- Numberings, especially Gödel numbering
- Reducability of decision problems via mappings
- Turing reducibility and arithmetic hierarchy
- Applications in logic and fundamentals in mathematics, especially Gödel's incompleteness theorem
- Analytical hierarchy and computability of higher levels
- Further lookouts and applications

Qualification aims

- Competence in classifying and applying results and techniques of the computability theory in the overlap of mathematical logic and theoretical computer science
- Competence in evaluating Gödels results
- Ability to handle questions concerning effectivity and formalisation

Prior knowledge	Theoretical computer science, analysis, algebra
Examination	The module examination consists of an oral exam.
Mark	Mark of the module examination
Workload in h	180 (lecture: 60, self-study: 120)
Course credits	6

Degree courses

M.Sc. Mathematik - discrete mathematics/algorithmics/algebra
M.Sc. Biomathematik - discrete Mathematics/algorithmics/algebra

Module Bioinformatics	
Responsible professor	Professorship of bioinformatics
Teaching methods	Lecture (2 credit hours) and tutorial (2 credit hours)
Duration/cycle	1 sem., annually in summer semester (B)
Contents	
• Proabilistic models in bioinformatics (CRFs, HMMs, graphical models) • Parameter estimation (Baum-Welch and EM algorithm) • Structural bioinformatics (3D structure, interface, docking) • Quantification of transcripts and expression analysis (RNA-seq) • Methods for evaluating predictions and classifications (ROC analysis, cross-validation)	
Qualification aims	
• Ability to create own models for new biological problems, estimate their parameters and evaluate their efficiency using test data • Ability to perform expression analysis on typical data sets • Ability to deal with current bioinformatics tools	
Prior knowledge	Genome analysis, bioinformatics computer lab course, stochastics
Language	German
Examination	The module examination consists of a 30 min oral exam. Active participation in the tutorial is expected. Both contents of lecture and tutorial are examined.
Mark	Mark of the module examination
Workload in h	180 (lecture: 30, tutorial: 30, self-study: 120)
Course credits	6
Degree courses	
M.Sc. Biomathematik - discrete mathematics/algorithmics	

Module Coding theory	
Responsible professor	Professorship of algebra and functional analytical applications, professorship of biomathematics
Teaching methods	Lecture (4 credit hours)
Duration/cycle	1 sem., biennially in winter semester odd years (E)
Contents	
• Linear codes, cyclic codes, square rest-codes • Coding and decoding • Error correcting and error detecting codes • Geometric coding, doubly periodic functions • Elements of cryptography, assymetric coding	
Qualification aims	
• Profound understanding of the basic principles of coding • Knowledge about the application of algebra (e.g. Galois fields) and analysis (e.g. Weierstraß's p-function) in coding	
Prior knowledge	Algebra, complex analysis
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam.
Mark	Mark of the module examination
Workload in h	180 (lecture: 60, self-study: 120)
Course credits	6
Degree courses	
MSc. Mathematik - discrete mathematics/algorithmics/algebra M.Sc. Biomathematik - diskrete mathematics/algorithmics/algebra	

Module Computer graphics	
Responsible professor	Professorship of computer science
Teaching methods	Lecture (2 credit hours) and tutorial (2 credit hours)
Duration/cycle	1 sem., biennially in winter semester even years (C)
Contents	
• Mathematical basics of computer graphics • Human colour perception • Theory of image formation • OpenGL • Object oriented graphics programming • File formats • OpenGLSL	
Qualification aims	
• Understanding the problems that occur in the context of computer graphics representations • Ability to solve the corresponding problems with current libraries • Advanced practical competence in solving programming tasks and applying i.a. OpenGL	
Prior knowledge	Algorithms and programming, linear algebra and analytical geometry, practical programming course
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam. An active participation in the tutorial is expected. Both contents of lecture and tutorial are examined.
Mark	Mark of the module examination
Workload in h	180 (lecture: 30, tutorial: 30, self-study: 120)
Course credits	6
Degree courses	
B.Sc. Mathematik mit Informatik - elective - rec. in 5th or 6th sem. M.Sc. Mathematik - special lecture discrete mathematics/algorithmics/algebra M.Sc. Biomathematik - discrete mathematics/algorithmics	

Module Databases	
Responsible professor	Professorship of computer science
Teaching methods	Lecture (2 credit hours) and tutorial (2 credit hours)
Duration/cycle	1 sem., biennially in winter semester

Contents

- Database architecture
- Relational database model
- Database query language SQL
- Entity-relationship model
- Normalisation
- File organisation and indices
- XML
- Database applications

Qualification aims

- Ability to design a relational database schema
- Competence in evaluating such schemata based on objective criteria like functional dependencies
- Competence in formulating database queries, even if several tables are linked
- Knowledge in data structures and methods that are internally used by the database to organise data, taking the safety of the data into account for cases of hardware failure
- Competence in implementing database applications in at least one programming language

