UNIVERSITÄT ZU LÜBECK

Module Guide for the Study Path

Bachelor CLS

Version from 1. April 2019

1st semester

2nd semester

3rd or 5th semester

3rd semester

4th or 6th semester

4th semester

5th and 6th semester

5th or 6th semester

5th semester

6th semester

CS1000-KP08, CS1000SJ14-MML/MI, CS1000SJ14-MIW - Introduction to Programming (EinfProg14)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	8

Course of study, specific field and term:

- Bachelor MES since 2014 (compulsory), computer science, 3rd semester
- Bachelor Medical Informatics since 2019 in planning (compulsory: aptitude test), computer science, 1st semester
- Bachelor CLS (compulsory), foundations of computer science, 1st semester
- Bachelor Medical Informatics since 2014 (compulsory: aptitude test), computer science, 1st semester
- Bachelor CLS starting 2016 (compulsory), foundations of computer science, 1st semester

Classes and lectures:

- Introduction to Programming (lecture, 2 SWS)
- Introduction to Programming (exercise, 1 SWS)
- see CS1000 A or CS1000 B (Lab course) (lecture, 1 SWS)
- see CS1000 A or CS1000 B (Lab course) (exercise, 2 SWS)

Workload:

- 130 Hours private studies
- 90 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Definition: Algorithm
- Basic concepts of imperative and OO programming
- Programming in C++ or java

Qualification-goals/Competencies:

- Understanding the nature of algorithms and their definition
- Basic knowledge about different programming paradigms (imperative, declarative, object-oriented, etc.)
- Profound knowledge about imperative and object-oriented programming
- Ability to define abstract data types
- Ability to design, to implement, and to test simple programs
- In-depth knowledge of the C++ or Java programming language
- Ability to develop and implement solutions satisfying commonly accepted quality standards

Grading through:

- Exercises
- written exam

Is requisite for:

- Algorithms and Data Structures (CS1001-KP08, CS1001)

Responsible for this module:

- Prof. Dr. Stefan Fischer

Teacher:

- Institute of Telematics

- Prof. Dr. Stefan Fischer

Literature:

- M. Broy: Informatik - eine grundlegende Einführung (Band 1 und 2) - Springer-Verlag 1998
- G. Goos und W. Zimmermann: Vorlesungen über Informatik (Band 1 und 2) - Springer-Verlag, 2006
- B. Stroustrup: Einführung in die Programmierung mit C++ - Pearson Studium - IT, 2010

Language:

- offered only in German

LS1100-MML - Basic Chemistry (ACMML)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	7

Course of study, specific field and term:

- Bachelor CLS (compulsory), life sciences, 1st semester

Classes and lectures:

- Basic Chemistry (lecture, 3 SWS)
- Basic Chemistry (practical course, 2 SWS)
- Basic Chemistry (exercise, 1 SWS)

Workload:

- 110 Hours private studies
- 60 Hours in-classroom work
- 40 Hours exam preparation

Contents of teaching:

- Lectures: Organisation of matter and the periodic table of the elements
- Chemical bonds, molecules and ions
- Chemical formula and stoichiometry
- The threedimensional structure of molecules: From the VSEPR model to molecular orbitals
- Special properties of water
- Chemical equilibrium
- Acids and bases
- Redox reactions and electrochemistry
- Complexes and metal-ligand bonds
- Interactions between matter and radiation - spectroscopy
- Thermodynamics
- Chemical kinetics
- Practical course

Qualification-goals/Competencies:

- Basics of general and inorganic chemistry
- Understanding basic chemical concepts
- Learning basic laboratory techniques. Safety at work in chemical laboratories
- Practicing of teamwork (groups of two during the practical course)

Grading through:

- written exam

Is requisite for:

- Organic Chemistry (LS1600-MML)

Responsible for this module:

- PD Dr. phil. nat. Thomas Weimar

Teacher:

- Institute of Chemistry and Metabolomics

- PD Dr. phil. nat. Thomas Weimar
- Dr. rer. nat. Kerstin Lüdtke-Buzug

Literature:

- Schmuck et al.: Chemie für Mediziner - Pearson Studium
- Binnewies et al.: Allgemeine und Anorganische Chemie - Spektrum

Language:

- offered only in German

Notes:

Prerequisite for examination is the successful participation in the practical course; written examination

MA1000-KP08, MA1000 - Linear Algebra and Discrete Structures 1 (LADS1)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	8

Course of study, specific field and term:

- Minor in Teaching Mathematics, Bachelor of Arts (compulsory), mathematics, 3rd semester
- Bachelor Computer Science since 2016 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor CLS starting 2016 (compulsory), mathematics, 1st semester
- Bachelor IT-Security (compulsory), mathematics, 1st semester
- Bachelor Robotics and Autonomous Systems (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Biophysics (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Medical Informatics since 2014 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor MES since 2014 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Media Informatics (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Medical Informatics since 2019 in planning (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Computer Science 2014 and 2015 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Medical Informatics before 2014 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Computer Science before 2014 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor MES before 2014 (compulsory), mathematics, 1st semester
- Bachelor CLS (compulsory), mathematics, 1st semester

Classes and lectures:

- Linear Algebra and Discrete Structures 1 (lecture, 4 SWS)
- Linear Algebra and Discrete Structures 1 (exercise, 2 SWS)

Workload:

- 125 Hours private studies and exercises
- 90 Hours in-classroom work
- 25 Hours exam preparation

Contents of teaching:

- Fundamentals: logic, sets, mappings
- Relations, equivalence relations, orderings
- Proof by induction
- Groups: fundamentals, finite groups, permutations, matrices
- Rings, fields, congruencies
- Complex numbers: calculus, representation, roots of unity
- Vector spaces: bases, dimension, scalar product, norms

Qualification-goals/Competencies:

- Students understand the fundamental concepts of linear algebra.
- They understand basic thought processes and methods of proof.
- They can explain fundamental relationships in linear algebra.
- They can apply fundamental concepts and methods of proof to algebraic problems.
- They have an understanding of abstract thought processes.
- Interdisciplinary qualifications:
- Students have basic competency in modelling.
- They can transfer fundamental theoretical concepts to similar applications.
- They can work on elementary mathematics problems within a team.
- They can present elementary solutions to their problems to a group.

Grading through:

- Exercises
- Presentation of one´s own solution of an exercise
- written exam
- e-tests

Is requisite for:

- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)

Responsible for this module:

- Prof. Dr. rer. nat. Jan Modersitzki

Teacher:

- Institute of Mathematics and Image Computing

- Prof. Dr. rer. nat. Jan Modersitzki
- Prof. Dr. rer. nat. Jan Lellmann

Literature:

- G. Fischer: Lineare Algebra: Eine Einführung für Studienanfänger - Vieweg+Teubner
- G. Strang: Lineare Algebra - Springer
- K. Jänich: Lineare Algebra - Springer
- D. Lau: Algebra und diskrete Mathematik I + II - Springer
- G. Strang: Introduction to Linear Algebra - Cambridge Press
- K. Rosen: Discrete Mathematics and Its Applications - McGraw-Hill

Language:

- offered only in German

Notes:

Prerequisite tasks for taking the exam can be announced at the beginning of the semester. If any prerequisite tasks are defined, they must be completed and passed before taking the exam for the first time.

MA2000-KP08, MA2000 - Analysis 1 (Ana1KP08)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	8

Course of study, specific field and term:

- Minor in Teaching Mathematics, Bachelor of Arts (compulsory), mathematics, 5th semester
- Bachelor Computer Science since 2016 (compulsory), mathematics, 1st semester
- Bachelor CLS starting 2016 (compulsory), mathematics, 1st semester
- Bachelor Robotics and Autonomous Systems (compulsory: aptitude test), mathematics, 1st semester
- Bachelor IT-Security (compulsory), mathematics, 1st semester
- Bachelor Biophysics (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Medical Informatics since 2014 (compulsory), mathematics, 1st semester
- Bachelor Media Informatics (compulsory), mathematics, 1st semester
- Bachelor MES since 2014 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Computer Science 2014 and 2015 (compulsory), mathematics, 1st semester
- Bachelor Medical Informatics before 2014 (compulsory), mathematics, 3rd semester
- Bachelor CLS (compulsory), mathematics, 1st semester
- Bachelor MES before 2014 (compulsory), mathematics, 1st semester
- Bachelor Medical Informatics since 2019 in planning (compulsory), mathematics, 1st semester
- Bachelor Computer Science before 2014 (compulsory), mathematics, 3rd semester

Classes and lectures:

- Analysis 1 (lecture, 4 SWS)
- Analysis 1 (exercise, 2 SWS)

Workload:

- 125 Hours private studies
- 90 Hours in-classroom work
- 25 Hours exam preparation

Contents of teaching:

- Sequences and series
- Functions and continuity
- Differentiability, Taylor series
- Multivariate differential calculus

Qualification-goals/Competencies:

- Students understand the basic concepts of analysis.
- Students understand the basic thoughts and proof techniques.
- Students can explain basic relationships in analysis.
- Students can apply the basic concepts and proof techniques.
- Students have an understanding for abstract structures.
- Interdisciplinary qualifications:
- Students have a basic competence in modeling.
- Students can transfer theoretical concepts to similar applications.
- Students can work as a group on elementary mathematical problems.
- Students can present elementary solutions to their problems in front of a group.

Grading through:

- Exercises
- written exam
- e-tests

Is requisite for:

- Analysis 2 (MA2500-MML)
- Analysis 2 (MA2502-MIW)
- Analysis 2 (MA2500-MIWSJ14)
- Analysis 2 (MA2500-KP08)
- Analysis 2 (MA2500-KP09)
- Analysis 2 (MA2500-KP04, MA2500)

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institute for Mathematics
- Prof. Dr. rer. nat. Jürgen Prestin

Literature:

- K. Fritzsche: Grundkurs Analysis 1 +2
- H. Heuser: Lehrbuch der Analysis 1+2

Language:

- offered only in German

Notes:

Prerequisites for admission to the examination can be determined at the beginning of the semester. If such prerequisites are defined, they must have been fulfilled prior to the first attempt at the examination and must have been rated as positive.

CS1001-KP08, CS1001 - Algorithms and Data Structures (AuD)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	8

Course of study, specific field and term:

- Bachelor Computer Science since 2016 (compulsory: aptitude test), foundations of computer science, 2nd semester
- Bachelor CLS starting 2016 (compulsory), foundations of computer science, 2nd semester
- Bachelor Robotics and Autonomous Systems (compulsory), computer science, 2nd semester
- Bachelor IT-Security (compulsory: aptitude test), computer science, 2nd semester
- Bachelor Medical Informatics since 2014 (compulsory), computer science, 2nd semester
- Bachelor MES since 2014 (optional subject), computer science and electrical engineering, 4th or 6th semester
- Bachelor Media Informatics (compulsory), foundations of computer science, 2nd semester
- Bachelor Computer Science 2014 and 2015 (compulsory: aptitude test), foundations of computer science, 2nd semester
- Bachelor Medical Informatics before 2014 (compulsory), computer science, 2nd semester
- Bachelor MES before 2014 (compulsory), foundations of computer science, 4th semester
- Bachelor CLS (compulsory), foundations of computer science, 2nd semester
- Bachelor Computer Science before 2014 (compulsory: aptitude test), foundations of computer science, 2nd semester
- Bachelor Medical Informatics since 2019 in planning (compulsory), computer science, 2nd semester

Classes and lectures:

- Algorithms and Data Structures (lecture, 4 SWS)
- Algorithms and Data Structures (exercise, 2 SWS)

Workload:

- 125 Hours private studies
- 90 Hours in-classroom work
- 25 Hours exam preparation

Contents of teaching:

- Introduction, algorithms, design patterns: stepwise execution, one-step execution
- Sorting with comparisons, design patterns: linear reduction principle, divide and conquer, problem complexity, asymptotic complexity of an algorithm (O notation), problem classes, heaps as data structures, stability
- Distribution sort: counting sort, radix sort, bucket sort
- Priority queues, binomial heaps, Fibonacci heaps, amortized analysis
- Selection, k-smallest element
- Sets, self-adjusting data structures, binary search trees, iterators and navigation structures, balance, self-adjusting binary search trees: splay trees (access-time adjustment), red-black trees, AVL trees (insertion-time adjustment)
- Sets of strings, tries, PATRICIA tries
- Disjoint sets, union-find data structures
- Associating objects, hash tables, dynamic hashing (separate chaining, linear probing, quadratic probing, rehashing), static hashing, universal hashing
- Graphs, operators, graph representations, breadth-first and depth-first search, connected components, shortest paths, single-source shortest paths (Dijkstra s algorithm, A* algorithm, Bellmann-Ford algorithm), all-pairs shortest paths, transitive closure, minimal spanning tree (Kruskal s algorithm, Jarnik-Prim algorithm), network flows (Ford-Fulkerson algorithm, Edmonds-Karp algorithm), bipartite matching
- Search graph for game playing, minimax search, search space construction, alpha-beta pruning, chess playing
- Pruning and subgraph isomorphism, Ullmann s algorithm, character recognition, recognition of protein structures
- Dynamic Programming principle, greedy algorithms, optimization problems, sequence alignment (longest common subsequence), knapsack problem, planning and layout problems, determining change coins, notion of completeness of algorithms
- String matching: exact algorithms (Knuth-Morris-Pratt, Boyer-Moore, Rabin-Karp, suffix trees, suffix arrays), approximate string matching with dynamic programming
- Hard problems, satisfiability of propositional logic formulas, 3-SAT, P=NP?, clique problem, problem reduction, NP-hardness, NP-completeness, algorithmic design patterns for dealing with NP-hard problems (DPLL, dependency-directed backtracking), reducing Sudoku to 3-SAT, 2-SAT, constraint satisfaction problems, reduction of backtracking with heuristics (discussed using chromatic number and n-queen problems as an example)

Qualification-goals/Competencies:

- Knowledge of the properties of elementary and frequently used algorithms
- Understanding of the impact of complexity in theory and practice
- Competence in the design and understanding of algorithms and their underlying data structures

Grading through:

- Exercises
- written exam

Is requisite for:

- Databases (CS2700-KP04, CS2700)
- Lab Course Software Engineering (CS2301-KP06, CS2301)
- Software Engineering (CS2300-KP06, CS2300SJ14)
- Theoretical Computer Science (CS2000-KP08, CS2000)
- Algorithm Design (CS3000-KP04, CS3000)

Requires:

- Introduction to Programming (CS1000-KP08, CS1000SJ14-MML/MI, CS1000SJ14-MIW)
- Introduction to Programming (CS1000-KP10, CS1000SJ14)

Responsible for this module:

- Prof. Dr. rer. nat. habil. Ralf Möller

Teacher:

- Institute of Information Systems

- Prof. Dr. rer. nat. habil. Ralf Möller

Literature:

- T. Ottmann, P. Widmayer: Algorithmen und Datenstrukturen - Spektrum, 2002
- R. Sedgewick: Algorithmen in Java Teil 1 - 4 - Pearson Studium, 2003
- S. Baase und A. Van Gelder: Computer Algorithms - 3. Auflage, Addison-Wesley, 2000

Language:

- offered only in German

MA1500-KP08, MA1500 - Linear Algebra and Discrete Structures 2 (LADS2)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	8

Course of study, specific field and term:

- Minor in Teaching Mathematics, Bachelor of Arts (compulsory), mathematics, 4th semester
- Bachelor Medical Informatics since 2019 in planning (compulsory), mathematics, 2nd semester
- Bachelor Computer Science since 2016 (compulsory: aptitude test), mathematics, 2nd semester
- Bachelor CLS starting 2016 (compulsory), mathematics, 2nd semester
- Bachelor Robotics and Autonomous Systems (compulsory), mathematics, 2nd semester
- Bachelor IT-Security (compulsory), mathematics, 2nd semester
- Bachelor Biophysics (compulsory), mathematics, 2nd semester
- Bachelor Medical Informatics since 2014 (compulsory), mathematics, 2nd semester
- Bachelor MES since 2014 (compulsory), mathematics, 2nd semester
- Bachelor Computer Science 2014 and 2015 (compulsory: aptitude test), mathematics, 2nd semester
- Bachelor Medical Informatics before 2014 (compulsory), mathematics, 2nd semester
- Bachelor CLS (compulsory), mathematics, 2nd semester
- Bachelor MES before 2014 (compulsory), mathematics, 2nd semester
- Bachelor Computer Science before 2014 (compulsory: aptitude test), mathematics, 2nd semester

Classes and lectures:

- Linear Algebra and Discrete Structures 2 (lecture, 4 SWS)
- Linear Algebra and Discrete Structures 2 (exercise, 2 SWS)

Workload:

- 125 Hours private studies and exercises
- 90 Hours in-classroom work
- 25 Hours exam preparation

Contents of teaching:

- Systems of linear equations, matrices
- Determinants
- Linear mappings
- Orthogonality
- Eigenvalues

Qualification-goals/Competencies:

- The students understand advanced concepts of linear algebra.
- They understand advanced thought processes and methods of proof.
- They can apply advanced concepts and methods of proof to algebraic problems.
- They can explain advanced relationships in linear algebra.
- Interdisciplinary qualifications:
- Students can transfer advanced theoretical concepts to similar applications.
- They have an advanced competency in modeling.
- They can solve complex problems within a group.
- They can present the solution to complex problems to a group.

Grading through:

- Exercises
- Presentation of one´s own solution of an exercise
- written exam
- e-tests

Is requisite for:

- Image Registration (MA5030-KP05)
- Image Registration (MA5030-KP04, MA5030)
- Mathematical Methods in Image Processing (MA4500-KP05)
- Mathematical Methods in Image Processing (MA4500-KP04, MA4500)
- Optimization (MA4031-KP08)
- Module part: Optimization (MA4030 T)
- Optimization (MA4030-KP08, MA4030)

Requires:

- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)

Responsible for this module:

- Prof. Dr. rer. nat. Jan Modersitzki

Teacher:

- Institute of Mathematics and Image Computing

- Prof. Dr. rer. nat. Jan Modersitzki
- Prof. Dr. rer. nat. Jan Lellmann

Literature:

- G. Fischer: Lineare Algebra: Eine Einführung für Studienanfänger - Vieweg+Teubner
- G. Strang: Lineare Algebra - Springer
- K. Jänich: Lineare Algebra - Springer
- D. Lau: Algebra und diskrete Mathematik I + II - Springer
- G. Strang: Introduction to Linear Algebra - Cambridge Press
- K. Rosen: Discrete Mathematics and Its Applications - McGraw-Hill

Language:

- offered only in German

Notes:

Prerequisite tasks for taking the exam can be announced at the beginning of the semester. If any prerequisite tasks are defined, they must be completed and passed before taking the exam for the first time.

