



UNIVERSITÄT ZU LÜBECK

Module Guide for the Study Path

Master CLS 2010



1st semester

Introduction to Programming (CS1000-KP08, CS1000SJ14-MML/MI, CS1000SJ14-MIW, EinfProg14)	1
Basic Chemistry (LS1100-MML, ACMML)	3
Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000, LADS1)	4
Analysis 1 (MA2000-KP08, MA2000, Ana1KP08)	6

2nd semester

Algorithms and Data Structures (CS1001-KP08, CS1001, AuD)	8
Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500, LADS2)	10
Biostatistics 1 (MA1600-KP04, MA1600, MA1600-MML, BioStat1)	12
Analysis 2 (MA2500-MML, Ana2)	14
Stochastics 1 (MA2510-KP04, MA2510, Stoch1)	16

3rd or 5th semester

Clinical Studies (MA2214-KP04, MA2214, KlinStud)	18
Genetic Epidemiology 1 (MA3200-KP04, MA3200, GenEpi1)	20

3rd semester

Basic Biology and Course (LS1000-MML, BioMML)	22
Numerics 1 (MA3110-MML, Num1MML)	23
Biomathematics (MA3400-MML, BioMathMML)	25
Stochastics 2 (MA4020-MML, Stoch2MML)	26

4th or 6th semester

Nonlinear dynamic systems (MA4405, NLinDynSys)	28
Calculus of Variations and Partial Differential Equations (MA5034-KP04, MA5034, VariPDE)	30

4th semester

Organic Chemistry (LS1600-MML, OCMML)	32
Biostatistics 2 (MA2600-KP04, MA2600, BioStat2)	33
Proseminar (MA2700, Prosem)	35
Optimization (MA4030-KP08, MA4030, Opti)	36
Numerics 2 (MA4040-MML, Num2MML)	38
Fundamentals of Physics (ME1500, GrundPhys)	39



5th and 6th semester

Software Engineering I (CS2300, SWTech) 40

5th or 6th semester

Introduction to Robotics and Automation (CS1500-KP04, CS1500, ERA) 42

Introduction to Media Informatics (CS1600-KP04, CS1600, EinMedien) 44

Algorithm Design (CS3000-KP04, CS3000, AlgoDesign) 46

Programming Languages and Type Systems (CS3052-KP04, CS3052, ProgLan14) 48

Computer-Aided Design of Digital Circuits (CS3110-KP04, CS3110, SchaltEntw) 50

Software Engineering II (CS3200, SWEng) 52

Ubiquitous Computing (CS5159, UbiqComp) 53

Graph Theory (MA3445-KP04, MA3445, Graphen) 54

Chaos and Complexity of Biological Systems (MA4400, CKBS) 56

Approximation Theory (MA4410, Approx) 58

Mathematics of Linear Inverse Problems (MA4420, MathInvPro) 59

Approximation on Spheres (MA4430, ApproxSph) 60

Evolutionary Dynamics (MA4451, EvoDyn) 61

Evolutionary Game Theory - from Basics to Recent Developments (MA4452, EvoGameTh) 62

Evolutionary Dynamics: Population Genetic and Ecological Models (MA4453, EvDyPopEco) 63

Evolutionary Dynamics: Game Theory (MA4454, EvDyGameTh) 64

Markov-Prozesse (MA4611, MarkovProz) 65

Numerical methods for partial differential equations (MA4614, NumMethPDE) 66

Numerical methods for stochastic processes (MA4615, NumStochPr) 67

Advanced Numerics (MA4616, HoehereNum) 68

Fourier Analysis (MA4630, FourierAna) 69

Sampling in der Signalanalyse (MA4640, SampSignal) 70

Combinatorics (MA4670, Kombi) 71

Algebra (MA4675, Algebra) 72

Functional Analysis (MA4710, FunkAna) 73

Orthogonal Series in Banach Spaces (MA4720, ORiBanachR) 74

Fractal Geometry (MA4740, FraktGeo) 75

Elliptische Funktionen (MA4801, EllipFunk) 76

Spezielle und allgemeine Relativitätstheorie (MA4802, RelatiTheo) 77

Number Theory (MA4803, Zahlentheo) 78

Special Functions (MA4804, SpeFunktio) 80

Logistische Regression (MA4950, LogRegress) 82

Generalized Linear Models (MA4962, VLModelle) 83



5th semester

Introduction to Medical Informatics (CS1300-KP04, CS1300, EMI)	84
Introduction to Bioinformatics (CS1400-KP04, CS1400, EinBioinfo)	86
Introduction into Biophysics (LS2200-KP04, LS2200, EinBiophy)	88
Statistics - Practical Course (MA3210, StatPrakt)	90
Interdisciplinary Seminar (MA3300, InterdisS)	92
Modeling Biological Systems (MA4450-KP08, MA4450-MML, MoBS)	93
Design of Experiments and Variance Analysis (MA4970, VplVarianz)	95
Physics Lab Course (ME2053-MML, PhysPrakt)	96

6th semester

Introduction to Logics (CS1002-KP04, CS1002, Logik)	97
Basics of Multimedia Systems (CS1601-KP04, CS1601, MMTechnik)	99
Databases (CS2700-KP04, CS2700, DB)	101
Nonstandard Database Systems (CS3202-KP04, CS3202, NDB)	103
Artificial Intelligence 1 (CS3204-KP04, CS3204, KI1)	105
Computer Graphics (CS3205-KP04, CS3205, CompGrafik)	107
Wissenschaftliches Rechnen (CS5010, ScienComp)	109
Cell Biology (LS2700-MML, Zellbio)	110
Bachelor thesis (MA3990, BaArbMML)	111
Numerical Linear Algebra (MA4041, NumLinAlg)	112
Integralgleichungen (MA4200, Integral)	113
Time series analysis (MA4341, Zeitreihen)	114
Numerik dynamischer Systeme (MA4612, NumDynSyst)	115
Matrix algebra (MA4650, MatrixAlg)	116
Genetic Epidemiology 2 (MA4661-KP08, MA4661, GenEpi2)	118
Angewandte Analysis (MA4700, AngewAna)	120
Differenzialgeometrie (MA4800, Diffgeo)	121
Multivariate Statistics (MA4944, MultivStat)	122
Linear Models (MA4960, LinModelle)	123
Selected stochastic processes (MA5610, StochPrz2)	124
Introduction into Biomedical Optics (ME2100-KP04, ME2100SJ14, EinfBMO14)	125

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

1 Semester

Turnus of offer:

each winter semester

Credit points:

8

Course of study, specific field and term:

- Bachelor CLS 2023 (compulsory), foundations of computer science, 1st semester
- Bachelor MES 2020 (compulsory), computer science, 3rd semester
- Bachelor Medical Informatics 2019 (compulsory: aptitude test), computer science, 1st semester
- Bachelor MES 2014 (compulsory), computer science, 3rd semester
- Bachelor CLS 2010 (compulsory), foundations of computer science, 1st semester
- Bachelor Medical Informatics 2014 (compulsory: aptitude test), computer science, 1st semester
- Bachelor CLS 2016 (compulsory), foundations of computer science, 1st semester

Classes and lectures:

- Introduction to Programming (lecture, 2 SWS)
- Lab course Java / C++ (lecture, 2 SWS)
- Lab course Java / C++ (exercise, 2 SWS)

Workload:

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

Contents of teaching:

- Basic concepts of computer science: representation of information and numbers, hardware, software, operating systems, applications
- Algorithm, Specification, Program
- Syntax und Semantics of Programming Languages
- Basic concepts of imperative and OO programming
- Techniques of secure programming
- Programming in Java or C++
- Development environments for Java or C++

Qualification-goals/Competencies:

- Students can easily calculate in 2, 8 and 16 number systems and convert numbers into each other in these systems.
- Students can convert rational and real numbers into floating point numbers and vice versa.
- Students can explain the principles of text encoding in ASCII, Unicode, and UTF-8.
- Students can independently represent the term 'algorithm' and important properties.
- Students can explain the structure and semantics of imperative programs.
- Students master the technique of reading and understanding imperative algorithms and writing them down for simple problems.
- Students can apply basic algorithmic techniques such as iteration and recursion.
- Students are basically able to apply safe programming techniques.
- Students can design, implement and test simple programs
- Students can develop and implement solutions satisfying commonly accepted quality standards

Grading through:

- 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

Notes:

Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s):

- CS1000-L1: Successful completion of exercise assignments as specified at the beginning of the semester

Module Exam(s):

- CS1000-L1: Introduction to programming and programming course, written exam, 90min, 100% of module grade

Students of the study program Bachelor Medical Informatics attend the course 'CS1005-V/Ü: Programming Course Java'. Students of the study programs Bachelor Mathematics in Medicine and Life Sciences and Bachelor Medical Engineering attend the course 'CS1006-V: Programming Course C++'.

LS1100-MML - Basic Chemistry (ACMML)		
Duration: 1 Semester	Turnus of offer: each winter semester	Credit points: 7
Course of study, specific field and term: <ul style="list-style-type: none"> • Bachelor CLS 2010 (compulsory), life sciences, 1st semester 		
Classes and lectures: <ul style="list-style-type: none"> • Basic Chemistry (lecture, 3 SWS) • Basic Chemistry (practical course, 2 SWS) • Basic Chemistry (exercise, 1 SWS) 		Workload: <ul style="list-style-type: none"> • 110 Hours private studies • 60 Hours in-classroom work • 40 Hours exam preparation
Contents of teaching: <ul style="list-style-type: none"> • Lectures: Organisation of matter and the periodic table of the elements • Chemical bonds, molecules and ions • Chemical formula and stoichiometry • The threedimensional structure of molecules: From the VSEPR model to molecular orbitals • Special properties of water • Chemical equilibrium • Acids and bases • Redox reactions and electrochemistry • Complexes and metal-ligand bonds • Interactions between matter and radiation - spectroscopy • Thermodynamics • Chemical kinetics • Practical course 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • Basics of general and inorganic chemistry • Understanding basic chemical concepts • Learning basic laboratory techniques. Safety at work in chemical laboratories • Practicing of teamwork (groups of two during the practical course) 		
Grading through: <ul style="list-style-type: none"> • written exam 		
Is requisite for: <ul style="list-style-type: none"> • Organic Chemistry (LS1600-MML) 		
Responsible for this module: <ul style="list-style-type: none"> • PD Dr. phil. nat. Thomas Weimar 		
Teacher: <ul style="list-style-type: none"> • Institute of Chemistry and Metabolomics • PD Dr. phil. nat. Thomas Weimar • Dr. rer. nat. Kerstin Lüdtké-Buzug 		
Literature: <ul style="list-style-type: none"> • Schmuck et al.: Chemie für Mediziner - Pearson Studium • Binnewies et al.: Allgemeine und Anorganische Chemie - Spektrum 		
Language: <ul style="list-style-type: none"> • offered only in German 		
Notes: <p>Prerequisite for examination is the successful participation in the practical course; written examination</p>		

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

1 Semester

Turnus of offer:

each winter semester

Credit points:

8

Course of study, specific field and term:

- Minor in Teaching Mathematics, Bachelor of Arts 2023 (compulsory), mathematics, 3rd semester
- Bachelor CLS 2023 (compulsory), mathematics, 1st semester
- Bachelor Biophysics 2024 (compulsory), mathematics, 1st semester
- Bachelor Biophysics 2024 (compulsory), mathematics, 1st semester
- Bachelor MES 2020 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Media Informatics 2020 (compulsory), mathematics, 3rd semester
- Bachelor Computer Science 2019 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Robotics and Autonomous Systems 2020 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Medical Informatics 2019 (compulsory: aptitude test), mathematics, 1st semester
- Minor in Teaching Mathematics, Bachelor of Arts 2017 (compulsory), mathematics, 3rd semester
- Bachelor Computer Science 2016 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor CLS 2016 (compulsory), mathematics, 1st semester
- Bachelor IT-Security 2016 (compulsory), mathematics, 1st semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Biophysics 2016 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Medical Informatics 2014 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor MES 2014 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Media Informatics 2014 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Computer Science 2014 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Medical Informatics 2011 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Computer Science 2012 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor MES 2011 (compulsory), mathematics, 1st semester
- Bachelor CLS 2010 (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:

- written exam



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:

Prerequisites for attending the module:

- None

Prerequisites for the exam:

- Successful completion of homework assignments during the semester
- Successful completion of e-tests during the semester
- Presentation of homework assignment

Module exam:

- MA1000-L1: Linear Algebra and Discrete Structures 1, written exam, 90 min, 100 % of module grade

MA2000-KP08, MA2000 - Analysis 1 (Ana1KP08)
Duration:

1 Semester

Turnus of offer:

each winter semester

Credit points:

8

Course of study, specific field and term:

- Bachelor CLS 2023 (compulsory), mathematics, 1st semester
- Minor in Teaching Mathematics, Bachelor of Arts 2023 (compulsory), mathematics, 5th semester
- Bachelor Biophysics 2024 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor MES 2020 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Media Informatics 2020 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Computer Science 2019 (compulsory), mathematics, 1st semester
- Bachelor Robotics and Autonomous Systems 2020 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Medical Informatics 2019 (compulsory), mathematics, 1st semester
- Minor in Teaching Mathematics, Bachelor of Arts 2017 (compulsory), mathematics, 5th semester
- Bachelor Computer Science 2016 (compulsory), mathematics, 1st semester
- Bachelor CLS 2016 (compulsory), mathematics, 1st semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor IT-Security 2016 (compulsory), mathematics, 1st semester
- Bachelor Biophysics 2016 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Medical Informatics 2014 (compulsory), mathematics, 1st semester
- Bachelor Media Informatics 2014 (compulsory), mathematics, 1st semester
- Bachelor MES 2014 (compulsory: aptitude test), mathematics, 1st semester
- Bachelor Computer Science 2014 (compulsory), mathematics, 1st semester
- Bachelor Medical Informatics 2011 (compulsory), mathematics, 3rd semester
- Bachelor CLS 2010 (compulsory), mathematics, 1st semester
- Bachelor MES 2011 (compulsory), mathematics, 1st semester
- Bachelor Computer Science 2012 (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
- Metric and normalized spaces, basic topological concepts
- Multivariate differential calculus

Qualification-goals/Competencies:

- Students understand the basic terms of analysis, especially the concept of convergence.
- Students understand the basic thoughts and proof techniques and are able to use them for the analytical treatment of scientifically or technically motivated problems.
- Students can explain basic relationships in real analysis.
- Students can apply the basic concepts and proof techniques of differential calculus.
- 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.