Prior knowledge	Introduction to electronic data processing, algorithms and programming
Examination	The module examination consists of an oral exam. Active participation in the tutorial is expected. Both contents of lecture and tutorial are examined.
Mark	Mark of the module examination
Workload in h	180 (lecture: 30, tutorial: 30, self-study: 120)
Course credits	6

Degree courses

B.Sc. Mathematik mit Informatik - elective - rec. in 5th sem.
M.Sc. Mathematik - special lecture discrete mathematics/algorithmics/algebra
M.Sc. Biomathematik - special lecture discrete mathematics/algorithmics/algebra

Module Data structures and efficient algorithms	
Responsible professor	Professorship of computer science
Teaching methods	Lecture (4 credit hours) and tutorial (2 credit hours)
Duration/cycle	1 sem., annually in winter semester (A)

Contents

- Complex data structures and their analysis (hashing, heaps, height balanced search trees)
- String search algorithms
- Advanced analysing techniques (amortized analysis)
- Problems of combinatorial optimization (shortest paths in networks, minimal spanning trees, matchings, network flow)
- Strategies for solving NP-hard problems (approximation algorithms, parameterized algorithms)
- Implementation of a selection of data structures and algorithms

Qualification aims

- Overview of important and complex algorithmic problems and data structures
- Competence in the analysis of their performance
- Understanding of fundamental difficulties during the design of algorithms for NP-hard problems
- Ability to independently design and analyse algorithms for such problems
- Competence in the application of online source code libraries

Prior knowledge	Algorithms and programming, theoretical computer science
Language	German
Examination	The module examination consists of an oral axam. The criteria for receiving a tutorial certificate are specified by the lecturer in the first lecture week. If no specific criteria are set, it is required to solve 50% of the exercises successfully.
Mark	Mark of the module examination
Workload in h	270 (lecture: 60, tutorial: 30, self-study: 180)
Course credits	9

Degree courses

B.Sc. Mathematik mit Informatik - compulsory module - rec. in 5th sem.
M.Sc. Biomathematik - core module discrete mathematics/algorithmics/algebra

Module Discrete modelling in biology	
Responsible professor	Professorship of discrete biomathematics
Teaching methods	Lecture (4 credit hours)
Duration/cycle	1 sem., biennially in summer semester odd years (D)
Contents	
• Yule trees and coalescent trees • Conflicts between gene trees and species trees • Phylogenetic networks • Algebraic properties of Markov processes on trees • Neural networks	
Qualification aims	
Acquaintance with the basic concepts of discrete modelling of different biological situations as well as the advantages and disadvantages of the particular models.	
Prior knowledge	None
Language	German
Examination	90 min written exam or 30 min oral exam
Mark	Mark of the module examination
Workload in h	180 (lecture: 60, self-study: 120)
Course credits	6
Degree courses	
M.Sc. Biomathematik - discrete mathematics/algorithmics	

Module Discrete optimization	
Teaching methods	Lecture (4 credit hours)
Duration/cycle	1 sem., biennially in winter semester odd years (E)
Contents	
• Trees, paths, flows, pairings, stable sets in graphs • Approximation algorithms • LP-like problems • Integer LP-problems • Sectional plane algorithm • Branch and bound	
Qualification aims	
• Advanced knowledge about modern algorithms for solving discrete optimization problems • Knowledge about exemplaric approaches for solving difficult discrete optimization problems	
Prior knowledge	Optimization
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam.
Mark	Mark of the module examination
Workload in h	180 (lecture: 60, self-study: 120)
Course credits	6
Degree courses	
M.Sc. Mathematik - discrete mathematics/algorithmics/algebra M.Sc. Biomathematik - discrete mathematics/algorithmics	

Module Graph theory	
Teaching methods	Lecture (3 credit hours) and tutorial (1 credit hour)
Duration/cycle	1 sem., biennially in winter semester odd years (E)

Contents

Basic graph-theoretic concepts and properties of graphs:

- Examples and questions concerning undirected and directed graphs
- Trees, shortest paths, spanning trees
- Eulerian and Hamiltonian graphs
- Graph colourings
- Matchings and bipartite graphs

Additional topics, e.g.

