UNIVERSITÄT ZU LÜBECK

Module Guide for the Study Path

Bachelor CLS starting 2016

Version from 1. April 2019

1st semester

2nd semester

3rd or 5th semester

3rd semester

4th semester

5th or 6th semester

5th semester

6th semester

CS1000 A - Module part: Lab course C++ (EfProgKA)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	2

Course of study, specific field and term:

- Bachelor MES since 2014 (module part), computer science, 3rd semester
- Bachelor CLS starting 2016 (module part), foundations of computer science, 1st semester

Classes and lectures:

- Lab course C++ (lecture, 1 SWS)
- Lab course C++ (exercise, 2 SWS)

Workload:

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

Contents of teaching:

- Syntax of the imperative language elements of C ++
- Syntax of object-oriented elements of C ++
- Development of own programs in C ++
- Development environments for C ++

Qualification-goals/Competencies:

- Students can design, implement and test simple simple programs
- Students are familiar with the syntax and semantics of the language C ++ and can explain and apply them
- Students can develop and implement solutions satisfying commonly accepted quality standardsThe students can develop and implement solutions satisfying commonly accepted quality standards

Grading through:

- exam type depends on main module

Is requisite for:

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

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Telematics
- Prof. Dr. Stefan Fischer

Literature:

- M. Broy: - Springer-Verlag 1998
- G. Goos und W. Zimmermann: - Springer-Verlag, 2006
- B. Stroustrup: Einführung in die Programmierung mit C++ - Pearson Studium - IT, 2010

Language:

- offered only in German

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

LS1000-KP08, LS1000-MLS - Biology 1 (Bio1KP08)

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

Course of study, specific field and term:

- Bachelor Nutritional Medicine starting 2018 (compulsory), life sciences, 1st semester
- Bachelor CLS starting 2016 (compulsory), life sciences, 1st semester
- Bachelor Nutritional Medicine (compulsory), life sciences, 1st semester
- Bachelor MLS starting 2016 (compulsory), life sciences, 1st semester
- Bachelor MLS starting 2018 (compulsory), life sciences, 1st semester

Classes and lectures:

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

Workload:

- 150 Hours private studies
- 90 Hours in-classroom work

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 testHandling 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
- Basal practical skills in light microscopy

Grading through:

- continuous, successful participation in course, >80% (academic achievement)
- written exam (test achievement)

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:

- : Cambell Biology

Language:

- offered only in German

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-KP09 - Analysis 2 (Ana2KP09)

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

Course of study, specific field and term:

- Bachelor CLS starting 2016 (compulsory), mathematics, 2nd semester
- Minor in Teaching Mathematics, Bachelor of Arts (compulsory), mathematics, 6th 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:

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

Grading through:

- Exercises
- written exam
- e-tests

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

Notes:

The module MA2500-KP09 is identical to module MA2500-MML.

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.

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.

LS1100-KP04 - General Chemistry (ACKP04)

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), advanced curriculum, arbitrary semester
- Bachelor Medical Informatics since 2014 (optional subject), medical computer science, 5th or 6th semester
- Bachelor Computer Science since 2016 (optional subject), Canonical Specialization Bioinformatics, 3rd semester
- Bachelor CLS starting 2016 (compulsory), life sciences, 3rd semester
- Bachelor Biophysics (compulsory), life sciences, 1st semester

Classes and lectures:

- General Chemistry (lecture, 3 SWS)
- General Chemistry (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 60 Hours in-classroom work

Contents of teaching:

- Lectures:
- The structure of atoms and the periodic table of the elements
- Chemical bonds, molecules and Ions
- Reaction equations 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 mater and radiation - Molecular spectroscopy
- Thermodynamics
- Chemical kinetics
- Exercises:
- Students discuss problems covering all topics of the lectures on the black board

Qualification-goals/Competencies:

- Students have fundamental knowledge of general and inorganic chemistry.
- Students understand the fundamental concepts of general and inorganic chemistry and can apply them to reactions and general scientific topics.
- Students are able to perform chemical calculations from all subareas of the course.
- They can transfer the acquired knowledge to problems of other branches in chemistry and related sciences and are thus able to participate in continuative courses.

Grading through:

- written exam

Is requisite for:

- Practical course chemistry (LS1610-KP04)
- Organic Chemistry (LS1600-KP04)

Responsible for this module:

- PD Dr. phil. nat. Thomas Weimar

Teacher:

- Institute of Chemistry and Metabolomics

- PD Dr. phil. nat. Thomas Weimar

Literature:

- Schmuck et al.: Chemie für Mediziner - Pearson Studium

- Binnewies et al.: Allgemeine und Anorganische Chemie - Spektrum Verlag

Language:

- offered only in German

MA2700-KP04 - Proseminar (ProsemKP04)

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

Course of study, specific field and term:

- Bachelor CLS starting 2016 (compulsory), Interdisciplinary modules, 3rd semester
- Minor in Teaching Mathematics, Bachelor of Arts (compulsory), mathematics, 8th 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-KP09)
- 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

MA3110-KP06 - Numerics 1 (Num1KP06)

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

Course of study, specific field and term:

- Bachelor CLS starting 2016 (compulsory), mathematics, 3rd semester
- Minor in Teaching Mathematics, Bachelor of Arts (compulsory), mathematics, 7th semester

Classes and lectures:

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

Workload:

- 100 Hours private studies and exercises
- 60 Hours in-classroom work
- 20 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-KP09)
- 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:

- W. Dahmen, A. Reusken: Numerische Mathematik für Ingenieure und Naturwissenschaftler - 2. Auflage, Springer (2008)
- P. Deuflhard, A. Hohmann: Numerische Mathematik I - 4. Auflage, De Gruyter (2008)
- P. Deuflhard, F. Bornemann: Numerische Mathematik II - 4. Auflage, De Gruyter (2013)
- M. Hanke-Bourgeois: Grundlagen der Numerischen Mathematik und des Wissenschaftlichen Rechnens - 3. Auflage, Teubner (2009)
- H. R. Schwarz, N. Köckler: Numerische Mathematik - 8. Auflage, Teubner (2011)
- J. Stoer: Numerische Mathematik I - 10. Auflage, Springer (2007)
- J. Stoer, R. Bulirsch: Numerische Mathematik II - 6. Auflage, Springer (2011)
- A. M. Quarteroni, R. Sacco, F. Salieri: Numerical Mathematics - 2. Auflage, Springer (2007)

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.

MA3400-KP05 - Biomathematics (BioMaKP05)

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

Course of study, specific field and term:

- Bachelor Computer Science since 2016 (optional subject), advanced curriculum, arbitrary semester
- Bachelor Computer Science since 2016 (compulsory), Canonical Specialization Bioinformatics, 5th semester
- Master MLS starting 2016 (optional subject), interdisciplinary competence, 1st semester
- Bachelor CLS starting 2016 (compulsory), mathematics, 3rd semester
- Bachelor Biophysics (compulsory), mathematics, 3rd semester
- Master MLS starting 2018 (optional subject), interdisciplinary competence, 1st semester

Classes and lectures:

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

Workload:

- 70 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 2009 (6th edition)
- R. Schuster: Biomathematik - Teubner Studienbücher 1995
- S. Handrock-Meyer: Differenzialgleichungen für Einsteiger - Hanser 2007

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.

MA4020-KP05 - Stochastics 2 (Stoch2KP05)

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

Course of study, specific field and term:

- Bachelor IT-Security (optional subject), mathematics, arbitrary semester
- Minor in Teaching Mathematics, Master of Education (compulsory), mathematics, 1st semester
- Bachelor Computer Science since 2016 (optional subject), advanced curriculum, arbitrary semester
- Bachelor CLS starting 2016 (compulsory), mathematics, 3rd semester

Classes and lectures:

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

Workload:

- 70 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

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.