Grading through:

- written exam

Is requisite for:

- Analysis 2 (MA2500-KP09)
- Analysis 2 (MA2500-KP08)

- Analysis 2 (MA2500-KP05, MA2500-MLS)
- 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](#)
- [PD Dr. rer. nat. Jörn Schnieder](#)

Literature:

- K. Fritzsche: Grundkurs Analysis 1 + 2
- H. Heuser: Lehrbuch der Analysis 1 + 2
- K. Burg, H. Haf, F. Wille, A. Meister: Höhere Mathematik für Ingenieure
- R. Lasser, F. Hofmaier: Analysis 1 + 2

Language:

- offered only in German

Notes:

Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s):

- Successful completion of homework assignments during the semester
- Successful completion of e-tests

Modul exam:

- MA2000-L1: Analysis 1, written exam, 90 min, 100 % of module grade

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

1 Semester

Turnus of offer:

each summer semester

Credit points:

8

Course of study, specific field and term:

- Bachelor CLS 2023 (compulsory), foundations of computer science, 2nd semester
- Bachelor MES 2020 (optional subject), computer science / electrical engineering, 3rd semester at the earliest
- Bachelor Media Informatics 2020 (compulsory), computer science, 2nd semester
- Bachelor Computer Science 2019 (compulsory: aptitude test), foundations of computer science, 2nd semester
- Bachelor Robotics and Autonomous Systems 2020 (compulsory), computer science, 2nd semester
- Bachelor Medical Informatics 2019 (compulsory), computer science, 2nd semester
- Bachelor Computer Science 2016 (compulsory: aptitude test), foundations of computer science, 2nd semester
- Bachelor CLS 2016 (compulsory), foundations of computer science, 2nd semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory), computer science, 2nd semester
- Bachelor IT-Security 2016 (compulsory: aptitude test), computer science, 2nd semester
- Bachelor Medical Informatics 2014 (compulsory), computer science, 2nd semester
- Bachelor MES 2014 (optional subject), computer science / electrical engineering, 4th or 6th semester
- Bachelor Media Informatics 2014 (compulsory), foundations of computer science, 2nd semester
- Bachelor Computer Science 2014 (compulsory: aptitude test), foundations of computer science, 2nd semester
- Bachelor Medical Informatics 2011 (compulsory), computer science, 2nd semester
- Bachelor MES 2011 (compulsory), foundations of computer science, 4th semester
- Bachelor CLS 2010 (compulsory), foundations of computer science, 2nd semester
- Bachelor Computer Science 2012 (compulsory: aptitude test), foundations of 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:

- Sorting, algorithm analysis, heaps
- Distribution sort
- Priority queues
- Sets
- Sets
- Sets of strings
- Disjoint sets
- Associating objects
- Graphs
- Search graph for game playing
- 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
- Hard problems
- Pruning and subgraph isomorphism
- Approximation

Qualification-goals/Competencies:

- The students can explain the central ideas, define the relevant concepts and explain the functioning of algorithms with help of application scenarios for all the items listed in contents of teaching.

Grading through:

- 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. Esfandiar Mohammadi](#)

Teacher:

- [Institute for IT Security](#)
- [Prof. Dr. rer. nat. Esfandiar Mohammadi](#)

Literature:

- Thomas H. Cormen, Charles E. Leiserson, Ronald Rivest, Clifford Stein: *Algorithmen - Eine Einführung* - Oldenbourg Verlag, 2013

Language:

- offered only in German

Notes:

Admission requirements for taking the module:

- None (The competencies of the modules listed under 'Requires' are needed for this module, but are not a formal prerequisite.)

Admission requirements for participation in module examination(s):

- Successful completion of exercise sheets as specified at the beginning of the semester.

Module exam(s):

- CS1001-L1: Algorithms and Data Structures, written exam, 90min, 100% of the module grade.

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

1 Semester

Turnus of offer:

each summer semester

Credit points:

8

Course of study, specific field and term:

- Minor in Teaching Mathematics, Bachelor of Arts 2023 (compulsory), mathematics, 4th semester
- Bachelor CLS 2023 (compulsory), mathematics, 2nd semester
- Bachelor Biophysics 2024 (compulsory), mathematics, 2nd semester
- Bachelor MES 2020 (compulsory), mathematics, 2nd semester
- Bachelor Computer Science 2019 (compulsory: aptitude test), mathematics, 2nd semester
- Bachelor Robotics and Autonomous Systems 2020 (compulsory), mathematics, 2nd semester
- Bachelor Medical Informatics 2019 (compulsory), mathematics, 2nd semester
- Minor in Teaching Mathematics, Bachelor of Arts 2017 (compulsory), mathematics, 4th semester
- Bachelor Computer Science 2016 (compulsory: aptitude test), mathematics, 2nd semester
- Bachelor CLS 2016 (compulsory), mathematics, 2nd semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory), mathematics, 2nd semester
- Bachelor IT-Security 2016 (compulsory), mathematics, 2nd semester
- Bachelor Biophysics 2016 (compulsory), mathematics, 2nd semester
- Bachelor Medical Informatics 2014 (compulsory), mathematics, 2nd semester
- Bachelor MES 2014 (compulsory), mathematics, 2nd semester
- Bachelor Computer Science 2014 (compulsory: aptitude test), mathematics, 2nd semester
- Bachelor Medical Informatics 2011 (compulsory), mathematics, 2nd semester
- Bachelor CLS 2010 (compulsory), mathematics, 2nd semester
- Bachelor MES 2011 (compulsory), mathematics, 2nd semester
- Bachelor Computer Science 2012 (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:

- written exam

Is requisite for:

- Image Registration (MA5030-KP05)
- Image Registration (MA5030-KP04, MA5030)
- Mathematical Methods of Image Processing (MA4500-KP05)
- Mathematical Methods in Image Processing (MA4500-KP04, MA4500)
- Optimization (Advanced Mathematics) (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:

Prerequisites for attending the module:

- None (The competencies of the modules listed under 'Requires' are needed for this module, but are not a formal prerequisite)

Prerequisites for the exam:

- Successful completion of homework assignments during the semester
- Successful completion of e-tests during the semester
- Presentation of homework assignment

Module exam:

- MA1500-L1: Linear Algebra and Discrete Structures 2, written exam, 90 min, 100 % of module grade

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 CLS 2023 (compulsory), mathematics, 2nd semester
- Bachelor Biophysics 2024 (compulsory), Elective Computer Science, 4th semester
- Bachelor Nutritional Medicine 2024 (compulsory), mathematics / natural sciences, 4th semester
- Bachelor MES 2014 (optional subject), mathematics / natural sciences, 3rd semester at the earliest
- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester
- Bachelor Computer Science 2019 (compulsory), Canonical Specialization Bioinformatics and Systems Biology, 6th semester
- Bachelor Medical Informatics 2019 (compulsory), medical computer science, 6th semester
- Bachelor MLS 2018 (compulsory), life sciences, 6th semester
- Bachelor Nutritional Medicine 2018 (compulsory), mathematics / computer science, 6th semester
- Bachelor CLS 2016 (compulsory), mathematics, 2nd semester
- Bachelor CLS 2010 (compulsory), mathematics, 2nd semester
- Bachelor Computer Science 2016 (optional subject), advanced curriculum, Arbitrary semester
- Bachelor Computer Science 2016 (compulsory), Canonical Specialization Bioinformatics, 4th semester
- Bachelor MLS 2016 (compulsory), life sciences, 6th semester
- Bachelor Biophysics 2016 (compulsory), Elective Computer Science, 4th semester
- Bachelor Nutritional Medicine 2016 (compulsory), mathematics / computer science, 6th semester
- Bachelor Medical Informatics 2014 (compulsory), medical computer science, 4th semester
- Bachelor Computer Science 2014 (compulsory), specialization field bioinformatics, 6th semester
- Master MES 2011 (advanced curriculum), biophysics and biomedical optics, 2nd semester
- Bachelor Medical Informatics 2011 (compulsory), medical computer science, 4th semester
- Master Computer Science 2012 (optional subject), specialization field bioinformatics, 2nd or 3rd semester
- Master Computer Science 2012 (compulsory), advanced curriculum stochastics, 2nd semester
- Bachelor Computer Science 2012 (optional subject), specialization field bioinformatics, 6th semester
- Bachelor MLS 2009 (compulsory), life sciences, 6th semester
- Bachelor MES 2011 (optional subject), medical engineering science, 6th semester
- Bachelor Molecular Life Science 2024 (compulsory), mathematics / computer science, 4th 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:

- With regard to the roles of GSP of the University of Lübeck and of the DFG-guidelines the student were able to work with the following statistical methods: 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

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

Notes:

Prerequisites for attending the module:

- None

Prerequisites for the exam:

- Active and regular participation in the exercise groups as specified at the beginning of the semester.

Module exam:

-MA1600-L1: Biostatistics 1, written exam, 90 min, 100 % of module grade

MA2500-MML - Analysis 2 (Ana2)		
Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	9
Course of study, specific field and term:		
<ul style="list-style-type: none"> Bachelor CLS 2010 (compulsory), mathematics, 2nd semester 		
Classes and lectures:		Workload:
<ul style="list-style-type: none"> Analysis 2 (lecture, 4 SWS) Analysis 2 (exercise, 3 SWS) 		<ul style="list-style-type: none"> 130 Hours private studies 110 Hours in-classroom work 30 Hours exam preparation
Contents of teaching:		
<ul style="list-style-type: none"> Advanced multivariate differential calculus Integral calculus for functions of one real variable (indefinite integrals, antiderivatives, substitution, partial fractions, definite integrals, fundamental theorem of calculus) Curvilinear integrals, bounded variation Function series, power series Fourier series (trigonometric polynomials, convergence) Linear operators in Hilbert spaces Working with the programming language Mathematica 		
Qualification-goals/Competencies:		
<ul style="list-style-type: none"> Students understand the advanced terms of analysis, such as even convergence. 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. 		
Grading through:		
<ul style="list-style-type: none"> written exam 		
Requires:		
<ul style="list-style-type: none"> Analysis 1 (MA2000-KP08, MA2000) Analysis 1 (MA2000-KP09) 		
Responsible for this module:		
<ul style="list-style-type: none"> Prof. Dr. rer. nat. Jürgen Prestin 		
Teacher:		
<ul style="list-style-type: none"> Institute for Mathematics Prof. Dr. rer. nat. Jürgen Prestin 		
Literature:		
<ul style="list-style-type: none"> H. Heuser: Lehrbuch der Analysis 1+2 K. Fritzsche: Grundkurs Analysis 1+2 K. Burg, H. Haf, F. Wille, A. Meister: Höhere Mathematik für Ingenieure R. Lasser, F. Hofmaier: Analysis 1 + 2 		
Language:		
<ul style="list-style-type: none"> offered only in German 		
Notes:		



Prerequisites for attending the module:

- None

Prerequisites for the exam:

- Successful completion of homework assignments during the semester.
- Successful completion of e-tests

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

MA2510-KP04, MA2510 - Stochastics 1 (Stoch1)
Duration:

1 Semester

Turnus of offer:

each summer semester

Credit points:

4

Course of study, specific field and term:

- Minor in Teaching Mathematics, Bachelor of Arts 2023 (compulsory), mathematics, 8th semester
- Bachelor CLS 2023 (compulsory), mathematics, 2nd semester
- Bachelor MES 2020 (optional subject), mathematics / natural sciences, 3rd semester at the earliest
- Bachelor Biophysics 2024 (optional subject), mathematics, 6th semester
- Bachelor Computer Science 2019 (compulsory), mathematics, 4th semester
- Bachelor Robotics and Autonomous Systems 2020 (compulsory), mathematics, 4th semester
- Bachelor Medical Informatics 2019 (optional subject), mathematics, 4th to 6th semester
- Minor in Teaching Mathematics, Bachelor of Arts 2017 (compulsory), mathematics, 8th semester
- Bachelor Computer Science 2016 (compulsory), mathematics, 4th semester
- Bachelor CLS 2016 (compulsory), mathematics, 2nd semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory), mathematics, 4th semester
- Bachelor IT-Security 2016 (compulsory), mathematics, 2nd semester
- Bachelor Biophysics 2016 (optional subject), mathematics, 6th semester
- Bachelor Medical Informatics 2014 (optional subject), mathematics, 5th or 6th semester
- Bachelor MES 2014 (optional subject), mathematics / natural sciences, 4th or 6th semester
- Bachelor Computer Science 2014 (compulsory), mathematics, 4th semester
- Bachelor Computer Science 2012 (compulsory), mathematics, 4th semester
- Bachelor MES 2011 (compulsory), mathematics, 4th semester
- Bachelor CLS 2010 (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:

- written exam

Is requisite for:

- Stochastic processes (MA4610-KP05)
- Stochastic processes and modeling (MA4610-KP04, MA4610)
- Modeling Biological Systems (MA4450-KP08, 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)

Responsible for this module:

- [Nachfolge von Prof. Dr. rer. nat. Karsten Keller](#)

Teacher:

- [Institute for Mathematics](#)
- [Nachfolge von 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:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of homework assignments during the semester

Module exam(s):
- MA2510-L1: Stochastics 1, written exam, 90 min, 100 % of module grade

MA2214-KP04, MA2214 - Clinical Studies (KlinStud)
Duration:

1 Semester

Turnus of offer:

each winter semester

Credit points:

4

Course of study, specific field and term:

- Bachelor CLS 2023 (compulsory), mathematics, 3rd or 5th semester
- Master Nutritional Medicine 2023 (compulsory), medical computer science, 1st semester
- Bachelor Medical Informatics 2019 (optional subject), medical computer science, 4th to 6th semester
- Bachelor CLS 2016 (compulsory), mathematics, 3rd or 5th semester
- Master Nutritional Medicine 2019 (compulsory), medical computer science, 1st semester
- Bachelor Medical Informatics 2014 (optional subject), medical computer science, 5th or 6th semester
- Master Computer Science 2012 (optional subject), specialization field medical informatics, 3rd semester
- Bachelor Medical Informatics 2011 (optional subject), medical computer science, 4th to 6th semester
- Bachelor MES 2011 (optional subject), life sciences, 3rd or 5th semester
- Bachelor CLS 2010 (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:

- Definition of a clinical study according to the German Drug Law, classification of clinical studies, clinical development
- Basic principles of clinical trials and measures against bias
- Regulations and study documents
- Development of a clinical study, especially a study protocol
- Contents of a study protocol
- Link to health economics
- Further topics like
- Special study designs
- Advanced statistical analyses
- Report and publication
- Professional fields in clinical studies (study statistics, data management, monitoring, quality management, pharmacovigilance, project management)

Qualification-goals/Competencies:

- Students can describe the regulatory framework of clinical trials with drugs.
- They can describe the main areas of activity in the fields of study statistics, data management, monitoring, information technology and quality assurance.
- They can explain the basic principles of clinical trials and measures to achieve these basic principles.
- They can create relevant parts of a study protocol.
- They can represent study populations descriptively.
- They can perform case number planning for simple clinical studies.
- Students can assign studies and their key points to the stages of clinical development.
- They can explain different study designs.
- They are informed about ethical problems and guidelines and the principles of data protection.
- Acquisition of german and english technical language

Grading through:

- portfolio exam

Requires:

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

Responsible for this module:

- Prof. Dr. rer. biol. hum. Inke König
- [PD Dr. rer. pol. Reinhard Vonthein](#)

Teacher:

- Institute of Medical Biometry and Statistics
- PD Dr. rer. pol. Reinhard Vonthein
- Prof. Dr. rer. biol. hum. Inke König

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)
- Friedman, L.M., Furberg, C.D., DeMets, D.L., Reboussin, D.M., Granger, C.B.: Fundamentals of Clinical Trials - Springer 2015 (5th edition)

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s):

- None

Module exam(s):

- MA2214-L1: Clinical Studies, portfolio exam, 100% of module grade with contributions from written exam (50%) and project work (50%)

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

1 Semester

Turnus of offer:

each winter semester

Credit points:

4

Course of study, specific field and term:

- Bachelor CLS 2023 (compulsory), mathematics, 3rd or 5th semester
- Master Medical Informatics 2019 (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester
- Bachelor CLS 2016 (compulsory), mathematics, 3rd or 5th semester
- Master Medical Informatics 2014 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master Computer Science 2012 (optional subject), specialization field medical informatics, 3rd semester
- Bachelor CLS 2010 (compulsory), mathematics, 3rd or 5th 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:

- Monogenic and complex diseases
- Hardy-Weinberg-equilibrium
- Coupling imbalance
- Genetic markers and genotyping
- Quality control
- Basics of association analysis
- Genome-wide association studies
- Population stratification
- Gene-environment interaction
- Replication, meta-analysis and imputation
- Ethical aspects

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.
- They are able to apply the basic test procedures manually and to interpret the results.
- They are able to describe the statistical evaluation steps in a genome-wide association study and interpret the results.

Grading through:

- Written or oral exam as announced by the examiner

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. nat. Silke Szymczak

Teacher:

- [Institute of Medical Biometry and Statistics](#)
- Prof. Dr. rer. nat. Silke Szymczak
- MitarbeiterInnen des Instituts

Literature:

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



- Bickeböllner H, Fischer, C: Einführung in die Genetische Epidemiologie - 2007. ISBN: 978-3-540-25616-8

Language:

- German or English

Notes:

Prerequisites for attending the module:

- None (The competencies of the modules listed under 'Requires' are needed for this module, but are not a formal prerequisite)

Prerequisites for the exam:

- Examination prerequisites can be defined at the beginning of the semester. If preliminary work is defined, it must have been completed and positively evaluated before the first examination.

Module exam(s):

- MA3200-L1: Genetic Epidemiology 1, oral exam, 30 min, or written exam, 90 min, 100% of module grade

LS1000-MML - Basic Biology and Course (BioMML)		
Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	9
Course of study, specific field and term:		
<ul style="list-style-type: none"> • Bachelor CLS 2010 (compulsory), life sciences, 3rd semester 		
Classes and lectures:		Workload:
<ul style="list-style-type: none"> • Basic Biology and Course (lecture, 4 SWS) • Basic Biology and Course (practical course, 2 SWS) 		<ul style="list-style-type: none"> • 160 Hours private studies • 90 Hours in-classroom work • 20 Hours exam preparation
Contents of teaching:		
<ul style="list-style-type: none"> • Lectures: • Introduction • Structure and functions of the prokaryotic cell • Structure of the eukaryotic cells • Selected topics of multicellular organisation • Storage, duplication and realization of the hereditary information • Cell cycle • Fertilization and development • Formal and molecular genetics, evolution • Practical course (individual test): • Handling of light microscopes • Structure of prokaryotic cells • Structure of cells from metazoan • Human chromosomes • Cell cycle and mitosis • Genetics • Bacteria 		
Qualification-goals/Competencies:		
<ul style="list-style-type: none"> • 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:		
<ul style="list-style-type: none"> • written exam 		
Responsible for this module:		
<ul style="list-style-type: none"> • Prof. Dr. rer. nat. Enno Hartmann 		
Teacher:		
<ul style="list-style-type: none"> • 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:		
<ul style="list-style-type: none"> • Campbell: Biology 		
Language:		
<ul style="list-style-type: none"> • offered only in German 		

MA3110-MML - Numerics 1 (Num1MML)		
Duration: 1 Semester	Turnus of offer: each winter semester	Credit points: 5
Course of study, specific field and term: <ul style="list-style-type: none"> Bachelor CLS 2010 (compulsory), mathematics, 3rd semester 		
Classes and lectures: <ul style="list-style-type: none"> Numerics 1 (lecture, 2 SWS) Numerics 1 (exercise, 2 SWS) 		Workload: <ul style="list-style-type: none"> 75 Hours private studies 60 Hours in-classroom work 15 Hours exam preparation
Contents of teaching: <ul style="list-style-type: none"> Round-off errors and condition Direct solvers for linear equations LR decomposition Perturbation theory Cholesky decomposition QR decomposition, least squares fit 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> written exam 		
Requires: <ul style="list-style-type: none"> Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500) Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000) Analysis 2 (MA2500-MML) Analysis 1 (MA2000-KP08, MA2000) 		
Responsible for this module: <ul style="list-style-type: none"> Prof. Dr. rer. nat. Andreas Rößler 		
Teacher: <ul style="list-style-type: none"> Institute for Mathematics Prof. Dr. rer. nat. Andreas Rößler 		
Literature: <ul style="list-style-type: none"> M. Bollhöfer, V. Mehrmann: Numerische Mathematik - Vieweg (2004) P. Deuffhard, A. Hohmann: Numerische Mathematik I - 4. Auflage, De Gruyter (2008) P. Deuffhard, F. Bornemann: Numerische Mathematik II - 3. Auflage, De Gruyter (2008) M. Hanke-Bourgeois: Grundlagen der Numerischen Mathematik und des Wissenschaftlichen Rechnens - 3. Aufl., Teubner (2009) H. R. Schwarz, N. Köckler: Numerische Mathematik - 6. Auflage, Teubner (2006) J. Stoer: Numerische Mathematik I - 10. Auflage, Springer (2007) J. Stoer, R. Bulirsch: Numerische Mathematik II - 5. Auflage, Springer (2005) A. M. Quarteroni, R. Sacco, F. Saleri: Numerical Mathematics - 2. Auflage, Springer (2006) 		
Language: <ul style="list-style-type: none"> offered only in German 		
Notes:		



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

MA3400-MML - Biomathematics (BioMathMML)		
Duration: 1 Semester	Turnus of offer: each winter semester	Credit points: 7
Course of study, specific field and term: <ul style="list-style-type: none"> • Bachelor CLS 2010 (compulsory), mathematics, 3rd semester 		
Classes and lectures: <ul style="list-style-type: none"> • Biomathematics (lecture, 2 SWS) • Biomathematics (exercise, 2 SWS) 		Workload: <ul style="list-style-type: none"> • 100 Hours private studies and exercises • 60 Hours in-classroom work • 20 Hours exam preparation
Contents of teaching: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • written exam 		
Responsible for this module: <ul style="list-style-type: none"> • PD Dr. rer. nat. Hanns-Martin Teichert 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • PD Dr. rer. nat. Hanns-Martin Teichert 		
Literature: <ul style="list-style-type: none"> • J. D. Murray: <i>Mathematical Biology</i> - Springer • H. Heuser: <i>Gewöhnliche Differentialgleichungen</i> - Teubner Verlag 1991 • R. Schuster: <i>Biomathematik</i> - Teubner Studienbücher 1995 • S. Handrock-Meyer: <i>Differenzialgleichungen für Einsteiger</i> - Hanser 2007 		
Language: <ul style="list-style-type: none"> • offered only in German 		
Notes: <p>The lecture is identical to MA3400 Biomathematics</p>		

MA4020-MML - Stochastics 2 (Stoch2MML)		
Duration: 1 Semester	Turnus of offer: each winter semester	Credit points: 6
Course of study, specific field and term: <ul style="list-style-type: none"> Bachelor CLS 2010 (compulsory), mathematics, 3rd semester 		
Classes and lectures: <ul style="list-style-type: none"> Stochastics 2 (lecture, 2 SWS) Stochastics 2 (exercise, 2 SWS) 		Workload: <ul style="list-style-type: none"> 100 Hours private studies and exercises 60 Hours in-classroom work 20 Hours exam preparation
Contents of teaching: <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> Students 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: <ul style="list-style-type: none"> written exam Exercises 		
Is requisite for: <ul style="list-style-type: none"> Stochastic processes and modeling (MA4610-KP04, MA4610) Modeling Biological Systems (MA4450-KP08, MA4450-MML) 		
Requires: <ul style="list-style-type: none"> Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500) Stochastics 1 (MA2510-KP04, MA2510) Analysis 2 (MA2500-MML) 		
Responsible for this module: <ul style="list-style-type: none"> Nachfolge von Prof. Dr. rer. nat. Karsten Keller 		
Teacher: <ul style="list-style-type: none"> Institute for Mathematics Nachfolge von Prof. Dr. rer. nat. Karsten Keller 		
Literature: <ul style="list-style-type: none"> J. Elstrodt: Maß- und Integrationstheorie - Springer M. Fisz: Wahrscheinlichkeitsrechnung und mathematische Statistik - Deutscher Verlag der Wissenschaften 		
Language: <ul style="list-style-type: none"> offered only in German 		
Notes:		



The lecture is identical to that in module MA4020.

Prerequisites for attending the module:

- None

Prerequisites for the exam:

- Successful completion of homework assignments during the semester.

MA4405 - Nonlinear dynamic systems (NLinDynSys)		
Duration: 1 Semester	Turnus of offer: irregularly	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master CLS 2010 (optional subject), computer science, Arbitrary semester • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), computer science, 4th or 6th semester • Bachelor CLS 2010 (optional subject), mathematics, 4th or 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Nonlinear dynamic systems (lecture, 2 SWS) • Nonlinear dynamic systems (exercise, 1 SWS) 	Workload: <ul style="list-style-type: none"> • 65 Hours private studies • 45 Hours in-classroom work • 10 Hours exam preparation 	
Contents of teaching: <ul style="list-style-type: none"> • 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • • • • • 		
Grading through: <ul style="list-style-type: none"> • Written or oral exam as announced by the examiner 		
Requires: <ul style="list-style-type: none"> • Analysis 2 (MA2500-MML) • Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000) 		
Responsible for this module: <ul style="list-style-type: none"> • PD Dr. rer. nat. Jens Christian Claussen 		
Teacher: <ul style="list-style-type: none"> • Institute for Neuro- and Bioinformatics • PD Dr. rer. nat. Jens Christian Claussen 		
Literature: <ul style="list-style-type: none"> • Argyris, Faust, Haase: Die Erforschung des Chaos • Jetschke: Mathematik der Selbstorganisation • Heinz Georg Schuster: Deterministic Chaos • Edward Ott: Nonlinear Dynamics and Chaos 		
Language: <ul style="list-style-type: none"> • German and English skills required 		



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

1 Semester

Turnus of offer:

every second summer semester

Credit points:

4

Course of study, specific field and term:

- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), medical image processing, 1st or 2nd semester
- Master MES 2014 (optional subject), mathematics / natural sciences, Arbitrary semester
- Bachelor CLS 2010 (optional subject), mathematics, 4th or 6th semester
- Master Medical Informatics 2014 (optional subject), medical image processing, 1st or 2nd semester
- Master MES 2011 (optional subject), mathematics, 2nd or 4th semester
- Master Computer Science 2012 (optional subject), advanced curriculum numerical image processing, 2nd or 3rd semester
- Master MES 2011 (advanced curriculum), imaging systems, signal and image processing, 2nd or 4th semester
- Master CLS 2010 (optional subject), mathematics, 2nd or 4th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Motivation and application examples
- Functional-analytic foundations
- Direct methods in the calculus of variations
- The dual space, weak convergence, Sobolev spaces
- Optimality conditions
- Classification of partial differential equations and typical PDEs
- Fundamental solutions, maximum principle
- Finite elements for elliptical partial differential equations

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:

- Written or oral exam as announced by the examiner

Responsible for this module:

- [Prof. Dr. rer. nat. Jan Modersitzki](#)

Teacher:

- [Institute of Mathematics and Image Computing](#)

- [Prof. Dr. rer. nat. Jan Modersitzki](#)
- [Prof. Dr. rer. nat. Jan Lellmann](#)

Literature:



- 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:

Prerequisites for attending the module:

- None (Familiarity with the topics of the required modules is assumed, but the modules are not a formal prerequisite for attending the course).