- Planar graphs, four-colour-problem, Euler's formula
- Flows in networks
- Examples and problems concerning complex networks

Qualification aims

- Knowledge of basic terms in graph theory
- Ability to apply the basic techniques (algorithms) of counting, parameter determination and optimization of graph-theoretic structures
- Competence in a variety of combinatorial proof techniques
- Basic knowledge about the topology of surfaces

Prior knowledge	Elementary combinatorics, linear algebra, algorithmics
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam. An active participation in the tutorial is expected. Both contents of lecture and tutorial are examined.
Mark	Mark of the module examination
Workload in h	180 (lecture: 45, tutorial: 15, self-study: 120)
Course credits	6

Degree courses

M.Sc. Mathematik - discrete mathematics/algorithmics/algebra
M.Sc. Biomathematik - discrete mathematics/algorithmics

Module Combinatorics	
Responsible professor	Professorship of stochastics, professorship of biomathematics
Teaching methods	Lecture (4 credit hours)
Duration/cycle	1 sem., biennially in summer semester odd years (D)

Contents

- Words, selections, subsets, counting principles
- Counting problems for permutations
- Recursions
- Summation, generating functions
- Difference calculus, discrete integration, inversions
- Patterns, counting patterns
- Orthogonal latin squares, block maps, affine geometries

Qualification aims

- Profound understanding of the basic principles of combinatorics
- Knowledge about algebraic methods for solving combinatorical problems

Prior knowledge	Algebra
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam.
Mark	Mark of the module examination
Workload in h	180 (lecture: 60, self-study: 120)
Course credits	6

Degree courses

M.Sc. Mathematik - discrete mathematics/algorithmics/algebra
M.Sc. Biomathematik - discrete mathematics/algorithmics

Module Mathematical logic	
Responsible professor	Chairman of examination committee
Teaching methods	Lecture (4 credit hours)
Duration/cycle	1 Sem., biennially in summer semester even years (F)
Contents	
• Syntax, semantics and proof systems for propositional logic and predicate logic of first order • Completeness theorems, particularly Gödel's completeness theorem • Compactness theorems, applications and consequences • Elementary and non-elementary theories and model classes • Motivating examples from mathematics and applications in mathematics	
Qualification aims	
• Deeper knowledge of basic techniques for defining syntax and semantics of logic systems • Advanced competence in the language of mathematics • Competence in evaluating mathematical proof methods • Advanced understanding of the interplay between mathematical intuition and its logical formalisation • Understanding of the importance of the fundamental theorems of mathematical logic (on compactness, completeness, incompleteness) for the mathematics	
Prior knowledge	Analysis, linear algebra and analytical geometry
Language	German
Examination	The module examination consists of a 30 min oral exam.
Mark	Mark of the module examination
Workload in h	180 (lecture: 60, self-study: 120)
Course credits	6
Degree courses	
B.Sc. Mathematik mit Informatik - elective - rec. in 6th sem. M.Sc. Mathematik - discrete mathematics/algorithmics/algebra M.Sc. Biomathematik - discrete mathematics/algoritmics	

Module Molecular evolution	
Responsible professor	Professorship of discrete biomathematics, professorship of bioinformatics
Teaching methods	Lecture (2 credit hours) and tutorial (2 credit hours)
Duration/cycle	1 sem., annually in winter semester (A)

Contents

- Essentials and fundamental terms of evolution (homology, recombination, Wright-Fisher model)
- Stochastic models in evolution (Markov chains in continuous time, Jukes-Cantor model, GTR model, rates across sites, selection)
- Tree reconstruction methods
  - Distance-based methods (clustering)
  - Character-based methods (parsimony, likelihood, Bayes)
- Sampling methods in tree space (tree moves (NNI, SPR, TBR), Metropolis-Hastings algorithm)

Qualification aims

- Understanding of model assumptions made by phylogenetic methods
- Understanding of advantages and disadvantages of different approaches in tree reconstruction
- Knowledge of the principles and general parameters, which are used in phylogeny programs

Prior knowledge	Genome analysis, stochastics
Language	German
Examination	30 min oral examination
Mark	Mark of the module examination
Workload in h	180 (lecture: 30, tutorial: 30, self-study: 120)
Course credits	6

Degree courses

M.Sc. Biomathematik - discrete mathematics/algorithmics

Module Practical course software engineering	
Teaching methods	Lecture (1 credit hour) and practical course (3 credit hours)
Duration/cycle	1 sem., annually in summer semester (F)
Contents	
• Tools and methods in developing and maintaining large software systems • Project planning • Design and implementation • Documentation, testing and quality management	
Qualification aims	
• Knowledge of the main phases in creating complex software • Competence in evaluation and design of necessary ressources during realisation of a project • Competence in accepting responsibility for an essential part of developmental work in a team project • Ability to present opportunities and boundaries of the created software	
Prior knowledge	Programming practice
Examination	The criteria for receiving a tutorial certificate are specified by the lecturer in the first lecture week. If no specific criteria are set, it is required to solve 50% of the exercises successfully.
Mark	Mark of the module examination
Workload in h	180 (lecture: 15, tutorial: 45, self-study:120)
Course credits	6
Degree courses	
B.Sc. Mathematik mit Informatik - compulsory module - rec. in 6th sem. M.Sc. Biomathematik - discrete mathematics/algorithmics/algebra	