LS1600-KP04 - Organic Chemistry (OCKP04)

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

Course of study, specific field and term:

- Master Medical Informatics (optional subject), bioinformatics, 1st or 2nd semester
- Bachelor CLS starting 2016 (compulsory), life sciences, 4th semester
- Bachelor Biophysics (compulsory), life sciences, 2nd semester
- Master Medical Informatics since 2019 in planing (optional subject), bioinformatics, 1st or 2nd semester

Classes and lectures:

- Organic Chemistry (lecture, 3 SWS)
- Organic Chemistry (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 60 Hours in-classroom work

Contents of teaching:

- Lectures:
- Alkanes, cycloalkanes
- Alkenes and Alkynes
- Aromatics
- Stereochemistry
- Substitution and elimination reactions
- Alcohols, phenols and thiols
- Ether and epoxides
- Aldehydes and ketones
- Carboxylic acids and derivativs
- Amines and derivativs
- Heterocycles
- Lipids
- Carbohydrates
- Amino acids and peptides
- Nucleotides and nucleic acids
- Exercises:
- Students discuss problems covering all topics of the lectures on the black board

Qualification-goals/Competencies:

- After successful completion of the course, students have a fundamental knowledge of organic chemistry. They are confident using structural formulas of substance classes and functional groups presented in the course. They are confident in the nomenclature and can correctly describe relative and absolute configurations of molecules.
- Students know the most important reactions, reaction types and reaction principles of organic chemistry. They understand the structural properties of functional groups and are able to formulate organic chemical reaction mechanisms of these groups.
- Students can transfer and apply the acquired skills to problems of other branches of chemistry and related sciences and are thus able to participate in continuative courses.

Grading through:

- written exam

Requires:

- General Chemistry (LS1100-KP04)

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

LS1610-KP04 - Practical course chemistry (ACPKP04)

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

Course of study, specific field and term:

- Bachelor CLS starting 2016 (compulsory), life sciences, 4th semester
- Bachelor Biophysics (compulsory), life sciences, 1st and 2nd semester

Classes and lectures:

- Practical course chemistry (practical course, 4 SWS)

Workload:

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

Contents of teaching:

- Practical course:
- The students work independently under supervision
- Selected experiments related to topics of the lectures general and organic chemistry

Qualification-goals/Competencies:

- From their independent work in the lab course students have fundamental practical skills to perform simple experiments and analyzes in the chemical laboratory. They are competent in basic techniques of the handling of hazardous materials according to GHS (Globally Harmonized System of Classification and Labeling of Chemicals).
- Students are capable to document, interpret and present the results of conducted experiments (laboratory journal and concluding discussion).

Grading through:

- Continuous, successful participation in practical course. All experiments habe to be conducted.

Requires:

- General Chemistry (LS1100-KP04)

Responsible for this module:

- PD Dr. phil. nat. Thomas Weimar

Teacher:

- Institute of Medical Engineering

- Dr. rer. nat. Kerstin Lüdtke-Buzug
- Dr. rer. nat. Thorsten Biet

Literature:

- Thomas Weimar: Script of the practical course

Language:

- offered only in German

Notes:

Course ist not graded. In order to pass the course students have to conduct experiments within defined error margins and present an experiment of the course in a talk.

MA2600-KP07 - Biostatistics 2 (BioSt2KP07)

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

Course of study, specific field and term:

- Bachelor CLS starting 2016 (compulsory), mathematics, 4th semester

Classes and lectures:

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

Workload:

- 85 Hours programming
- 70 Hours in-classroom work
- 40 Hours private studies
- 15 Hours exam preparation

Contents of teaching:

- Assumptions in the classical linear model
- Last squares method and geometric representation
- Stochastic properties, testing the general linear hypothesis, construction of confidence intervals and confidence ellipsoids
- Regression diagnostics and model choice
- Logistic regression: basics, model specification, threshold model, maximum likelihood estimation, tests and confidence intervals
- Survival Analysis: Kaplan-Meier curves, Log-Rank test, assumptions and parameter estimation in Cox regression
- Data structures in R, functions and functionals in R
- Statistical analysis in R: descriptive statistics (frequency tables, metrics), graphical representation, statistical tests (t-, X2-, U-, Log-Rank-), executable protocolls (literate programming) with knitr, bootstrapping, cross-validation, linear regression, logistic regression, Cox regression

Qualification-goals/Competencies:

- The students are able to enumerate and explain the assumptions of the classical linear model.
- They are able to describe typical applications of the classical linear model.
- They are able to list the differences between the linear model and the logistic regression model.
- They are able to describe possible error sources in modelling the linear model.
- They are able to calculate the estimators (point and interval estimators, residual, prediction) in the linear model by hand.
- They are able to evaluate the graphics for regression diagnostics in the linear model.
- They are able to interpret the results of studies, where a linear, a logistic or a Cox regression model was applied.
- They are able to draw and interpret Kaplan-Meier curves.
- They are able to perform data transformations.
- They are able to program their own R functions.
- They are able to present data by suitable and pleasing graphics.
- They are able to conduct linear, logistic and Cox regression analysis by means of R packages and to evaluate the results on the computer.
- They are able to execute statistical tests (t-, X2-, U-, Log-Rank-) in R, to formulate the hypotheses and to make a test decision.
- They are able to illustrate the principle of bootstrapping and cross-validation and to implement it in R.
- They are able to create a report that meets the requirements of academic work by means of the R package knitr.

Grading through:

- Exercises
- written exam

Is requisite for:

- Prognostic models (MA4660-KP05)
- Genetic Epidemiology 2 (MA4661-KP08, MA4661)
- Interdisciplinary Seminar (MA3300-KP04)
- Generalized Linear Models (MA4962-KP05)
- Multivariate Statistics (MA4944-KP05)

Requires:

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

- Fahrmeir, Ludwig; Kneib, Thomas; Lang, Stefan (2009): Regression: Modelle, Methoden und Anwendungen - Springer: Heidelberg
- Dobson, Annette J & Barnett, Adrian (2008): An Introduction to Generalized Linear Models, 3rd ed. - Chapman & Hall/CRC: Boca Raton
- Sachs, Lothar; Hedderich, Jürgen: Angewandte Statistik: Methodensammlung mit R - 15. Auflage, Springer: Heidelberg
- Ligges, Uwe: Programmieren mit R - 3. Auflage, Springer: Heidelberg

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.

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-KP06 - Numerics 2 (Num2KP06)

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

Course of study, specific field and term:

- Bachelor CLS starting 2016 (compulsory), mathematics, 4th semester
- Minor in Teaching Mathematics, Master of Education (compulsory), mathematics, 2nd 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-KP06)
- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)
- Analysis 2 (MA2500-KP09)
- 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:

- W. Dahmen, A. Reusken: Numerische Mathematik für Ingenieure und Naturwissenschaftler - 2. Auflage, Springer (2008)
- P. Deuflhard, A. Hohmann: Numerische Mathematik I - 4. Auflage, De Gruyter (2008)
- P. Deuflhard, F. Bornemann: Numerische Mathematik II - 4. Auflage, De Gruyter (2013)
- M. Hanke-Bourgeois: Grundlagen der Numerischen Mathematik und des Wissenschaftlichen Rechnens - 3. Auflage, Teubner (2009)
- H. R. Schwarz, N. Köckler: Numerische Mathematik - 8. Auflage, Teubner (2011)
- J. Stoer: Numerische Mathematik I - 10. Auflage, Springer (2007)
- J. Stoer, R. Bulirsch: Numerische Mathematik II - 6. Auflage, Springer (2011)
- A. M. Quarteroni, R. Sacco, F. Salieri: Numerical Mathematics - 2. Auflage, Springer (2007)

Language:

- offered only in German

Notes:

The module MA4040-KP06 is identical to module MA4040-MML.