MA1600-KP04, MA1600, MA1600-MML - Biostatistics 1 (BioStat1)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Bachelor Medical Informatics since 2019 in planning (compulsory), medical computer science, 6th semester
- Bachelor MLS starting 2018 (compulsory), life sciences, 6th semester
- Bachelor Nutritional Medicine starting 2018 (compulsory), mathematics / computer science, 6th semester
- Bachelor CLS starting 2016 (compulsory), mathematics, 2nd semester
- Bachelor CLS (compulsory), mathematics, 2nd semester
- Bachelor Computer Science since 2016 (optional subject), advanced curriculum, arbitrary semester
- Bachelor Computer Science since 2016 (compulsory), Canonical Specialization Bioinformatics, 4th semester
- Bachelor MLS starting 2016 (compulsory), life sciences, 6th semester
- Bachelor Biophysics (compulsory), Elective Computer Science, 4th semester
- Bachelor Nutritional Medicine (compulsory), mathematics / computer science, 6th semester
- Bachelor Medical Informatics since 2014 (compulsory), medical computer science, 4th semester
- Bachelor Computer Science 2014 and 2015 (compulsory), specialization field bioinformatics, 6th semester
- Master MES before 2014 (advanced curriculum), biophysics and biomedical optics, 2nd semester
- Bachelor Medical Informatics before 2014 (compulsory), medical computer science, 4th semester
- Master Computer Science before 2014 (optional subject), specialization field bioinformatics, 2nd or 3rd semester
- Master Computer Science before 2014 (compulsory), advanced curriculum stochastics, 2nd semester
- Bachelor Computer Science before 2014 (optional subject), specialization field bioinformatics, 6th semester
- Bachelor MLS (compulsory), life sciences, 6th semester
- Bachelor MES before 2014 (optional subject), Medical Engineering Science, 6th semester
- Bachelor Computer Science before 2014 (compulsory), specialization field medical informatics, 6th semester

Classes and lectures:

- Biostatistics 1 (lecture, 2 SWS)
- Biostatistics 1 (exercise, 1 SWS)

Workload:

- 66 Hours private studies
- 39 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Descriptive statistics
- Probability theory, including random variables, density, and cumulative distribution function
- Normal distribution, other distributions
- Diagnostic tests, reference range, normal range, coefficient of variation
- Statistical testing
- Sample size calculations
- Confidence intervals
- Selected statistical tests I
- Selected statistical tests II
- Linear simple regression
- Analysis of variance (one-way-classification)
- Clinical trials
- Multiple Testing: Bonferroni, Bonferroni-Holm, Bonferroni-Holm-Shaffer, Wiens, hierarchical Testing

Qualification-goals/Competencies:

- The students are able to calculate descriptive statistics.
- They are able to calculate quantiles and surfaces of the normal distribution.
- They are able to explain terms of diagnostic testing, such as sensitivity or specificity.
- They are able to list the basic principles of statistical testing, sample size calculation and confidence interval construction.
- They are able to carry out a set of elementary statistical tests, such as t-test, test of proportions, X2 independence test, and to interpret the results.
- They are able to explain the basic principles of linear regression.
- They are able to apply the linear simple regression.
- They are able to explain the basic idea for the one-way analysis of variance (ANOVA).
- They are able to explain the results table for the one-way and two-way ANOVA.
- They are able to interpret the results of the ANOVA.

- They know the basic principles of clinical therapeutic studies.
- They know the assumptions that need to be fulfilled for the application of specific statistical tests.
- They are able to calculate simple adjustments for multiple comparisons.

Grading through:

- written exam

Is requisite for:

- Module part: Biostatistics 2 (MA2600 T)
- Biostatistics 2 (MA2600-KP07)
- Biostatistics 2 (MA2600-KP04, MA2600)

Responsible for this module:

- Prof. Dr. rer. biol. hum. Inke König

Teacher:

- Institute of Medical Biometry and Statistics

- Prof. Dr. rer. biol. hum. Inke König
- MitarbeiterInnen des Instituts
- Dr. Reinhard Vonthein

Literature:

- Matthias Rudolf, Wiltrud Kuhlisch: Biostatistik: Eine Einführung für Biowissenschaftler - 1. Auflage, Pearson: Deutschland
- Lothar Sachs, Jürgen Hedderich: Angewandte Statistik: Methodensammlung mit R - 15. Auflage, Springer: Heidelberg

Language:

- offered only in German

MA2500-MML - Analysis 2 (Ana2)

Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	each summer semester	9

Course of study, specific field and term:

- Bachelor CLS (compulsory), mathematics, 2nd semester

Classes and lectures:

- Analysis 2 (lecture, 4 SWS)
- Analysis 2 (exercise, 3 SWS)

Workload:

- 130 Hours exam preparation
- 110 Hours in-classroom work
- 30 Hours private studies

Contents of teaching:

- Advanced multivariate differential calculus
- Indefinite and definite integrals, fundamental theorem of calculus
- Curvilinear integrals, bounded variation
- Function series, power series
- Trigonometric polynomials, Fourier series, Fourier coefficients
- Linear operators in Hilbert spaces

Qualification-goals/Competencies:

- Deeper insight into some selected aspects of analysis
- Deepening the basic knowledge in theory formation and model building competence
- Learning to use a computer algebra system

Grading through:

- Exercises
- written exam

Is requisite for:

- Numerical Linear Algebra (MA4041)

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Jürgen Prestin

Literature:

- H. Heuser: Lehrbuch der Analysis 1+2
- K. Fritzsche: Grundkurs Analysis 1+2

Language:

- offered only in German

MA2510-KP04, MA2510 - Stochastics 1 (Stoch1)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Bachelor Medical Informatics since 2019 in planning (optional subject), mathematics, 4th to 6th semester
- Minor in Teaching Mathematics, Bachelor of Arts (compulsory), mathematics, 8th semester
- Bachelor Computer Science since 2016 (compulsory), mathematics, 4th semester
- Bachelor CLS starting 2016 (compulsory), mathematics, 2nd semester
- Bachelor Robotics and Autonomous Systems (compulsory), mathematics, 4th semester
- Bachelor IT-Security (compulsory), mathematics, 2nd semester
- Bachelor Biophysics (optional subject), mathematics, 6th semester
- Bachelor Medical Informatics since 2014 (optional subject), mathematics, 5th or 6th semester
- Bachelor MES since 2014 (optional subject), mathematics / natural sciences, 4th or 6th semester
- Bachelor Computer Science 2014 and 2015 (compulsory), mathematics, 4th semester
- Bachelor Computer Science before 2014 (compulsory), mathematics, 4th semester
- Bachelor MES before 2014 (compulsory), mathematics, 4th semester
- Bachelor CLS (compulsory), mathematics, 2nd semester

Classes and lectures:

- Stochastics 1 (lecture, 2 SWS)
- Stochastic 1 (exercise, 1 SWS)

Workload:

- 65 Hours private studies and exercises
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- probability spaces
- basics of combinatorics
- conditional probability and stochastic independency
- random variables
- important discrete and continuous one-dimensional probability distributions
- characteristics of distributions
- law of large numbers, central limit theorem
- modeling examples from the life sciences

Qualification-goals/Competencies:

- Students are able to explain basic stochastic models formally correct and in the context of their application
- They are able to formalize stochastic problems
- They are able to identify basic combinatorial patterns and to use them for solving stochastic problems
- They understand central statements of elementary stochastics

Grading through:

- Exercises
- written exam

Is requisite for:

- Stochastic processes (MA4610-KP05)
- Stochastic processes and modeling (MA4610)
- Modeling Biological Systems (MA4450-MML)
- Modeling Biological Systems (MA4450-KP07)
- Module part: Modeling Biological Systems (MA4450 T-INF)
- Module part: Modeling Biological Systems (MA4450 T)
- Modeling Biological Systems (MA4450)
- Modeling (MA4449-KP07)
- Module part: Stochastics 2 (MA4020 T)
- Stochastics 2 (MA4020-KP05)
- Stochastics 2 (MA4020-MML)
- Stochastics 2 (MA4020-KP04, MA4020)

Requires:

- Analysis 1 (MA2000-KP08, MA2000)

Responsible for this module:

- Prof. Dr. rer. nat. Karsten Keller

Teacher:

- Institute for Mathematics
- Prof. Dr. rer. nat. Karsten Keller

Literature:

- N. Henze: Stochastik für Einsteiger - Vieweg
- U. Krengel: Einführung in die Wahrscheinlichkeitstheorie - Vieweg

Language:

- offered only in German

Notes:

Only students who have passed the exercises are admitted to the examination.

MA2214-KP04, MA2214 - Clinical Studies (KlinStud)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Bachelor Medical Informatics since 2019 in planning (optional subject), medical computer science, 4th to 6th semester
- Bachelor CLS starting 2016 (compulsory), mathematics, 3rd or 5th semester
- Master Nutritional Medicine in planning (compulsory), medical computer science, 1st semester
- Bachelor Medical Informatics since 2014 (optional subject), medical computer science, 5th or 6th semester
- Master Computer Science before 2014 (optional subject), specialization field medical informatics, 3rd semester
- Bachelor Medical Informatics before 2014 (optional subject), medical computer science, 4th to 6th semester
- Bachelor MES before 2014 (optional subject), life sciences, 3rd or 5th semester
- Bachelor CLS (compulsory), mathematics, 3rd or 5th semester

Classes and lectures:

- Clinical Studies (lecture, 2 SWS)
- Clinical Studies (exercise, 1 SWS)

Workload:

- 60 Hours private studies and exercises
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Clinical benefit, clinical development, specific study designs
- Regulations and study documents
- Techniques to avoid bias
- Sample size calculation
- Survival analysis (main features)
- Clinical investigation plan
- Case report form (CRF), data management, monitoring
- Quality management and system validation
- Analysis populations and effect measures
- Clinical investigation report and publication
- Systematic review and meta-analysis
- Connection to health economics

Qualification-goals/Competencies:

- The students are able to describe the regulatory framework for clinical trials with drugs and medical devices.
- They are able to describe the fields of data management, monitoring, information technology, quality management.
- They are able to explain the basic principles of clinical studies and the steps to reach these principles.
- They are able to edit a clinical investigation plan.
- They are able to depict a study population descriptively.
- They are able to carry out sample size calculations for simple clinical trials.
- The students can assign studies and their key points to the stages of clinical development
- They are able to describe and perform the Kaplan-Maier method and the log-rank test.
- They are able to explain different study designs.
- They are aware of ethical issues and principles as well as principles of data protection.
- They are able to appraise clinical investigation reports and systematic reviews.
- They command the jargon of health benefit evaluation.

Grading through:

- written exam

Requires:

- Biostatistics 1 (MA1600-KP04, MA1600, MA1600-MML)

Responsible for this module:

- Dr. Reinhard Vonthein

Teacher:

- Centre for Clinical Studies

- Institute of Medical Biometry and Statistics

- Dr. Reinhard Vonthein
- Dr. Maren Vens
- Wolfgang Rudolph-Rothfeld

Literature:

- Gaus W., Chase D.: Klinische Studien: Regelwerke, Strukturen, Dokumente und Daten - Norderstedt: Books on Demand GmbH 2007 (2. Auflage)
- Stapff M.: Arzneimittelstudien - Eine Einführung in klinische Prüfungen für Ärzte, Studenten, medizinisches Assistenzpersonal und interessierte Laien - Germering/München: W. Zuckschwerdt Verlag GmbH 2008 (5. Auflage)
- Schumacher, M., Schulgen, G.: Methodik klinischer Studien: Methodische Grundlagen der Planung, Durchführung und Auswertung - Berlin: Springer 2008 (3. Auflage)

Language:

- German and English skills required

Notes:

For the master programme Nutrional Medicine the module will be lectured on an annual basis starting winter term 2019/2020. The language will be alternating German and English!

Prerequisite tasks for taking the exam can be announced at the beginning of the semester. If any prerequisite tasks are defined, they must be completed and passed before taking the exam for the first time.

MA3200-KP04, MA3200 - Genetic Epidemiology 1 (GenEpi1)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second year	4

Course of study, specific field and term:

- Bachelor CLS starting 2016 (compulsory), mathematics, 3rd or 5th semester
- Master Medical Informatics (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master Computer Science before 2014 (optional subject), specialization field medical informatics, 3rd semester
- Bachelor CLS (compulsory), mathematics, 3rd or 5th semester
- Master Medical Informatics since 2019 in planing (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester

Classes and lectures:

- Genetic Epidemiology 1 (lecture, 2 SWS)
- Genetic Epidemiology 1 (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Fundamentals in molecular genetics: Genetic information, transmission and variation of genetic information, genotyping methods
- Fundamentals in formal genetics: Mendelian laws, segregation patterns, Hardy-Weinberg-equilibrium
- Genetic markers
- Data quality: Errors in the data, methods of error detection
- Association studies: Study designs, tests, estimates, linkage disequilibrium, bias in the data
- Haplotype-based association: Estimation of haplotypes, tests, haplotype blocks
- Genome-wide association: Study designs, study conduct, specific problems

Qualification-goals/Competencies:

- Students are able to describe the generation of genetic data, its error sources and methods of detection.
- They can select and describe the most important approaches for genetic epidemiological association studies on the level of single markers and haplotypes.
- They are able to apply the basic test procedures manually and more complex test procedures using the computer and to interpret the results.
- They have the methodological competence to solve large-scale tasks cost- and time- efficiently.
- They have the management competence to organize their own work and that of collaborators involved in the project.
- They have the methods competence to develop solutions with limited resources (time, personnel, etc.) that comply with general quality criteria.

Grading through:

- written exam

Is requisite for:

- Seminar Genetic Epidemiology (MA5129-KP04, MA5129)
- Genetic Epidemiology 2 (MA4661-KP08, MA4661)

Requires:

- Biostatistics 1 (MA1600-KP04, MA1600, MA1600-MML)

Responsible for this module:

- Prof. Dr. rer. biol. hum. Inke König

Teacher:

- Institute of Medical Biometry and Statistics

- Prof. Dr. rer. biol. hum. Inke König
- MitarbeiterInnen des Instituts

Literature:

- Ziegler A, König IR.: A statistical approach to genetic epidemiology. Concepts and applications. - 2010. ISBN: 978-3-527-32389-0

Language:

- English, except in case of only German-speaking participants

Notes:

Prerequisite tasks for taking the exam can be announced at the beginning of the semester. If any prerequisite tasks are defined, they must be completed and passed before taking the exam for the first time.

For students of the master Infection Biology program me, this is not a stand-alone module, but rather part of module CS4011.

LS1000-MML - Basic Biology and Course (BioMML)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	9

Course of study, specific field and term:

- Bachelor CLS (compulsory), life sciences, 3rd semester

Classes and lectures:

- Basic Biology and Course (lecture, 4 SWS)
- Basic Biology and Course (practical course, 2 SWS)

Workload:

- 160 Hours private studies
- 90 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Lectures:
- Introduction
- Structure and functions of the prokaryotic cell
- Structure of the eukaryotic cells
- Selected topics of multicellular organisation
- Storage, duplication and realization of the hereditary information
- Cell cycle
- Fertilization and development
- Formal and molecular genetics, evolution
- Practical course (individual test):
- Handling of light microscopes
- Structure of prokaryotic cells
- Structure of cells from metazoan
- Human chromosomes
- Cell cycle and mitosis
- Genetics
- Bacteria

Qualification-goals/Competencies:

- Improvement of basic knowledge for life-science education
- Ability to understand, reproduce and use in the further studies basics of all areas listed in "contents of teaching", espacially in cell biology and fomal and molecular genetics
- Basal practical skills in light microscopy

Grading through:

- continuous, successful participation in course
- written exam

Responsible for this module:

- Prof. Dr. rer. nat. Enno Hartmann

Teacher:

- Institute for Biology

- Prof. Dr. rer. nat. Enno Hartmann
- Prof. Dr. rer nat. Rainer Duden
- PD Dr. rer. nat. Kai-Uwe Kalies
- PD Dr. rer. nat. Bärbel Kunze

Literature:

- Campbell: Biology

Language:

- offered only in German

MA3110-MML - Numerics 1 (Num1MML)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	5

Course of study, specific field and term:

- Bachelor CLS (compulsory), mathematics, 3rd semester

Classes and lectures:

- Numerics 1 (lecture, 2 SWS)
- Numerics 1 (exercise, 2 SWS)

Workload:

- 75 Hours private studies
- 60 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Round-off errors and condition
- Direct solvers for linear equations
- LR decomposition
- Perturbation theory
- Cholesky decomposition
- QR decomposition, least squares fit

Qualification-goals/Competencies:

- Basic understanding of numeric tasks
- Mastering the modern programming language MATLAB
- Experience in the implementation of theoretical algorithms
- Ability to judge the quality of a method (accuracy, stability, complexity)

Grading through:

- Exercises
- programming exercises
- written exam

Requires:

- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)
- Analysis 2 (MA2500-MML)
- Analysis 1 (MA2000-KP08, MA2000)

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Rößler

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Andreas Rößler

Literature:

- M. Bollhöfer, V. Mehrmann: Numerische Mathematik - Vieweg (2004)
- P. Deuflhard, A. Hohmann: Numerische Mathematik I - 4. Auflage, De Gruyter (2008)
- P. Deuflhard, F. Bornemann: Numerische Mathematik II - 3. Auflage, De Gruyter (2008)
- M. Hanke-Bourgeois: Grundlagen der Numerischen Mathematik und des Wissenschaftlichen Rechnens - 3. Aufl., Teubner (2009)
- H. R. Schwarz, N. Köckler: Numerische Mathematik - 6. Auflage, Teubner (2006)
- J. Stoer: Numerische Mathematik I - 10. Auflage, Springer (2007)
- J. Stoer, R. Bulirsch: Numerische Mathematik II - 5. Auflage, Springer (2005)
- A. M. Quarteroni, R. Sacco, F. Salieri: Numerical Mathematics - 2. Auflage, Springer (2006)

Language:

- offered only in German

Notes:

The lecture is identical to that in module MA3110/Numerics 1

MA3400-MML - Biomathematics (BioMathMML)		
Duration: 1 Semester	**Turnus of offer:** each winter semester	**Credit points:** 7

Course of study, specific field and term:

- Bachelor CLS (compulsory), mathematics, 3rd semester

Classes and lectures:

- Biomathematics (lecture, 2 SWS)
- Biomathematics (exercise, 2 SWS)

Workload:

- 100 Hours private studies and exercises
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Basics of differential equations
- Differential equations of first order
- Linear differential equations of n-th order
- Systems of linear differential equations with constant coefficients
- Notes on numerics and qualitative analysis; the prey-predator model

Qualification-goals/Competencies:

- Learning the basics of ordinary differential equations
- Ability to apply differential equations
- Learning by means of examples how to use differential equations for models in biology, chemistry and medicine
- Basic understanding of simple numerical methods

Grading through:

- Exercises
- written exam

Responsible for this module:

- PD Dr. rer. nat. Hanns-Martin Teichert

Teacher:

- Institute for Mathematics

- PD Dr. rer. nat. Hanns-Martin Teichert

Literature:

- J. D. Murray: Mathematical Biology - Springer
- H. Heuser: Gewöhnliche Differentialgleichungen - Teubner Verlag 1991
- R. Schuster: Biomathematik - Teubner Studienbücher 1995
- S. Handrock-Meyer: Differenzialgleichungen für Einsteiger - Hanser 2007

Language:

- offered only in German

Notes:

The lecture is identical to MA3400 Biomathematics

MA4020-MML - Stochastics 2 (Stoch2MML)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	6

Course of study, specific field and term:

- Bachelor CLS (compulsory), mathematics, 3rd semester

Classes and lectures:

- Stochastics 2 (lecture, 2 SWS)
- Stochastics 2 (exercise, 2 SWS)

Workload:

- 100 Hours private studies and exercises
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Lebesgue integral und Riemann integral
- transformations of measures and integrals
- product measures and Fubini's theorem
- moments and dependency measures
- normally distributed random vectors and distributions closely related to the normal distribution

Qualification-goals/Competencies:

- Studends get insights into basic stochastic structures
- They master techniques of integration being relevant to stochastics
- They master the treatment of (particularly normally distributed) random vectors and their distributions
- They are able to formalize complex stochastic problems

Grading through:

- Exercises
- written exam

Is requisite for:

- Stochastic processes and modeling (MA4610)
- Modeling Biological Systems (MA4450-MML)

Requires:

- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Stochastics 1 (MA2510-KP04, MA2510)
- Analysis 2 (MA2500-MML)

Responsible for this module:

- Prof. Dr. rer. nat. Karsten Keller

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Karsten Keller

Literature:

- J. Elstrodt: Maß- und Integrationstheorie - Springer
- M. Fisz: Wahrscheinlichkeitsrechnung und mathematische Statistik - Deutscher Verlag der Wissenschaften

Language:

- offered only in German

Notes:

The lecture is identical to that in module MA4020.