Module Randomised algorithms	
Responsible professor	Professorship of computer science
Teaching methods	Lecture (4 credit hours)
Duration/cycle	1 sem., biennially in summer semester even years (F)
Contents	
• Basic terms and techniques (types of randomised algorithms, runtime as expected value, Chernoff bounds, probabilistic models, random walks) • Randomised data structures • Randomised algorithms for problems on graphs • Randomised algorithms for problems in number theory • Randomised approximation algorithms	
Qualification aims	
• Ability to analyse and design randomised algorithms • Understanding basic problems, which occur during analysis and design • Competence in using a variety of tools and techniques, which can be used to solve those problems	
Prior knowledge	Algorithms and programming, stochastics, theoretical computer science
Language	German
Examination	The module examination consists of a 30 min oral exam.
Mark	Mark of the module examination
Workload in h	180 (lecture: 60, self-study:120)
Course credits	6
Degree courses	
B.Sc. Mathematik mit Informatik - compulsory module - rec. in 6th sem. M.Sc. Mathematik - discrete mathematics/algorithmics/algebra M.Sc. Biomathematik - discrete mathematics/algorithmics	

Module Special course I discrete mathematics/algorithmics	
Responsible professor	Professorship of computer science, professorship of algebra and functional analytical applications, professorship of algebraic methods of analysis
Teaching methods	Lecture (2 credit hours)
Duration/cycle	1 Sem., on demand
Contents	
• Special topics from discrete mathematics/algorithmics/algebra	
Qualification aims	
Advanced knowledge and enhanced competence in a selected special field.	
Prior knowledge	Analysis, linear algebra and analytical geometry
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam.
Mark	Mark of the module examination
Workload in h	90 (lecture: 30, self-study: 60)
Course credits	3
Degree courses	
M.Sc. Mathematik - discrete mathematics/algorithmics/algebra M.Sc. Biomathematik - discrete mathematics/algorithmics	

Module Special course II discrete mathematics/algorithmics	
Responsible professor	Professorship of computer science, professorship of algebra and functional analytical applications, professorship of algebraic methods of analysis
Teaching methods	Lecture (2 credit hours) and tutorial (2 credit hours)
Duration/cycle	1 sem., on demand
Contents	
• Special topics from discrete mathematics/algorithmics/algebra	
Qualification aims	
Advanced knowledge and enhanced competence in a selected special field.	
Prior knowledge	Analysis, linear algebra and analytical geometry
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam.
Mark	Mark of the module examination
Workload in h	180 (lecture: 30, tutorial: 30, self-study: 120)
Course credits	6
Degree courses	
M.Sc. Mathematik - discrete mathematics/algorithmics/algebra M.Sc. Biomathematik - discrete mathematics/algorithmics	

Module Theoretical computer science	
Responsible professor	Chairman of examination committee
Teaching methods	Lecture (4 credit hours) and tutorial (2 credit hours)
Duration/cycle	1 sem., annually in summer semester (B)

Contents

- Formal foundations of the computability theory and the theory of algorithms: the intuitive notion of algorithm and mathematical models of computation (goto programs, while and loop programs, Turing machines, ...), Church-Turing thesis, universal functions and unsolvable problems
- Finite automata and string functions, Boolean functions, two-element Boolean algebra
- Formal languages, the classes of the Chomsky hierarchy and the types of acceptors

Qualification aims

- Knowledge of the basic properties and limits of computability
- Understanding of the meaning of computability for computer science
- Understanding of mathematical models of computation and their application
- Ability to classify grammars and formal languages by the types of automata accepting these languages and their power
- Advanced understanding of the interplay between mathematical intuition and the formalization of the notion of computability
- Ability to communicate orally through free speech and discussions (tutorial)

Prior knowledge	Linear algebra, analysis, algorithms and programming
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam. An active participation in the tutorial is expected. Both contents of lecture and tutorial are examined.
Mark	Mark of the module examination
Workload in h	270 (lecture: 60, tutorial: 30, self-study: 180)
Course credits	9

Degree courses

B.Sc. Mathematik mit Informatik - compulsory module - rec. in 4th sem.
M.Sc. Biomathematik - discrete mathematics/algorithmics

Stochastics / statistics

Module Financial and insurance mathematics	
Responsible professor	Professorship of stochastics
Teaching methods	Lecture (3 credit hours) and tutorial (1 credit hour)
Duration/cycle	1 sem., biennially in winter semester odd years (E)

Contents

- Basic concepts of financial mathematics: interest, present value, rates, fixed income, credits, effective rate
- Life insurance: principle of equivalence, demographic statistics and mortality tables, actuarial reserve
- Property insurance and risk management: risk parameters, portfolios, individual and collective model, law of large numbers and Wald's theorem, distribution of number of claims and amount of claims
- Risk process and ruin problem, Lundberg's theorem
- Capital market: market price, hedging, financial derivatives

Qualification aims

- Understanding the mathematical modelling of economic problems and financial questions
- Competence in independent and considerate solving of problems in financial mathematics
- Understanding the principles of life and property insurance and the associated concepts of stochastics