Prerequisites for the exam:

- Preliminary examinations can be determined at the beginning of the semester. If preliminary work has been defined, it must have been completed and positively assessed before the first examination.

Examination:

- MA5034-L1: Calculus of Variations and Partial Differential Equations, written examination (90min) or oral examination (30min) as decided by examiner, 100% of final mark

LS1600-MML - Organic Chemistry (OCMML)
Duration:

1 Semester

Turnus of offer:

each summer semester

Credit points:

4

Course of study, specific field and term:

- Bachelor MES 2011 (optional subject), optional subject medical engineering science, 6th semester
- Bachelor CLS 2010 (compulsory), life sciences, 4th semester

Classes and lectures:

- Organic Chemistry (lecture, 3 SWS)

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

- Understanding the principles of organic chemistry

Grading through:

- written exam

Requires:

- Basic Chemistry (LS1100-MML)

Responsible for this module:

- PD Dr. phil. nat. Thomas Weimar

Teacher:

- [Institute of Chemistry and Metabolomics](#)
- PD Dr. phil. nat. Thomas Weimar

Literature:

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

Language:

- offered only in German

MA2600-KP04, MA2600 - Biostatistics 2 (BioStat2)
Duration:

1 Semester

Turnus of offer:

each summer semester

Credit points:

4

Course of study, specific field and term:

- Master Medical Informatics 2019 (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester
- Master Biophysics 2019 (optional subject), Elective, 2nd semester
- Master Medical Informatics 2014 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master Computer Science 2012 (optional subject), specialization field medical informatics, 3rd semester
- Master Computer Science 2012 (optional subject), specialization field bioinformatics, 2nd or 3rd semester
- Master Computer Science 2012 (optional subject), advanced curriculum stochastics, 2nd semester
- Bachelor CLS 2010 (compulsory), mathematics, 4th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

- The students are able to enumerate and explain the assumptions of the classical linear model.
- The students are able to describe typical applications of the classical linear model.
- The students are able to list the differences between the linear model and the logistic regression model.
- The students are able to describe possible error sources in modelling the linear model.
- The students are able to calculate the estimators (point and interval estimators, residual) in the linear model by hand.
- The students are able to evaluate the graphics for regression diagnostics in the linear model.
- The students are able to interpret the results of studies, where a linear, a logistic or a Cox regression model was applied.
- The students are able to draw and interpret Kaplan-Meier curves.
- The students are able to perform data transformations.

Grading through:

- written exam

Is requisite for:

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

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
- [Dr. rer. hum. biol. Markus Scheinhardt](#)

Literature:

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

Language:

- offered only in German

Notes:

Prerequisites for attending the module:

- None (The competences of the required modules are required for this module, but the modules are not a prerequisite for admission.)

Prerequisites for the exam:

- Preliminary examinations can be determined at the beginning of the semester. If preliminary work has been defined, it must have been completed and positively assessed before the initial examination.

MA2700 - Proseminar (Prosem)		
Duration: 1 Semester	Turnus of offer: each summer semester	Credit points: 4 (Typ B)
Course of study, specific field and term: <ul style="list-style-type: none"> Bachelor CLS 2010 (compulsory), Computational Life Science, 4th semester 		
Classes and lectures: <ul style="list-style-type: none"> Proseminar (seminar, 2 SWS) 		Workload: <ul style="list-style-type: none"> 90 Hours oral presentation (including preparation) 30 Hours in-classroom work
Contents of teaching: <ul style="list-style-type: none"> Reading scientific literature 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> Preparing and giving a scientific talk Practising scientific discussion Training of English language 		
Grading through: <ul style="list-style-type: none"> Oral presentation and written report 		
Requires: <ul style="list-style-type: none"> Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500) Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000) Analysis 2 (MA2500-MML) Analysis 1 (MA2000-KP08, MA2000) 		
Responsible for this module: <ul style="list-style-type: none"> PD Dr. rer. nat. Hanns-Martin Teichert 		
Teacher: <ul style="list-style-type: none"> Institute for Mathematics Prof. Dr. rer. nat. Andreas Rößler PD Dr. rer. nat. Hanns-Martin Teichert 		
Language: <ul style="list-style-type: none"> offered only in English 		

MA4030-KP08, MA4030 - Optimization (Opti)
Duration:

1 Semester

Turnus of offer:

each summer semester

Credit points:

8

Course of study, specific field and term:

- Minor in Teaching Mathematics, Bachelor of Arts 2023 (compulsory), mathematics, 8th semester
- Bachelor CLS 2023 (compulsory), mathematics, 4th semester
- Master Auditory Technology 2022 (optional subject), mathematics, 2nd semester
- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester
- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, Arbitrary semester
- Minor in Teaching Mathematics, Bachelor of Arts 2017 (compulsory), mathematics, 8th semester
- Master Auditory Technology 2017 (optional subject), mathematics, 1st or 2nd semester
- Bachelor Computer Science 2016 (optional subject), advanced curriculum, Arbitrary semester
- Bachelor CLS 2016 (compulsory), mathematics, 4th semester
- Master MES 2014 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master MES 2011 (optional subject), mathematics, 2nd semester
- Master Computer Science 2012 (optional subject), advanced curriculum numerical image processing, 2nd or 3rd semester
- Bachelor MES 2011 (optional subject), medical engineering science, 6th semester
- Master Computer Science 2012 (optional subject), advanced curriculum analysis, 2nd or 3rd semester
- Bachelor CLS 2010 (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, conjugate gradients, Newton method, Quasi-Newton methods, globalization)
- Equality- and inequality-constrained nonlinear optimization (Lagrange multipliers, active set methods)
- Stochastic methods for machine learning

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:

- Written or oral exam as announced by the examiner

Is requisite for:

- 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:

Prerequisites for attending the module:

- None (Familiarity with the topics of the required modules is assumed, but the modules are not a formal prerequisite for attending the course).

Prerequisites for the exam:

- Examination prerequisites can be defined at the beginning of the semester. If preliminary work is defined, it must have been completed and positively evaluated before the first examination.

Examination:

- MA4030-L1: Optimization, written examination (90 min) or oral examination (30 min) as decided by examiner, 100 % of final mark

MA4040-MML - Numerics 2 (Num2MML)		
Duration: 1 Semester	Turnus of offer: each summer semester	Credit points: 6
Course of study, specific field and term: <ul style="list-style-type: none"> Bachelor CLS 2010 (compulsory), mathematics, 4th semester 		
Classes and lectures: <ul style="list-style-type: none"> Numerics 2 (lecture, 2 SWS) Numerics 2 (exercise, 2 SWS) 		Workload: <ul style="list-style-type: none"> 100 Hours private studies and exercises 60 Hours in-classroom work 20 Hours exam preparation
Contents of teaching: <ul style="list-style-type: none"> Polynomial interpolation Hermite interpolation Approximation Numerical quadrature 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> Becoming acquainted with fundamental numerical 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: <ul style="list-style-type: none"> written exam 		
Requires: <ul style="list-style-type: none"> Numerics 1 (MA3110-MML) Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500) Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000) Analysis 2 (MA2500-MML) Analysis 1 (MA2000-KP08, MA2000) 		
Responsible for this module: <ul style="list-style-type: none"> Prof. Dr. rer. nat. Andreas Rößler 		
Teacher: <ul style="list-style-type: none"> Institute for Mathematics Prof. Dr. rer. nat. Andreas Rößler 		
Literature: <ul style="list-style-type: none"> M. Bollhöfer, V. Mehrmann: Numerische Mathematik - Vieweg (2004) P. Deuffhard, A. Hohmann: Numerische Mathematik I - 4. Auflage, De Gruyter (2008) P. Deuffhard, F. Bornemann: Numerische Mathematik II - 3. Auflage, De Gruyter (2008) M. Hanke-Bourgeois: Grundlagen der Numerischen Mathematik und des Wissenschaftlichen Rechnens - 3. Aufl., Teubner (2009) H. R. Schwarz, N. Köckler: Numerische Mathematik - 6. Auflage, Teubner (2006) J. Stoer: Numerische Mathematik I - 10. Auflage, Springer (2007) J. Stoer, R. Bulirsch: Numerische Mathematik II - 5. Auflage, Springer (2005) A. M. Quarteroni, R. Sacco, F. Saleri: Numerical Mathematics - 2. Auflage, Springer (2006) 		
Language: <ul style="list-style-type: none"> offered only in German 		
Notes: <p>The lecture is identical to that in module MA4040/Numerics 2</p>		

ME1500 - Fundamentals of Physics (GrundPhys)		
Duration: 1 Semester	Turnus of offer: each summer semester	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Bachelor Computer Science 2014 (compulsory), specialization field bioinformatics, 4th semester • Bachelor CLS 2010 (compulsory), life sciences, 4th semester • Bachelor Computer Science 2012 (compulsory), specialization field bioinformatics, 2nd semester 		
Classes and lectures: <ul style="list-style-type: none"> • Fundamentals of Physics (lecture, 2 SWS) • Fundamentals of Physics (exercise, 1 SWS) 	Workload: <ul style="list-style-type: none"> • 60 Hours private studies and exercises • 45 Hours in-classroom work • 15 Hours exam preparation 	
Contents of teaching: <ul style="list-style-type: none"> • Mechanics: Newton's laws, laws of conservation, 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • written exam 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. rer. nat. Robert Huber Teacher: <ul style="list-style-type: none"> • Institute of Biomedical Optics • Dr. rer. nat. Norbert Linz 		
Literature: <ul style="list-style-type: none"> • Giancoli: Physik 		
Language: <ul style="list-style-type: none"> • offered only in German 		

CS2300 - Software Engineering I (SWTech)			
Duration: 2 Semester	Turnus of offer: each winter semester	Credit points: 8	Max. group size: 12
Course of study, specific field and term:			
<ul style="list-style-type: none"> • Bachelor Medical Informatics 2011 (compulsory), computer science, 3rd and 4th semester • Bachelor CLS 2010 (optional subject), computer science, 5th and 6th semester • Bachelor Computer Science 2012 (compulsory), foundations of computer science, 3rd and 4th semester 			
Classes and lectures:		Workload:	
<ul style="list-style-type: none"> • Software Engineering I (lecture, 2 SWS) • Software Engineering I (exercise, 1 SWS) • Software Engineering I (practical course, 3 SWS) 		<ul style="list-style-type: none"> • 60 Hours private studies and exercises • 45 Hours in-classroom work • 45 Hours in-classroom work • 40 Hours group work • 35 Hours work on project • 15 Hours exam preparation 	
Contents of teaching:			
<ul style="list-style-type: none"> • overview on major fields of software engineering • Software development, software process models • Basic concepts of software systems • System analysis and requirements engineering • Software design and software architectures • Implementation • Testing and integration • Installation, acceptance, maintainance 			
Qualification-goals/Competencies:			
<ul style="list-style-type: none"> • Understanding software design as an engineering process • Knowledge of major software process models and description formalisms for software artefacts • Ability to model software systems on different levels of abstraction • Ability to systematically design software systems whose implementation meets the requirements • Knowing the basic concepts of object-oriented modelling and design • Usage of UML and CASE tools • Qualification to work in a team, to present artefacts, to comply to standards and to observe time limits 			
Grading through:			
<ul style="list-style-type: none"> • Written or oral exam as announced by the examiner 			
Requires:			
<ul style="list-style-type: none"> • Algorithms and Data Structures (CS1001-KP08, CS1001) • Programming (CS1000) 			
Responsible for this module:			
<ul style="list-style-type: none"> • Prof. Dr. Martin Leucker 			
Teacher:			
<ul style="list-style-type: none"> • Institute of Software Technology and Programming Languages • Prof. Dr. Martin Leucker 			
Literature:			
<ul style="list-style-type: none"> • H. Balzert: Lehrbuch der Software-Technik: Software-Entwicklung - Spektrum Akademischer Verlag 2001 • B. Brügge, A. H. Dutoit: Objektorientierte Softwaretechnik mit UML, Entwurfsmustern und Java - Pearson Studium 2004 • I. Sommerville: Software Engineering - Addison-Wesley 2006 • B. Oestereich: Analyse und Design mit der UML 2.1 - Objektorientierte Softwareentwicklung - Oldenbourg 2006 • D. Bjorner: Software Engineering 1-3 - Springer 2006 			



Language:

- offered only in German

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

Duration:

1 Semester

Turnus of offer:

each winter semester

Credit points:

4

Course of study, specific field and term:

- Bachelor IT-Security 2016 (optional subject), interdisciplinary, Arbitrary semester
- Bachelor Biophysics 2024 (compulsory), Elective Computer Science, 5th semester
- Bachelor Computer Science 2019 (optional subject), Introductory Module Computer Science, 1st semester
- Bachelor Robotics and Autonomous Systems 2020 (compulsory), Robotics and Autonomous Systems, 1st semester
- Bachelor Medical Informatics 2019 (optional subject), medical computer science, 4th to 6th semester
- Bachelor Computer Science 2016 (optional subject), Introductory Module Computer Science, 1st semester
- Bachelor Biophysics 2016 (compulsory), Elective Computer Science, 5th semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory), Robotics and Autonomous Systems, 1st semester
- Bachelor Medical Informatics 2014 (optional subject), medical computer science, 5th or 6th semester
- Bachelor Computer Science 2014 (compulsory), specialization field robotics and automation, 1st semester
- Bachelor CLS 2010 (optional subject), computer science, 5th or 6th semester
- Bachelor MES 2011 (optional subject), medical engineering science, 5th semester
- Bachelor Computer Science 2012 (compulsory), specialization field robotics and automation, 1st semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written exam

Responsible for this module:

- [Prof. Dr.-Ing. Mladen Berekovic](#)

Teacher:

- [Institute of Computer Engineering](#)

- [Dr.-Ing. Kristian Ehlers](#)

Literature:

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

Language:

- offered only in German

Notes:

-Computer Science students are issued a B certificate, after having finished entire assignments including the tests and having passed the written exam at the end of the term.