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.

CS2500-KP05 - Robotics (Robotik5)

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

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), computer science, 5th or 6th semester

Classes and lectures:

- Robotics (lecture, 2 SWS)
- Robotics Exercise (exercise, 2 SWS)

Workload:

- 60 Hours in-classroom work
- 55 Hours private studies
- 20 Hours exam preparation
- 15 Hours work on project

Contents of teaching:

- Description of serial robotic systems: This part includes the basic components like different types of joints, sensors and actors. Exemplarily, the differing kinematic types are introduced. Also, the mathematical backgrounds are presented, necessary for the description of robots. The direct and inverse kinematics for typical 6-jointed industrial robots is explained.
- Parallel robot systems: This part deals with the transfer of the results and mathematical models of part 1 onto robotic systems with parallel kinematics.
- Movement: Robot movements along trajectories/geometric paths are analyzed. Different techniques of path planning are presented as well as methods to determine the configuration space and to perform velocity planning and kinematics.
- Robot Control: Techniques of control theory and examples of programming techniques in robotics are introduced. Sensor and systems calibration as a typical application of robotics is explained in detail.

Qualification-goals/Competencies:

- The students are able to solve application-oriented exercises with mathematical background self-dependent, timely and in team work.
- They have gained basic understanding for the kinematic features of serial and simple parallel robots (includes knowledge of transformations, Euler-/Tail-Bryan-Angles, quaternions, etc.)
- They made first experiences with the programming of simple robotic applications.
- They comprehend the complexity and necessity for different path and dynamic planning techniques.
- The students gained an insight into simple methods for system and sensor calibration.

Grading through:

- written exam

Is requisite for:

- Lab Course Robotics and Automation (CS3501-KP04, CS3501)

Requires:

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

Responsible for this module:

- Prof. Dr.-Ing. Achim Schweikard

Teacher:

- Institute for Robotics and Cognitive Systems

- Prof. Dr.-Ing. Achim Schweikard
- Prof. Dr. rer. nat. Floris Ernst

Literature:

- A. Schweikard, F. Ernst: Medical Robotics - Springer Verlag, 2015
- M. Spong et al.: Robot Modeling and Control - Wiley & Sons, 2005
- H.-J. Siegert, S. Bocionek:: Robotik: Programmierung intelligenter Roboter - Springer Verlag, 1996
- J.-P. Merlet: Parallel Robots - Springer Verlag, 2006
- M. Haun: Handbuch Robotik - Springer Verlag, 2007
- S. Niku: Introduction to Robotics: Analysis, Control, Applications - Wiley & Sons, 2010

Language:

- offered only in German

CS3204-KP05 - Artificial Intelligence 1 (KI15)

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

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), computer science, 5th or 6th semester

Classes and lectures:

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

Workload:

- 60 Hours in-classroom work
- 55 Hours private studies
- 20 Hours exam preparation
- 15 Hours work on project

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.

MA3445-KP05 - Graph Theory (GraphTKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second year	5

Course of study, specific field and term:

- Minor in Teaching Mathematics, Master of Education (optional subject), mathematics, 2nd or 3rd semester
- Bachelor Computer Science since 2016 (optional subject), advanced curriculum, arbitrary semester
- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

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

Workload:

- 85 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
- Ability to learn independently by studying relevant literature

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 2010 (4th edition)
- 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

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.

MA4100-KP05 - Survival Analysis (UebAnaKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional suject), mathematics, 5th or 6th semester
- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester

Classes and lectures:

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

Workload:

- 90 Hours private studies
- 30 Hours work on project
- 15 Hours exam preparation
- 15 Hours in-classroom work

Contents of teaching:

- Introduction to survival analysis
- Kaplan-Meier method
- Log rank test
- The Cox regression model and its characteristics
- Evaluating the proportional hazards assumption
- Stratified Cox model
- Parametric survival analysis
- Regression trees for survival analysis
- Random forests for survival analysis

Qualification-goals/Competencies:

- The students are able to explain the different censoring mechanisms leading to survival analysis.
- They are able to define the most important terms of survival analysis.
- They are able to calculate point and interval estimators for the Kaplan-Maier approach.
- They are able to calculate the log-rank test for two or more groups.
- They are able to explain the assumption of proportionality of the Cox model.
- They are able to estimate Cox models.
- They are able to check the assumption of proportionality.
- They are able to calculate exponential and Weibull models.
- They are able to explain the ideas and algorithms of regression trees and random forests for survival analysis.
- They are able to estimate regression trees and random forests for survival analysis.

Grading through:

- project work
- Viva Voce or test

Requires:

- Biostatistics 2 (MA2600-KP07)
- Biostatistics 1 (MA1600-KP04, MA1600, MA1600-MML)
- Stochastics 2 (MA4020-KP05)
- 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

Literature:

- Kleinbaum DG, Klein M: Survival Analysis: A Self-Learning Text - 2005 - ISBN: 978-0-387-23918-7

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.

MA4341-KP05 - Time series analysis (ZeitAnKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester
- Minor in Teaching Mathematics, Master of Education (optional subject), mathematics, 2nd or 3rd semester

Classes and lectures:

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

Workload:

- 85 Hours private studies and exercises
- 45 Hours in-classroom work
- 20 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 long-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-KP05)

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:

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.

MA4345-KP05 - Functional Analysis (AKFunkKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester
- Minor in Teaching Mathematics, Master of Education (optional subject), mathematics, 2nd or 3rd semester

Classes and lectures:

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

Workload:

- 85 Hours private studies and exercises
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- metric spaces
- elements of topology, in particular, compactness
- Banach and Hilbert spaces
- L^p-spaces
- duality
- bounded linear functionals and operators

Qualification-goals/Competencies:

- Understanding the transfer of simple analytic ideas to general structures
- Lerning and applying techniques of functional analysis

Grading through:

- Exercises
- Oral examination
- written exam

Requires:

- Analysis 2 (MA2500-KP04, MA2500)

Responsible for this module:

- Prof. Dr. rer. nat. Karsten Keller

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Karsten Keller

Literature:

- A. N. Kolmogorov, S. V. Fomin: Reelle Funktionen und Funktionalanalysis - Deutscher Verlag der Wissenschaften, Berlin 1975

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.

MA4400-KP05 - Chaos and Complexity (ChaKomKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester
- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Master Biophysics (optional subject), Elective, 1st or 2nd semester

Classes and lectures:

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

Workload:

- 85 Hours private studies and exercises
- 45 Hours in-classroom work
- 20 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

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.

MA4410-KP05 - Approximation Theory (ApproxKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester
- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Minor in Teaching Mathematics, Master of Education (optional subject), mathematics, 2nd or 3rd 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
- 30 Hours work on project
- 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, project, oral or written exam

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
- R. A. Devore, G. G. Lorentz: Constructive Approximation - Springer 1993

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.

MA4453-KP05 - Evolutionary Dynamics: Population Genetic and Ecological Models (EDPGEMKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS starting 2016 (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
- 30 Hours work on project
- 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
- project work
- 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-KP05 - Evolutionary Dynamics: Game Theory (EvDyGTKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS starting 2016 (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
- 30 Hours work on project
- 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
- project work
- 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.

MA4510-KP05 - Wavelet Theory (WaveThKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester
- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Haar system
- Discrete Haar transformation
- Orthonormal wavelet bases
- Multiresolution Analysis
- Algorithms for reconstruction and decomposition
- Multivariate generalizations
- Periodic wavelets

Qualification-goals/Competencies:

- Knowledge of the basic principles of wavelet analysis
- Understanding the applications in signal analysis
- The students learn how to work with wavelet algorithms and wavelet software.