Prior knowledge	Analysis I, II, linear algebra I, stochastics, statistics
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam. An active participation in the tutorial is expected. Both contents of lecture and tutorial are examined.
Mark	Mark of the module examination
Workload in h	180 (lecture: 45, tutorial: 15, self-study: 120)
Course credits	6

Degree courses

B.Sc. Mathematik mit Informatik - elective - rec. in 5th sem.
M.Sc. Mathematik - stochastics/statistics
M.Sc. Biomathematik - stochastics/statistics

Module Mathematical statistics	
Responsible professor	Professorship of biomathematics, professorship of statistics
Teaching methods	Lecture (3 credit hours) and tutorial (1 credit hour)
Duration/cycle	1 sem., biennially in summer semester odd years (D)

Contents

- Statistical models, parametric distribution assumptions
- Dominated classes of distributions, families of exponential distributions
- Sufficiency
- Point estimator, confidence regions, tests
- Quality criterion and optimality of estimators and tests
- Likelihood methods
- Bayesian methods
- Statistical decision theory
- Asymptotic statistics
- Non-parametric models
- Resampling methods

Qualification aims

- Profound competence in mathematical fundamentals of statistics
- Substancial knowledge of key results in mathematical statistics
- Ability to reasonably evaluate statistical methods
- Ability to refine statistical methods with respect to new problems
- Knowledge about the variety of approaches and the current state of mathematical statistics
- Ability to read scientific theses from the field of mathematical statistics
- Ability to independently work scientifically in statistics

Prior knowledge	Statistics, probability theory
Language	German
Examination	The module examination consists of a 30 min oral exam. An active participation in the tutorial is expected. Both contents of lecture and tutorial are examined.
Mark	Mark of the module examination
Workload in h	180 (lecture: 45, tutorial: 15, self-study: 120)
Course credits	6

Degree courses

M.Sc. Mathematik - stochastic/statistic
M.Sc. Biomathematik - stochastics/statistics

Module Multivariate statistics	
Responsible professor	Professorship of statistics, professorship of biomathematics
Teaching methods	Lecture (4 credit hours) and tutorials (2 credit hours)
Duration/cycle	1 sem., biennially in winter semester odd years (E)

Contents

Fundamentals of multivariate statistics

- General linear models
- Generalised linear models
- Principal component analysis
- Latent structure analysis
- Discriminant analysis
- Cluster analysis
- Multidimensional scaling

Qualification aims

- Profound knowledge about models and methods in multivariate statistics
- Competence in independently choosing adequate models and methods for real data and ability to interpret the results
- Advanced knowledge in data analysis (tutorial)

Prior knowledge	Stochastics, statistics
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam. An active participation in the tutorial is expected. Both contents of lecture and tutorial are examined.
Mark	Mark of the module examination
Workload in h	270 (lecture: 60, tutorial: 30, self-study: 180)
Course credits	9

Degree courses

B.Sc. Mathematik mit Informatik - elective - rec. in 5th sem.
M.Sc. Mathematik - stochastics/statistics
M.Sc. Biomathematik - stochastics/statistics

Module Spatial statistics	
Responsible professor	Professorship of biomathematics
Teaching methods	Lecture (2 credit hours) and tutorial (2 credit hours)
Duration/cycle	1 sem., biennially in summer semester even years (F)
Contents	
• Random fields in continuous space and time: mean and covariogram estimation • Point processes and characteristics: Poisson process, K- and L-functions, moment measures, estimation and inference • Random sets and random measures, Boolean model • Application examples	
Qualification aims	
• Knowledge about basic models of generalised stationary spatial and spatial-temporal processes and the fundamental methods for estimating their characteristics • Knowledge about basic models of point processes and the fundamental methods for estimating their characteristics • Ability to choose, evaluate and apply statistical methods on spatial and spatio-temporal data	
Prior knowledge	Stochastics I, linear algebra I, II
Language	German
Examination	The module examination consists of a 30 min oral exam. An active participation in the tutorial is expected. Both contents of lecture and tutorial are examined.
Mark	Mark of the module examination
Workload in h	180 (lecture: 30, tutorial: 30, self-study: 120)
Course credits	6
Degree courses	
M.Sc. Mathematik - stochastics/statistics M.Sc. Biomathematik - stochastics/statistics	

Module Special course I stochastics/statistics	
Responsible professor	Professorship of stochastics, professorship of statistics
Teaching methods	Lecture (2 credit hours)
Duration/cycle	1 sem., on demand
Contents	
• Special topics from stochastics/statistics	
Qualification aims	
Advanced knowledge and enhanced competence in a selected special field.	
Prior knowledge	Stochastics, statistics
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam.
Mark	Mark of the module examination
Workload in h	90 (lecture: 30, self-study: 60)
Course credits	3
Degree courses	
M.Sc. Mathematik - stochastics/statistics M.Sc. Biomathematik - stochastics/statistics	