Students of other majors are issued an A-certificate after having passed the written exam.

Prerequisites for attending the module:

- None

Prerequisites for the exam:

- Successful completion of homework assignments during the semester.

Written exam:

-CS1500-L1: Introduction to Robotics and Automation, written exam, 60 - 120 min, 100% modul grade.

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

1 Semester

Turnus of offer:

each winter semester

Credit points:

4

Course of study, specific field and term:

- Bachelor Media Informatics 2020 (compulsory: aptitude test), media informatics, 1st semester
- Bachelor Media Informatics 2014 (compulsory: aptitude test), media informatics, 1st semester
- Bachelor CLS 2010 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2012 (compulsory), specialization field media informatics, 1st semester
- Bachelor IT-Security 2016 (optional subject), interdisciplinary, Arbitrary semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Oral examination

Is requisite for:

- Interaction Design and User Experience (CS2600-KP08, CS2600SJ14)

Responsible for this module:

- [Prof. Dr.-Ing. Nicole Jochems](#)

Teacher:

- [Institute for Multimedia and Interactive Systems](#)
- [Prof. Dr.-Ing. Nicole Jochems](#)

Literature:

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

Language:

- offered only in German



Notes:

Prerequisites for attending the module:

- None

Prerequisites for the exam:

- Successful completion of project work as stated at the beginning of the semester

Exam(s):

- CS1600-L1: Einführung in die Medieninformatik, Klausur, 90min, 100% der Modulnote

CS3000-KP04, CS3000 - Algorithm Design (AlgoDesign)
Duration:

1 Semester

Turnus of offer:

each winter semester

Credit points:

4

Course of study, specific field and term:

- Master CLS 2023 (optional subject), computer science, 3rd semester
- Bachelor Computer Science 2019 (compulsory), foundations of computer science, 5th semester
- Bachelor Robotics and Autonomous Systems 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester
- Bachelor Computer Science 2016 (compulsory), foundations of computer science, 5th semester
- Master CLS 2016 (optional subject), computer science, 3rd semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), computer science, 5th or 6th semester
- Bachelor IT-Security 2016 (compulsory), computer science, 5th semester
- Bachelor Medical Informatics 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2014 (compulsory), foundations of computer science, 5th semester
- Bachelor CLS 2010 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2012 (compulsory), foundations of computer science, 5th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

- The students can safely apply the principles of algorithm design.
- They can analyze algorithms with respect to correctness and efficiency.
- They are able to apply these principles to concrete problems.
- They can contribute their proficiency in solving similar algorithmic problems.

Grading through:

- written exam

Requires:

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

Responsible for this module:

- [Prof. Dr. Rüdiger Reischuk](#)

Teacher:

- [Institute for Theoretical Computer Science](#)
- [Prof. Dr. Rüdiger Reischuk](#)
- [Prof. Dr. rer. nat. Till Tantau](#)

Literature:

- J. Kleinberg, E. Tardos: Algorithm Design - Addison Wesley, 2005



- T. Cormen, C. Leiserson, R. Rivest, C. Stein: Introduction to Algorithms - MIT Press, 2009
- S. Skiena: The Algorithmic Design Manual - Springer, 2012

Language:

- offered only in German

Notes:

Prerequisites for attending the module:

- None (The competencies of the modules listed under 'Requires' are needed for this module, but are not a formal prerequisite)

Prerequisites for the exam:

- Successful completion of homework and project assignments as specified at the beginning of the semester.

Module exam(s):

- CS3000-L1: Algorithm Design, written exam, 90 min, 100 % of module grade

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

1 Semester

Turnus of offer:

each winter semester

Credit points:

4

Course of study, specific field and term:

- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2019 (optional subject), Canonical Specialization Web and Data Science, 3rd semester
- Bachelor Computer Science 2019 (compulsory), Canonical Specialization SSE, 3rd semester
- Bachelor Media Informatics 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Media Informatics 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2016 (compulsory), Canonical Specialization SSE, 3rd semester
- Bachelor Computer Science 2012 (optional subject), central topics of computer science, 5th or 6th semester
- Bachelor Computer Science 2012 (compulsory), specialization field IT security and safety, 4th semester
- Master Computer Science 2012 (compulsory), advanced curriculum programming, 2nd or 3rd semester
- Bachelor IT-Security 2016 (optional subject), computer science, Arbitrary semester
- Bachelor CLS 2010 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2014 (optional subject), central topics of computer science, 5th semester
- Bachelor Computer Science 2014 (compulsory), specialization field IT security and safety, 5th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)
- Algorithms and Data Structures (CS1001-KP08, CS1001)
- Introduction to Programming (CS1000-KP10, CS1000S14)

Responsible for this module:

- [Prof. Dr. Martin Leucker](#)

Teacher:



- [Institute of Software Technology and Programming Languages](#)
- [Dr. Annette Stümpel](#)
- [Prof. Dr. Martin Leucker](#)

Literature:

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

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None (the competencies of the modules listed under

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

1 Semester

Turnus of offer:

each winter semester

Credit points:

4

Course of study, specific field and term:

- Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, Arbitrary semester
- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), computer science, 5th or 6th semester
- Bachelor IT-Security 2016 (optional subject), computer science, Arbitrary semester
- Bachelor MES 2014 (optional subject), computer science / electrical engineering, 5th or 6th semester
- Bachelor Computer Science 2014 (optional subject), central topics of computer science, 5th or 6th semester
- Bachelor MES 2011 (optional subject), Applied computer science, 3rd, 5th, or 6th semester
- Bachelor CLS 2010 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2012 (optional subject), central topics of computer science, 5th or 6th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written exam

Responsible for this module:

- [Prof. Dr.-Ing. Mladen Berekovic](#)

Teacher:

- [Institute of Computer Engineering](#)
- [Prof. Dr.-Ing. Mladen Berekovic](#)

Literature:

- F. Kesel, R. Bartholomä: Entwurf von digitalen Schaltungen und Systemen mit HDLs und FPGAs - Oldenbour Verlag 2009
- C.Maxfield: The Design Warrior's Guide to FPGAs - Newnes 2004

Language:



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

Notes:

Admission requirements for taking the module:

- None

CS3200 - Software Engineering II (SWEng)		
Duration: 1 Semester	Turnus of offer: not available anymore	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Bachelor Medical Informatics 2011 (optional subject), software engineering, 4th to 6th semester • Bachelor CLS 2010 (optional subject), computer science, 5th or 6th semester • Bachelor MES 2011 (compulsory), foundations of computer science, 5th semester • Bachelor Computer Science 2012 (compulsory), foundations of computer science, 5th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Software Engineering II (lecture, 2 SWS) • Software Engineering II (exercise, 1 SWS) 	Workload: <ul style="list-style-type: none"> • 60 Hours private studies and exercises • 45 Hours in-classroom work • 15 Hours exam preparation 	
Contents of teaching: <ul style="list-style-type: none"> • Introduction to software engineering • Software management • Software quality assurance • Software evolution • Software reuse • Re-engineering and phase-out • Software productivity, expense, and estimation • Legal aspects 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • Knowing the basic procedures of software engineering • Quality awareness • Knowing activities and factors of software management • Ability to organize software projects and to evaluate software engineering processes • Understanding software evolution 		
Grading through: <ul style="list-style-type: none"> • Written or oral exam as announced by the examiner 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. Martin Leucker 		
Teacher: <ul style="list-style-type: none"> • Institute of Software Technology and Programming Languages • PD Dr. Gerhard Buntrock 		
Literature: <ul style="list-style-type: none"> • H. Balzert: Lehrbuch der Software-Technik: Software-Management, Software-Qualitätssicherung - Akademischer Verlag 1998 • A. Behforooz, F. J. Hudson: Software Engineering Fundamentals - Oxford University Press 1996 • C. Ghezzi, M. Jazayeri, D. Mandrioli: Fundamentals of Software Engineering - Prentice Hall 2002 • B. Hughes, M. Cotterell: Software Project Management - McGraw-Hill 1999 • I. Sommerville: Software Engineering - Addison Wesley 2006 		
Language: <ul style="list-style-type: none"> • offered only in German 		

CS5159 - Ubiquitous Computing (UbiqComp)		
Duration: 1 Semester	Turnus of offer: not available anymore	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master CLS 2010 (optional subject), mathematics, 2nd or 3rd semester • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester • Master Computer Science 2012 (optional subject), advanced curriculum organic computing, 2nd or 3rd semester • Master Computer Science 2012 (optional subject), specialization field media informatics, 2nd or 3rd semester 		
Classes and lectures: <ul style="list-style-type: none"> • Ubiquitous Computing (lecture with exercises, 3 SWS) 	Workload: <ul style="list-style-type: none"> • 60 Hours private studies and exercises • 45 Hours in-classroom work • 15 Hours exam preparation 	
Contents of teaching: <ul style="list-style-type: none"> • The • Technology trends: information technology, new materials • Wireless communication and mobile computing • Spontaneous networking • Context awareness: location, context, and situation • Smart labels (RFIDs) and wireless chipcards • Embedded systems and sensors • Energy aspects • Wearable computing • Interaction with invisible computers • Software infrastructures • Selected research projects • Applications scenarios • Social implications 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • Understand fundamental challenges, concepts, approaches, and limitations of UC • Follow and judge recent UC research papers • Design, implementation, and analysis of exemplary UC systems 		
Grading through: <ul style="list-style-type: none"> • Viva Voce or test 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr.-Ing. Thilo Pionteck (Nachfolger NN) 		
Teacher: <ul style="list-style-type: none"> • Institute of Computer Engineering • Prof. Dr.-Ing. Thilo Pionteck (Nachfolger NN) 		
Literature: <ul style="list-style-type: none"> • Friedemann Mattern (Ed.): Die Informatisierung des Alltags - Leben in smarten Umgebungen - Springer-Verlag, 2007 • Elgar Fleisch, Friedemann Mattern (Eds.): Das Internet der Dinge - Ubiquitous Computing und RFID in der Praxis - Springer-Verlag, 2005 		
Language: <ul style="list-style-type: none"> • offered only in German 		

MA3445-KP04, MA3445 - Graph Theory (Graphen)
Duration:

1 Semester

Turnus of offer:

every second year

Credit points:

4

Course of study, specific field and term:

- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester
- Bachelor Robotics and Autonomous Systems 2020 (optional subject), mathematics, 5th or 6th semester
- Bachelor Medical Informatics 2019 (optional subject), mathematics, 4th to 6th semester
- Bachelor IT-Security 2016 (optional subject), mathematics, Arbitrary semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), mathematics, 5th or 6th semester
- Bachelor Medical Informatics 2014 (optional subject), mathematics, 5th or 6th semester
- Master MES 2014 (optional subject), mathematics / natural sciences, 1st or 2nd semester
- Bachelor Computer Science 2014 (optional subject), central topics of computer science, 5th or 6th semester
- Master CLS 2010 (optional subject), mathematics, Arbitrary semester
- Master MES 2011 (optional subject), mathematics, 1st or 2nd semester
- Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester
- Bachelor Computer Science 2012 (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- 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. Christian Bey](#)

Teacher:

- [Institute for Mathematics](#)
- [PD Dr. rer. nat. Christian Bey](#)

Literature:

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



Language:

- offered only in German

Notes:

Admission requirements for taking the module:

- None (the competencies of the modules listed under "Requires" are required for this module, but are not a formal prerequisite).

Admission requirements for taking module examination(s):

- Successful completion of exercises as specified at the beginning of the semester.

Module Exam(s):

- MA3445-L1: Graph Theory, oral exam, 30 min, 100% of module grade.