Grading through:

- exercises, project, oral or written exam

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Jürgen Prestin

Literature:

- I. Daubechies: Ten lectures on wavelets - SIAM Publ., Philadelphia, 1992
- A.K. Louis, P. Maass, A. Rieder: Wavelets - Teubner Studienbücher Mathematik, 1994

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.

MA4611-KP05 - Markov-Prozesse (MarkPrKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

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

Workload:

- 85 Hours private studies and exercises
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Markov chains
- General Markov processes
- Brownian Motion
- Poisson process
- birth-and-death processes
- life science applications

Qualification-goals/Competencies:

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

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

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.

MA4614-KP05 - Numerical methods for partial differential equations (NMPDGKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester
- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester

Classes and lectures:

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

Workload:

- 85 Hours private studies and exercises
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Introduction to the theory of partial differential equations
- 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
- programming exercises
- Written or oral exam as announced by the examiner

Requires:

- Numerics 2 (MA4040-KP06)
- Numerics 1 (MA3110-KP06)
- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)
- Analysis 2 (MA2500-KP09)
- 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:

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

Notes:

Literature will be announced in the lecture.

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.

MA4615-KP05 - Numerical methods for stochastic processes (NuStPrKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester
- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester

Classes and lectures:

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

Workload:

- 85 Hours private studies and exercises
- 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
- programming exercises
- Written or oral exam as announced by the examiner

Requires:

- Stochastics 2 (MA4020-KP05)
- Stochastics 1 (MA2510-KP04, MA2510)
- Stochastic processes (MA4610-KP05)

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, 2003
- G. N. Milstein, M. V. Tretyakov: Stochastic Numerics for Mathematical Physics - Springer-Verlag, Berlin, 2004

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.

MA4616-KP05 - Advanced Numerics (HoeNumKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester
- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Minor in Teaching Mathematics, Master of Education (optional subject), mathematics, 2nd or 3rd semester

Classes and lectures:

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

Workload:

- 85 Hours private studies and exercises
- 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
- programming exercises
- Written or oral exam as announced by the examiner

Requires:

- Numerics 2 (MA4040-KP06)
- Numerics 1 (MA3110-KP06)

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Rößler

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Andreas Rößler

Language:

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

Notes:

Literature will be announced in the lecture.

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.

MA4630-KP05 - Fourier Analysis (FouAnaKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional suject), mathematics, 5th or 6th semester
- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester

Classes and lectures:

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

Workload:

- 65 Hours private studies
- 45 Hours in-classroom work
- 30 Hours work on project
- 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, project, oral or 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
- Pinsky, M. A.: Introduction to Fourier Analysis and Wavelets - Brooks/Cole 2002

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.

MA4650-KP05 - Matrix algebra (MatAlgKP05)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	irregularly	5	20

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 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
- 30 Hours work on project
- 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:

- Students know numerous rules of matrix algebra.
- They understand proofs, especially concerning generalized linear models and multivariate procedures.
- They command matrix calculus.
- They apply linear algebra to linear models.
- They can deal with practical problems from statistics in an abstract manner.

Grading through:

- project work
- written exam

Requires:

- Biostatistics 1 (MA1600-KP04, MA1600, MA1600-MML)
- Analysis 2 (MA2500-KP09)
- Biostatistics 2 (MA2600-KP07)

Responsible for this module:

- Dr. Reinhard Vonthein

Teacher:

- Institute of Medical Biometry and Statistics

- Dr. Reinhard Vonthein
- MitarbeiterInnen des Instituts

Literature:

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

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.

MA4660-KP05 - Prognostic models (ProMoKP05)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	irregularly	5	20

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester
- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester

Classes and lectures:

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

Workload:

- 40 Hours private studies
- 35 Hours in-classroom work
- 30 Hours programming
- 30 Hours work on project
- 15 Hours exam preparation

Contents of teaching:

- Aims and applications of prognostic models
- General approach to develop valid prognostic models
- Classical statistical approaches to develop prognostic models (variable selection, risk estimation, interaction modelling and identification, nonlinear effect identification and modelling)
- Approaches to validate prognostic models: internal validation (cross vali- dation, bootstrapping), temporal validation, external validation
- Generalization, calibration
- Penalised regression methods: Lasso, Ridge regression, elastic net
- Bootstrap aggregating (Bagging) regression models
- Boosting: Adaboost, gradient boosting, likelihood boosting

Qualification-goals/Competencies:

- The students are able to describe the general procedure for developing valid prognostic models.
- They are able to explain the methods for validating of prognostic models.
- They are able to estimate the risks in the dichotomous regression modelby hand and on the computer.
- They are able to interpret model interactions and implement interactions on the computer in standard statistical software.
- They are able to model nonlinear effects using splines and fractional polynomials and estimate them on the computer in standard statistical software.
- They are able to choose a suitable model with interactions and nonlinear effects.
- They are able to calibrate dichotomous prognostic models.
- They are able to estimate penalised regression models.
- They are able to interpret the results of penalised regression models.
- They are able to describe different bagging and boosting procedures.
- They are able to estimate bagging and boosting procedures and interpret the results.

Grading through:

- project work
- Viva Voce or test

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Ziegler

Teacher:

- Institute of Medical Biometry and Statistics

- Prof. Dr. rer. biol. hum. Inke König
- Prof. Dr. rer. nat. Andreas Ziegler

Literature:

- Harrel, Frank E. (2001): Regression modeling strategies - New York: Springer
- Royston, Patrick; Sauerbrei, Willi (2008): Multivariable Model-Building: A Pragmatic Approach to Regression Analysis Based on Fractional Polynomials for Continuous Variables - Chichester: John Wiley & Sons

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.

MA4665-KP05 - Statistical Learning (StaLerKP05)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	irregularly	5	20

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Statistical Learning (lecture, 2 SWS)
- Statistical Learning (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- k-nearest neighbours (k-NN)
- Classification and regression trees (CART), probability estimation trees(PET)
- bootstrap aggregating (bagging)
- Bagged nearest neighbours (b-NN)
- Random forests: classical random forests (RF) and conditional inferenceforests (CIF)
- Naive Bayes classifiers
- Neural Networks (ANN)
- Boosting
- Support vector machines (SVM)
- Quality measures, sample repetition and hyperparameter optimization
- Variable importance, variable selection
- Statistical properties of k-NN, b-NN, RF, CIF, SVM, PET and random forests with PET, ANN, i.e. consistence, convergence speed, asymptotic normal distribution, distortion

Qualification-goals/Competencies:

- The students are able to explain the basic ideas of k-NN, b-NN, CART, PET, RF, CIF, naive Bayes and SVM.
- They are able to explain the difference between the different procedures of statistical learning.
- They know the statistical properties of the procedures.
- They are able to choose a suitable procedure for a practical situation.
- They are able to estimate the procedures using R.

Grading through:

- Viva Voce or test

Requires:

- Stochastics 1 (MA2510-KP04, MA2510)
- Biostatistics 2 (MA2600-KP07)

Responsible for this module:

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

Teacher:

- Institute of Medical Biometry and Statistics

- Damian Gola, M.Sc.

Literature:

- Hastie, Trevor, Tibshirani, Ron, Friedman, Jerome (2009): The Elements of Statistical Learning: ata Mining, Inference, and Prediction - 2nd ed., Springer: New York
- Malley, James D., Malley, Karen G., Pajevic, Sinisa (2010): Statistical Learning for Biomedical Data - Cambridge University Press: Cambridge
- Wu, Xindong & Kumar, Vipin eds. (2009): The Top Ten Algorithms in Data Mining - CRC Press: Boca Raton

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.