Only students who have passed the exercises are admitted to the examination.

MA4405 - Nonlinear dynamic systems (NLinDynSys)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Bachelor CLS (optional subject), mathematics, 4th or 6th semester
- Bachelor CLS (optional subject), computer science, 4th or 6th semester
- Master CLS (optional suject), mathematics, arbitrary semester
- Master CLS (optional subject), computer science, arbitrary semester

Classes and lectures:

- Nonlinear dynamic systems (lecture, 2 SWS)
- Nonlinear dynamic systems (exercise, 1 SWS)

Workload:

- 65 Hours private studies
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

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Qualification-goals/Competencies:

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Grading through:

- Written or oral exam as announced by the examiner
- Oral examination
- Exercises

Requires:

- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)
- Analysis 2 (MA2500-MML)

Responsible for this module:

- PD Dr. rer. nat. Jens Christian Claussen

Teacher:

- Institute for Neuro- and Bioinformatics

- PD Dr. rer. nat. Jens Christian Claussen

Literature:

- Argyris, Faust, Haase: Die Erforschung des Chaos
- Jetschke: Mathematik der Selbstorganisation
- Heinz Georg Schuster: Deterministic Chaos
- Edward Ott: Nonlinear Dynamics and Chaos

Language:

- German and English skills required

MA5034-KP04, MA5034 - Calculus of Variations and Partial Differential Equations (VariPDE)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second summer semester	4

Course of study, specific field and term:

- Master MES since 2014 (optional subject), mathematics / natural sciences, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 4th or 6th semester
- Master Medical Informatics (optional subject), medical image processing, 1st or 2nd semester
- Master MES before 2014 (optional subject), mathematics, 2nd or 4th semester
- Master Computer Science before 2014 (optional subject), advanced curriculum numerical image processing, 2nd or 3rd semester
- Master MES before 2014 (advanced curriculum), imaging systems, signal and image processing, 2nd or 4th semester
- Master CLS (optional subject), mathematics, 2nd or 4th semester
- Master Medical Informatics since 2019 in planing (optional subject), medical image processing, 1st or 2nd semester

Classes and lectures:

- Calculus of Variations and Partial Differential Equations (lecture, 2 SWS)
- Calculus of Variations and Partial Differential Equations (exercise, 1 SWS)

Workload:

- 65 Hours private studies and exercises
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Fundamentals of functional analysis
- Introduction to the calculus of variations
- Introduction to partial differential equations
- Applications in image and data processing

Qualification-goals/Competencies:

- Students understand variational modeling.
- They are able to formulate basic physical problems in a variational setting.
- They understand the connections between variational methods and partial differential equations.
- They can derive optimality conditions for energy functionals.
- They understand the mathematical theory behind selected variational problems.
- They can implement selected fundamental variational problems.
- They can formulate selected practical problems in the variational setting.
- Interdisciplinary qualifications:
- Students have advanced skills in modeling.
- They can translate theoretical concepts into practical solutions.
- They are experienced in implementation.
- They can think abstractly about practical problems.

Grading through:

- Exercises
- Presentation of one´s own solution of an exercise
- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. rer. nat. Jan Modersitzki

Teacher:

- Institute of Mathematics and Image Computing

- Prof. Dr. rer. nat. Jan Modersitzki
- Prof. Dr. rer. nat. Jan Lellmann

Literature:

- Chan & Shen: Image Processing and Analysis - SIAM
- Modersitzki: Flexible Algorithms for Image Registration - SIAM
- Vogel: Computational Methods for Inverse Methods - SIAM

- Aubert, Kornprobst: Mathematical Problems in Image Processing: Partial Differential Equations and the Calculus of Variations - Springer
- Scherzer, Grasmair, Grossauer, Haltmeier, Lenzen: Variational Methods in Imaging - Springer

Language:

- German and English skills required

Notes:

Prerequisite tasks for taking the exam can be announced at the beginning of the semester. If any prerequisite tasks are defined, they must be completed and passed before taking the exam for the first time.

LS1600-MML - Organic Chemistry (OCMML)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Bachelor MES before 2014 (optional subject), optional subject medical engineering science, 6th semester
- Bachelor CLS (compulsory), life sciences, 4th semester

Classes and lectures:

- Organic Chemistry (lecture, 3 SWS)

Workload:

- 80 Hours private studies
- 40 Hours in-classroom work

Contents of teaching:

- Introduction
- Alkanes, cycloalkanes
- Alkene and alkynes
- Aromatic compounds
- Stereoisomery
- Substitution and elimination reactions
- Alcohols, phenols and thiols
- Ether and epoxides
- Aldehydes and ketones
- Carboxylic acids and derivates
- Amines and derivates
- Heterocycles
- Lipids
- Carbohydrates
- Amino acids and peptides
- Nucleotides and nucleic acids

Qualification-goals/Competencies:

- Understanding the principles of organic chemistry

Grading through:

- written exam

Requires:

- Basic Chemistry (LS1100-MML)

Responsible for this module:

- PD Dr. phil. nat. Thomas Weimar

Teacher:

- Institute of Chemistry and Metabolomics

- PD Dr. phil. nat. Thomas Weimar

Literature:

- Hart, H., L. E. Craine, D. J. Hart: Organische Chemie - Wiley-VCH
- Buddrus, J.: Organische Chemie - De Gruyter Verlag

Language:

- offered only in German

MA2600-KP04, MA2600 - Biostatistics 2 (BioStat2)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Master Biophysics (optional subject), Elective, 2nd semester
- Master Medical Informatics (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master Computer Science before 2014 (optional subject), specialization field medical informatics, 3rd semester
- Master Computer Science before 2014 (optional subject), specialization field bioinformatics, 2nd or 3rd semester
- Master Computer Science before 2014 (optional subject), advanced curriculum stochastics, 2nd semester
- Bachelor CLS (compulsory), mathematics, 4th semester
- Master Medical Informatics since 2019 in planing (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester

Classes and lectures:

- Biostatistics 2 (lecture, 2 SWS)
- Biostatistics 2 (exercise, 1 SWS)

Workload:

- 45 Hours in-classroom work
- 35 Hours private studies
- 25 Hours programming
- 15 Hours exam preparation

Contents of teaching:

- Knowledge of model assumptions and mathematical foundation of model assumptions for the linear model
- Knowledge of possible sources of errors in the modelling
- Competence in independent analysis of a study using the linear model
- Competence in correctly interpreting study results
- Competence in parameter interpretation and regression diagnostics
- Knowledge of model assumptions and mathematical foundation of the generalized linear model
- Competence in the independent analysis of a simple study with a dichotomous outcome
- Competence in correctly interpreting study results of a study with a dichotomous outcome

Qualification-goals/Competencies:

- Communication of knowledge of theoretical foundation of the general linear model and its application
- Communication of knowledge of theoretical foundation of the generalized linear model and its application to dichotomous endpoints

Grading through:

- Exercises
- written exam

Is requisite for:

- Multivariate Statistics (MA4944)
- Interdisciplinary Seminar (MA3300)

Requires:

- Biostatistics 1 (UngenutztMA1600-MML)
- Biostatistics 1 (MA1600-KP04, MA1600, MA1600-MML)

Responsible for this module:

- Prof. Dr. rer. biol. hum. Inke König

Teacher:

- Institute of Medical Biometry and Statistics

- Prof. Dr. rer. biol. hum. Inke König
- Dr. rer. hum. biol. Markus Scheinhardt

Literature:

- Ludwig Fahrmeir, Thomas Kneib, Stefan Lang: Regression: Modelle, Methoden und Anwendungen - ISBN-13 9783540339328
- Dobson, Annette J & Barnett, Adrian: An Introduction to Generalized Linear Models, 3rd ed. - Chapman & Hall/CRC: Boca Raton (FL), 2008

Language:

- offered only in German

MA2700 - Proseminar (Prosem)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4 (Typ B)

Course of study, specific field and term:

- Bachelor CLS (compulsory), Computational Life Science, 4th semester

Classes and lectures:

- Proseminar (seminar, 2 SWS)

Workload:

- 90 Hours oral presentation (including preparation)
- 30 Hours in-classroom work

Contents of teaching:

- Reading scientific literature

Qualification-goals/Competencies:

- Preparing and giving a scientific talk
- Practising scientific discussion
- Training of English language

Grading through:

- Oral presentation and written report

Requires:

- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)
- Analysis 2 (MA2500-MML)
- Analysis 1 (MA2000-KP08, MA2000)

Responsible for this module:

- PD Dr. rer. nat. Hanns-Martin Teichert

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Andreas Rößler
- PD Dr. rer. nat. Hanns-Martin Teichert

Language:

- offered only in English

MA4030-KP08, MA4030 - Optimization (Opti)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	8

Course of study, specific field and term:

- Minor in Teaching Mathematics, Bachelor of Arts (compulsory), mathematics, 8th semester
- Master Auditory Technology (optional subject), mathematics, 1st or 2nd semester
- Bachelor Computer Science since 2016 (optional subject), advanced curriculum, arbitrary semester
- Bachelor CLS starting 2016 (compulsory), mathematics, 4th semester
- Master MES since 2014 (optional subject), mathematics / natural sciences, arbitrary semester
- Master MES before 2014 (optional subject), mathematics, 2nd semester
- Master Computer Science before 2014 (optional subject), advanced curriculum numerical image processing, 2nd or 3rd semester
- Bachelor MES before 2014 (optional subject), Medical Engineering Science, 6th semester
- Master Computer Science before 2014 (optional subject), advanced curriculum analysis, 2nd or 3rd semester
- Bachelor CLS (compulsory), mathematics, 4th semester

Classes and lectures:

- Optimization (lecture, 4 SWS)
- Optimization (exercise, 2 SWS)

Workload:

- 130 Hours private studies and exercises
- 90 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Linear optimization (Simplex method)
- Unconstrained nonlinear optimization (gradient descent, Newton method, Quasi-Newton methods)
- Constrained nonlinear optimization (Lagrange multipliers)
- Discrete optimization

Qualification-goals/Competencies:

- Students can model real-life problems as optimization problems.
- They understand central optimization techniques.
- They can explain central optimization techniques.
- They can compare and assess central optimization techniques.
- They can implement central optimization techniques.
- They can assess numerical results.
- They can select suitable optimization techniques for practical problems.
- Interdisciplinary qualifications:
- Students can transfer theoretical concepts into practical solutions.
- They are experienced in implementation.
- They can think abstractly about practical problems.

Grading through:

- Exercises
- Presentation of one´s own solution of an exercise
- written exam

Is requisite for:

- Multi- and High-Dimensional Data Processing (MA5036-KP05)
- Non-smooth Optimization and Analysis (MA5035-KP05)

Requires:

- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Analysis 2 (MA2500-KP09)
- Analysis 2 (MA2500-KP04, MA2500)

Responsible for this module:

- Prof. Dr. rer. nat. Jan Modersitzki

Teacher:

- Institute of Mathematics and Image Computing

- Prof. Dr. rer. nat. Jan Modersitzki
- Prof. Dr. rer. nat. Jan Lellmann

Literature:

- J. Nocedal, S. Wright: Numerical Optimization - Springer
- F. Jarre: Optimierung - Springer
- C. Geiger: Theorie und Numerik restringierter Optimierungsaufgaben - Springer

Language:

- offered only in German

Notes:

Prerequisite tasks for taking the exam can be announced at the beginning of the semester. If any prerequisite tasks are defined, they must be completed and passed before taking the exam for the first time.

MA4040-MML - Numerics 2 (Num2MML)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	6

Course of study, specific field and term:

- Bachelor CLS (compulsory), mathematics, 4th semester

Classes and lectures:

- Numerics 2 (lecture, 2 SWS)
- Numerics 2 (exercise, 2 SWS)

Workload:

- 100 Hours private studies and exercises
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Polynomial interpolation
- Hermite interpolation
- Approximation
- Numerical quadrature

Qualification-goals/Competencies:

- Becoming acquainted with fundamental munerical methods
- Understanding the transformation of a continuous problem into a discrete one
- Secure competencies in using both stable and robust numeric algorithms
- Experience in the implementation of practical tasks

Grading through:

- Exercises
- programming exercises
- written exam

Requires:

- Numerics 1 (MA3110-MML)
- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)
- Analysis 2 (MA2500-MML)
- Analysis 1 (MA2000-KP08, MA2000)

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Rößler

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Andreas Rößler

Literature:

- M. Bollhöfer, V. Mehrmann: Numerische Mathematik - Vieweg (2004)
- P. Deuflhard, A. Hohmann: Numerische Mathematik I - 4. Auflage, De Gruyter (2008)
- P. Deuflhard, F. Bornemann: Numerische Mathematik II - 3. Auflage, De Gruyter (2008)
- M. Hanke-Bourgeois: Grundlagen der Numerischen Mathematik und des Wissenschaftlichen Rechnens - 3. Aufl., Teubner (2009)
- H. R. Schwarz, N. Köckler: Numerische Mathematik - 6. Auflage, Teubner (2006)
- J. Stoer: Numerische Mathematik I - 10. Auflage, Springer (2007)
- J. Stoer, R. Bulirsch: Numerische Mathematik II - 5. Auflage, Springer (2005)
- A. M. Quarteroni, R. Sacco, F. Salieri: Numerical Mathematics - 2. Auflage, Springer (2006)

Language:

- offered only in German

Notes:

The lecture is identical to that in module MA4040/Numerics 2

ME1500 - Fundamentals of Physics (GrundPhys)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Bachelor Computer Science 2014 and 2015 (compulsory), specialization field bioinformatics, 4th semester
- Bachelor CLS (compulsory), life sciences, 4th semester
- Bachelor Computer Science before 2014 (compulsory), specialization field bioinformatics, 2nd semester

Classes and lectures:

- Fundamentals of Physics (lecture, 2 SWS)
- Fundamentals of Physics (exercise, 1 SWS)

Workload:

- 60 Hours private studies and exercises
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Mechanics: Newton s laws, laws of conversation, molecular dynamics, flow in vascular system
- Mechanical oscillations and waves: wave propagation, ultrasound, Doppler effect
- Thermodynamics: temperature, entropy, ideal gas, laws of thermodynamics
- Electricity & magnetism: electrostatic field, Coulomb s law, Ohm s law, Lorentz force, oscillating circuit, electromagnetic waves
- Optics: wave optics, polarization, geometrical optics, law of reflection, image equation
- Atomic physics: atomic structure, radioactivity, X-ray tube

Qualification-goals/Competencies:

- The students are able to describe the content of the fundamentals of physics and to develop and draw mathematically the corresponding models by use of physical formula.
- They can judge what fundamental physics can and cannot achieve in principle.
- They are able to transfer their acquired knowledge to simple practical applications.
- They are able to classify physical problems according to their complexity and draw the solutions. Thereby, they have the expertise to first analyze complex tasks and to structure them into subtasks.
- The students have social and communication competencies to discuss within smaller tutorial groups and the methodological competence to elucidate a common solution for the physical exercises.
- They have the communication competency to present their results in front of the tutorial group.

Grading through:

- Exercises
- written exam

Responsible for this module:

- Prof. Dr. rer. nat. Alfred Vogel

Teacher:

- Institute of Biomedical Optics

- Dr. rer. nat. Norbert Linz

Literature:

- Giancoli: Physik

Language:

- offered only in German

CS2300 - Software Engineering I (SWTech)

Duration:	Turnus of offer:	Credit points:	Max. group size:
2 Semester	each winter semester	8	12

Course of study, specific field and term:

- Bachelor Medical Informatics before 2014 (compulsory), computer science, 3rd and 4th semester
- Bachelor CLS (optional suject), computer science, 5th and 6th semester
- Bachelor Computer Science before 2014 (compulsory), foundations of computer science, 3rd and 4th semester

Classes and lectures:

- Software Engineering I (lecture, 2 SWS)
- Software Engineering I (exercise, 1 SWS)
- Software Engineering I (project work, 3 SWS)

Workload:

- 60 Hours private studies and exercises
- 45 Hours in-classroom work
- 45 Hours in-classroom work
- 40 Hours group work
- 35 Hours work on project
- 15 Hours exam preparation

Contents of teaching:

- overview on major fields of software engineering
- Software development, software process models
- Basic concepts of software sysems
- System analysis and requirements engineering
- Software design and software architectures
- Implementation
- Testing and integration
- Installation, acceptance, maintainance

Qualification-goals/Competencies:

- Understanding software design as an engineering process
- Kowledge of major software process models and description formalisms for software artefacts
- Ability to model software systemson different levels of abtraction
- Ability to systematically design software systems whose implemention meets the requirements
- Knowing the basic concepts of object-oriented modelling and design
- Usage of UML and CASE tools
- Qualification to work in a team,to present artefacts, to comply tostandards and to observe time limits

Grading through:

- Exercises
- programming project
- Written or oral exam as announced by the examiner

Requires:

- Algorithms and Data Structures (CS1001-KP08, CS1001)
- Programming (CS1000)

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages

- Prof. Dr. Martin Leucker

Literature:

- H. Balzert: Lehrbuch der Software-Technik: Software-Entwicklung - Spektrum Akademischer Verlag 2001
- B. Brügge, A. H. Dutoit: Objektorientierte Softwaretechnik mit UML, Entwurfsmustern und Java - Pearson Studium 2004
- I. Sommerville: Software Engineering - Addison-Wesley 2006
- B. Oestereich: Analyse und Design mit der UML 2.1 - Objektorientierte Softwareentwicklung - Oldenbourg 2006

- D. Bjorner: Software Engineering 1-3 - Springer 2006

Language:

- offered only in German

CS1500-KP04, CS1500 - Introduction to Robotics and Automation (ERA)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Bachelor Medical Informatics since 2019 in planning (optional subject), medical computer science, 4th to 6th semester
- Bachelor Computer Science since 2016 (optional subject), Introductory Module Computer Science, 1st semester
- Bachelor Biophysics (compulsory), Elective Computer Science, 5th semester
- Bachelor Robotics and Autonomous Systems (compulsory), Robotics and Autonomous Systems, 1st semester
- Bachelor Medical Informatics since 2014 (optional subject), medical computer science, 5th or 6th semester
- Bachelor Computer Science 2014 and 2015 (compulsory), specialization field robotics and automation, 1st semester
- Bachelor CLS (optional subject), computer science, 5th or 6th semester
- Bachelor MES before 2014 (optional subject), Medical Engineering Science, 5th semester
- Bachelor Computer Science before 2014 (compulsory), specialization field robotics and automation, 1st semester

Classes and lectures:

- Introduction to Robotics and Automation (lecture, 2 SWS)
- Introduction to Robotics and Automation (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Introduction
- Control systems
- Programmable Logic Controller (PLC)
- Combinatorial control
- Sequential control
- Feedback control systems
- Plants
- PID controller
- Controller parameterization
- Autonomous mobile robots
- AI-paradigms
- Elementary and emergent behaviors
- Signal acquisition and processing
- Actuators

Qualification-goals/Competencies:

- The students are able to explain the principles of control systems.
- The students are able to design combinatorial and sequential control systems.
- The students are able to program simple application problems as PLC-program in the IEC-languages.
- The students are able to analyze closed-loop controlled systems (plants) and to select and parameterize a suitable feedback PID controller.
- The students are able to present the principal structure and functionality of autonomous wheel-driven robots.
- The students are able to program simple autonomous robots in a behavior-based way..