MA4400 - Chaos and Complexity of Biological Systems (CKBS)		
Duration: 1 Semester	Turnus of offer: irregularly	Credit points: 4
Course of study, specific field and term:		
<ul style="list-style-type: none"> • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester • Master MES 2011 (optional subject), mathematics, 1st or 2nd semester • Master Computer Science 2012 (optional subject), specialization field bioinformatics, 2nd or 3rd semester • Master MES 2011 (advanced curriculum), biophysics and biomedical optics, 1st or 2nd semester • Master CLS 2010 (optional subject), mathematics, Arbitrary semester 		
Classes and lectures:		Workload:
<ul style="list-style-type: none"> • Chaos and Complexity of Biological Systems (lecture, 2 SWS) • Chaos and Complexity of Biological Systems (exercise, 1 SWS) 		<ul style="list-style-type: none"> • 65 Hours private studies and exercises • 45 Hours in-classroom work • 10 Hours exam preparation
Contents of teaching:		
<ul style="list-style-type: none"> • 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:		
<ul style="list-style-type: none"> • 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:		
<ul style="list-style-type: none"> • Written or oral exam as announced by the examiner 		
Requires:		
<ul style="list-style-type: none"> • Stochastics 1 (MA2510-KP04, MA2510) • Analysis 1 (MA2000-KP08, MA2000) 		
Responsible for this module:		
<ul style="list-style-type: none"> • Nachfolge von Prof. Dr. rer. nat. Karsten Keller 		
Teacher:		
<ul style="list-style-type: none"> • Institute for Mathematics • Nachfolge von Prof. Dr. rer. nat. Karsten Keller 		
Literature:		
<ul style="list-style-type: none"> • 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:		
<ul style="list-style-type: none"> • depends on the chosen courses 		
Notes:		
<p>lecture notes in English</p> <p>Prerequisite tasks for taking the exam can be announced at the beginning of the semester. If any prerequisite tasks are defined, they</p>		



must be completed and passed before taking the exam for the first time.

MA4410 - Approximation Theory (Approx)		
Duration: 1 Semester	Turnus of offer: irregularly	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester • Master Computer Science 2012 (optional subject), advanced curriculum analysis, 2nd or 3rd semester • Master CLS 2010 (optional subject), mathematics, Arbitrary semester 		
Classes and lectures: <ul style="list-style-type: none"> • Approximation theory (lecture, 2 SWS) • Approximation theory (exercise, 1 SWS) 	Workload: <ul style="list-style-type: none"> • 65 Hours private studies and exercises • 45 Hours in-classroom work • 10 Hours exam preparation 	
Contents of teaching: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Learning the basic principles of approximation theory • Understanding the relationship between order of convergence and smoothness • Knowledge of the basic approximation methods 		
Grading through: <ul style="list-style-type: none"> • Written or oral exam as announced by the examiner 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. rer. nat. Jürgen Prestin 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Prof. Dr. rer. nat. Jürgen Prestin 		
Literature: <ul style="list-style-type: none"> • P. L. Butzer, R. J. Nessel: Fourier Analysis and Approximation - Birkhäuser Verlag 1971 • A. Schönhage: Approximationstheorie - de Gruyter 1971 		
Language: <ul style="list-style-type: none"> • English, except in case of only German-speaking participants 		

MA4420 - Mathematics of Linear Inverse Problems (MathInvPro)		
Duration: 1 Semester	Turnus of offer: irregularly	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Mathematics of Linear Inverse Problems (lecture, 2 SWS) • Mathematics of Linear Inverse Problems (exercise, 1 SWS) 	Workload: <ul style="list-style-type: none"> • 55 Hours private studies • 45 Hours in-classroom work • 20 Hours exam preparation 	
Contents of teaching: <ul style="list-style-type: none"> • Ill-posed linear operator equations • Spectral decomposition of compact operators • Stabilization of ill-posed problems • Regularization methods • Numerical realization • Application examples of linear inverse problems 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • Study of the mathematical theory and the regularization possibilities of ill-posed linear inverse problems • Learning analytical and numerical methods for the solution of linear inverse problems 		
Grading through: <ul style="list-style-type: none"> • Oral examination 		
Responsible for this module: <ul style="list-style-type: none"> • Dr. rer. nat. Wolfgang Erb 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Dr. rer. nat. Wolfgang Erb 		
Literature: <ul style="list-style-type: none"> • Engl, Hanke, Neubauer: Regularization of Inverse Problems - Kluwer, 2000 • Kirsch: An Introduction to the Mathematical Theory of Inverse Problems - Springer, 1996 • Louis: Inverse und schlecht gestellte Probleme - Teubner, 1989 • Rieder: Keine Probleme mit Inversen Problemen - Vieweg, 2003 		
Language: <ul style="list-style-type: none"> • offered only in German 		

MA4430 - Approximation on Spheres (ApproxSph)		
Duration: 1 Semester	Turnus of offer: irregularly	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester • Master Computer Science 2012 (optional subject), advanced curriculum analysis, 2nd or 3rd semester • Master CLS 2010 (optional subject), mathematics, Arbitrary semester 		
Classes and lectures: <ul style="list-style-type: none"> • Approximation on spheres (lecture, 2 SWS) • Approximation on spheres (exercise, 1 SWS) 	Workload: <ul style="list-style-type: none"> • 65 Hours private studies and exercises • 45 Hours in-classroom work • 10 Hours exam preparation 	
Contents of teaching: <ul style="list-style-type: none"> • Polynomial systems on spheres • Approximation methods • Fast algorithms • Scattered data 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • Learning the basic principles of approximation theory on spheres • Understanding the function systems on spheres • Knowledge of the basic approximation methods on spheres 		
Grading through: <ul style="list-style-type: none"> • Written or oral exam as announced by the examiner 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. rer. nat. Jürgen Prestin 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Prof. Dr. rer. nat. Jürgen Prestin 		
Literature: <ul style="list-style-type: none"> • V. Michel: Lectures on Constructive Approximation - Fourier, Spline, and Wavelet Methods on the Real Line, the Sphere, and the Ball - Birkhäuser Verlag, Boston, 2013 • W. Freeden, T. Gervens, and M. Schreiner: Constructive Approximation on the Sphere (With Applications to Geomathematics) - Oxford Science Publication, Clarendon Press, 1998 		
Language: <ul style="list-style-type: none"> • English, except in case of only German-speaking participants 		

MA4451 - Evolutionary Dynamics (EvoDyn)		
Duration: 1 Semester	Turnus of offer: not available anymore	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Evolutionary Dynamics (lecture, 2 SWS) • Evolutionary Dynamics (exercise, 1 SWS) 		Workload: <ul style="list-style-type: none"> • 65 Hours private studies • 45 Hours in-classroom work • 10 Hours exam preparation
Contents of teaching: <ul style="list-style-type: none"> • Stochastic models of population genetics • Dynamic systems • Basics of classical game theory • Evolutionary game theory • Applications of evolutionary dynamics to medical problems 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • Knowledge of elementary models in evolutionary dynamics • Basic knowledge in game theory • Modelling and simulation competence 		
Grading through: <ul style="list-style-type: none"> • Oral examination 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. Arne Traulsen 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Prof. Dr. Arne Traulsen • Andere Dozenten 		
Literature: <ul style="list-style-type: none"> • M.A. Nowak: Evolutionary Dynamics - Exploring the equations of life - Harvard University Press, 2006 • J. Hofbauer and K. Sigmund: Evolutionary Games and Population Dynamics - Cambridge University Press, 1998 		
Language: <ul style="list-style-type: none"> • offered only in English 		

MA4452 - Evolutionary Game Theory - from Basics to Recent Developments (EvoGameTh)		
Duration: 1 Semester	Turnus of offer: not available anymore	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Evolutionary Game Theory - from Basics to Recent Developments (lecture, 2 SWS) • Evolutionary Game Theory - from Basics to Recent Developments (blockseminar (compact course), 1 SWS) 		Workload: <ul style="list-style-type: none"> • 65 Hours private studies • 45 Hours in-classroom work • 10 Hours exam preparation
Contents of teaching: <ul style="list-style-type: none"> • Basics of classical game theory • Deterministic and stochastic evolutionary game theory • The evolution of cooperation and punishment • Repeated games • Adaptive dynamics 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • Familiarity with mathematical concepts of classical and evolutionary game theory • Understanding of recent developments and recently published literature in the field • Familiarity with scientific communication at the interface between applied mathematics and biology 		
Grading through: <ul style="list-style-type: none"> • Oral presentation 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. Arne Traulsen Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Prof. Dr. Arne Traulsen • Andere Dozenten 		
Literature: <ul style="list-style-type: none"> • M.A. Nowak: Evolutionary Dynamics - Exploring the equations of life - Harvard University Press, 2006 • K. Sigmund: The calculus of selfishness - Princeton University Press, 2010 		
Language: <ul style="list-style-type: none"> • offered only in English 		
Notes: <p>The lecture is offered in German only if desired by all participants.</p>		

MA4453 - Evolutionary Dynamics: Population Genetic and Ecological Models (EvDyPopEco)		
Duration: 1 Semester	Turnus of offer: irregularly	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Evolutionary Dynamics: Population Genetic and Ecological Models (lecture, 2 SWS) • Evolutionary Dynamics: Population Genetic and Ecological Models (exercise, 1 SWS) 		Workload: <ul style="list-style-type: none"> • 65 Hours private studies • 45 Hours in-classroom work • 10 Hours exam preparation
Contents of teaching: <ul style="list-style-type: none"> • Basics of mathematical population genetics • Discrete stochastic models • Genetic drift • Natural selection • Coupling of genetic and ecological models • Dynamics of infectious diseases 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Oral examination 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. Arne Traulsen Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Prof. Dr. Arne Traulsen • N.N. 		
Literature: <ul style="list-style-type: none"> • S.P. Otto and T.Day: A Biologist's Guide to Mathematical Modeling in Ecology and Evolution. - Princeton University Press, 2007 		
Language: <ul style="list-style-type: none"> • offered only in English 		
Notes: <p>The lecture is offered in German only if desired by all participants.</p> <p>For admission to the oral exam students must have obtained at least 50% of the points in the exercises.</p>		

MA4454 - Evolutionary Dynamics: Game Theory (EvDyGameTh)		
Duration: 1 Semester	Turnus of offer: irregularly	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Evolutionary Game Theory - from Basics to Recent Developments (lecture, 2 SWS) • Evolutionary Game Theory - from Basics to Recent Developments (exercise, 1 SWS) 		Workload: <ul style="list-style-type: none"> • 65 Hours private studies • 45 Hours in-classroom work • 10 Hours exam preparation
Contents of teaching: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Oral examination 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. Arne Traulsen Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Prof. Dr. Arne Traulsen • N.N. 		
Literature: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • offered only in English 		
Notes: <p>The lecture is offered in German only if desired by all participants.</p> <p>For admission to the oral exam students must have obtained at least 50% of the points in the exercises.</p>		

MA4611 - Markov-Prozesse (MarkovProz)		
Duration: 1 Semester	Turnus of offer: not available anymore	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Markov-Prozesse (lecture, 2 SWS) • Markov-Prozesse (exercise, 1 SWS) 	Workload: <ul style="list-style-type: none"> • 60 Hours private studies and exercises • 45 Hours in-classroom work • 15 Hours exam preparation 	
Contents of teaching:		
Grading through: <ul style="list-style-type: none"> • Written or oral exam as announced by the examiner 		
Responsible for this module: <ul style="list-style-type: none"> • Nachfolge von Prof. Dr. rer. nat. Karsten Keller 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Nachfolge von Prof. Dr. rer. nat. Karsten Keller • Prof. Dr. rer. nat. Jürgen Prestin 		
Language: <ul style="list-style-type: none"> • offered only in German 		

MA4614 - Numerical methods for partial differential equations (NumMethPDE)		
Duration: 1 Semester	Turnus of offer: irregularly	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester • Master CLS 2010 (optional subject), mathematics, Arbitrary semester 		
Classes and lectures: <ul style="list-style-type: none"> • Numerical methods for partial differential equations (lecture, 2 SWS) • Numerical methods for partial differential equations (exercise, 1 SWS) 		Workload: <ul style="list-style-type: none"> • 55 Hours private studies • 45 Hours in-classroom work • 20 Hours exam preparation
Contents of teaching: <ul style="list-style-type: none"> • Numerics for partial differential equations • Discretization of initial and boundary value problems • Numerical approximation schemes • Error analysis • Stability and consistency 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Written or oral exam as announced by the examiner 		
Requires: <ul style="list-style-type: none"> • Numerics 2 (MA4040-MML) • Numerics 1 (MA3110-MML) • Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500) • Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000) • Analysis 2 (MA2500-MML) • Analysis 1 (MA2000-KP08, MA2000) 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. rer. nat. Andreas Rößler 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Prof. Dr. rer. nat. Andreas Rößler • MitarbeiterInnen des Instituts 		
Language: <ul style="list-style-type: none"> • offered only in German 		
Notes: <p>Literature will be announced in the lecture.</p> <p>Criteria for admission to the examination will be established by the lecturer.</p>		

MA4615 - Numerical methods for stochastic processes (NumStochPr)
Duration:

1 Semester

Turnus of offer:

irregularly

Credit points:

4

Course of study, specific field and term:

- Master MES 2011 (optional subject), mathematics, 1st or 2nd semester
- Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester
- Master CLS 2010 (optional subject), mathematics, Arbitrary semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Written or oral exam as announced by the examiner

Requires:

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

Responsible for this module:

- [Prof. Dr. rer. nat. Andreas Rößler](#)

Teacher:

- [Institute for Mathematics](#)
- [Prof. Dr. rer. nat. Andreas Rößler](#)

Literature:

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

Language:

- offered only in German

Notes:

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

MA4616 - Advanced Numerics (HoehereNum)		
Duration: 1 Semester	Turnus of offer: irregularly	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master MES 2011 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester • Master CLS 2010 (optional subject), mathematics, Arbitrary semester 		
Classes and lectures: <ul style="list-style-type: none"> • Advanced Numerics (lecture, 2 SWS) • Advanced Numerics (exercise, 1 SWS) 	Workload: <ul style="list-style-type: none"> • 55 Hours private studies • 45 Hours in-classroom work • 20 Hours exam preparation 	
Contents of teaching: <ul style="list-style-type: none"> • Numerics for ordinary differential equations • One-step methods, local and global error analysis • Orders of consistence and convergence • Stiff differential equations, implicit schemes, stability 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Written or oral exam as announced by the examiner 		
Requires: <ul style="list-style-type: none"> • Numerics 2 (MA4040-MML) • Numerics 2 (MA4040-KP04, MA4040) • Numerics 1 (MA3110-MML) • Numerics 1 (MA3110-KP04, MA3110) 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. rer. nat. Andreas Rößler 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Prof. Dr. rer. nat. Andreas Rößler 		
Language: <ul style="list-style-type: none"> • offered only in German 		
Notes: <p>Literature will be announced in the lecture.</p> <p>Criteria for admission to the examination will be established by the lecturer.</p>		

MA4630 - Fourier Analysis (FourierAna)		
Duration: 1 Semester	Turnus of offer: irregularly	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester • Master MES 2011 (optional subject), mathematics, 1st or 2nd semester • Master CLS 2010 (optional subject), mathematics, Arbitrary semester 		
Classes and lectures: <ul style="list-style-type: none"> • Fourier Analysis (lecture, 2 SWS) • Fourier Analysis (exercise, 1 SWS) 	Workload: <ul style="list-style-type: none"> • 65 Hours private studies • 45 Hours in-classroom work • 10 Hours exam preparation 	
Contents of teaching: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Knowledge of integral transforms • A comprehensive understanding for the Fourier transform 		
Grading through: <ul style="list-style-type: none"> • written exam 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. rer. nat. Jürgen Prestin 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Prof. Dr. rer. nat. Jürgen Prestin 		
Literature: <ul style="list-style-type: none"> • Chandrasekharan, K.: Classical Fourier Transforms - Springer 1989 		
Language: <ul style="list-style-type: none"> • offered only in German 		

MA4640 - Sampling in der Signalanalyse (SampSignal)		
Duration: 1 Semester	Turnus of offer: irregularly	Credit points: 4 (Typ B)
Course of study, specific field and term: <ul style="list-style-type: none"> • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester • Master MES 2011 (optional subject), mathematics, 1st or 2nd semester • Master CLS 2010 (optional subject), computer science, Arbitrary semester 		
Classes and lectures: <ul style="list-style-type: none"> • Sampling-Verfahren in der Signalanalyse (seminar, 2 SWS) 		Workload: <ul style="list-style-type: none"> • 70 Hours private studies • 30 Hours in-classroom work • 20 Hours work on an individual topic with written and oral presentation
Contents of teaching: <ul style="list-style-type: none"> • Hilberträume, Basen und Frames • Endliches und Unendliches Sampling • Anwendungen auf lineare gewöhnliche Differentialgleichungen • Multi-band und Multi-channel Sampling • Sampling und Eigenwert-Probleme 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • • • 		
Grading through: <ul style="list-style-type: none"> • participation in discussions 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. rer. nat. Jürgen Prestin 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Prof. Dr. rer. nat. Jürgen Prestin 		
Language: <ul style="list-style-type: none"> • offered only in German 		

MA4670 - Combinatorics (Kombi)		
Duration: 1 Semester	Turnus of offer: every second year	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master MES 2011 (optional subject), mathematics, 1st or 2nd semester • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • combinatorics (lecture, 2 SWS) • combinatorics (exercise, 1 SWS) 	Workload: <ul style="list-style-type: none"> • 55 Hours private studies • 45 Hours in-classroom work • 20 Hours exam preparation 	
Contents of teaching: <ul style="list-style-type: none"> • Permutations, combinations, variations • Partitions • Generating functions • Recurrence equations • Sums and differences • Inclusion - exclusion 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • Learning the basics of combinatorics • Knowledge of different proof techniques and combinatorial approaches • Teaching fundamental results and deepening some selected aspects of combinatorics 		
Grading through: <ul style="list-style-type: none"> • Oral examination 		
Requires: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • PD Dr. rer. nat. Hanns-Martin Teichert 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • PD Dr. rer. nat. Hanns-Martin Teichert 		
Literature: <ul style="list-style-type: none"> • Peter Tittmann: Einführung in die Kombinatorik - Spektrum Akademischer Verlag 2000 • Richard A. Brualdi: Introductory Combinatorics - Pearson Prentice Hall 2004 		
Language: <ul style="list-style-type: none"> • offered only in German 		

MA4675 - Algebra (Algebra)		
Duration: 1 Semester	Turnus of offer: every second year	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester • Master CLS 2010 (optional subject), mathematics, Arbitrary semester 		
Classes and lectures: <ul style="list-style-type: none"> • Algebra (lecture, 2 SWS) • Algebra (exercise, 1 SWS) 	Workload: <ul style="list-style-type: none"> • 55 Hours private studies • 45 Hours in-classroom work • 20 Hours exam preparation 	
Contents of teaching: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Learning the basics of algebra • Knowledge of different proof techniques and algebraic approaches • Teaching fundamental results and deepening some selected aspects of algebra 		
Grading through: <ul style="list-style-type: none"> • Oral examination 		
Requires: <ul style="list-style-type: none"> • Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500) • Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000) 		
Responsible for this module: <ul style="list-style-type: none"> • PD Dr. rer. nat. Hanns-Martin Teichert 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • PD Dr. rer. nat. Hanns-Martin Teichert 		
Literature: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • offered only in German 		

MA4710 - Functional Analysis (FunkAna)		
Duration: 1 Semester	Turnus of offer: irregularly	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master MES 2011 (optional subject), mathematics, 1st or 2nd semester • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Functional Analysis (lecture, 2 SWS) • Functional Analysis (exercise, 1 SWS) 	Workload: <ul style="list-style-type: none"> • 55 Hours private studies • 45 Hours in-classroom work • 20 Hours exam preparation 	
Contents of teaching: <ul style="list-style-type: none"> • Metric spaces and their topology • Banach spaces, Hilbert spaces and their geometry • Duality, Hahn-Banach theorems • Bounded linear operators, open mapping principle • L^p-spaces and the theorem of Riesz-Fischer • Weak topologies and reflexive spaces 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • Learning the basic techniques for the analysis of linear functionals and operators on Banach and Hilbert spaces • Study of the fundamental principles of functional analysis 		
Grading through: <ul style="list-style-type: none"> • Oral examination 		
Responsible for this module: <ul style="list-style-type: none"> • Dr. rer. nat. Wolfgang Erb Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Dr. rer. nat. Wolfgang Erb 		
Literature: <ul style="list-style-type: none"> • Hirzebruch, Scharlau: Einführung in die Funktionalanalysis - BI-Hochschulbücher, 1991 • Rudin: Functional Analysis - McGraw Hill, 1991 • Heuser: Funktionalanalysis - 4. Auflage, Teubner, 2006 • Hille, Phillips: Functional Analysis and Semi-Groups - AMS, 1957 		
Language: <ul style="list-style-type: none"> • offered only in German 		

MA4720 - Orthogonal Series in Banach Spaces (ORiBanachR)		
Duration: 1 Semester	Turnus of offer: irregularly	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Orthogonal Series in Banach Spaces (lecture, 2 SWS) • Orthogonal Series in Banach Spaces (exercise, 1 SWS) 		Workload: <ul style="list-style-type: none"> • 65 Hours private studies • 45 Hours in-classroom work • 10 Hours exam preparation
Contents of teaching: <ul style="list-style-type: none"> • Conditional und unconditional convergence and bases in general Banach spaces • General existence- and non-existence results concerning basis especially in the spaces L_1 and $C(I)$ • Haar and Franklin Systems as bases in the spaces L_p, H_1 and BMO 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • A competent knowledge of the construction methods of bases in special Banach spaces 		
Grading through: <ul style="list-style-type: none"> • active participation in the exercises 		
Responsible for this module: <ul style="list-style-type: none"> • PD Dr. rer. nat. Jörn Schnieder 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • PD Dr. rer. nat. Jörn Schnieder 		
Literature: <ul style="list-style-type: none"> • Kashin, B. S., Saakyan, A. A.: Orthogonal Series - AMS 1989 		
Language: <ul style="list-style-type: none"> • offered only in German 		

MA4740 - Fractal Geometry (FraktGeo)		
Duration: 1 Semester	Turnus of offer: irregularly	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Fractal Geometry (lecture, 2 SWS) • Fractal Geometry (exercise, 1 SWS) 		Workload: <ul style="list-style-type: none"> • 65 Hours private studies • 45 Hours in-classroom work • 10 Hours exam preparation
Contents of teaching: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Oral examination 		
Responsible for this module: <ul style="list-style-type: none"> • Dr. Sabrina Kombrink 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Dr. Sabrina Kombrink 		
Literature: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • offered only in German 		
Notes: <p>For admission to the oral exam students must have obtained at least 50% of the points in the exercises.</p>		

MA4801 - Elliptische Funktionen (EllipFunk)		
Duration: 1 Semester	Turnus of offer: every second year	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Elliptische Funktionen (lecture, 2 SWS) • Elliptische Funktionen (exercise, 1 SWS) 		Workload: <ul style="list-style-type: none"> • 60 Hours private studies • 45 Hours in-classroom work • 15 Hours exam preparation
Contents of teaching: <ul style="list-style-type: none"> • • • • • • • • 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • • 		
Grading through: <ul style="list-style-type: none"> • Written or oral exam as announced by the examiner 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. Reinhard Schuster 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Prof. Dr. Reinhard Schuster 		
Language: <ul style="list-style-type: none"> • offered only in German 		

MA4802 - Spezielle und allgemeine Relativitätstheorie (RelatiTheo)		
Duration: 1 Semester	Turnus of offer: every second year	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master MES 2011 (optional subject), mathematics, 1st or 2nd semester • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Spezielle und allgemeine Relativitätstheorie (lecture, 2 SWS) • Spezielle und allgemeine Relativitätstheorie (exercise, 1 SWS) 	Workload: <ul style="list-style-type: none"> • 60 Hours private studies • 45 Hours in-classroom work • 15 Hours exam preparation 	
Contents of teaching:		
Grading through: <ul style="list-style-type: none"> • Written or oral exam as announced by the examiner 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. Reinhard Schuster 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Prof. Dr. Reinhard Schuster 		
Language: <ul style="list-style-type: none"> • offered only in German 		

MA4803 - Number Theory (Zahlentheo)		
Duration: 1 Semester	Turnus of offer: every second year	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Number Theory (lecture, 2 SWS) • Number Theory (exercise, 1 SWS) 		Workload: <ul style="list-style-type: none"> • 60 Hours private studies • 45 Hours in-classroom work • 15 Hours exam preparation
Contents of teaching: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Theoretical knowledge of the mentioned topics • Historical and most recent issues • Solve questions in this filed • Recognize interdisciplinary aspects 		
Grading through: <ul style="list-style-type: none"> • Written or oral exam as announced by the examiner 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. Reinhard Schuster 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Prof. Dr. Reinhard Schuster 		
Literature: <ul style="list-style-type: none"> • 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 • Winogrodow: Elemente der Zahlentheorie - Prestel-Verlag 1956 		



Language:

- offered only in German

MA4804 - Special Functions (SpeFunktio)		
Duration: 1 Semester	Turnus of offer: irregularly	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Special Functions (lecture, 2 SWS) • Special Functions (exercise, 1 SWS) 	Workload: <ul style="list-style-type: none"> • 60 Hours private studies • 45 Hours in-classroom work • 15 Hours exam preparation 	
Contents of teaching: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Theoretical knowledge of the mentioned topics • Historical and latest questions • Solve questions in this field • Recognize interdisciplinary aspects 		
Grading through: <ul style="list-style-type: none"> • Written or oral exam as announced by the examiner 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. Reinhard Schuster 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Prof. Dr. Reinhard Schuster 		
Literature: <ul style="list-style-type: none"> • 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 Course of Modern Analysis - Cambridge University Press 1902 ... 1999

Language:

- offered only in German

MA4950 - Logistische Regression (LogRegress)		
Duration: 1 Semester	Turnus of offer: every second year	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Logistische Regression (lecture, 2 SWS) • Logistische Regression (exercise, 1 SWS) 	Workload: <ul style="list-style-type: none"> • 60 Hours private studies • 45 Hours in-classroom work • 15 Hours exam preparation 	
Contents of teaching: <ul style="list-style-type: none"> • • • 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • • • 		
Grading through: <ul style="list-style-type: none"> • Written or oral exam as announced by the examiner 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. rer. nat. Andreas Ziegler 		
Teacher: <ul style="list-style-type: none"> • Institute of Medical Biometry and Statistics • Prof. Dr. rer. nat. Andreas Ziegler 		
Language: <ul style="list-style-type: none"> • offered only in German 		