Module Special course II stochastics/statistics	
Responsible professor	Professorship of stochastics, professorship of statistics
Teaching methods	Lecture (2 credit hours) and tutorial (2 credit hours)
Duration/cycle	1 sem., on demand
Contents	
• Special topics from stochastics/statistics	
Qualification aims	
Advanced knowledge and enhanced competence in a selected special field.	
Prior knowledge	Stochastics, statistics
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam.
Mark	Mark of the module examination
Workload in h	180 (lecture: 30, tutorial: 30, self-study: 120)
Course credits	6
Degree courses	
M.Sc. Mathematik - stochastics/statistics M.Sc. Biomathematik - stochastics/statistics	

Module Game theory	
Responsible professor	Professorship of stochastics, professorship of biomathematics
Teaching methods	Lecture (3 credit hours) and tutorial (1 credit hour)
Duration/cycle	1 sem., biennially in winter semester even years (C)

Contents

- Solving of combinatorial games
- Classical two-person matrix games, pure and mixed strategies
- Minimax solution and Nash equilibrium, existence theorems
- Evolutionary game theory, evolutionary stable equilibria
- Dynamic modelling of games
- Multi-player games, formation of coalitions, core, Shapley index

Qualification aims

- Competence in strategic thinking and formulating counterpoints of interest
- Knowledge of solution concepts
- Understanding of structures of conflict situations and their mathematical modelling based on problems found in politics, economy and everyday life
- Knowledge of modern approaches in evolutionary and dynamical game theory in connection and contrast to classical solution concepts
- Understanding the complexity and variety of modifications in multi-player games
- Knowledge of easy approaches like the core or Shapley index
- Advanced knowledge in stochastics, analysis and optimization through new applications

Prior knowledge	Analysis, linear algebra, stochastics
Language	German
Examination	The module examination consists of a written or an oral exam. An active participation in the tutorial is expected. Both contents of lecture and tutorial are examined.
Mark	Mark of the module examination
Workload in h	180 (lecture: 45, tutorial: 15, self-study: 120)
Course credits	6

Degree courses

B.Sc. Mathematik mit Informatik - elective - rec. in 5th sem.
M.Sc. Mathematik - stochastics/statistics
M.Sc. Biomathematik - stochastics/statistics

Module Stochastic models in biology	
Responsible professor	Professorship of stochastics
Teaching methods	Lecture (2 credit hours) and tutorial (2 credit hours)
Duration/cycle	1 sem., biennially in winter semester even years (C)

Contents

Fundamental principles of Markov processes and biological applications:

- Markov chains, structure determination, mean rules of absorbing chains and limit behaviour of irreducible chains
- Galton-Watson branching processes
- Stochastic models in population genetics
- Markov processes in continuous time

Qualification aims

- Knowledge of the theorem of finite homogenous Markov chains and their application as an easy modelling tool
- Knowledge of a variety of basic models in biology
- Advanced and profound knowledge of stochastics, linear algebra and discrete structures
- Competence with basic concepts and motivating examples for advanced modules (stochastic processes, molecular evolution, game theory, dynamic systems)

Prior knowledge	Analysis, linear algebra, stochastics, differential equations
Language	German
Examination	The module examination consists of a 90 min written exam or a 30 min oral exam. An active participation in the tutorial is expected. Both contents of lecture and tutorial are examined.
Mark	Mark of the module examination
Workload in h	180 (lecture: 30, tutorial: 30, self-study: 120)
Course credits	6

Degree courses

M.Sc. Mathematik - stochastics/statistics
M.Sc. Biomathematik - stochastics/statistics

Module Stochastic processes	
Responsible professor	Professorship of stochastics, professorship of biomathematics, professorship of algebra and functional analytical applications
Teaching methods	Lecture (4 credit hours)
Duration/cycle	1 sem., biennially in summer semester even years (F)
Contents	
• Basic terms, filtrations, stopping times • Markov processes in discrete and continuous time • Brownian motion (Wiener process) • Martingales • Stochastic integration, stochastic differential equations	
Qualification aims	
• Knowledge about the basic models of temporal (stochastic) processes and their properties • Knowledge about the basic characteristics of Brownian motion and evaluation of its importance in modelling	
Prior knowledge	Stochastics I, analaysis I, II, ordinary differential equations, linear algebra I, II
Language	German
Examination	The module examination consists of a 30 min oral exam.
Mark	Mark of the module examination
Workload in h	180 (lecture: 60, self-study: 120)
Course credits	6
Degree courses	
M.Sc. Mathematik - stochastics/statistics M.Sc. Biomathematik - stochastics/statistics	

Module Probability theory	
Responsible professor	Professorship of stochastics, professorship of statistics, professorship of algebra and functional analytical applications
Teaching methods	Lecture (4 credit hours) and tutorial (2 credit hours)
Duration/cycle	1 sem., biennially in winter semester odd years (E)