Grading through:

- Lab exercises
- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering

- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- J. L. Jones, D. Roth: Robot Programming - A Practical Guide to Behavior-Based Robotics - New York: Mc Graw Hill 2004
- J. Knespl: Automatisierungstechnik 1 - Regelungstechnik - Köln: Stam-Verlag 1999
- R. R. Murphy: Introduction to AI Robotics - Cambridge, MA: The MIT Press 2000
- G. Wellenreuther, D. Zastrow: Automatisieren mit SPS - Theorie und Praxis - Braunschweig: Vieweg 2008

Language:

- offered only in German

Notes:

Computer Science students get a B certificate.

CS1600-KP04, CS1600 - Introduction to Media Informatics (EinMedien)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Bachelor Media Informatics (compulsory: aptitude test), media informatics, 1st semester
- Bachelor CLS (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science before 2014 (compulsory), specialization field media informatics, 1st semester

Classes and lectures:

- Introduction to Media Informatics (lecture, 2 SWS)
- Introduction to Media Informatics (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Overview of the lecture
- Social context
- Terms and theories of media
- Milestones of media technology
- Interactive media technologies
- Multimeda applications
- Human-centered media
- Designing interactive media
- Development processes for interactive media
- Ethics of new media
- Summary

Qualification-goals/Competencies:

- The students know the structure and the most important contents of media informatics.
- They are prepared for the following media informatics lectures.
- They know the main tasks and fields of work in media informatics.
- They know the challenges and requirements of designing interactive multimedia systems.

Grading through:

- Exercises
- written exam

Is requisite for:

- Interaction Design (CS2600-KP08, CS2600SJ14)

Responsible for this module:

- Prof. Dr.-Ing. Nicole Jochems

Teacher:

- Institute for Multimedia and Interactive Systems

- Prof. Dr.-Ing. Nicole Jochems

Literature:

- M. Herczeg: Einführung in die Medieninformatik - Oldenbourg-Verlag, 2007
- R. Malaka et al.: Medieninformatik - Eine Einführung - Pearson Verlag, 2009

Language:

- offered only in German

CS3000-KP04, CS3000 - Algorithm Design (AlgoDesign)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Bachelor Medical Informatics since 2019 in planning (optional subject), computer science, 4th to 6th semester
- Bachelor Computer Science since 2016 (compulsory), foundations of computer science, 5th semester
- Master CLS starting 2016 (optional subject), computer science, 3rd semester
- Bachelor Robotics and Autonomous Systems (optional subject), computer science, 5th or 6th semester
- Bachelor IT-Security (compulsory), computer science, 5th semester
- Bachelor Medical Informatics since 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2014 and 2015 (compulsory), foundations of computer science, 5th semester
- Bachelor CLS (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science before 2014 (compulsory), foundations of computer science, 5th semester

Classes and lectures:

- Algorithm Design (lecture, 2 SWS)
- Algorithm Design (exercise, 1 SWS)

Workload:

- 65 Hours private studies and exercises
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Dynamic programming and heuristic search methods
- Complex data structures and union find data structures
- Efficiency analysis and correctness proofs
- Probabilistic algorithms
- Online algorithms
- Graph, matching and scheduling problems
- String processing
- Approximation algorithms

Qualification-goals/Competencies:

- Knowledge of the principles of algorithm design
- Being able to apply these principles to concrete problems
- Proficiency in solving algorithmic problems

Grading through:

- exercises and project assignments
- written exam

Requires:

- Stochastics 1 (MA2510-KP04, MA2510)
- Theoretical Computer Science (CS2000-KP08, CS2000)
- Algorithms and Data Structures (CS1001-KP08, CS1001)

Responsible for this module:

- Prof. Dr. Rüdiger Reischuk

Teacher:

- Institute for Theoretical Computer Science

- Prof. Dr. Rüdiger Reischuk
- Prof. Dr. rer. nat. Till Tantau

Literature:

- J. Kleinberg, E. Tardos: Algorithm Design - Addison Wesley, 2005
- T. Cormen, C. Leiserson, R. Rivest, C. Stein: Introduction to Algorithms - MIT Press, 2009
- S. Skiena: The Algorithmic Design Manual - Springer, 2012

Language:

- offered only in German

CS3052-KP04, CS3052 - Programming Languages and Type Systems (ProgLan14)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Bachelor Media Informatics (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science since 2016 (optional subject), major subject informatics, arbitrary semester
- Bachelor Computer Science since 2016 (optional subject), Canonical Specialization Web and Data Science from WS19, 3rd semester
- Bachelor Computer Science since 2016 (compulsory), Canonical Specialization SSE, 3rd semester
- Bachelor Computer Science before 2014 (optional subject), central topics of computer science, 5th or 6th semester
- Bachelor Computer Science before 2014 (compulsory), specialization field IT security and safety, 4th semester
- Master Computer Science before 2014 (compulsory), advanced curriculum programming, 2nd or 3rd semester
- Bachelor IT-Security (optional subject), computer science, arbitrary semester
- Bachelor CLS (optional suject), computer science, 5th or 6th semester
- Bachelor Computer Science 2014 and 2015 (optional subject), central topics of computer science, 5th semester
- Bachelor Computer Science 2014 and 2015 (compulsory), specialization field IT security and safety, 5th semester

Classes and lectures:

- Progamming Languages and Type Systems (lecture, 2 SWS)
- Progamming Languages and Type Systems (exercise, 1 SWS)

Workload:

- 60 Hours private studies and exercises
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Overview on programming languages
- Syntactic description of programming languages
- Language elements for data structures
- Type systems for programming languages
- Language elements for control structures
- Language elements for abstraction and modularization
- Typing and type systems
- Semantics of programming languages
- Language paradigms
- Language elements for concurrent programming
- Tools for programming languages

Qualification-goals/Competencies:

- The students can characterize major programming languages and can compare their application domains.
- They can understand, adapt and extend syntacic and semantic descriptions of programming languages.
- They can analyse the structure and principles of programming languages.
- They can learn on their own and classify new language elements.
- They can argue on the support of type systems for writing correct programs.
- The can evaluate possible programming languages for an application.

Grading through:

- Exercises
- Written or oral exam as announced by the examiner

Requires:

- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)
- Algorithms and Data Structures (CS1001-KP08, CS1001)
- Introduction to Programming (CS1000-KP10, CS1000SJ14)

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages

- Dr. Annette Stümpel
- Prof. Dr. Martin Leucker

Literature:

- K.C. Louden: Programming Languages: Principles and Practice - Course Technology 2011
- J.C. Mitchell: Concepts in Programming Languages - Cambridge University Press 2003
- T.W. Pratt, M.V. Zelkowitz: Programming Languages: Design and Implementation - Prentice Hall 2000
- R.W. Sebesta: Concepts of Programming Languages - Pearson Education 2012
- R. Sethi: Programming Languages: Concepts and Constructs - Addison-Wesley 2003
- D.A. Watt: Programming Language Design Concepts - John Wiley & Sons 2004
- G. Winskel: The Formal Semantics of Programming Languages - MIT Press 1993

Language:

- German and English skills required

Notes:

CS2000 Theoretical Computer Science is a recommended companion.

CS3110-KP04, CS3110 - Computer-Aided Design of Digital Circuits (SchaltEntw)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly in the winter semester	4

Course of study, specific field and term:

- Bachelor Computer Science since 2016 (optional subject), major subject informatics, arbitrary semester
- Bachelor Robotics and Autonomous Systems (optional subject), computer science, 5th or 6th semester
- Bachelor IT-Security (optional subject), computer science, arbitrary semester
- Bachelor MES since 2014 (optional subject), computer science and electrical engineering, 5th or 6th semester
- Bachelor Computer Science 2014 and 2015 (optional subject), central topics of computer science, 5th or 6th semester
- Bachelor MES before 2014 (optional subject), applied computer science, 3rd, 5th, or 6th semester
- Bachelor CLS (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science before 2014 (optional subject), central topics of computer science, 5th or 6th semester

Classes and lectures:

- Computer-Aided Design of Digital Circuits (lecture, 2 SWS)
- Computer-Aided Design of Digital Circuits (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Abstraction levels in circuit design
- Design cycle and design strategies
- FPGA architectures
- Introduction of the hardware description language VHDL
- Design of standard components in VHDL
- Circuit design at different abstraction levels
- Circuit design for synthesis
- VHDL simulation cycle
- VHDL circuit design for FPGAs
- Designing Testbenches
- High-Level-Synthesis

Qualification-goals/Competencies:

- Based on a non-formal description of a digital system, students are able to design digital circuits using VHDL
- They are able to simulate and test VHDL descriptions
- They are able to explain the internal structures of FPGAs
- They are able to determine which VHDL construct will result in which circuit structure
- They are able to explain the VHDL simulation cycle
- They are able to write synthesizable VHDL code

Grading through:

- Exercises
- Oral examination
- written exam

Requires:

- Fundamentals of Computer Engineering 2 (CS1202-KP06, CS1202)

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering

- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- F. Kesel, R. Bartholomä: Entwurf von digitalen Schaltungen und Systemen mit HDLs und FPGAs - Oldenbour Verlag 2009

- C.Maxfield: The Design Warrior's Guide to FPGAs - Newnes 2004

Language:

- offered only in German

CS3200 - Software Engineering II (SWEng)

Duration:	Turnus of offer:	Credit points:
1 Semester	not available anymore	4

Course of study, specific field and term:

- Bachelor Medical Informatics before 2014 (optional subject), software engineering, 4th to 6th semester
- Bachelor CLS (optional subject), computer science, 5th or 6th semester
- Bachelor MES before 2014 (compulsory), foundations of computer science, 5th semester
- Bachelor Computer Science before 2014 (compulsory), foundations of computer science, 5th semester

Classes and lectures:

- Software Engineering II (lecture, 2 SWS)
- Software Engineering II (exercise, 1 SWS)

Workload:

- 60 Hours private studies and exercises
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Introduction to software engineering
- Software management
- Software quality assurance
- Software evolution
- Software reuse
- Re-engineering and phase-out
- Software productivity, expense, and estimation
- Legal aspects

Qualification-goals/Competencies:

- Knowing the basic procedures of software engineering
- Quality awareness
- Knowing activities and factors of software management
- Ability to organize software projects and to evaluate software engineering processes
- Understanding software evolution

Grading through:

- Exercises
- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages

- PD Dr. Gerhard Buntrock

Literature:

- H. Balzert: Lehrbuch der Software-Technik: Software-Management, Software-Qualitätssicherung - Akademischer Verlag 1998
- A. Behforooz, F. J. Hudson: Software Engineering Fundamentals - Oxford University Press 1996
- C. Ghezzi, M. Jazayeri, D. Mandrioli: Fundamentals of Software Engineering - Prentice Hall 2002
- B. Hughes, M. Cotterell: Software Project Management - McGraw-Hill 1999
- I. Sommerville: Software Engineering - Addison Wesley 2006

Language:

- offered only in German

CS5159 - Ubiquitous Computing (UbiqComp)		
Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	not available anymore	4

Course of study, specific field and term:

- Master CLS (optional subject), mathematics, 2nd or 3rd semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester
- Master Computer Science before 2014 (optional subject), advanced curriculum organic computing, 2nd or 3rd semester
- Master Computer Science before 2014 (optional subject), specialization field media informatics, 2nd or 3rd semester

Classes and lectures:

- Ubiquitous Computing (lecture with exercises, 3 SWS)

Workload:

- 60 Hours private studies and exercises
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- The
- Technology trends: information technology, new materials
- Wireless communication and mobile computing
- Spontaneous networking
- Context awareness: location, context, and situation
- Smart labels (RFIDs) and wireless chipcards
- Embedded systems and sensors
- Energy aspects
- Wearable computing
- Interaction with invisible computers
- Software infrastructures
- Selected research projects
- Applications scenarios
- Social implications

Qualification-goals/Competencies:

- Understand fundamental challenges, concepts, approaches, and limitations of UC
- Follow and judge recent UC research papers
- Design, implementation, and analysis of exemplary UC systems

Grading through:

- Viva Voce or test

Responsible for this module:

- Prof. Dr.-Ing. Thilo Pionteck (Nachfolger NN)

Teacher:

- Institute of Computer Engineering

- Prof. Dr.-Ing. Thilo Pionteck (Nachfolger NN)

Literature:

- Friedemann Mattern (Ed.): Die Informatisierung des Alltags - Leben in smarten Umgebungen - Springer-Verlag, 2007
- Elgar Fleisch, Friedemann Mattern (Eds.): Das Internet der Dinge - Ubiquitous Computing und RFID in der Praxis - Springer-Verlag, 2005

Language:

- offered only in German

MA3445-KP04, MA3445 - Graph Theory (Graphen)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second year	4

Course of study, specific field and term:

- Bachelor Medical Informatics since 2019 in planning (optional subject), mathematics, 4th to 6th semester
- Bachelor IT-Security (optional subject), mathematics, arbitrary semester
- Bachelor Robotics and Autonomous Systems (optional subject), mathematics, 5th or 6th semester
- Bachelor Medical Informatics since 2014 (optional subject), mathematics, 5th or 6th semester
- Master MES since 2014 (optional subject), mathematics / natural sciences, 1st or 2nd semester
- Bachelor Computer Science 2014 and 2015 (optional subject), central topics of computer science, 5th or 6th semester
- Master CLS (optional subject), mathematics, arbitrary semester
- Master MES before 2014 (optional subject), mathematics, 1st or 2nd semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester
- Bachelor Computer Science before 2014 (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Graph theory (lecture, 2 SWS)
- Graph theory (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Hamiltonian graphs and degree sequences
- Menger's theorem - new proofs
- Matchings and decompositions of graphs
- The theorems of Turan and Ramsey
- Vertex and edge colourings
- The four colour theorem

Qualification-goals/Competencies:

- Ability to solve discrete problems using graph theoretical methods
- Knowledge of proof techniques and ideas of discrete mathematics
- Knowledge of fundamental and selected recent research results

Grading through:

- Exercises
- Oral examination

Requires:

- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)

Responsible for this module:

- PD Dr. rer. nat. Hanns-Martin Teichert

Teacher:

- Institute for Mathematics

- PD Dr. rer. nat. Hanns-Martin Teichert

Literature:

- F. Harary: Graph Theory - Reading, MA:.Addison-Wesley 1969
- R. Diestel: Graphentheorie - Berlin: Springer 2000
- D. Jungnickel: Graphen, Netzwerke und Algorithmen - Mannheim: BI-Wissenschaftsverlag1994
- J. Bang-Jensen, G. Gutin: Digraphs: Theory, Algorithms and Applications - London: Springer 2001
- B. Bollobas: Modern Graph Theory - Berlin: Springer 1998

Language:

- offered only in German

MA4400 - Chaos and Complexity of Biological Systems (CKBS)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Bachelor CLS (optional subject), mathematics, 5th or 6th semester
- Master MES before 2014 (optional subject), mathematics, 1st or 2nd semester
- Master Computer Science before 2014 (optional subject), specialization field bioinformatics, 2nd or 3rd semester
- Master MES before 2014 (advanced curriculum), biophysics and biomedical optics, 1st or 2nd semester
- Master CLS (optional subject), mathematics, arbitrary semester

Classes and lectures:

- Chaos and Complexity of Biological Systems (lecture, 2 SWS)
- Chaos and Complexity of Biological Systems (exercise, 1 SWS)

Workload:

- 65 Hours private studies and exercises
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Time-discrete dynamical systems and stochastic processes
- Nonlinearity and chaos
- Ergodicity
- Symbolic dynamics
- Information-theoretic complexity measures
- Ordinal time series analysis
- Biological and medical applications, in particular EEG analysis

Qualification-goals/Competencies:

- Students get insights into basic aspects of nonlinear dynamics
- They have skills in analyzing and modeling complex data and time series
- They have competencies in simulating and illustrating nonlinear dynamic phenomena

Grading through:

- Exercises
- Written or oral exam as announced by the examiner

Requires:

- Stochastics 1 (MA2510-KP04, MA2510)
- Analysis 1 (MA2000-KP08, MA2000)

Responsible for this module:

- Prof. Dr. rer. nat. Karsten Keller

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Karsten Keller

Literature:

- M. Brin, G. Stuck: Introduction to Dynamical Systems - Cambridge University Press 2002
- J. M. Amigó: Permutation Complexity in Dynamical Systems - Springer 2010
- R. L. Devaney: An Introduction to Chaotic Dynamical Systems - Westview Press 2003

Language:

- depends on the chosen courses

Notes:

lecture notes in English

Prerequisites for admission to the examination can be determined at the beginning of the semester. If such prerequisites are defined, they must have been fulfilled prior to the first attempt at the examination and must have been rated as positive.