MA4670-KP05 - Combinatorics (KombiKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second year	5

Course of study, specific field and term:

- Minor in Teaching Mathematics, Master of Education (optional subject), mathematics, 2nd or 3rd semester
- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

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

Workload:

- 85 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
- Ability to learn independently by studying relevant literature

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

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.

MA4675-KP05 - Algebra (AlgebrKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second year	5

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester
- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester

Classes and lectures:

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

Workload:

- 85 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
- Ability to learn independently by studying relevant literature

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

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.

MA4735-KP05 - Geometry (GeoKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Minor in Teaching Mathematics, Master of Education (optional subject), mathematics, 2nd or 3rd semester
- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

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

Workload:

- 85 Hours private studies and exercises
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Euclidean Geometry
- Non-Euclidean Geometries
- Introduction to Differential Geometry

Qualification-goals/Competencies:

- Mastery of basic geometric results
- Gaining an overview over different geometries and their specifics

Grading through:

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

Requires:

- Analysis 2 (MA2500-KP09)
- Analysis 1 (MA2000-KP08, MA2000)
- 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. Christian Bey

Teacher:

- Institute for Mathematics

- PD Dr. rer. nat. Christian Bey

Literature:

- Bär: Elementare Differentialgeometrie
- Berger: Geometry I, II
- Coxeter: Introduction to Geometry
- Knörrer: Geometrie
- Kumaresan, Santhanam: An Expedition to Geometry
- Nikulin, Shafarevich: Geometries and Groups
- McCleary: Geometry from a Differentiable Viewpoint
- Rees: Notes on Geometry
- Sossinsky: Geometries
- Stahl: A Gateway to Modern Geometry, The Poincare Half-Plane

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.

MA4740-KP05 - Fractal Geometry (FraGeoKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS starting 2016 (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
- 30 Hours work on project
- 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.

MA4750-KP05 - Topology (TopoKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester
- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester

Classes and lectures:

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

Workload:

- 85 Hours private studies and exercises
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Topological spaces and continuous maps
- Fundamental group and covering spaces
- Introduction to Homology
- Applications

Qualification-goals/Competencies:

- Mastery of basic results and proof techniques of topology
- Understanding of applications of topological methods

Grading through:

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

Requires:

- Analysis 2 (MA2500-KP09)
- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Analysis 1 (MA2000-KP08, MA2000)
- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)

Responsible for this module:

- PD Dr. rer. nat. Christian Bey

Teacher:

- Institute for Mathematics

- PD Dr. rer. nat. Christian Bey

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.

MA4760-KP05 - Integral Theorems in Analysis (IntAnaKP05)

Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	irregularly	5

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Integral Theorems in Analysis (lecture, 2 SWS)
- Integral Theorems in Analysis (exercise, 1 SWS)

Workload:

- 85 Hours private studies and exercises
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Integration on submanifolds
- Gauss' Integral Theorem and applications
- One-forms, line integrals, Green's Integral Theorem
- Higher-order differential forms, Integration
- Stokes' Integral Theorem and applications
- Cauchy's Integral Theorem and applications

Qualification-goals/Competencies:

- Mastery of basic results and proof techniques of vector analysis
- Understanding of applications of vector analysis

Grading through:

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

Requires:

- Analysis 2 (MA2500-KP09)
- Analysis 1 (MA2000-KP08, MA2000)
- 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. Christian Bey

Teacher:

- Institute for Mathematics

- PD Dr. rer. nat. Christian Bey

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.

MA4801-KP05 - Elliptic Functions and Function Theory (EFFThKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second year	5

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Elliptic Functions and Function Theory (lecture, 2 SWS)
- Elliptic Functions and Function Theory (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Complex analysis
- Periodic functions and lattices
- Simple and double periods
- Liouville Theorem, residue theorem
- Weierstrass P-, Zeta- and Sigma-function
- The field of elliptic functions
- Elliptic integrals
- Moduls of elliptic functions

Qualification-goals/Competencies:

- Getting familiar with and developing skills in concepts and techiques in complex analysis
- Extension of the background for different applications, e.a. signal processing, to develop problem solving strategies
- Getting familiar with Mathematica in the considered topic
- Developing competencies for self-sufficient problem solving
- Gaining experience in project work in the field

Grading through:

- exercises, project, oral or written exam

Responsible for this module:

- Prof. Dr. Reinhard Schuster

Teacher:

- Institute for Mathematics

- Prof. Dr. Reinhard Schuster

Literature:

- Andrews, G. E., Askey, R. and Roy, R.: Special Functions - Cambridge University Press 1999
- Armitage, J. V. and Eberlein, W. F.: Elliptic Functions - Cambridge University Press 2006
- Hurwitz, A.: Vorlesungen über Allgemeine Funktionentheorie und Elliptische Funktionen - Springer 2000
- Koecher, M und Krieg, A.: Elliptische Funktionen und Modulformen - Springer 2007
- Stramp, W., Ganzha, V. und Vorozhtsov, E.: Höhere Mathematik mit Mathematica - Vieweg 1997
- Werner, A.: Elliptische Kurven in der Kryptographie - Springer 2002
- Whittaker, E. T. and Watson, G. N.: A course of modern analysis - Cambridge University Press 1902 (Reprinted 1999)

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.

MA4802-KP05 - Theory of Relativity (RelaThKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second year	5

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Theory of Relativity (lecture, 2 SWS)
- Theory of Relativity (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Part A, Special Relativity:
- Classical space time references system and Newton laws
- Electrodynamics , Lorentz and Minkowsky geometry
- Hyperbolic geometry und trigonometry
- Time-like, space-like and light cone
- Relativistic kinematics
- Simultaneity and velocity addition
- Length contraction and time dilation
- Twin paradox
- Mass and energy relativistic
- Part B, General Theory of Relativity:
- Four-dimensional space time as a manifold
- Christoffel symbols, curvature tensor, covariant derivative
- Coupling of matter and fields with geometry by the Einstein equation
- Equivalence principle for mass

Qualification-goals/Competencies:

- Getting familiar with and developing skills in concepts and techniques in complex analysis
- Extension of the mathematic and physical background for different applications to develop problem solving strategies
- Getting familiar with Mathematica in the considered topic
- Developing competencies for self-sufficient problem solving
- Gaining experience in project work in the field

Grading through:

- exercises, project, oral or written exam

Responsible for this module:

- Prof. Dr. Reinhard Schuster

Teacher:

- Institute for Mathematics

- Prof. Dr. Reinhard Schuster

Literature:

- Baumann, G.: Mathematica for Theoretical Physics. Part 1: Classical Mechanics and Nonlinear Dynamics. Part 2: Electrodynamics, Quantum Mechanics, General Relativity, and Fractals - Springer 2005
- Goenner, H.: Spezielle Relativitätstheorie und die klassische Feldtheorie - Spectrum 2003
- Gray A., Abbena, E. and Salomon, S.: Modern Differential Geometry of Surfaces with Mathematica. Studies in Advanced Mathematics - Chapman and Hall 2006
- Haken, H. und Wolf, H. Ch.: Atom- und Quantenphysik. Einführung in die experimentellen und theoretischen Grundlagen - Springer 2003
- Hawking, S. W. and Ellis, G. F. R.: The large scale structure of space-time - Cambridge Monographs on Mathematical Physics 1973, 2006

- Helgason, S.: Differential Geometry, Lie Groups and Symmetric Spaces. Graduate Studies in Mathematics - American Mathematical Society 1978, 2001
- Kobayashi, S. and Nomizu, K.: Foundations of Differential Geometry I, II - Interscience Publishers 1963
- Schröder, U. E.: Gravitation. Einführung in die Allgemeine Relativitätstheorie - Harri Deutsch 2007
- Weber, H. J. und Arfen, G. B.: Essential Mathematical Methods for Physics - Elsevier 2004
- Weil, H.: Raum - Zeit - Materie. Vorlesungen über allgemeine Relativitätstheorie - Springer 1923
- Wald, R. M.: General Relativity - The University of Chicago Press 1984

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.