Contents

- Measure theoretical foundation of probability theory
- Notions of convergence for random variables, weak convergence of probability measures
- Conditional expenctation
- Probability measures in product spaces
- Zero-One laws
- Laws of large numbers
- Characteristic functions, central limit theorem
- Additonal questions: e.g. martingales in discrete time, theory of great deviation, ergodic theorem, infinitely divisible distributions

Qualification aims

- Knowledge about the mathematical basics of modern probability theory
- Competence in formulating, systematic classification and solving stochastic problems using the language of probability theory
- Overview of the variety of stochastic methods
- Ability to independently work with scientific thesis of probability theory
- Ability to independently work scientifically

Prior knowledge	Analysis I, II, stochastics, measure theory
Language	German
Examination	The module examination consists of a 30 min oral exam. The criteria for receiving a tutorial certificate are specified by the lecturer in the first lecture week.If no specific criteria are set, it is required to solve 50% of the exercises successfully.
Mark	Mark of the module examination
Workload in h	270 (lecture: 60, tutorial: 30, self-study: 180)
Course credits	9

Degree courses

M.Sc. Mathematik - stochastics/statistics
M.Sc. Biomathematik - stochastics/statistics

Module Time series analysis	
Responsible professor	Professorship of stochastics, professorship of biomathematics
Teaching methods	Lecture (2 credit hours) and tutorial (2 credit hours)
Duration/cycle	1 sem., annually in summer semester (B)

Contents

Methods and applications of time series analysis:

- Basic time series model, trend, periodic and random components
- ARMA processes and their stationarity
- Auto correlation and cross correlation, problems of estimation
- Spectrum and periodogram
- Linear filter and their admittance function
- Multivariate time series, data mining and visualisation

Additional topics, e.g.

- Non-linear time series analysis, more dimensional distributions, entropies
- Time series models in financial mathematics
- VAR-models and Granger causality

Qualification aims

- Knowledge about the basic models and statistic processes of time series, both conceptional and in the interactive work with data
- Knowledge about additional methods, questions and approaches
- Collecting practical experiences in dealing with big and complex data structures
- Understanding the specifics of time series (e.g. from economy, financial markets, medicine, language and music)
- Acquisition of a practical view in additon to the modules differential equations, stochastic processes, dynamic systems
- Competence in the abstract geometrical language and mind, which reduces complex systems to their essential properties
- Ability to explore complex systems via computer experiments in the tuorial

Prior knowledge	Analysis, linear algebra, stochastics, statistics, differential equations
Language	German
Examination	The module examination consists of a 30 min oral exam. An active participation in the tutorial is expected. Both contents of lecture and tutorial are examined.
Mark	Mark of the module examination
Workload in h	180 (lecture: 30, tutorial: 30, self-study: 120)
Course credits	6

Degree courses

M.Sc. Mathematik - stochastics/statistics
M.Sc. Biomathematik - stochastics/statistics

Seminar modules

Module Seminar A	
Responsible professor	Professorship of analysis, professorship of numerical mathematics and optimization, professorship of applied mathematics, professorship of computer science, professorship of algebra and functional analytical applications, professorship of stochastics, professorship of statistics, professorship of algebraic methods of analysis
Teaching methods	seminar (2 x 2 credit hours)
Duration/cycle	2 sem., each semester (G)
Contents	
• Additional topics from analysis/optimization, discrete mathematics/algorithmics/algebra or stochastics/statistics	
Qualification aims	
• Ability to independently handle a mathematical topic • Ability to give a well-structured, efficient talk that is customised for the audience • Competence in leading a discussion	
Prior knowledge	Analysis, linear algebra, stochastics, statistics
Language	German
Examination	The module examination consists of two 60 min presentations about agreed topics (seminar certificate).
Mark	None
Workload in h	180 (seminar: 60, self-study: 120)
Course credits	6
Degree courses	
M.Sc. Mathematik - seminar modules M.Sc. Biomathematik - analysis/optimization	

Module Seminar B	
Responsible professor	Professorship of analysis, professorship of numerical mathematics and optimization, professorship of applied mathematics, professorship of computer science, professorship of algebra and functional analytical applications, professorship of stochastics, professorship of statistics, professorship of algebraic methods of analysis
Teaching methods	Seminar (2 credit hours)
Duration/cycle	1 sem., each semester (G)
Contents	
• Additional topics from analysis/optimization, discrete mathematics/algorithmics/algebra or stochastics/statistics	
Qualification aims	
• Ability to independently handle a mathematical topic • Ability to give a well-structured, efficient talk that is customised for the audience • Competence in leading a discussion	
Prior knowledge	Analysis, linear algebra, stochastics, statistics
Language	German
Examination	The module examination consists of a 60 min presentation (seminar certificate) and a written report in the scope of 10 to 20 pages about an agreed topic.
Mark	None
Workload in h	180 (seminar: 30, report: 30 self-study: 120)
Course credits	6
Degree courses	
M.Sc. Mathematik - seminar modules M.Sc. Biomathematik - analysis/optimization	