MA4410 - Approximation Theory (Approx)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Bachelor CLS (optional subject), mathematics, 5th or 6th semester
- Master Computer Science before 2014 (optional subject), advanced curriculum analysis, 2nd or 3rd semester
- Master CLS (optional subject), mathematics, arbitrary semester

Classes and lectures:

- Approximation theory (lecture, 2 SWS)
- Approximation theory (exercise, 1 SWS)

Workload:

- 65 Hours private studies and exercises
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Fundamentals of functional analysis
- Best approximation
- Linear methods, trigonometric kernels
- Theorems of Jackson and Bernstein
- Moduli of continuity
- Singular integrals
- Theorem of Banach--Steinhaus
- Interpolation methods
- Stability inequalities

Qualification-goals/Competencies:

- Learning the basic principles of approximation theory
- Understanding the relationship between order of convergence and smoothness
- Knowledge of the basic approximation methods

Grading through:

- Exercises
- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Jürgen Prestin

Literature:

- P. L. Butzer, R. J. Nessel: Fourier Analysis and Approximation - Birkhäuser Verlag 1971
- A. Schönhage: Approximationstheorie - de Gruyter 1971

Language:

- English, except in case of only German-speaking participants

MA4420 - Mathematics of Linear Inverse Problems (MathInvPro)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Master CLS (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Mathematics of Linear Inverse Problems (lecture, 2 SWS)
- Mathematics of Linear Inverse Problems (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Ill-posed linear operator equations
- Spectral decomposition of compact operators
- Stabilization of ill-posed problems
- Regularization methods
- Numerical realization
- Application examples of linear inverse problems

Qualification-goals/Competencies:

- Study of the mathematical theory and the regularization possiblities of ill-posed linear inverse problems
- Learning analytical and numerical methods for the solution of linear inverse problems

Grading through:

- Exercises
- Oral examination

Responsible for this module:

- Dr. rer. nat. Wolfgang Erb

Teacher:

- Institute for Mathematics

- Dr. rer. nat. Wolfgang Erb

Literature:

- Engl, Hanke, Neubauer: Regularization of Inverse Problems - Kluwer, 2000
- Kirsch: An Introduction to the Mathematical Theory of Inverse Problems - Springer, 1996
- Louis: Inverse und schlecht gestellte Probleme - Teubner, 1989
- Rieder: Keine Probleme mit Inversen Problemen - Vieweg, 2003

Language:

- offered only in German

MA4430 - Approximation on Spheres (ApproxSph)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Master CLS (optional subject), mathematics, arbitrary semester
- Master Computer Science before 2014 (optional subject), advanced curriculum analysis, 2nd or 3rd semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Approximation on spheres (lecture, 2 SWS)
- Approximation on spheres (exercise, 1 SWS)

Workload:

- 65 Hours private studies and exercises
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Polynomial systems on spheres
- Approximation methods
- Fast algorithms
- Scattered data

Qualification-goals/Competencies:

- Learning the basic principles of approximation theory on spheres
- Understanding the function systems on spheres
- Knowledge of the basic approximation methods on spheres

Grading through:

- Exercises
- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Jürgen Prestin

Literature:

- V. Michel: Lectures on Constructive Approximation - Fourier, Spline, and Wavelet Methods on the Real Line, the Sphere, and the Ball - Birkhäuser Verlag, Boston, 2013
- W. Freeden, T. Gervens, and M. Schreiner: Constructive Approximation on the Sphere (With Applica- tions to Geomathematics) - Oxford Science Publication, Clarendon Press, 1998

Language:

- English, except in case of only German-speaking participants

MA4451 - Evolutionary Dynamics (EvoDyn)

Duration:	Turnus of offer:	Credit points:
1 Semester	not available anymore	4

Course of study, specific field and term:

- Master CLS (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Evolutionary Dynamics (lecture, 2 SWS)
- Evolutionary Dynamics (exercise, 1 SWS)

Workload:

- 65 Hours private studies
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Stochastic models of population genetics
- Dynamic systems
- Basics of classical game theory
- Evolutionary game theory
- Applications of evolutionary dynamics to medical problems

Qualification-goals/Competencies:

- Knowledge of elementary models in evolutionary dynamics
- Basic knowledge in game theory
- Modelling and simulation competence

Grading through:

- Exercises
- Oral examination

Responsible for this module:

- Prof. Dr. Arne Traulsen

Teacher:

- Institute for Mathematics

- Prof. Dr. Arne Traulsen
- Andere Dozenten

Literature:

- M.A. Nowak: Evolutionary Dynamics - Exploring the equations of life - Harvard University Press, 2006
- J. Hofbauer and K. Sigmund: Evolutionary Games and Population Dynamics - Cambridge University Press, 1998

Language:

- offered only in English

MA4452 - Evolutionary Game Theory - from Basics to Recent Developments (EvoGameTh)

Duration:	Turnus of offer:	Credit points:
1 Semester	not available anymore	4

Course of study, specific field and term:

- Master CLS (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Evolutionary Game Theory - from Basics to Recent Developments (lecture, 2 SWS)
- Evolutionary Game Theory - from Basics to Recent Developments (blockseminar (compact course), 1 SWS)

Workload:

- 65 Hours private studies
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Basics of classical game theory
- Deterministic and stochastic evolutionary game theory
- The evolution of cooperation and punishment
- Repeated games
- Adaptive dynamics

Qualification-goals/Competencies:

- Familiarity with mathematical concepts of classical and evolutionary game theory
- Understanding of recent developments and recently published literature in the field
- Familiarity with scientific communication at the interface between applied mathematics and biology

Grading through:

- written summary of an original research paper
- Oral presentation

Responsible for this module:

- Prof. Dr. Arne Traulsen

Teacher:

- Institute for Mathematics

- Prof. Dr. Arne Traulsen
- Andere Dozenten

Literature:

- M.A. Nowak: Evolutionary Dynamics - Exploring the equations of life - Harvard University Press, 2006
- K. Sigmund: The calculus of selfishness - Princeton University Press, 2010

Language:

- offered only in English

Notes:

The lecture is offered in German only if desired by all participants.

MA4453 - Evolutionary Dynamics: Population Genetic and Ecological Models (EvDyPopEco)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Master CLS (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Evolutionary Dynamics: Population Genetic and Ecological Models (lecture, 2 SWS)
- Evolutionary Dynamics: Population Genetic and Ecological Models (exercise, 1 SWS)

Workload:

- 65 Hours private studies
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Basics of mathematical population genetics
- Discrete stochastic models
- Genetic drift
- Natural selection
- Diffusion approximation
- Coupling of genetic and ecological models

Qualification-goals/Competencies:

- The students can explain the basic biological and mathematical concepts of population genetics.
- The students can construct simple stochastic models and analyse them formally.
- The students can perform approximations of simple models.

Grading through:

- Exercises
- Oral examination

Responsible for this module:

- Prof. Dr. Arne Traulsen

Teacher:

- Institute for Mathematics

- Prof. Dr. Arne Traulsen
- N.N.

Literature:

- J. H. Gillespie: Population genetics - A concise guide - Johns Hopkins University Press, 2004

Language:

- offered only in English

Notes:

The lecture is offered in German only if desired by all participants.

For admission to the oral exam students must have obtained at least 50% of the points in the exercises.

MA4454 - Evolutionary Dynamics: Game Theory (EvDyGameTh)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Master CLS (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Evolutionary Game Theory - from Basics to Recent Developments (lecture, 2 SWS)
- Evolutionary Game Theory - from Basics to Recent Developments (exercise, 1 SWS)

Workload:

- 65 Hours private studies
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Basics of classical game theory
- Deterministic and stochastic evolutionary game theory
- The evolution of cooperation and punishment
- Repeated games
- Applications in genetics, ecology and social dynamics

Qualification-goals/Competencies:

- The students can explain and apply the basic concepts of game theory.
- They can construct evolutionary models based on game theoretic interactions.
- They can analyse evolutionary games formally.

Grading through:

- Exercises
- Oral examination

Responsible for this module:

- Prof. Dr. Arne Traulsen

Teacher:

- Institute for Mathematics

- Prof. Dr. Arne Traulsen
- N.N.

Literature:

- M.A. Nowak: Evolutionary Dynamics - Exploring the equations of life - Harvard University Press, 2006
- Broom & Rychtar: Game-Theoretical Models in Biology - Chapman & Hall, 2013

Language:

- offered only in English

Notes:

The lecture is offered in German only if desired by all participants.

For admission to the oral exam students must have obtained at least 50% of the points in the exercises.

MA4611 - Markov-Prozesse (MarkovProz)

Duration:	Turnus of offer:	Credit points:
1 Semester	not available anymore	4

Course of study, specific field and term:

- Master CLS (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Markov-Prozesse (lecture, 2 SWS)
- Markov-Prozesse (exercise, 1 SWS)

Workload:

- 60 Hours private studies and exercises
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

Grading through:

- Exercises
- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. rer. nat. Karsten Keller

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Karsten Keller
- Prof. Dr. rer. nat. Jürgen Prestin

Language:

- offered only in German

MA4614 - Numerical methods for partial differential equations (NumMethPDE)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Bachelor CLS (optional subject), mathematics, 5th or 6th semester
- Master CLS (optional subject), mathematics, arbitrary semester

Classes and lectures:

- Numerical methods for partial differential equations (lecture, 2 SWS)
- Numerical methods for partial differential equations (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Numerics for partial differential equations
- Discretization of initial and boundary value problems
- Numerical approximation schemes
- Error analysis
- Stability and consistency

Qualification-goals/Competencies:

- To impart basic principles of numerics for partial differential equations
- To learn methods of proofs as well as the application of results from numerics for partial differential equations
- Accomplished handling of essential concepts and results as well as of selected advanced topics

Grading through:

- Exercises
- Written or oral exam as announced by the examiner

Requires:

- Numerics 2 (MA4040-MML)
- Numerics 1 (MA3110-MML)
- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)
- Analysis 2 (MA2500-MML)
- Analysis 1 (MA2000-KP08, MA2000)

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Rößler

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Andreas Rößler
- MitarbeiterInnen des Instituts

Language:

- offered only in German

Notes:

Literature will be announced in the lecture.

Criteria for admission to the examination will be established by the lecturer.

MA4615 - Numerical methods for stochastic processes (NumStochPr)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Master MES before 2014 (optional subject), mathematics, 1st or 2nd semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester
- Master CLS (optional subject), mathematics, arbitrary semester

Classes and lectures:

- Numerical methods for stochastic processes (lecture, 2 SWS)
- Numerical methods for stochastic processes (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Basic principles of stochastic processes in continuous time
- Stochastic differential equations
- Discrete time approximations for solutions of stochastic differential equations
- Numerical schemes for strong and weak approximations

Qualification-goals/Competencies:

- To impart basic principles of stochastic processes and of some numerical schemes
- To learn methods of proof as well as the application of algorithms
- Accomplished handling of essential concepts and results as well as of selected advanced topics

Grading through:

- Exercises
- Written or oral exam as announced by the examiner

Requires:

- Stochastics 2 (MA4020-KP04, MA4020)
- Stochastics 1 (MA2510-KP04, MA2510)

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Rößler

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Andreas Rößler

Literature:

- P. E. Kloeden, E. Platen: Numerical Solution of Stochastic Differential Equations - Springer-Verlag, Berlin, 1999
- P. E. Kloeden, E. Platen, H. Schurz: Numerical Solution of SDE Through Computer Experiments - Springer-Verlag, Berlin, 2002
- G. N. Milstein, M. V. Tretyakov: Stochastic Numerics for Mathematical Physics - Springer-Verlag, Berlin, 2004

Language:

- offered only in German

Notes:

Criteria for admission to the examination will be established by the lecturer.

MA4616 - Advanced Numerics (HoehereNum)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Master MES before 2014 (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester
- Master CLS (optional subject), mathematics, arbitrary semester

Classes and lectures:

- Advanced Numerics (lecture, 2 SWS)
- Advanced Numerics (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Numerics for ordinary differential equations
- One-step methods, local and global error analysis
- Orders of consistence and convergence
- Stiff differentual equations, implicit schemes, stability

Qualification-goals/Competencies:

- To impart basic principles of numerics for differential equations
- To learn methods of proofs as well as the application of results from numerics for differential equations
- Accomplished handling of essential concepts and results as well as of selected advanced topics

Grading through:

- Exercises
- Written or oral exam as announced by the examiner

Requires:

- Numerics 2 (MA4040-MML)
- Numerics 2 (MA4040)
- Numerics 1 (MA3110-MML)
- Numerics 1 (MA3110-KP04, MA3110)

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Rößler

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Andreas Rößler

Language:

- offered only in German

Notes:

Literature will be announced in the lecture.

Criteria for admission to the examination will be established by the lecturer.

MA4630 - Fourier Analysis (FourierAna)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Bachelor CLS (optional suject), mathematics, 5th or 6th semester
- Master MES before 2014 (optional subject), mathematics, 1st or 2nd semester
- Master CLS (optional subject), mathematics, arbitrary semester

Classes and lectures:

- Fourier Analysis (lecture, 2 SWS)
- Fourier Analysis (exercise, 1 SWS)

Workload:

- 65 Hours private studies
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Theory of the Fourier transform
- Fourier transform in the Hilbert space
- Summability methods
- Applying Fourier transforms in solving differential equations
- Laplace and Mellin transforms
- Numerical aspects and relation to discrete Fourier transforms

Qualification-goals/Competencies:

- Knowledge of integral transforms
- A comprehensive understanding for the Fourier transform

Grading through:

- Exercises
- written exam

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institute for Mathematics
- Prof. Dr. rer. nat. Jürgen Prestin

Literature:

- Chandrasekharan, K.: Classical Fourier Transforms - Springer 1989

Language:

- offered only in German

MA4640 - Sampling in der Signalanalyse (SampSignal)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4 (Typ B)

Course of study, specific field and term:

- Bachelor CLS (optional suject), mathematics, 5th or 6th semester
- Master MES before 2014 (optional subject), mathematics, 1st or 2nd semester
- Master CLS (optional subject), computer science, arbitrary semester

Classes and lectures:

- Sampling-Verfahren in der Signalanalyse (seminar, 2 SWS)

Workload:

- 70 Hours private studies
- 30 Hours in-classroom work
- 20 Hours work on an individual topic with written and oral presentation

Contents of teaching:

- Hilberträume, Basen und Frames
- Endliches und Unendliches Sampling
- Anwendungen auf lineare gewöhnliche Differentialgleichungen
- Multi-band und Multi-channel Sampling
- Sampling und Eigenwert-Probleme

Qualification-goals/Competencies:

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Grading through:

- oral presentation
- Written report
- participation in discussions

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Jürgen Prestin

Language:

- offered only in German

MA4670 - Combinatorics (Kombi)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second year	4

Course of study, specific field and term:

- Master MES before 2014 (optional subject), mathematics, 1st or 2nd semester
- Master CLS (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- combinatorics (lecture, 2 SWS)
- combinatorics (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Permutations, combinations, variations
- Partitions
- Generating functions
- Recurrence equations
- Sums and differences
- Inclusion - exclusion

Qualification-goals/Competencies:

- Learning the basics of combinatorics
- Knowledge of different proof techniques and combinatorial approaches
- Teaching fundamental results and deepening some selected aspects of combinatorics

Grading through:

- Exercises
- Oral examination

Requires:

- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)
- Analysis 1 (MA2000-KP08, MA2000)

Responsible for this module:

- PD Dr. rer. nat. Hanns-Martin Teichert

Teacher:

- Institute for Mathematics

- PD Dr. rer. nat. Hanns-Martin Teichert

Literature:

- Peter Tittmann: Einführung in die Kombinatorik - Spektrum Akademischer Verlag 2000
- Richard A. Brualdi: Introductory Combinatorics - Pearson Prentice Hall 2004

Language:

- offered only in German

MA4675 - Algebra (Algebra)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second year	4

Course of study, specific field and term:

- Bachelor CLS (optional subject), mathematics, 5th or 6th semester
- Master CLS (optional subject), mathematics, arbitrary semester

Classes and lectures:

- Algebra (lecture, 2 SWS)
- Algebra (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Groups (semigroups, subgroups, homomorphisms, invariant subgroups, isomorphism theorems, products of groups)
- Rings (units, ring homomorphisms, polynomial rings, quotient fields, ideals)
- Field extensions (field characteristic, prime fields, field degree, algebraic and transcendent elements, algebraical field extensions, splitting field of a polynomial)
- Geometric constructions (compass-and-straightedge construction, field of constructible points, constructing regular polygons)

Qualification-goals/Competencies:

- Learning the basics of algebra
- Knowledge of different proof techniques and algebraic approaches
- Teaching fundamental results and deepening some selected aspects of algebra

Grading through:

- Exercises
- Oral examination

Requires:

- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)

Responsible for this module:

- PD Dr. rer. nat. Hanns-Martin Teichert

Teacher:

- Institute for Mathematics

- PD Dr. rer. nat. Hanns-Martin Teichert

Literature:

- G. Fischer: Lehrbuch der Algebra - Vieweg, 2011 (2. Auflage)
- M. Artin: Algebra - Birkhäuser, 1998
- B. L. van der Waerden: Algebra I - Springer, 1993 (9. Auflage)

Language:

- offered only in German

MA4710 - Functional Analysis (FunkAna)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Master MES before 2014 (optional subject), mathematics, 1st or 2nd semester
- Master CLS (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Functional Analysis (lecture, 2 SWS)
- Functional Analysis (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Metric spaces and their topology
- Banach spaces, Hilbert spaces and their geometry
- Duality, Hahn-Banach theorems
- Bounded linear operators, open mapping principle
- L^p-spaces and the theorem of Riesz-Fischer
- Weak topologies and reflexive spaces

Qualification-goals/Competencies:

- Learning the basic techniques for the analysis of linear functionals and operators on Banach and Hilbert spaces
- Study of the fundamental principles of functional analysis

Grading through:

- Exercises
- Oral examination

Responsible for this module:

- Dr. rer. nat. Wolfgang Erb

Teacher:

- Institute for Mathematics

- Dr. rer. nat. Wolfgang Erb

Literature:

- Hirzebruch, Scharlau: Einführung in die Funktionalanlysis - BI-Hochschulbücher, 1991
- Rudin: Functional Analysis - McGraw Hill, 1991
- Heuser: Funktionalanalysis - 4. Auflage, Teubner, 2006
- Hille, Phillips: Functional Analysis and Semi-Groups - AMS, 1957

Language:

- offered only in German

MA4720 - Orthogonal Series in Banach Spaces (ORiBanachR)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Master CLS (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Orthogonal Series in Banach Spaces (lecture, 2 SWS)
- Orthogonal Series in Banach Spaces (exercise, 1 SWS)

Workload:

- 65 Hours private studies
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Conditional und unconditional convergence and bases in general Banach spaces
- General existence- and non-existence results concerning basis especially in the spaces L1 and C(I)
- Haar and Franklin Systems as bases in the spaces Lp, H1 and BMO

Qualification-goals/Competencies:

- A competent knowledge of the construction methods of bases in special Banach spaces

Grading through:

- Oral examination
- planning and conducting exercises in a two-person-team
- active participation in the exercises

Responsible for this module:

- Dr. Jörn Schnieder

Teacher:

- Institute for Mathematics

- Dr. Jörn Schnieder

Literature:

- Kashin, B. S., Saakyan, A. A.: Orthogonal Series - AMS 1989

Language:

- offered only in German

MA4740 - Fractal Geometry (FraktGeo)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Master CLS (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Fractal Geometry (lecture, 2 SWS)
- Fractal Geometry (exercise, 1 SWS)

Workload:

- 65 Hours private studies
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Exploring classical fractal sets (e.g. self-similar sets, Mandelbrot set and Julia sets)
- Geometric characterisation by means of dimensions and determination of these dimensions
- Further geometric characteristics (refining the notions of dimension)
- Thermodynamic formalism and symbolic dynamics

Qualification-goals/Competencies:

- The students are familiar with classical fractal sets and are able to classify them.
- They can characterise highly irregular sets with regard to their roughness.

Grading through:

- Exercises
- Oral examination

Responsible for this module:

- Dr. Sabrina Kombrink

Teacher:

- Institute for Mathematics

- Dr. Sabrina Kombrink

Literature:

- K. J. Falconer: Fractal Geometry. Mathematical foundations and applications - 2. edition, John Wiley & Sons, Inc., Hoboken, NJ, 2003
- K. J. Falconer: Techniques in fractal geometry - John Wiley & Sons Ltd., Chichester, 1997
- B. B. Mandelbrot: The fractal geometry of nature - W. H. Freeman and Co., San Francisco, Calif.,1982

Language:

- offered only in German

Notes:

For admission to the oral exam students must have obtained at least 50% of the points in the exercises.