MA4803-KP05 - Number Theory (ZahlThKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second year	5

Course of study, specific field and term:

- Minor in Teaching Mathematics, Master of Education (optional subject), mathematics, 2nd or 3rd semester
- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS starting 2016 (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
- 30 Hours work on project
- 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, project, oral or written exam

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

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.

MA4804-KP05 - Special Functions (SpFunkKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester
- Minor in Teaching Mathematics, Master of Education (optional subject), mathematics, 2nd or 3rd semester

Classes and lectures:

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

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 30 Hours work on project
- 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, project, oral or written exam

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

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.

MA4944-KP05 - Multivariate Statistics (MulStaKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester
- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Multivariate probability distributions
- Multiple and multivariate regression
- Discriminant analysis and logistic regression
- Cluster analysis with various distance and similarity measures
- Principal component and factor analysis
- Correspondence analysis and multidimensional scaling
- Structural equation models

Qualification-goals/Competencies:

- Students command a broad repertoire of multivariate statistical methods.
- They are able to explain the ideas behind several representative methods.
- They apply these methods by hand and with R packages.
- They analyse problems and choose suitable methods.
- They are able to decide for a better option, e.g. standardization, variance structures, distance measures, factor numbers or rotations.
- They develop multivariate models.

Grading through:

- project work
- written exam

Requires:

- Biostatistics 2 (MA2600-KP07)
- Biostatistics 1 (MA1600-KP04, MA1600, MA1600-MML)
- Stochastics 2 (MA4020-KP05)
- Stochastics 1 (MA2510-KP04, MA2510)

Responsible for this module:

- Dr. Reinhard Vonthein

Teacher:

- Institute of Medical Biometry and Statistics

- Dr. Reinhard Vonthein
- MitarbeiterInnen des Instituts

Literature:

- Fahrmeir, Ludwig; Hamerle, Alfred; Tutz, Gerhard: Multivariate statistische Verfahren - ISBN-13 9783110138061
- Johnson, R. J.; Wichern, D. W.: Applied Multivariate Statistical Analysis - 5. Ed. Prentice Hall, 2002 - ISBN-13: 000-0131877151

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.

MA4947-KP05 - Nonparametric statistics (NpStatKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester
- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester

Classes and lectures:

- Nonparametric statistics (lecture, 2 SWS)
- Nonparametric statistics (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Recall and extension: properties of parametric procedures
- Fundametal limit theorems (quantiles, U-statistics, M-estimators, rank statistics, empirical processes)
- Nonparametric estimation of functionals, confidence intervals, comparison to parametric methods
- Rank tests
- Selected applications in life sciences (reading and critique of medical publications, analysis of data from recent projects)

Qualification-goals/Competencies:

- Know the nonparametric statistical procedures of highest practical importance
- Understand pros and cons of parametric and nonparametric methods with resprect to efficiency, robustness and interpretability
- Competence in the selection of suitable procedures in applied work

Grading through:

- project work
- Viva Voce or test

Requires:

- Stochastics 2 (MA4020-KP05)
- Stochastics 1 (MA2510-KP04, MA2510)
- Biostatistics 2 (MA2600-KP07)
- 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
- Dr. Reinhard Vonthein

Literature:

- Herbert Büning, Götz Trenkler: Nichtparametrische statistische Methoden - ISBN-13 9783110163513

Language:

- offered only in German

Notes:

Prüfungsvorleistungen können zu Beginn des Semesters festgelegt werden. Sind Vor- leistungen definiert, müssen diese vor der Erstprüfung erbracht und positiv bewertet worden sein.

MA4955-KP05 - Applied Multiple Regression (AMuRegKP05)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	irregularly	5	20

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester
- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester

Classes and lectures:

- Applied Multiple Regression (lecture, 2 SWS)
- Applied Multiple Regression (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Need and use of multivariable analyses in epidemiological and clinical research
- Types of outcome variables and available multivariable models
- Incorporation of independent variables in the model
- Dealing with the issues of limited sample size and missing data
- Coding and entering the variables in the model
- Assessing the regression coefficient and strength of the model
- Checking the underlying assumptions and improving the fit of the model
- Communicating the results to the publishing house

Qualification-goals/Competencies:

- The students are able to understand different study designs and multivariable models.
- They are able to understand impact of a variable on an outcome in a multivariable model.
- They are able to understand assumptions underlying the model.
- They are able to design their own multivariable analysis plan.
- They are able to interpret and critically evaluate the published studies.
- They are able to communicate their own study results using the standard available guidelines.

Grading through:

- written examination
- continuous, successful participation in course

Requires:

- Biostatistics 2 (MA2600-KP07)

Responsible for this module:

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

Teacher:

- Institute of Medical Biometry and Statistics

- Dr. Sandeep Grover

Literature:

- Mitchell H. Katz. 2011: Multivariable Analysis: A Practical Guide for Clinicians and Public Health Researchers - 3rd ed. Cambridge University Press. ISBN -13: 978-0-521-14107-9
- Betty R. Kirkwood, Jonathan A. C. Sterne. 2003: Essential Medical Statistics - 2nd ed. Wiley-Blackwell. ISBN-13: 978-0-865-42871-3

Language:

- offered only in English

MA4962-KP05 - Generalized Linear Models (VLModKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester
- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- General overview of generalized linear models (GLM): - link and response function, - GLM algorithms: Newton-Raphson, Fisher Scoring, iterated weighted least squares, - convergence, - quality of the adaption, - residuals
- Continuous response models: Gaussian, log-normal, Gamma, log-Gamma for survival analysis, inverse Gaussian
- Dichotomous response models: logit, probit, cloglog
- Count data: Poisson, negative binomial with over- and underdispersion
- Ordinal response models: proportional odds model
- Disordered categorial response models: Multinomial logit and probit model
- Censored continuous response models: Tobit model

Qualification-goals/Competencies:

- The students are able to explain the theoretical bases of generalized linear models (GLM).
- They are able to explain areas of application for GLM.
- They are able to select a suitable GLM.
- They are able to estimate GLMs in R.
- They are able to explain the R source code in a presentation.
- They are able to judge the results of GLMs in R critically.
- They are able to evaluate algorithmic challenges of GLMs.
- They are able to explain conceptual problems of GLMs for categorialresponse variables.
- They are able to implement GLM in R.
- They are able to apply regression diagnostics to GLMs and to judge the results.
- They are able to describe the most important estimation algorithms for GLMs.
- They are able to list the statistical properties of GLMs.

Grading through:

- Viva Voce or test
- project work

Requires:

- Biostatistics 2 (MA2600-KP07)

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:

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

Notes:

Prüfungsvorleistungen können zu Beginn des Semesters festgelegt werden. Sind Vor- leistungen definiert, müssen diese vor der Erstprüfung erbracht und positiv bewertet worden sein.

MA4970-KP05 - Design of Experiments and Variance Analysis (VerVarKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Models for regression analysis and analysis of variance (ANOVA)
- Generalized inverse
- Singular linear models
- Two-factorial trial designs
- Multi-factorial trial designs
- Deterministic and stochastic factors
- Latin and Graeco-Latin squares
- Split plot designs

Qualification-goals/Competencies:

- The students are able to calculate generalized inverses.
- They know the difference between experimental and observational studies.
- They are able to enumerate the advantages of the statistical design for multifactorial experiments.
- They are able to interpret experimental factorial designs.
- They are able to choose and implement a suitable experimental variance-analytical design.
- They are able to formulate the ANOVA model as regression model in matrix notation.
- They are able to formulate and implement ANOVA models with repeated measures.
- They know the statistical properties of linear models with singular design matrix and singular hypotheses matrix.
- They can estimate linear models with singular design matrix and singular hypotheses matrix.
- They are able to create and interpret graphics for the summary of results and for model diagnostics.