Ecology

Module Ecology of animals	
Responsible professor	English description not available yet
Teaching methods	
Duration/cycle	,
Contents	
Contents	
Qualification aims	
Prior knowledge	
Language	
Examination	
Mark	
Workload in h	
Course credits	10
Degree courses	

Module Ecology of plants	
Responsible professor	English description not available yet
Teaching methods	
Duration/cycle	,
Contents	
Contents	
Qualification aims	
Prior knowledge	
Language	
Examination	
Mark	
Workload in h	
Course credits	10
Degree courses	

Module Ecology of microbes	
Responsible professor	English description not available yet
Teaching methods	
Duration/cycle	,
Contents	
Contents	
Qualification aims	
Prior knowledge	
Language	
Examination	
Mark	
Workload in h	
Course credits	10
Degree courses	

Module Plant reproductive biology	
Responsible professor	English description not available yet
Teaching methods	
Duration/cycle	,
Contents	
Contents	
Qualification aims	
Prior knowledge	
Language	
Examination	
Mark	
Workload in h	
Course credits	10
Degree courses	

Molecular biology

Module General molecular biology	
Responsible professor	English description not available yet
Teaching methods	
Duration/cycle	,
Contents	
Qualification aims	
Prior knowledge	
Language	
Examination	
Mark	
Workload in h	
Course credits	10
Degree courses	

Module Special molecular biology I	
Responsible professor	English description not available yet
Teaching methods	
Duration/cycle	,
Contents	
Qualification aims	
Prior knowledge	
Language	
Examination	
Mark	
Workload in h	
Course credits	10
Degree courses	

Module Special molecular biology II	
Responsible professor	English description not available yet
Teaching methods	
Duration/cycle	,
Contents	
Qualification aims	
Prior knowledge	
Language	
Examination	
Mark	
Workload in h	
Course credits	10
Degree courses	

Module Special molecular biology III	
Responsible professor	English description not available yet
Teaching methods	
Duration/cycle	,
Contents	
Contents	
Qualification aims	
Prior knowledge	
Language	
Examination	
Mark	
Workload in h	
Course credits	10
Degree courses	

Module Molecular phylogenetics	
Responsible professor	English description not available yet
Teaching methods	
Duration/cycle	,
Contents	
Qualification aims	
Prior knowledge	
Language	
Examination	
Mark	
Workload in h	
Course credits	10
Degree courses	

Functional cell biology and physiology

Module Physiology of animals and cells	
Responsible professor	English description not available yet
Teaching methods	
Duration/cycle	,
Contents	
Qualification aims	
Prior knowledge	
Language	
Examination	
Mark	
Workload in h	
Course credits	10
Degree courses	

Module Special physiology I	
Responsible professor	English description not available yet
Teaching methods	
Duration/cycle	,
Contents	
Qualification aims	
Prior knowledge	
Language	
Examination	
Mark	
Workload in h	
Course credits	10
Degree courses	

Module Special physiology II	
Responsible professor	English description not available yet
Teaching methods	
Duration/cycle	,
Contents	
Qualification aims	
Prior knowledge	
Language	
Examination	
Mark	
Workload in h	
Course credits	10
Degree courses	

Module Special physiology III	
Responsible professor	English description not available yet
Teaching methods	
Duration/cycle	,
Contents	
Qualification aims	
Prior knowledge	
Language	
Examination	
Mark	
Workload in h	
Course credits	10
Degree courses	

Internship / master thesis

Module Occupational internship	
Responsible professor	Chairman of examination committee
Teaching methods	Internship
Duration/cycle	4 weeks, in recess time
Contents	
• Internship in a company with mathematics or computer related tasks	
Qualification aims	
• Insights in the professional practice of a mathematician or a computer scientist • Wide-ranging experience in applying special functional skills in an economic environment • Competence in project- and research-oriented team work and communication	
Prior knowledge	Advanced knowledge in application-oriented subdomains of mathematics and computer science
Language	German
Examination	The examination consists of a 3 page report about the internship.
Mark	No mark
Workload in h	160
Course credits	6
Degree courses	
B.Sc. Mathematik mit Informatik - elective - semester, in which the internship is done	

Module Master thesis	
Responsible professor	Supervising faculty member
Teaching methods	Written thesis
Duration/cycle	9 months, anytime
Contents	
• Depending on the topic	
Qualification aims	
• Ability to independently work on a complex, research-oriented question for a limited time period • Competence in recording the achieved results in the form of a scientific thesis	
Prior knowledge	Depending on the topic
Language	German
Examination	Written thesis with examination
Mark	Averaged mark of the supervisors
Workload in h	900 (self-study: 900)
Course credits	30
Degree courses	
M.Sc. Mathematik - compulsory module - rec. in 3rd - 4th sem.	