MA4801 - Elliptische Funktionen (EllipFunk)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second year	4

Course of study, specific field and term:

- Master CLS (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Elliptische Funktionen (lecture, 2 SWS)
- Elliptische Funktionen (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

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Qualification-goals/Competencies:

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Grading through:

- Exercises
- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Reinhard Schuster

Teacher:

- Institute for Mathematics
- Prof. Dr. Reinhard Schuster

Language:

- offered only in German

MA4802 - Spezielle und allgemeine Relativitätstheorie (RelatiTheo)

Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	every second year	4

Course of study, specific field and term:

- Master MES before 2014 (optional subject), mathematics, 1st or 2nd semester
- Master CLS (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Spezielle und allgemeine Relativitätstheorie (lecture, 2 SWS)
- Spezielle und allgemeine Relativitätstheorie (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

Grading through:

- Exercises
- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Reinhard Schuster

Teacher:

- Institute for Mathematics
- Prof. Dr. Reinhard Schuster

Language:

- offered only in German

MA4803 - Number Theory (Zahlentheo)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second year	4

Course of study, specific field and term:

- Master CLS (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Number Theory (lecture, 2 SWS)
- Number Theory (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Divisibility of integers, Farey sequencees, Fibonacci Numbers
- Approximation of real numbers by rational numbers
- Modulo operations: Complete and reduced residue system, Theorems of Euler and Fermat
- Representation of natural numbers sums of 2, 3 or 4 squares
- Quadratic residues
- Quadratic reciprocity
- Prime number criteria and pseudo prime numbers
- Pythagorean triples
- Rational points on curves of degree 2
- Number theoretic functions
- Prime number theorem, prime numbers in arithmetic progression
- Riemann zeta function and its functional equation
- Known problems and conjectures, i.e. Goldbach conjecture
- Stochastic prime numbers

Qualification-goals/Competencies:

- Theoretical knowledge of the mentioned topics
- Historical and most recent issues
- Solve questions in this filed
- Recognize interdisciplinary aspects

Grading through:

- Exercises
- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Reinhard Schuster

Teacher:

- Institute for Mathematics

- Prof. Dr. Reinhard Schuster

Literature:

- Chandrasekharan: Einführung in die analytische Zahlentheorie - Springer Lecture Notes 2008
- Bundschuh: Einführung in die Zahlentheorie - Springer 1992
- Menzer: Zahlentheorie: Fünf ausgewählte Themenstellungen der Zahlentheorie - Oldenbourg Wissenschaftsverlag 2010
- Remmert u. Ullrich: Elementare Zahlentheorie - Birkhäuser 1995
- Rempe: Primzahltests für Einsteiger: Zahlentheorie - Algorithmik - Kryptographie - Vieweg+Teubner 2009
- Scharlau, Opolka: Von Fermat bis Minkowski: Eine Vorlesung über Zahlentheorie und ihre Entwicklung - Springer 2009
- Scheid: Zahlentheorie - Spektrum 2003
- Schmidt: Einführung in die algebraische Zahlentheorie - Springer 2009
- Weil: Zahlentheorie - Spektrum 1992
- Winogradow: Elemente der Zahlentheorie - Prestel-Verlag 1956

Language:

- offered only in German

MA4804 - Special Functions (SpeFunktio)		
Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	irregularly	4

Course of study, specific field and term:

- Master CLS (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Special Functions (lecture, 2 SWS)
- Special Functions (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Algebraic operations with complex numbers
- Exponential function, angle functions, hyperbolic angle functions, derived functions
- Gamma and beta functions
- Hypergeometric function
- Bessel function, Legendre function, Laguerre function, Tscheybyscheff function, Hermite function, Jacobi hypergeometric function
- Elliptic functions, theta functions
- Number theoretic functions
- Riemann zeta function
- Used mathematical theories and concepts:
- Complex function theory
- Infinite products
- Differential equations (ordinary, partial)
- Functional equations
- Integral representation
- Taylor series expansions for eigenvalues and eigenfunctions (using space and time, defined on geometric objects)
- Producing functions (a Taylor series in two variables is considered as a series in one variable and the coefficients are special functions in the other variable)
- Addition theorems
- Fourier transformations
- Transformation groups, matrix groups

Qualification-goals/Competencies:

- Theoretical knowlege of the mentioned topics
- Historical and latest questions
- Solve questions in this field
- Recognize interdisciplinary aspects

Grading through:

- Exercises
- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Reinhard Schuster

Teacher:

- Institute for Mathematics

- Prof. Dr. Reinhard Schuster

Literature:

- Andrews G.E., Askey R., Roy R.: Special Functions.Encyclopedia of Mathematics and its Application 71 - Cambridge University Press 2006
- Courant, R., Hilbert, D.: Methoden der mathematischen Physik - Springer 1993
- Erdélyi, A. , Magnus, W., Oberhettinger, F., Tricomi, F.: Higher Transcendental Functions - McGraw-Hill, New York, 1953
- Fichtenholz, G.M.: Differential- und Integralrechnung, Band 1-3 - H. Deutsch 1997

- Hurwitz, A., Courant, R.: Vorlesungen über Allgemeine Funktionentheorie und Elliptische Funktionen - Springer 2000
- Stegun, I. A., Abramowitz, M.: Handbook of Mathematical Functions - Dover Press
- Strampp, W., Ganzha, V., Vorozhtsov, E.: Höhere Mathematik mit Mathematica, Bd.4, Funktionentheorie, Fouriertransformationen und Laplacetransformationen: Funktionentheorie, Fourier- und Laplacetransformation - Vieweg 1997
- Wawrzynczyk, A.: Group Representations and Special Functions - Reidel Publishing Company 1983
- Whittaker, E. T., Watson, G. N.: A Cource of Modern Analysis - Cambridge University Press 1902 ... 1999

Language:

- offered only in German

MA4950 - Logistische Regression (LogRegress)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second year	4

Course of study, specific field and term:

- Master CLS (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Logistische Regression (lecture, 2 SWS)
- Logistische Regression (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

-
-
-

Qualification-goals/Competencies:

-
-
-

Grading through:

- Exercises
- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Ziegler

Teacher:

- Institute of Medical Biometry and Statistics

- Prof. Dr. rer. nat. Andreas Ziegler

Language:

- offered only in German

MA4962 - Generalized Linear Models (VLModelle)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Bachelor CLS (optional subject), mathematics, 5th or 6th semester
- Master CLS (optional subject), mathematics, arbitrary semester

Classes and lectures:

- Generalized Linear Models (lecture, 2 SWS)
- Generalized Linear Models (exercise, 1 SWS)

Workload:

- 46 Hours private studies
- 36 Hours in-classroom work
- 24 Hours programming
- 14 Hours exam preparation

Contents of teaching:

- General overview of generalized linear models (GLM): - derivation of GLM functions,- GLM algorithms: Fisher scoring, iteratively weighted least squares,- goodness of fit and residuals
- Continuous response models: Gaussian, log-normal, Gamma, log-Gamma for survival analysis, inverse Gaussian
- Discrete response models:- dichotomous: logit, probit, cloglog, loglog, - count data: Poisson, negative binomial, geometric
- Ordered logistic and probit regression
- Multinomial logit and probit model
- Introduction to panel models

Qualification-goals/Competencies:

- Knowledge of the theoretical foundation of the generalized linear model and its application
- Competence for the critical appraisal of regression models
- Competence to detect algorithmic issues in generalized linear models
- Knowledge of conceptual problems with models using categorical dependent variables
- Knowledge for the adequate interpretation of study results
- Competence in parameter interpretation and regression diagnostics

Grading through:

- written exam

Requires:

- Biostatistics 2 (MA2600-KP04, MA2600)

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Ziegler

Teacher:

- Institute of Medical Biometry and Statistics

- Prof. Dr. rer. nat. Andreas Ziegler

Literature:

- Dobson, Annette J & Barnett, Adrian: An Introduction to Generalized Linear Models, 3rd ed. - Chapman & Hall/CRC: Boca Raton (FL), 2008
- Hardin, James W & Hilbe, Joseph M: Generalized Linear Models and Extensions, 3rd ed. - College Station (TX), Stata Press, 2012

Language:

- offered only in German

CS1300-KP04, CS1300 - Introduction to Medical Informatics (EMI)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Bachelor Computer Science since 2016 (optional subject), Introductory Module Computer Science, 1st semester
- Bachelor Robotics and Autonomous Systems (optional subject), computer science, 5th or 6th semester
- Bachelor Medical Informatics since 2014 (compulsory: aptitude test), medical computer science, 1st semester
- Bachelor Medical Informatics before 2014 (compulsory: aptitude test), medical computer science, 1st semester
- Bachelor CLS (optional subject), computer science, 5th semester
- Bachelor MES before 2014 (compulsory), foundations of computer science, 3rd semester
- Bachelor Computer Science before 2014 (compulsory), specialization field medical informatics, 1st semester
- Bachelor Medical Informatics since 2019 in planning (compulsory: aptitude test), medical computer science, 1st semester

Classes and lectures:

- Introduction to Medical Informatics (lecture, 2 SWS)
- Introduction to Medical Informatics (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Basic concepts and methods of medical informatics
- Overview of the occupational field in medical informatics
- Introduction to the German healthcare system
- Introduction to eHealth: medical documentation, hospital information systems
- Medical imaging techniques
- Fundamentals of medical image computing
- Fundamentals of medical visualisation
- Health telematics
- Medical data security
- Fundamentals of knowledge based systems
- Introduction to bioinformatics
- Computer based evaluation of clinical and epidemiological studies

Qualification-goals/Competencies:

- Overview of the methods in the art of medical informatics
- Knowledge of the institutional, organizational and legal framework in healthcare
- Knowledge of the essential concepts, methods and procedures in selected fields of medical informatics

Grading through:

- Exercises
- written exam

Responsible for this module:

- Prof. Dr. rer. nat. habil. Heinz Handels

Teacher:

- Institute of Medical Informatics

- Prof. Dr. rer. nat. habil. Heinz Handels
- Prof. Dr. rer. nat. habil. Josef Ingenerf
- Prof. Dr.-Ing. Marcin Grzegorzek

Literature:

- Th. Lehmann: Handbuch der Medizinischen Informatik - 2nd Edition, München: Hanser 2004
- P. Haas: Medizinische Informationssysteme und Elektronische Krankenakten - Berlin: Springer 2005
- F. Leiner, W. Gaus, R. Haux: Medizinische Dokumentation - 4th Edition, Stuttgart: Schattauer 2003

Language:

- offered only in German

CS1400-KP04, CS1400 - Introduction to Bioinformatics (EinBioinfo)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Bachelor MLS starting 2018 (compulsory), life sciences, 5th semester
- Bachelor MES since 2014 (optional subject), computer science and electrical engineering
- Bachelor Computer Science since 2016 (optional subject), Introductory Module Computer Science, 1st semester
- Bachelor Computer Science since 2016 (compulsory), Canonical Specialization Bioinformatics, 1st semester
- Bachelor MLS starting 2016 (compulsory), life sciences, 5th semester
- Bachelor Medical Informatics since 2014 (compulsory), medical computer science, 3rd semester
- Bachelor Computer Science 2014 and 2015 (compulsory), specialization field bioinformatics, 1st semester
- Bachelor Medical Informatics before 2014 (compulsory), medical computer science, 3rd semester
- Bachelor MLS (compulsory), life sciences, 5th semester
- Bachelor CLS (compulsory), specialization field bioinformatics, 5th semester
- Bachelor MES before 2014 (optional subject), Medical Engineering Science, 3rd or 5th semester
- Bachelor Computer Science before 2014 (compulsory), specialization field bioinformatics, 1st semester

Classes and lectures:

- Introduction to Bioinformatics (lecture, 2 SWS)
- Introduction to Bioinformatics (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Life, Evolution & the Genome
- Sequence assembly - Industrial reading of genetic information
- DNA sequence models & hidden markov models
- Viterbi-Algoritm
- Sequence alignment & dynamic programming
- Unsupervised data analysis (k-means, PCA, ICA)
- DNA microarrays & GeneChip technologies

Qualification-goals/Competencies:

- Students are able to explain the basic concepts of coding, transcription and translation of information in living beings.
- They are able to explain how a solution of the shortest common superstring problem can be estimated with a simple greedy algorithm.
- They are able to create a Markov chain or a Hidden Markov Model (HMM) for a given modelling problem.
- They are able to give examples on how to solve a problem using dynamic programming.
- They are able to implement the introduced algorithms (in Matlab)
- They are able to use unsupervised learning methods and they are able to interpret the results.
- They are able to explain basic Microarray-and DNA-Chip-Technologies.

Grading through:

- portfolio exam - the concrete examination elements and their weights will be published in the course

Responsible for this module:

- Prof. Dr. rer. nat. Amir Madany Mamlouk

Teacher:

- Institute for Neuro- and Bioinformatics

- Prof. Dr. rer. nat. Amir Madany Mamlouk

Literature:

- H. Lodish, A. Berk, S. L. Zipursky and J. Darnell: Molekulare Zellbiologie - Spektrum Akademischer Verlag, 4. Auflage, 2001, ISBN-13: 978-3827410771
- A. M. Lesk: Introduction to Bioinformatics - Oxford University Press, 3. Auflage, 2008, ISBN-13: 978-0199208043
- R. Merkl and S. Waack: Bioinformatik Interaktiv: Grundlagen, Algorithmen, Anwendungen - Wiley-VCH Verlag, 2. Auflage, 2009, ISBN-13: 978-3527325948

- M. S. Waterman: Introduction to Computational Biology - Chapman and Hall, 1995

Language:

- offered only in German

Notes:

For students of the master programme Infection Biology, this is not a stand-alone module, but rather part of the module CS4011.

Computer Science students get a B certificate.

LS2200-KP04, LS2200 - Introduction into Biophysics (EinBiophy)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Bachelor MLS starting 2016 (compulsory), life sciences, 3rd and 4th semester
- Bachelor CLS starting 2016 (optional subject), life sciences, 5th semester
- Bachelor Nutritional Medicine (compulsory), biophysics, 3rd semester
- Bachelor Biophysics (compulsory), biophysics, 3rd semester
- Bachelor MES since 2014 (optional subject), mathematics / natural sciences, 3rd or 5th semester
- Bachelor MLS (compulsory), life sciences, 3rd and 4th semester
- Bachelor CLS (optional subject), life sciences, 5th semester
- Bachelor MES before 2014 (compulsory), Medical Engineering Science, 5th semester
- Bachelor MLS starting 2018 (compulsory), life sciences, 3rd and 4th semester

Classes and lectures:

- Biophysics (lecture, 2 SWS)
- Biophysics (practical course, 1 SWS)

Workload:

- 50 Hours private studies
- 45 Hours in-classroom work
- 15 Hours written report
- 10 Hours exam preparation

Contents of teaching:

- Biological macro molecules, structure, forces
- Proteins, structure, properties
- Biomembranes, structure, properties
- Mechanical properties of cells
- Thermo dynamics of biological processes

Qualification-goals/Competencies:

- You can assign forces in biological systems
- You become familiar with the basic aspects of living matter
- You gain the expertise to simplify complex living systems
- You can choose and apply appropriate experimental methods for the study of living matter

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. rer. nat. Christian Hübner

Teacher:

- Institute of Physics

- Prof. Dr. rer. nat. Christian Hübner
- Dr. Young-Hwa Song

Literature:

- Volker Schünemann: Biophysik: Eine Einführung
- Werner Mäntele: Biophysik

Language:

- offered only in German

Notes:

The lecture occurs every winter semester. The practical course occurs every summer semester.

MA3210 - Statistics - Practical Course (StatPrakt)		
Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	each winter semester	3 (Typ B)

Course of study, specific field and term:

- Bachelor Computer Science before 2014 (optional subject), specialization field bioinformatics, 5th semester
- Bachelor Computer Science before 2014 (optional subject), specialization field medical informatics, 5th semester
- Bachelor CLS (compulsory), mathematics, 5th semester

Classes and lectures:

- Statistics - Practical Course (practical course, 2 SWS)

Workload:

- 60 Hours work on project
- 30 Hours in-classroom work

Contents of teaching:

- Data management
- Literate programming (Sweave or knitr)
- Descriptive statistics (frequency tables, measures of location and dispersion)
- Simple graphics (box-whisker plot, scatter plots, histograms)
- t-Test, Mann-Whitney U-test, Kruskal-Wallis-test
- Bootstrap
- Programming of functions

Qualification-goals/Competencies:

- Independent data management in R
- Independent realization of simple statistical analyses
- Independent generation of simple graphics
- Independent creation of literate programming scripts
- Independent calculation of bootstrap confidence intervals
- Independent writing of functions

Grading through:

- continuous, successful participation in practical course, >80%

Is requisite for:

- Genetic Epidemiology 2 (MA4661-KP08, MA4661)
- Prognostic models (MA4660)

Requires:

- Biostatistics 1 (MA1600-KP04, MA1600, MA1600-MML)

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Ziegler

Teacher:

- Institute of Medical Biometry and Statistics

- Prof. Dr. rer. nat. Andreas Ziegler

Literature:

- Helge Toutenburg, Christian Heumann: Deskriptive Statistik: Eine Einführung in Methoden und Anwendungen mit R und SPSS - ISBN-13 9783540777878
- Helge Toutenburg, Christian Heumann: Induktive Statistik: Eine Einführung mit R und SPSS - ISBN-13 9783540775096
- Lothar Sachs, Jürgen Hedderich: Angewandte Statistik: Methodensammlung mit R - ISBN-13 9783540889014

Language:

- offered only in German

Notes:

This module is for bachelor medical informatics and bachelor computer science (compulsory field of application: bioinformatics or medical informatics) only an additional offer. It is not eligible for the study.

MA3300 - Interdisciplinary Seminar (InterdisS)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	5

Course of study, specific field and term:

- Bachelor CLS (compulsory), mathematics, 5th semester

Classes and lectures:

- Interdisciplinary Seminar (seminar, 2 SWS)

Workload:

- 120 Hours oral presentation (including preparation)
- 30 Hours in-classroom work

Contents of teaching:

- Mathematics in the context of medicine and life sciences
- individual topics in fields as biostatistics, image processing, signal analysis, machine learning, robotic, biochemistry etc.

Qualification-goals/Competencies:

- Students are able to become acquainted with an interdisciplinary scientific topic
- They are able to summarize important contents in written form
- They are able to present complex scientific contents in anintelligible oral presentation
- They are able to discuss scientific problems

Grading through:

- oral presentation
- Written report
- participation in discussions

Responsible for this module:

- Prof. Dr. rer. nat. Karsten Keller

Teacher:

- Institute of Medical Biometry and Statistics
- Institute of Mathematics and Image Computing
- Institute for Mathematics

- Prof. Dr. rer. nat. Jan Modersitzki
- Prof. Dr. rer. nat. Karsten Keller
- Prof. Dr. rer. biol. hum. Inke König

Language:

- offered only in German

MA4450-MML - Modeling Biological Systems (MoBS)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	8

Course of study, specific field and term:

- Master MES since 2014 (optional subject), mathematics / natural sciences, arbitrary semester
- Master MES before 2014 (optional subject), mathematics, 1st or 3rd semester
- Bachelor CLS (compulsory), mathematics, 5th semester

Classes and lectures:

- Modeling Biological Systems (lecture, 2 SWS)
- Modeling Biological Systems (exercise, 2 SWS)

Workload:

- 130 Hours private studies and exercises
- 60 Hours in-classroom work
- 30 Hours work on project
- 20 Hours exam preparation

Contents of teaching:

- Elementary time-discrete deterministic models
- Structured time-discrete population dynamics
- Generating functions, Galton-Watson processes
- Markov chains with applications
- Modeling of data and data analysis

Qualification-goals/Competencies:

- Students have knowledge of elementary time-discrete models for modeling biological processes
- They develop skills in connecting ideas from different fields of mathematics
- They have competencies in data analysis and modelling
- They develop competencies in interdisciplinary work

Grading through:

- exercises, project, oral or written exam

Requires:

- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Stochastics 1 (MA2510-KP04, MA2510)
- Analysis 2 (MA2500-MML)

Responsible for this module:

- Prof. Dr. rer. nat. Karsten Keller

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Karsten Keller

Literature:

- F. Braer, C. Castillo-Chavez: Mathematical Models in Population Biology - New York: Springer 2000
- H. Caswell: Matrix Population Models - Sunderland: Sinauer Associates 2001
- S. N. Elaydi: An Introduction to Difference Equations - New York: Springer 1999
- B. Huppert: Angewandte Lineare Algebra - Berlin: de Gruyter 1990
- U. Krengel: Einführung in die Wahrscheinlichkeitstheorie und Statistik - Wiesbaden: Vieweg 2002
- E. Seneta: Non-negative Matrices and Markov Chains - New York: Springer 1981

Language:

- offered only in German

Notes:

The lecture is identical to that in module MA4450.