Grading through:

- project work
- Viva Voce or test

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:

- 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: 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

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.

MA5008-KP05 - Mathematical course (PrakMaKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	on request	5 (Typ B)

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), mathematics, 5th or 6th semester
- Master CLS starting 2016 (optional subject), mathematics, 2nd or 3rd semester

Classes and lectures:

- Mathematical course (practical course, 5 SWS)

Workload:

- 120 Hours in-classroom work
- 30 Hours written report

Contents of teaching:

- Planning and execution of a scientific project by mathematical methods
- Presenting the methods and results in a detailed written report

Qualification-goals/Competencies:

- Ability to analyze a given problem and to develop mathematical approaches for it
- Ability to make oneself familiar with adequate mathematical structures without any help
- Ability to integrate partial results into the overall solution
- Proficiency in documenting and presenting results

Grading through:

- Written report

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institutes of the Department of Computer Science/ Engineering

Language:

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

CS4013-KP04 - Biointeractivity (BioinfKP04)

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), medical computer science, 5th semester
- Bachelor CLS starting 2016 (compulsory), specialization field bioinformatics, 5th semester

Classes and lectures:

- Bioinformatics (lecture, 2 SWS)
- 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:

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

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

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.

MA3300-KP04 - Interdisciplinary Seminar (InterSKP04)

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

Course of study, specific field and term:

- Bachelor CLS starting 2016 (compulsory), Interdisciplinary modules, 5th semester

Classes and lectures:

- Interdisciplinary Seminar (seminar, 2 SWS)

Workload:

- 90 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-KP07 - Modeling Biological Systems (MoBSKP07)

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

Course of study, specific field and term:

- Bachelor CLS starting 2016 (compulsory), mathematics, 5th semester

Classes and lectures:

- Modeling Biological Systems (lecture, 3 SWS)
- Modeling Biological Systems (exercise, 2 SWS)

Workload:

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

Contents of teaching:

- Elementary time-discrete deterministic models
- Structured time-discrete population dynamics
- Markov-Ketten mit Anwendungen
- Galton-Watson processes
- Multitype Galton-Watson processes
- 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.

MA5030-KP05 - Image Registration (BildreKP05)

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

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), mathematics, 5th semester
- Master CLS starting 2016 (optional subject), mathematics, 1st or 3rd semester

Classes and lectures:

- Image Registration (lecture, 2 SWS)
- Image Registration (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Introduction and basic principles
- Interpolation
- Deformation models
- Landmark-based registration
- Parametric registration
- Non-parametric registration and regularization strategies

Qualification-goals/Competencies:

- Students know the fundamental concepts of image registration.
- They are able to translate concrete problems into adequate models.
- They have experience with parametric registration and can determine optimal parameters.
- They understand nonparametric image registration.
- 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, project, oral or written exam
- Presentation of one´s own solution of an exercise

Requires:

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

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:

- Goshtasby: 2D and 3D Image Registration - Wiley
- Modersitzki: Numerical Methods for Image Registration - Oxford University Press
- Modersitzki: FAIR: Flexible Algorithms for Image Registration - SIAM
- Rohr: Landmark-Based Image Analysis - Kluwer

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.

ME1500-KP04 - Fundamentals of Physics (GrPhysKP04)

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

Course of study, specific field and term:

- Bachelor CLS starting 2016 (compulsory), life sciences, 5th semester
- Bachelor Computer Science since 2016 (optional subject), Canonical Specialization Bioinformatics, 5th semester
- Bachelor Computer Science since 2016 (optional subject), advanced curriculum, arbitrary 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

ME2053-KP03 - Physics Lab Course (PhyPraKP03)

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

Course of study, specific field and term:

- Bachelor CLS starting 2016 (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: non stationary current
- Experiment 2: stationary current
- Experiment 3: sound and ultrasound
- Experiment 4: spectrometer
- Experiment 5: diffusion
- Experiment 6: 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

LS1500-KP04 - Biology 2 (Bio2KP04)

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

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), life sciences, 6th semester

Classes and lectures:

- Genetics (lecture, 2 SWS)
- Histology (lecture, 1 SWS)
- Histology (practical course, 1 SWS)

Workload:

- 60 Hours in-classroom work
- 60 Hours private studies

Contents of teaching:

- Part A, Genetics:
- a) Bacterial Genetics (Dr. U. Mamat)
- The bacterial cell
- Cell division and replication of the bacterial chromosome - part 2
- Gene organization and gene expression - part 2
- Bacterial pathogenicity factors
- Mutations in bacteria
- Accessory genetic elements and gene transfer mechanisms - part 1
- Accessory genetic elements and gene transfer mechanisms - part 2
- b) Human Genetics (Dr. F. Kaiser)
- Hereditary transmissions, mechanisms and definitions
- Overwiew: Cytogenetics
- Trinukleotid-Repeat-Expansions (TRE)
- Epigenetics
- Molecular pathology
- Mutations and RNA surveillance
- Methods in molecular genetics
- Part B, Histology:
- a) Lecture:
- Preparation of tissue specimen:Epithelium, glands
- b) Practical course Microscopy, Histology:
- Microscopy of cell structure and cell size as taught in the histology lectures. Critical investigation under the microscope. Drawing of the corresponded tissues (from the histology lectures)

Qualification-goals/Competencies:

- Part A, Genetics:
- Understanding of the heredity
- Mutations and verific
- Bacterial genetics
- Part B, Histology section:
- They can identify different histological stainings
- They can explain the structure of tissues containing site-specific cells and extracellular matrix molecules
- They can distiguish various cell shapes and functions, especially of epithelial tissues.
- Basic skills to design and perform their own experiments

Grading through:

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

Responsible for this module:

- PD Dr. rer. nat. Kathrin Kalies

Teacher:

- LIED | Lübecker Institut für experimentelle Dermatologie (Lübeck Institute of Experimental Dermatology)
- Institute of Human Genetics

- Institute of Anatomy

- Dr. rer. nat. Susanne Lemcke
- PD Dr. rer. nat. Kathrin Kalies
- Prof. Dr. Frank Kaiser

Literature:

- Lüllmann-Rauch: Histologie - Thieme Verlag, Stuttgart

Language:

- offered only in German

LS3500-KP04 - Introduction into Structural Analysis (EStrukKP04)

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

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), life sciences, 6th semester

Classes and lectures:

- Introduction into Structural Analysis (lecture, 2 SWS)
- Introduction into Structural Analysis (seminar / exercises, 2 SWS)

Workload:

- 120 Hours private studies
- 60 Hours in-classroom work

Contents of teaching:

- Part A: Protein structure analysis by crystal X-ray diffraction:
- Crystal growth: precipitant and phasediagram
- Crystal morphology: symmetry and space groups
- X-ray diffraction: Bragg's law, reciprocal lattice and the Ewald-sphere construction
- Phase determination: Patterson map and molecular replacement
- Part B: Basic NMR spectroscopy for the investigation of biomolecular structures: Basics of NMR spectroscopy: NMR experiments, Spin systems, the classical vector model
- The nuclear Overhauser effect
- Identification and characterisation of protein-ligand interactions: The transfer nOe, the STD-NMR-experiment, the HSQC experiment, the cross-saturation experiment
- Building blocks for NMR experiments
- Part C: Basics of mass spectrometry:Indroduction and basics
- Ion sources and their fields of application
- Mass analysers
- Structural analysis of biomolecules

Qualification-goals/Competencies:

- The students will acquire basic skills in selected biophysical techniques to analyze the structure and dynamics of biological macromolecules. The emphasis is on understanding the concepts behind these techniques.
- Furthermore, the students will learn how to elucidate the structure of small organic molecules
-

Grading through:

- attendance at exercises
- attendance, >90%
- presentation
- written exam

Responsible for this module:

- Prof. Dr. rer. nat. Thomas Peters

Teacher:

- Research Center Borstel
- Institute of Biochemistry
- Institute of Chemistry and Metabolomics

- Prof. Dr. rer. nat. Thomas Peters
- Prof. Dr. rer. nat. Rolf Hilgenfeld
- Dr. math. et dis. nat. Jeroen Mesters
- PD Dr. rer. nat. Karsten Seeger
- Dr. Dominik Schwudke

Literature:

- Wird den aktuellen Gegebenheiten angepasst und in der Vorlesung angegeben. Siehe auch in den entsprechenden Skripten:
- Teil B: Horst Friebolin: Ein- und zweidimensionale NMR-Spektroskopie. Eine Einführung - Wiley-VCH

- Alexander Mc Pherson: Introduction to Macromolecular Crystallography - 1st edition, 2003, Wiley

Language:

- offered only in German

MA3990-KP13 - Bachelor's thesis in Computational Life Science (BAMMLKP13)

Duration:	Turnus of offer:	Credit points:
1 Semester	each semester	13

Course of study, specific field and term:

- Bachelor CLS starting 2016 (compulsory), Interdisciplinary modules, 6th semester

Classes and lectures:

- Bachelor's thesis (supervised self studies, 1 SWS)
- Colloquium (presentation (incl. preparation), 1 SWS)

Workload:

- 360 Hours work on an individual topic from a recent field of research and written elaboration
- 30 Hours oral presentation and discussion (including preparation)

Contents of teaching:

- Investigating a given problem in mathematics or its application areas and developing a good solution
- Colloquium to represent the results including a discussion with the referees

Qualification-goals/Competencies:

- Solving a moderately difficult problem with state-of-the-art methods in mathematics
- Being able to write a scientific thesis
- Being able to present own results in a scientific talk

Grading through:

- oral presentation
- Written report

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

Notes:

The Bachelor's thesis is worth 12 credits, the preparation and performance of the colloquium 1 credit.

The basic prerequisite for starting the Bachelor's thesis is the successful completion of 120 credits.

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.

MA5032-KP05 - Numerical Methods for Image Computing (NumBVKP05)		
Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	every second summer semester	5

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), mathematics, 6th semester
- Master CLS starting 2016 (optional subject), mathematics, 2nd semester

Classes and lectures:

- Numerical Methods for Image Computing (lecture, 2 SWS)
- Numerical Methods for Image Computing (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Modeling
- Discretization
- Numerical methods for partial differential equations
- Multilevel and multiscale approaches
- Optimization methods
- Multigrid methods
- Operator splitting

Qualification-goals/Competencies:

- The students are familiar with fundamental numerical concepts in image computing.
- They have experience in realizing practical solutions.
- They can implement numerical algorithms on a computer.
- They understand selected methods for solving large linear systems.
- They can implement selected methods for solving large linear systems.
- 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, project, oral or written exam
- Presentation of one´s own solution of an exercise

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:

- Nocedal Wright: Numerical Optimization - Springer
- Modersitzki: FAIR: Flexible Algorithms for Image Registration - SIAM
- Weickert: Anisotropic Diffusion in Image Processing - Wiley

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.

MA5034-KP05 - Calculus of Variations and Partial Differential Equations (VarPDGKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second summer semester	5

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), mathematics, 6th semester
- Master CLS starting 2016 (optional subject), mathematics, 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
- 30 Hours work on project
- 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, project, oral or written exam
- Presentation of one´s own solution of an exercise

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.

MA5035-KP05 - Non-smooth Optimization and Analysis (NiOpAnKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), mathematics, 2nd semester
- Bachelor CLS starting 2016 (optional subject), mathematics, 6th semester

Classes and lectures:

- Non-smooth Optimization and Analysis (lecture, 2 SWS)
- Non-smooth Optimization and Analysis (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Introduction to non-smooth analysis: convexity, subdifferentials, existence, Legendre- Fenchel conjugate, duality
- First- and higher-order numerical optimization methods
- Approximation of discrete and non-convex problems
- Applications in image processing and computer vision

Qualification-goals/Competencies:

- The students understand the strengths of non-smooth models.
- They can devise and analyse models for simple problems.
- They understand the advantages, disadvantages, and application areas of each optimization method.
- They know how to select and specialize a suitable optimization method for a given model.
- 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, project, oral or written exam
- Presentation of one´s own solution of an exercise

Requires:

- Optimization (MA4031-KP08)
- Optimization (MA4030-KP08, MA4030)

Responsible for this module:

- Prof. Dr. rer. nat. Jan Lellmann

Teacher:

- Institute of Mathematics and Image Computing

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

Literature:

- Rockafellar, Wets: Variational Analysis - Springer
- Boyd, Vandenberghe: Convex Optimization - Cambridge University Press
- Ben-Tal, Nemirovski: Lectures on Modern Convex Optimization - SIAM
- Paragios, Chen, Faugeras: Handbook of Mathematical Models in Computer Vision - 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.

MA5036-KP05 - Multi- and High-Dimensional Data Processing (MeHoDVKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	5

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), mathematics, 2nd semester
- Bachelor CLS starting 2016 (optional subject), mathematics, 6th semester

Classes and lectures:

- Multi- and High-Dimensional Data Processing (lecture, 2 SWS)
- Multi- and High-Dimensional Data Processing (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Energy-based methods for data processing
- Data terms and regularizers for non-scalar data
- Basics of differential geometry
- Manifold-constrained optimization
- Linear, non-linear, and robust dimensionality reduction
- Applications in statistics, image-/video processing, machine learning, and com- puter vision

Qualification-goals/Competencies:

- The students understand the difficulties when moving from scalar to higher-dimensional data.
- They are confident in selecting and implementing a suitable model for a given problem from a set of known models.
- They understand the special issues when solving manifold-constrained problems.
- They are familiar with selected methods for manifold-constrained optimizationand are confident in their implementation.
- They are familiar with selected methods for linear and non-linear dimensionality reduction.
- 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, project, oral or written exam
- Presentation of one´s own solution of an exercise

Requires:

- Optimization (MA4031-KP08)
- Optimization (MA4030-KP08, MA4030)

Responsible for this module:

- Prof. Dr. rer. nat. Jan Lellmann

Teacher:

- Institute of Mathematics and Image Computing

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

Literature:

- Absil: Optimization Algorithms on Matrix Manifolds - Princeton University Press

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.

ME4415-KP06 - Bildgebung (BildgbKP06)		
Duration: 1 Semester	**Turnus of offer:** each winter semester	**Credit points:** 6

Course of study, specific field and term:

- Bachelor CLS starting 2016 (optional subject), mathematics, 6th semester
- Master CLS starting 2016 (compulsory), MML with specialization in Image Processing, 1st semester

Classes and lectures:

- ME4411 T: Modul part: Computed Tomography (lecture, 2 SWS)
- ME4412 T: Modul part: Magnetic Resonance Imaging (lecture, 2 SWS)

Workload:

- 80 Hours private studies
- 70 Hours in-classroom work
- 30 Hours exam preparation

Contents of teaching:

- as described for the module parts

Qualification-goals/Competencies:

- as described for the module parts

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. rer. nat. Thorsten Buzug

Teacher:

- Institute of Medical Engineering

- Prof. Dr. rer. nat. Thorsten Buzug
- Prof. Dr. rer. nat. Martin Koch

Literature:

- T. M. Buzug:

Language:

- German and English skills required