MA4970 - Design of Experiments and Variance Analysis (VplVarianz)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Master Computer Science before 2014 (optional subject), specialization field medical informatics, 3rd semester
- Master CLS (optional subject), mathematics, 1st or 3rd semester
- Bachelor CLS (optional subject), mathematics, 5th semester

Classes and lectures:

- Design of Experiments and Variance Analysis (lecture, 2 SWS)
- Design of Experiments and Variance Analysis (exercise, 1 SWS)

Workload:

- 50 Hours private studies
- 30 Hours in-classroom work
- 25 Hours programming
- 15 Hours exam preparation

Contents of teaching:

- Ability to calculate generalized inverse
- Knowledge of the differences between experiments and observational studies
- Knowledge of the advantages of the statistical design of multifactorial experiments
- Ability to interpret a suitable experimental ANOVA design
- Ability to implement a suitable experimental ANOVA design
- Ability to express the ANOVA model as regression model by matrix notation
- Ability to express and analyze models with repeated measurements
- Ability to draw up and analyze diagrams for an abstract of the results and a model diagnosis

Qualification-goals/Competencies:

- Comprehension of the theoretical principles of the design of experiments
- Comprehension of the theoretical principles of the analysis of variance

Grading through:

- written exam

Requires:

- Biostatistics 2 (MA2600-KP04, MA2600)
- Linear Models (MA4960)
- Biostatistics 1 (UngenutztMA1600-MML)

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Ziegler

Teacher:

- Institute of Medical Biometry and Statistics

- Prof. Dr. rer. nat. Andreas Ziegler

Literature:

- Kursbuch: Montgomery, Douglas C. 2012: Design and Analysis of Experiments. 8th ed. International Student Version - John Wiley & Sons, New York. ISBN 978-1-118-09793-9
- Supplementary literature: Kleppmann, Wilhelm. 2008: Taschenbuch Versuchsplanung. 5. Auflage - Carl Hanser, Wien. ISBN 978-3-446-41595-9
- Supplementary literature: Mason, Robert L., Gunst, Richard F., Hess, James L. 2003: Statistical Design and Analysis of Experiments. 2nd ed. - John Wiley & Sons, New York. ISBN 0-471-37216-1

Language:

- offered only in German

ME2053-MML - Physics Lab Course (PhysPrakt)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	3

Course of study, specific field and term:

- Bachelor CLS (compulsory), physics, 5th semester

Classes and lectures:

- Physics Lab Course (practical course, 2 SWS)

Workload:

- 45 Hours written report
- 30 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Experiment 1: fluid dynamics
- Experiment 2: heat
- Experiment 3: non stationary current
- Experiment 4: stationary current
- Experiment 5: sound and ultrasound
- Experiment 6: statistics
- Experiment 7: geometrical optics
- Experiment 8: spectrometer
- Experiment 9: diffusion
- Experiment 10: radio activity

Qualification-goals/Competencies:

- Hands-on access to physical relations
- Graphical representation of experimental data
- Excellence in interpreting data

Grading through:

- Written report
- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. rer. nat. Christian Hübner

Teacher:

- Institute of Biomedical Optics
- Institute of Physics
- Institute of Medical Engineering

- Prof. Dr. rer. nat. Christian Hübner

Literature:

- Giancoli: Physik

Language:

- offered only in German

CS1002-KP04, CS1002 - Introduction to Logics (Logik)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Bachelor Medical Informatics since 2019 in planning (compulsory), computer science, 2nd semester
- Bachelor Media Informatics (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science since 2016 (compulsory), foundations of computer science, 3rd semester
- Bachelor Robotics and Autonomous Systems (optional subject), computer science, 5th or 6th semester
- Bachelor IT-Security (compulsory), computer science, 3rd semester
- Bachelor Medical Informatics since 2014 (compulsory), computer science, 3rd semester
- Bachelor Computer Science 2014 and 2015 (compulsory), foundations of computer science, 3rd semester
- Bachelor Medical Informatics before 2014 (compulsory), computer science, 1st semester
- Bachelor MES before 2014 (optional subject), computer science, 3rd semester
- Bachelor CLS (optional subject), computer science, 6th semester
- Bachelor Computer Science before 2014 (compulsory), foundations of computer science, 1st semester

Classes and lectures:

- Logic (lecture, 2 SWS)
- Logic (exercise, 1 SWS)

Workload:

- 65 Hours private studies and exercises
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Key concepts of syntax: alphabet, string, term, formula
- Key concepts of semantics: assignment, structure, model
- Key concepts of proof calculus: axioms, proofs
- Formlization and coding of problems
- Validating correctness and satisfiability of formalizations
- Syntax and semantics of propositional logic
- Syntax and semantics of predicate logig
- Proof caculi

Qualification-goals/Competencies:

- Students are abel to explain the concepts of syntax and semantics for the examples of prepositional and predicate logic
- They are able to apply formal systems and proof systems
- They are able to transfer methods of mathematical logic to simple practical problems
- They are abel to formalize discrete problems
- They are able to modify proof templates in order to create simple proofs

Grading through:

- Exercises
- written exam

Responsible for this module:

- Prof. Dr. rer. nat. Till Tantau

Teacher:

- Institute for Theoretical Computer Science

- Prof. Dr. rer. nat. Till Tantau
- Prof. Dr. Rüdiger Reischuk

Literature:

- Uwe Schöning: Logik für Informatiker - Spektrum Verlag, 1995
- Kreuzer, Kühlig: Logik für Informatiker - Pearson Studium, 2006

Language:

- offered only in German

CS1601-KP04, CS1601 - Basics of Multimedia Systems (MMTechnik)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Bachelor Computer Science since 2016 (optional subject), major subject informatics, arbitrary semester
- Bachelor Robotics and Autonomous Systems (optional subject), computer science, 4th or 6th semester
- Bachelor IT-Security (optional subject), computer science, arbitrary semester
- Bachelor Media Informatics (compulsory), media informatics, 3rd semester
- Bachelor Computer Science 2014 and 2015 (optional subject), central topics of computer science, 5th semester
- Bachelor Computer Science before 2014 (optional subject), central topics of computer science, 6th semester
- Bachelor CLS (optional subject), computer science, 6th semester
- Bachelor Computer Science before 2014 (compulsory), specialization field media informatics, 2nd semester

Classes and lectures:

- Basics of Multimedia Systems (lecture, 2 SWS)
- Basics of Multimedia Systems (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Sensation and Perception
- Analog Media Technology
- Digitalisation
- Digital Audio, Image and Video Technology
- Haptical Technologies
- Foundations of Data Compression
- Storage Media
- Media Transmission (Broadcast / Streaming)

Qualification-goals/Competencies:

- Students are able to present to essential functions and principles of multimedia systems.
- They are able to judge possibilities and limitations of human perception.
- They are able to classify the conditions and technologies for capturing, processing, storing, transmitting and perception of multimedia.
- They can balance the specific advantages and disadvantages of analog and digital media technology.
- They are able to apply appropriate technical components and processes for the design of multimedia systems.

Grading through:

- Exercises
- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr.-Ing. Andreas Schrader

Teacher:

- Institute of Telematics

- Prof. Dr.-Ing. Andreas Schrader

Literature:

- Thomas Görne: Tontechnik - Hanser 2011
- Ulrich Schmidt: Professionelle Videotechnik - Springer 2009

Language:

- English, except in case of only German-speaking participants

CS2700-KP04, CS2700 - Databases (DB)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Bachelor Medical Informatics since 2019 in planning (compulsory), computer science, 3rd semester
- Bachelor Computer Science since 2016 (compulsory), foundations of computer science, 4th semester
- Bachelor Robotics and Autonomous Systems (optional subject), computer science, 5th or 6th semester
- Bachelor IT-Security (compulsory), computer science, 4th semester
- Bachelor Biophysics (optional subject), computer science, 6th semester
- Bachelor MES before 2014 (optional subject), computer science, 4th or 6th semester
- Bachelor Medical Informatics since 2014 (compulsory), computer science, 4th semester
- Bachelor MES since 2014 (optional subject), computer science and electrical engineering, 4th or 6th semester
- Bachelor Media Informatics (compulsory), foundations of computer science, 4th semester
- Bachelor Computer Science 2014 and 2015 (compulsory), foundations of computer science, 4th semester
- Bachelor Medical Informatics before 2014 (compulsory), computer science, 2nd semester
- Master CLS (optional subject), computer science, 2nd semester
- Bachelor CLS (optional subject), computer science, 6th semester
- Bachelor Computer Science before 2014 (compulsory), foundations of computer science, 4th semester

Classes and lectures:

- Databases (lecture, 2 SWS)
- Databases (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Introduction, conceptual view of database systems, conceptual data modeling with the Entity-Relationship (ER) modeling language
- The relational data model* Referential integrity, keys, foreign keys, functional dependencies (FDs)* Canonical mapping of entity types and relationships into the relational data model* Update, insertions, and deletion anomalies* Relational algebra as a query language* Database normalization, closure w.r.t. FD set, canonical cover of FD sets, normal forms, correct and dependency preserving decomposition of relation schemata, multi-value dependencies, inclusion dependencies
- Practical query language: SQL* Selection, projection, join, aggregation, grouping, sorting, difference, relational algebra in SQL* Data management* Integrity constraints
- Storage structures and database architecture* Characteristics of storage media, I/O complexity* DBMS architecture: disk space manager, buffer manager, files and access methods, record allocation strategies (row-wise, column-wise, mixed)
- Query processing* Indexing techniques, ISAM index, B+-tree index, hash index* Sorting: Two-way merge sort, blockwise processing, selection trees, query execution plans, join operator: nested loops join, blockwise nested loops join, index-based joins, sort-merge join, partition-based join with hashing* Addition operators: grouping and duplicate elimination, selection, projection, pipeline principle
- Query optimization* Cost metrics, Estimating sizes of intermediate tables, selectivity* Join optimization, physical plan properties, interesting orders, query transformation* Index cuts, bitmap indexes
- Transactions and recovery* ACID, anomalies, serializability, locks, 2-phase commit protocol, concurrent access to index structures, isolation levels* Implementation of transaction w.r.t. ACID, shadow pages, write ahead log, snapshots

Qualification-goals/Competencies:

- Basic understanding of database principles
- Knowledge about relational database design
- Knowledge of database query languages such as relational algebra and SQL
- Knowledge about principles of concurrent data access
- Introduction of database implementation techniques to allow for estimating resources required for answering queries

Grading through:

- Exercises
- written exam

Is requisite for:

- Nonstandard Databases and Data Mining (CS3130-KP08)
- Nonstandard Database Systems (CS3202-KP04, CS3202)

Requires:

- Introduction to Programming (CS1000-KP08, CS1000SJ14-MML/MI, CS1000SJ14-MIW)
- Introduction to Programming (CS1000-KP10, CS1000SJ14)

Responsible for this module:

- Prof. Dr. rer. nat. habil. Ralf Möller

Teacher:

- Institute of Information Systems
- Prof. Dr. rer. nat. habil. Ralf Möller

Literature:

- A. Kemper, A, Eickler: Datenbanksysteme - Eine Einführung - Oldenbourg-Verlag

Language:

- offered only in German

CS3202-KP04, CS3202 - Nonstandard Database Systems (NDB)

Duration:	Turnus of offer:	Credit points:
1 Semester	not available anymore	4

Course of study, specific field and term:

- Bachelor IT-Security (optional subject), computer science, arbitrary semester
- Bachelor Medical Informatics since 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor Media Informatics (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2014 and 2015 (optional subject), central topics of computer science, 5th or 6th semester
- Bachelor Medical Informatics before 2014 (optional subject), applied computer science, 4th to 6th semester
- Master Computer Science before 2014 (optional subject), specialization field media informatics, 2nd or 3rd semester
- Master CLS (optional suject), computer science, arbitrary semester
- Bachelor CLS (optional subject), computer science, 6th semester
- Master Computer Science before 2014 (optional subject), advanced curriculum distributed information systems, 2nd or 3rd semester
- Bachelor Computer Science before 2014 (optional subject), central topics of computer science, 5th or 6th semester

Classes and lectures:

- Nonstandard Database Systems (lecture, 2 SWS)
- Nonstandard Database Systems (exercise, 1 SWS)

Workload:

- 65 Hours private studies
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- introduction
- semistructured databases
- Temporal and spatial databases (temporally restricted validity, multidimensional index structures)
- Sequence Databases
- Databases for data streams (window concept)
- Databases for incomplete information (e.g., constraint databases)
- Probabilistic databases
- Databases with answer ranking (top-k queries)

Qualification-goals/Competencies:

- Knowledge:Students can name the main features of standard databases and, in addition, can explain which non-standard database models emerge if features are dropped. They can describe the main ideas behind non-standard databases presented in the course by explaining the main features of respective query languages (syntax and semantics) as well as the most important implementation techniques used for their practical realization.
- Skills:Students can apply query languages for non-standard data models introduced in the course to retrieve desired structures from sample datasets in order to satisfy information needs specified textually in natural language. Students are able to represent data in the relational data model using encoding techniques presented in the course such that they can demonstrate how new formalisms relate to or can be implemented in SQL (in particular, SQL-99). In case an SQL transformation cannot be found, students can explain and apply dedicated algorithms for query answering. Students can demonstrate how index structures help answering queries fast by showing how index structures are built, updated, and exploited for query answering. The participants of the course can derive query answers by evaluating queries step by step and by deriving optimized query execution plans.
- Social skills:Students work in teams to handle assignments, and they are encouraged to present their solution to other students in small presentations (in lab classes). In addition, self-dependence is fostered by giving pointers to query evaluation engines for various formalism presented in the lecture such that students get familiar with data models and query languages by self-controlled work.

Grading through:

- Exercises
- Written or oral exam as announced by the examiner

Requires:

- Databases (CS2700-KP04, CS2700)

Responsible for this module:

- Prof. Dr. rer. nat. habil. Ralf Möller

Teacher:

- Institute of Information Systems
- Prof. Dr. rer. nat. habil. Ralf Möller

Literature:

- S. Abiteboul, P. Buneman, D. Suciu: Data on the Web - From Relations to Semistructured Data and XML - Morgan Kaufmann, 1999
- J. Chomicki, G. Saake (Eds.): Logics for Databases and Information Systems - Springer, 1998
- P. Rigaux, M. Scholl, A. Voisard: Spatial Databases With Applications to GIS - Morgan Kaufmann, 2001
- P. Revesz: Introduction to Constraint Databases - Springer, 2002
- P. Revesz: Introduction to Databases- From Biological to Spatio-Temporal - Springer 2010
- S. Ceri, A. Bozzon, M. Brambilla, E. Della Valle, P. Fraternali, S. Quarteroni: Web Information Retrieval - Springer, 2013
- S. Chakravarthy, Q. Jiang: Stream Data Processing A Quality of Service Perspective - Springer, 2009
- D. Suciu, D. Olteanu, Chr. Re, Chr. Koch: Probabilistic Databases - Morgan & Claypool, 2011

Language:

- offered only in German

CS3204-KP04, CS3204 - Artificial Intelligence 1 (KI1)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Bachelor Medical Informatics since 2019 in planning (optional subject), computer science, 4th to 6th semester
- Bachelor MES since 2014 (optional subject), computer science and electrical engineering
- Bachelor Computer Science since 2016 (optional subject), major subject informatics, arbitrary semester
- Bachelor Computer Science since 2016 (compulsory), Canonical Specialization Web and Data Science WS16-SS19, 6th semester
- Bachelor Robotics and Autonomous Systems (compulsory), Robotics and Autonomous Systems, 6th semester
- Bachelor IT-Security (optional subject), computer science, arbitrary semester
- Bachelor Biophysics (optional subject), computer science, 6th semester
- Bachelor Medical Informatics since 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor Media Informatics (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2014 and 2015 (optional subject), central topics of computer science, 6th semester
- Bachelor Computer Science 2014 and 2015 (compulsory), specialization field robotics and automation, 6th semester
- Bachelor Medical Informatics before 2014 (optional subject), applied computer science, 4th to 6th semester
- Bachelor CLS (optional subject), computer science, 6th semester
- Bachelor MES before 2014 (optional subject), Medical Engineering Science, 6th semester
- Bachelor Computer Science before 2014 (compulsory), specialization field robotics and automation, 4th semester
- Bachelor Computer Science before 2014 (optional subject), central topics of computer science, 5th or 6th semester

Classes and lectures:

- Artificial Intelligence (lecture, 2 SWS)
- Artificial Intelligence (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Part 1: Search strategiesAs an introduction and a prerequisite for most of the principles of artificial intelligence search strategies are introduced and explained. We will introduce uninformed, informed, local search, adversial search as well as heuristic search. The concept of agents will be presented.
- Part 2: Learning and reasoningRevision of the foundations of mathematical logic and probability. Principles of machine learning (supervised and unsupervised) are introduced. An introduction to fuzzy logic is also included.
- Part 3: Applications of artificial intelligenceTypical applications in the fields or robotics, machine vision, and industrial image and data processing are identified. Ethical issues and risks of the development of artificial intelligence are discussed.

Qualification-goals/Competencies:

- The students are able to handle scope-oriented tutorials with a mathematical background in a team, and timely.
- They have developed an understanding for the benefits and disadvantages of the different search and problem solving techniques.
- The students are in a position to choose and apply independently appropriate algorithms for search and learning issues.
- They have gained an insight into the complex development of systems with artificial intelligence and the distinction of its various forms.
- The students have an understanding of the risks and possible technological consequences of the development of systems with strong AI.

Grading through:

- written exam

Is requisite for:

- Artificial Intelligence 2 (CS5204-KP04, CS5204)

Responsible for this module:

- Prof. Dr.-Ing. Achim Schweikard

Teacher:

- Institute for Robotics and Cognitive Systems

- Prof. Dr.-Ing. Achim Schweikard

- MitarbeiterInnen des Instituts
- Prof. Dr. rer. nat. Floris Ernst

Literature:

- G. Görz (Hrsg.): Handbuch der Künstlichen Intelligenz - München: Oldenbourg Wissenschaftsverlag, 2003
- C-M. Bishop: Pattern Recognition and Machine Learning - Springer Verlag, 2007
- Russell/Norvig: Artificial Intelligence: a modern approach - (3rd Ed.), Prentice Hall, 2009
- Mitchell: Machine Learning - McGraw-Hill, 1997
- Luger: Artificial Intelligence: Structures and Strategies for Complex Problem Solving - (6th Ed.), Addison-Wesley, 2008

Language:

- offered only in German

Notes:

It is recommended to attend the modules CS1001-KP08 Algorithms and Data Structures as well as MA2500 Analysis 2 beforehand.

Desirable pre-condition for a CS3701 Project in the field of Artificial Intelligence

CS3205-KP04, CS3205 - Computer Graphics (CompGrafik)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Bachelor Medical Informatics since 2019 in planning (optional subject), computer science, 4th to 6th semester
- Bachelor Computer Science since 2016 (optional subject), major subject informatics, arbitrary semester
- Bachelor Robotics and Autonomous Systems (optional subject), computer science, 5th or 6th semester
- Bachelor IT-Security (optional subject), computer science, arbitrary semester
- Bachelor Medical Informatics since 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor MES since 2014 (optional subject), computer science and electrical engineering, 4th or 6th semester
- Bachelor Media Informatics (compulsory), media informatics, 6th semester
- Bachelor Computer Science 2014 and 2015 (optional subject), central topics of computer science, 5th or 6th semester
- Bachelor Medical Informatics before 2014 (optional subject), computer science, 4th to 6th semester
- Master Computer Science before 2014 (optional subject), advanced curriculum imaging systems, 2nd or 3rd semester
- Bachelor CLS (optional subject), mathematics, 6th semester
- Bachelor Computer Science before 2014 (optional subject), central topics of computer science, 5th or 6th semester
- Master CLS (optional subject), mathematics, 2nd semester
- Bachelor Computer Science before 2014 (compulsory), specialization field media informatics, 5th or 6th semester

Classes and lectures:

- Computer Graphics (lecture, 2 SWS)
- Computer Graphics (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Homogeneous coordinates and geometrical transformations
- Planar and perspective projections
- Polygon meshes
- Bezier curves and surfaces
- B-spline curves and surfaces
- Culling and Clipping
- Hidden surface removal
- Raster graphics algorithms
- Illumination and shading

Qualification-goals/Competencies:

- Knowledge and understanding of the basic concepts, algorithms and methods
- Ability to implement the basic algorithms
- Ability to assess the possibilities and limitations of the learned techniques

Grading through:

- Exercises
- written exam

Requires:

- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)

Responsible for this module:

- Prof. Dr. rer. nat. habil. Heinz Handels

Teacher:

- Institute of Medical Informatics

- Dr. rer. nat. Jan Ehrhardt

Literature:

- Foley et. al: Grundlagen der Computergrafik - Addison-Wesley, 1994

Language:

- offered only in German

CS5010 - Wissenschaftliches Rechnen (ScienComp)

Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	not available anymore	4

Course of study, specific field and term:

- Master Computer Science before 2014 (optional subject), advanced curriculum algorithmics and complexity theory, 2nd or 3rd semester
- Bachelor MES before 2014 (optional subject), Medical Engineering Science, 3rd, 5th, or 6th semester
- Bachelor CLS (optional subject), computer science, 6th semester

Classes and lectures:

- Scientific Computing (lecture, 2 SWS)
- Scientific Computing (exercise, 1 SWS)

Workload:

- 65 Hours private studies and exercises
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- lineare und nichtlineare Gleichungssysteme, Eigenwertberechnungen
- High-Performance Computing (Parallesierungstechniken)
- Modellierungsaspekte

Qualification-goals/Competencies:

- Numerische Simulation von naturwissenschaftlichen Vorgängen
- Anwendung auf praxisrelevante Fragestellungen

Grading through:

- Exercises
- written exam

Responsible for this module:

- Prof. Dr. Rüdiger Reischuk

Teacher:

- Institute for Theoretical Computer Science
- Prof. Dr. Rüdiger Reischuk

Language:

- offered only in German

LS2700-MML - Cell Biology (Zellbio)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Bachelor CLS (optional subject), computational life science / life sciences, 6th semester

Classes and lectures:

- Cell Biology (lecture, 3 SWS)

Workload:

- 75 Hours private studies
- 45 Hours in-classroom work

Contents of teaching:

- Special structure of cells
- Cell cycle and apoptosis
- Introduction into developmental biology

Qualification-goals/Competencies:

- Principle of the basic function of the eukaryotic cells
- Detailed knowledge in all areas of cell biology covered by the lecture (see

Grading through:

- written exam

Responsible for this module:

- Prof. Dr. rer. nat. Enno Hartmann

Teacher:

- Institute of Virology and Cell Biology
- Institute for Biology

- Prof. Dr. rer. nat. Enno Hartmann
- PD Dr. rer. nat. Kai-Uwe Kalies
- Prof. Dr. rer. nat. Jürgen Rohwedel

Literature:

- Lodish: Molecular Cell Biology
- Pollard: Cell Biology
- Wolpert: Principles of Development
- Alberts: Molecular Biology of the Cell

Language:

- offered only in German

MA3990 - Bachelor thesis (BaArbMML)		
Duration: 1 Semester	**Turnus of offer:** each semester	**Credit points:** 12

Course of study, specific field and term:

- Bachelor CLS (compulsory), mathematics, 6th semester

Classes and lectures:

- Bachelor Thesis CLS (supervised self studies, 1 SWS)
- Colloquium (presentation (incl. preparation), 1 SWS)

Workload:

- 0 Hours

Contents of teaching:

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institutes of the Department of Computer Science/ Engineering
- Alle prüfungsberechtigten Dozentinnen/Dozenten des Studienganges

Language:

- thesis can be written in German or English

MA4041 - Numerical Linear Algebra (NumLinAlg)

Duration:	Turnus of offer:	Credit points:
1 Semester	Currently not available	4

Course of study, specific field and term:

- Bachelor CLS (optional suject), mathematics, 6th semester
- Master CLS (optional subject), mathematics, 2nd or 3rd semester

Classes and lectures:

- Numerical Linear Algebra (lecture, 2 SWS)
- Numerical Linear Algebra (exercise, 1 SWS)

Workload:

- 65 Hours private studies
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Iterative solving of big linear equation systems
- Numerics of eigenvalue problems

Qualification-goals/Competencies:

- Students know the most important algorithms of scientific computing.
- They know how to handle high-dimensional problems.
- They are able to handle computer specific problems like Cache and BLAS.
- They are able to implement practical problems originating from life sciences.
- Interdisciplinary qualifications:
- Students can transfer theoretical concepts to practical problems.
- Students have experience in implementation.
- Students can abstract practical problems.

Grading through:

- Exercises
- Presentation of one´s own solution of an exercise
- programming project
- Written or oral exam as announced by the examiner

Requires:

- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Analysis 2 (MA2500-MML)

Responsible for this module:

- Prof. Dr. rer. nat. Jan Modersitzki

Teacher:

- Institute of Mathematics and Image Computing

- Prof. Dr. rer. nat. Jan Modersitzki
- N.N.

Literature:

- A. Meister: Numerik linearer Gleichungssysteme - Vieweg+Teubner, 2011
- G. Strang: Computational Science and Engineering - Wellesley-Cambridge Press, 2007
- P. Van Dooren, S. P. Bhattacharyya, V. Olshevsky, R. H. Chan, A. Routray: Numerical Linear Algebra in Signals, Systems and Control - Springer, 2011

Language:

- German and English skills required

MA4200 - Integralgleichungen (Integral)

Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	every third semester	4

Course of study, specific field and term:

- Master CLS (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 6th semester

Classes and lectures:

- Integralgleichungen (lecture, 2 SWS)
- Integralgleichungen (exercise, 1 SWS)

Workload:

- 0 Hours

Contents of teaching:

- Volterrasche Integralgleichungen
- Fredholmsche Integralgleichungen
- Numerische Lösungsverfahren

Qualification-goals/Competencies:

- Modellierung praktischer Probleme der Life Sciences durch Integralgleichungen
- Verständnis des Zusammenhangs zwischen Integralgleichungen und Differentialgleichungen
- Klassifizierung von Integralgleichungen
- Praktische Umsetzung theoretischer Algorithmen

Grading through:

- Exercises
- programming project
- Oral examination
- written exam

Requires:

- Analysis 2 (MA2500-MML)

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Jürgen Prestin

Language:

- offered only in German

MA4341 - Time series analysis (Zeitreihen)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Master CLS (optional suject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 6th semester

Classes and lectures:

- Time series analysis (lecture, 2 SWS)
- Time series analysis (exercise, 1 SWS)

Workload:

- 65 Hours private studies and exercises
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Simple discriptive and explorative methods: smoothing, differentiating, autocorrelation, cross correlation
- Linear time series models: MA-processes, AR-processes, ARIMA-processes
- Time series and models with longe-range dependencies
- Time series in the frequency domain:autocorrelation function, spectral density and its estimation
- nonlinear methods by examples
- analysis and modelling of data from life sciences (software: R, Mathematica, SPSS)

Qualification-goals/Competencies:

- Students have basic knowledge of concepts and ideas of time series analysis
- They master simple linear methods of time series analysis
- They have competencies in analysis and modelling of real-world time series

Grading through:

- Exercises
- Oral examination
- written exam

Requires:

- Stochastics 2 (MA4020-MML)

Responsible for this module:

- Prof. Dr. rer. nat. Karsten Keller

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Karsten Keller

Literature:

- R. Schlittgen, B.Streitberg: Zeitreihenanalyse - Oldenburg-Verlag, München, Wien 1994
- P.J. Brockwell, R.A. Davis: Time Series: Theory and Methods - Springer, New York 1991

Language:

- offered only in German

Notes:

Prerequisites for admission to the examination can be determined at the beginning of the semester. If such prerequisites are defined, they must have been fulfilled prior to the first attempt at the examination and must have been rated as positive.

MA4612 - Numerik dynamischer Systeme (NumDynSyst)

Duration:	Turnus of offer:	Credit points:
1 Semester	not available anymore	4

Course of study, specific field and term:

- Master CLS (optional suject), mathematics, arbitrary semester
- Master MES before 2014 (optional subject), mathematics, 1st or 2nd semester
- Bachelor CLS (optional subject), mathematics, 6th semester

Classes and lectures:

- Numerik dynamischer Systeme (lecture, 2 SWS)
- Numerik dynamischer Systeme (exercise, 1 SWS)

Workload:

- 65 Hours private studies
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Diskrete dynamische Systeme
- Kontinuierliche dynamische Systeme (Systeme gewöhnlicher Differentialgleichungen)
- Modellierungsaspekte

Qualification-goals/Competencies:

- Modellierung, Simulation und Analyse lebender Systeme
- Numerische Umsetzung der einzelnen Ansätze
- Anwendung auf praxisrelevante Fragestellungen

Grading through:

- Exercises
- written exam

Responsible for this module:

- Prof. Dr. rer. nat. Jan Modersitzki

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Jan Modersitzki

Language:

- offered only in German

MA4650 - Matrix algebra (MatrixAlg)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	irregularly	4	20

Course of study, specific field and term:

- Master CLS (optional subject), mathematics, arbitrary semester
- Master MES before 2014 (optional subject), mathematics, 1st semester
- Bachelor CLS (optional subject), mathematics, 6th semester

Classes and lectures:

- Matrix algebra (lecture, 2 SWS)
- Matrix algebra (exercise, 1 SWS)

Workload:

- 60 Hours private studies and exercises
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Properties of matrices
- Special matrices
- Quadratic forms
- Decompositions
- Generalized inverses
- Differentiation
- Probability calculation
- Derivation and calculation of estimators
- Design matrices
- Linear hypotheses
- Examples: multiple linear regression, weighted least-squares estimation, shrinkage estimation

Qualification-goals/Competencies:

- Understanding of typical derivation techniques needed for generalized linear models and multivariate methods
- Command of matrix algebra
- Application of linear algebra to linear models
- Ability to work on practical statistical problems using matrix algebra

Grading through:

- written exam

Requires:

- Biostatistics 1 (MA1600-KP04, MA1600, MA1600-MML)
- Analysis 2 (MA2500-MML)

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Ziegler

Teacher:

- Institute of Medical Biometry and Statistics

- Prof. Dr. rer. nat. Andreas Ziegler
- Dr. Reinhard Vonthein

Literature:

- K. Schmidt, G. Trenkler: Einführung in die Moderne Matrix-Algebra: Mit Anwendungen in der Statistik - Springer: Heidelberg 2006, ISBN 9783540330073
- H. Toutenburg: Lineare Modelle - Physica: Heidelberg 1992 und 2006, ISBN 978-3790815191
- L. Fahrmeir, T. Kneib, S. Lang: Regression: Modelle, Methoden und Anwendungen - Springer: Heidelberg 2007, ISBN 9783642343339
- Michael Healy: Matrices for Statistics - ISBN 9780198507024

Language:

- offered only in German

MA4661-KP08, MA4661 - Genetic Epidemiology 2 (GenEpi2)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	each summer semester	8	20

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), mathematics, 6th semester
- Master CLS starting 2016 (optional subject), MML with specialization in Genetic Statistics, 2nd semester
- Bachelor CLS (optional subject), mathematics, 6th semester
- Master CLS (optional subject), mathematics, arbitrary semester

Classes and lectures:

- Genetic Epidemiology 2 (lecture, 2 SWS)
- Genetic Epidemiology 2 (exercise, 1 SWS)
- Genetic Epidemiology 2 (practical course, 2 SWS)

Workload:

- 135 Hours private studies
- 75 Hours in-classroom work
- 30 Hours exam preparation

Contents of teaching:

- Study designs for genetic epidemiological linkage studies within families
- Model-based linkage analysis: Linkage of two markers, linkage of one marker with one phenotype
- Model-free linkage analysis: Tests for sib-pairs
- Model-free linkage analysis: Extensions to many markers and extended pedigrees
- Linkage analysis for quantitative phenotypes: Haseman-Elston method and its extensions, variance components models
- Sample size estimation for linkage analysis
- Data analysis for genetic association studies
- Data analysis for gene expression studies

Qualification-goals/Competencies:

- The students are able to describe the most important study designs for genetic epidemiological linkage studies within families.
- They are able to name and describe the most important approaches for linkage analysis with qualititative and quantitative phenotypes.
- They are able to apply basic test statistics manually and interpret the results.
- They are able to apply more complex test statistics using the computer and interpret the results.
- They can conduct a standard quality control in genetic association studies in R.
- They can conduct basic analyses of genetic association studies in R.
- They can conduct a standard quality control in gene expression studies in R.
- They can conduct basic analyses of gene expression studies in R.
- They have the methodological competence to solve large-scale tasks cost- and time- efficiently.
- They have the management competence to organize their own work and that of collaborators involved in the project.
- They have the methods competence to develop solutions with limited resources (time, personnel, etc.) that comply with general quality criteria.
- They have the communication competence to present ideas and solutions in oral and written form.

Grading through:

- continuous, successful participation in practical course
- written exam

Is requisite for:

- Seminar Genetic Epidemiology (MA5129-KP04, MA5129)

Requires:

- Statistics - Practical Course (MA3210)
- Genetic Epidemiology 1 (MA3200-KP04, MA3200)

Responsible for this module:

- Prof. Dr. rer. biol. hum. Inke König

Teacher:

- Institute of Medical Biometry and Statistics

- Prof. Dr. rer. biol. hum. Inke König

- MitarbeiterInnen des Instituts

Literature:

- Ziegler A, König IR.: A statistical approach to genetic epidemiology. Concepts and applications. - 2010. ISBN: 978-3-527-32389-0

Language:

- offered only in German

Notes:

Prerequisite tasks for taking the exam can be announced at the beginning of the semester. If any prerequisite tasks are defined, they must be completed and passed before taking the exam for the first time.

MA4700 - Angewandte Analysis (AngewAna)		
Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master MES before 2014 (optional subject), mathematics, 1st semester
- Master CLS (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 6th semester

Classes and lectures:

- Applied Analysis (lecture, 2 SWS)
- Applied Analysis (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Maße und ihre Konstruktion
- Messbare Funktionen, Integration, Konvergenzsätze
- Produktmaße, Fubini
- Satz von Radon-Nikodym
- Lebesgue-Maße, Transformationsformel
- Kurven- und Oberflächenintegrale
- Integralsätze
- Partielle Differentialgleichungen erster Ordnung (Zusammenhang mit Systemen gewöhnlicher Diffferentialgleichungen)
- Klassifikation von Gleichungen zweiter Ordnung
- Beispielhafte Behandlung der drei Grundtypen

Qualification-goals/Competencies:

- Anwendungsbereites Verständnis der abstrakten Maß- und Integrationstheorie und ihrer konkreten Anwendungen in euklidischen Räumen
- Einführung in die Theorie partieller Differentialgleichungen
- Erlernen hierzu grundlegender analytischer Hilfsmittel
- Stärkung des Verständnisses für Modellierung

Grading through:

- Exercises
- written exam

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Jürgen Prestin

Language:

- offered only in German

MA4800 - Differenzialgeometrie (Diffgeo)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second year	4

Course of study, specific field and term:

- Master MES before 2014 (optional subject), mathematics, 1st or 2nd semester
- Master CLS (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 6th semester

Classes and lectures:

- Differenzialgeometrie (lecture, 2 SWS)
- Differenzialgeometrie (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

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Qualification-goals/Competencies:

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Grading through:

- Exercises
- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Reinhard Schuster

Teacher:

- Institute for Mathematics
- Prof. Dr. Reinhard Schuster

Language:

- offered only in German

MA4944 - Multivariate Statistics (MultivStat)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Bachelor CLS (optional subject), mathematics, 6th semester
- Master CLS (optional subject), mathematics, 2nd semester

Classes and lectures:

- Multivariate Statistics (lecture, 2 SWS)
- Multivariate Statistics (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Multivariate regression
- Discriminance analysis
- Logistic regression
- Cluster analysis
- Principal components and factor analysis

Qualification-goals/Competencies:

- Identification of applications in which multivariate statistical methods are required
- Knowledge of the fundamental ideas of various multivariate methods

Grading through:

- written exam

Requires:

- Biostatistics 2 (MA2600-KP04, MA2600)
- Biostatistics 1 (MA1600-KP04, MA1600, MA1600-MML)
- Stochastics 2 (MA4020-KP04, MA4020)
- Stochastics 1 (MA2510-KP04, MA2510)

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Ziegler

Teacher:

- Institute of Medical Biometry and Statistics

- Prof. Dr. rer. nat. Andreas Ziegler
- Dr. Reinhard Vonthein

Literature:

- Ludwig Fahrmeir, Alfred Hamerle, Gerhard Tutz: Multivariate statistische Verfahren - ISBN-13 9783110138061

Language:

- offered only in German

MA4960 - Linear Models (LinModelle)		
Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	irregularly	4

Course of study, specific field and term:

- Master CLS (optional subject), mathematics, arbitrary semester
- Bachelor CLS (optional subject), mathematics, 6th semester

Classes and lectures:

- Linear models (lecture, 2 SWS)
- Linear models (exercise, 1 SWS)

Workload:

- 65 Hours private studies
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

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Qualification-goals/Competencies:

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Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Biostatistics 1 (MA1600-KP04, MA1600, MA1600-MML)

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Ziegler

Teacher:

- Institute of Medical Biometry and Statistics

- Prof. Dr. rer. nat. Andreas Ziegler

Literature:

- :
- :

Language:

- offered only in German

MA5610 - Selected stochastic processes (StochPrz2)

Duration:	Turnus of offer:	Credit points:
1 Semester	not available anymore	4

Course of study, specific field and term:

- Bachelor CLS (optional suject), mathematics, 6th semester
- Master CLS (optional subject), mathematics, 2nd or 4th semester
- Master Computer Science before 2014 (optional subject), advanced curriculum stochastics, 2nd or 3rd semester

Classes and lectures:

- Selected stochastic processes (lecture, 2 SWS)
- Selected stochastic processes (exercise, 1 SWS)

Workload:

- 65 Hours private studies
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- branching processes
- Poisson process
- birth-and-death processes
- reneval processes
- Brownian and fractional Brownian motion
- life science applications

Qualification-goals/Competencies:

- Mastering some important classes of stochastic processes and understanding possible applications

Grading through:

- Oral examination

Requires:

- Stochastics 2 (MA4020-KP04, MA4020)

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Ziegler
- Prof. Dr. rer. nat. Karsten Keller

Teacher:

- Institute of Medical Biometry and Statistics
- Institute for Mathematics

- Prof. Dr. rer. nat. Karsten Keller
- Prof. Dr. rer. nat. Andreas Ziegler

Literature:

- R. Durrett: Probability: Theory and Examples - 3rd. edition, Thomson, 2005
- S. Karlin und H.M. Taylor: A First Course in Stochastic Processes - 2rd. edition, Academic Press, 1975

Language:

- offered only in German