MA4962 - Generalized Linear Models (VLModelle)		
Duration: 1 Semester	Turnus of offer: irregularly	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester • Master CLS 2010 (optional subject), mathematics, Arbitrary semester 		
Classes and lectures: <ul style="list-style-type: none"> • Generalized Linear Models (lecture, 2 SWS) • Generalized Linear Models (exercise, 1 SWS) 		Workload: <ul style="list-style-type: none"> • 46 Hours private studies • 36 Hours in-classroom work • 24 Hours programming • 14 Hours exam preparation
Contents of teaching: <ul style="list-style-type: none"> • General overview of generalized linear models (GLM): - derivation of GLM functions,- GLM algorithms: Fisher scoring, iteratively weighted least squares,- goodness of fit and residuals • Continuous response models: Gaussian, log-normal, Gamma, log-Gamma for survival analysis, inverse Gaussian • Discrete response models:- dichotomous: logit, probit, cloglog, loglog, - count data: Poisson, negative binomial, geometric • Ordered logistic and probit regression • Multinomial logit and probit model • Introduction to panel models 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • Knowledge of the theoretical foundation of the generalized linear model and its application • Competence for the critical appraisal of regression models • Competence to detect algorithmic issues in generalized linear models • Knowledge of conceptual problems with models using categorical dependent variables • Knowledge for the adequate interpretation of study results • Competence in parameter interpretation and regression diagnostics 		
Grading through: <ul style="list-style-type: none"> • written exam 		
Requires: <ul style="list-style-type: none"> • Biostatistics 2 (MA2600-KP04, MA2600) 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. rer. nat. Andreas Ziegler 		
Teacher: <ul style="list-style-type: none"> • Institute of Medical Biometry and Statistics • Prof. Dr. rer. nat. Andreas Ziegler 		
Literature: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • offered only in German 		

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

1 Semester

Turnus of offer:

each winter semester

Credit points:

4

Course of study, specific field and term:

- Bachelor IT-Security 2016 (optional subject), interdisciplinary, Arbitrary semester
- Bachelor Computer Science 2019 (optional subject), Introductory Module Computer Science, 1st semester
- Bachelor Robotics and Autonomous Systems 2020 (optional subject), medical computer science, 5th or 6th semester
- Bachelor Medical Informatics 2019 (compulsory: aptitude test), medical computer science, 1st semester
- Bachelor Computer Science 2016 (optional subject), Introductory Module Computer Science, 1st semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), computer science, 5th or 6th semester
- Bachelor Medical Informatics 2014 (compulsory: aptitude test), medical computer science, 1st semester
- Bachelor Medical Informatics 2011 (compulsory: aptitude test), medical computer science, 1st semester
- Bachelor CLS 2010 (optional subject), computer science, 5th semester
- Bachelor MES 2011 (compulsory), foundations of computer science, 3rd semester
- Bachelor Computer Science 2012 (compulsory), specialization field medical informatics, 1st semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Basic concepts and methods of medical informatics
- Overview of the occupational field in medical informatics
- Introduction to the German healthcare system
- Introduction to medical documentation, including patient record
- Information systems in the healthcare sector
- Conceptual systems in medicine (classifications, terminologies)
- Medical informatics in clinical practice
- Principles of medical imaging: X-ray, ultrasound, CT, MRI
- Fundamentals of medical image computing and visualisation
- Medical sensor data analysis
- Medical decision support for diagnostics and therapy
- Health telematics
- Medical data security

Qualification-goals/Competencies:

- Students know the fundamental terms and selected methods in the area of medical informatics.
- They know the main features of the German healthcare system.
- They are able to formulate the objectives and types of medical documentation including the electronic health record.
- They know the requirements for clinical information systems.
- They are able to formulate SQL queries and apply them to relational databases.
- They are able to explain the principles of medical imaging.
- They are able to explain the fundamentals of medical image processing and visualisation.
- They know selected application scenarios in the area of medical sensor data analysis.
- They know selected approaches for medical decision support.

Grading through:

- written exam

Responsible for this module:

- [Prof. Dr. rer. nat. habil. Heinz Handels](#)

Teacher:

- [Institute of Medical Informatics](#)
- [Prof. Dr. rer. nat. habil. Heinz Handels](#)



- Prof. Dr.-Ing. Marcin Grzegorzek
- Prof. Dr. Mattias Heinrich

Literature:

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

Language:

- offered only in German

Notes:

Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s):

- Successful completion of exercise slips as specified at the beginning of the semester
- Giving a short lecture as specified at the beginning of the semester

Module examinations:

- CS1300-L1: Introduction to Medical Informatics, written exam, 90min, 100% of module grade

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

1 Semester

Turnus of offer:

each winter semester

Credit points:

4

Course of study, specific field and term:

- Bachelor IT-Security 2016 (optional subject), interdisciplinary, Arbitrary semester
- Bachelor Nutritional Medicine 2024 (compulsory), mathematics / computer science, 5th semester
- Bachelor Molecular Life Science 2024 (compulsory), mathematics / computer science, 5th semester
- Bachelor MES 2020 (optional subject), computer science / electrical engineering, 3rd semester at the earliest
- Bachelor Computer Science 2019 (compulsory), Canonical Specialization Bioinformatics and Systems Biology, 1st semester
- Bachelor Computer Science 2019 (optional subject), Introductory Module Computer Science, 1st semester
- Bachelor MLS 2018 (compulsory), life sciences, 5th semester
- Bachelor MES 2014 (optional subject), computer science / electrical engineering, 3rd semester at the earliest
- Bachelor Computer Science 2016 (optional subject), Introductory Module Computer Science, 1st semester
- Bachelor Computer Science 2016 (compulsory), Canonical Specialization Bioinformatics, 1st semester
- Bachelor MLS 2016 (compulsory), life sciences, 5th semester
- Bachelor Medical Informatics 2014 (compulsory), medical computer science, 3rd semester
- Bachelor Computer Science 2014 (compulsory), specialization field bioinformatics, 1st semester
- Bachelor Medical Informatics 2011 (compulsory), medical computer science, 3rd semester
- Bachelor MLS 2009 (compulsory), life sciences, 5th semester
- Bachelor CLS 2010 (compulsory), specialization field bioinformatics, 5th semester
- Bachelor MES 2011 (optional subject), medical engineering science, 3rd or 5th semester
- Bachelor Computer Science 2012 (compulsory), specialization field bioinformatics, 1st semester
- Bachelor Biophysics 2024 (optional subject), computer science, 5th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- portfolio exam

Responsible for this module:

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

Teacher:

- [Institute for Neuro- and Bioinformatics](#)
- Prof. Dr. rer. nat. Amir Madany Mamlouk

**Literature:**

- H. Lodish, A. Berk, S. L. Zipursky and J. Darnell: Molekulare Zellbiologie - Spektrum Akademischer Verlag, 4. Auflage, 2001, ISBN-13: 978-3827410771
- A. M. Lesk: Introduction to Bioinformatics - Oxford University Press, 3. Auflage, 2008, ISBN-13: 978-0199208043
- R. Merkl and S. Waack: Bioinformatik Interaktiv: Grundlagen, Algorithmen, Anwendungen - Wiley-VCH Verlag, 2. Auflage, 2009, ISBN-13: 978-3527325948
- M. S. Waterman: Introduction to Computational Biology - Chapman and Hall, 1995

Language:

- offered only in German

Notes:

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

Prerequisites for attending the module:

- None

Computer Science students get a B certificate.

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

1 Semester

Turnus of offer:

each winter semester

Credit points:

4

Course of study, specific field and term:

- Bachelor CLS 2023 (optional subject), life sciences, 5th semester
- Bachelor Biophysics 2024 (compulsory), biophysics, 3rd semester
- Bachelor Molecular Life Science 2024 (compulsory), life sciences, 3rd semester
- Bachelor MES 2020 (optional subject), mathematics / natural sciences, 3rd semester at the earliest
- Bachelor MLS 2018 (compulsory), life sciences, 3rd semester
- Bachelor MLS 2016 (compulsory), life sciences, 3rd and 4th semester
- Bachelor CLS 2016 (optional subject), life sciences, 5th semester
- Bachelor Nutritional Medicine 2016 (compulsory), biophysics, 3rd semester
- Bachelor Biophysics 2016 (compulsory), biophysics, 3rd semester
- Bachelor MES 2014 (optional subject), mathematics / natural sciences, 3rd or 5th semester
- Bachelor MLS 2009 (compulsory), life sciences, 3rd and 4th semester
- Bachelor CLS 2010 (optional subject), life sciences, 5th semester
- Bachelor MES 2011 (compulsory), medical engineering science, 5th semester

Classes and lectures:

- Introduction into Biophysics (lecture, 2 SWS)
- Biophysics (Exercise or 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 exam

Responsible for this module:

- [Dr. Young-Hwa Song](#)

Teacher:

- [Institute of Physics](#)
- [Dr. Young-Hwa Song](#)
- [Prof. Dr. rer. nat. Christian Hübner](#)

Literature:

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

Language:

- offered only in German

Notes:



Prerequisites for the module:

- None

Prerequisites for admission to the written examination:

- Successful participation in the exercises as specified at the beginning of the semester

Module exam:

- LS2200-L1: Introduction into Biophysics, written exam, 120 min, 100 % of module grade

The lecture and exercises take place in the winter semester, the practical course in the summer semester.

Whether exercises or a practical course take place is specified in the SGO of the respective study program.

Prerequisite for the understanding of the lecture is the knowledge of the basics of inorganic and organic chemistry.

MA3210 - Statistics - Practical Course (StatPrakt)		
Duration: 1 Semester	Turnus of offer: each winter semester	Credit points: 3 (Typ B)
Course of study, specific field and term: <ul style="list-style-type: none"> • Bachelor Computer Science 2012 (optional subject), specialization field bioinformatics, 5th semester • Bachelor Computer Science 2012 (optional subject), specialization field medical informatics, 5th semester • Bachelor CLS 2010 (compulsory), mathematics, 5th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Statistics - Practical Course (practical course, 2 SWS) 	Workload: <ul style="list-style-type: none"> • 60 Hours work on project • 30 Hours in-classroom work 	
Contents of teaching: <ul style="list-style-type: none"> • Data management • Literate programming (Sweave or knitr) • Descriptive statistics (frequency tables, measures of location and dispersion) • Simple graphics (box-whisker plot, scatter plots, histograms) • t-Test, Mann-Whitney U-test, Kruskal-Wallis-test • Bootstrap • Programming of functions 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • Independent data management in R • Independent realization of simple statistical analyses • Independent generation of simple graphics • Independent creation of literate programming scripts • Independent calculation of bootstrap confidence intervals • Independent writing of functions 		
Grading through: <ul style="list-style-type: none"> • continuous, successful participation in practical course, >80% 		
Is requisite for: <ul style="list-style-type: none"> • Genetic Epidemiology 2 (MA4661-KP08, MA4661) • Prognostic models (MA4660) 		
Requires: <ul style="list-style-type: none"> • Biostatistics 1 (MA1600-KP04, MA1600, MA1600-MML) 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. rer. nat. Andreas Ziegler 		
Teacher: <ul style="list-style-type: none"> • Institute of Medical Biometry and Statistics • Prof. Dr. rer. nat. Andreas Ziegler 		
Literature: <ul style="list-style-type: none"> • Helge Toutenburg, Christian Heumann: Deskriptive Statistik: Eine Einführung in Methoden und Anwendungen mit R und SPSS - ISBN-13 9783540777878 • Helge Toutenburg, Christian Heumann: Induktive Statistik: Eine Einführung mit R und SPSS - ISBN-13 9783540775096 • Lothar Sachs, Jürgen Hedderich: Angewandte Statistik: Methodensammlung mit R - ISBN-13 9783540889014 		
Language: <ul style="list-style-type: none"> • offered only in German 		



Notes:

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

MA3300 - Interdisciplinary Seminar (InterdisS)		
Duration: 1 Semester	Turnus of offer: each winter semester	Credit points: 5
Course of study, specific field and term: <ul style="list-style-type: none"> Bachelor CLS 2010 (compulsory), mathematics, 5th semester 		
Classes and lectures: <ul style="list-style-type: none"> Interdisciplinary Seminar (seminar, 2 SWS) 		Workload: <ul style="list-style-type: none"> 120 Hours oral presentation (including preparation) 30 Hours in-classroom work
Contents of teaching: <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> 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 an intelligible oral presentation They are able to discuss scientific problems 		
Grading through: <ul style="list-style-type: none"> participation in discussions 		
Responsible for this module: <ul style="list-style-type: none"> Nachfolge von Prof. Dr. rer. nat. Karsten Keller 		
Teacher: <ul style="list-style-type: none"> Institute of Medical Biometry and Statistics Institute of Mathematics and Image Computing Institute for Mathematics Prof. Dr. rer. nat. Jan Modersitzki Nachfolge von Prof. Dr. rer. nat. Karsten Keller Prof. Dr. rer. biol. hum. Inke König 		
Language: <ul style="list-style-type: none"> offered only in German 		

MA4450-KP08, MA4450-MML - Modeling Biological Systems (MoBS)
Duration:

1 Semester

Turnus of offer:

each winter semester

Credit points:

8

Course of study, specific field and term:

- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master MES 2014 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master MES 2011 (optional subject), mathematics, 1st or 3rd semester
- Bachelor CLS 2010 (compulsory), mathematics, 5th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Elementary time-discrete deterministic models
- Structured time-discrete population dynamics
- Generating functions, Galton-Watson processes
- 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 and project assignments
- 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:

- [Nachfolge von Prof. Dr. rer. nat. Karsten Keller](#)

Teacher:

- [Institute for Mathematics](#)
- [Nachfolge von 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.

Prerequisites for attending the module:

- None (The competences of the required modules are required for this module, but the modules are not a prerequisite for admission.)

Prerequisites for the exam:

- Preliminary examinations can be determined at the beginning of the semester. If preliminary work has been defined, it must have been completed and positively assessed before the initial examination.

MA4970 - Design of Experiments and Variance Analysis (VpIVarianz)
Duration:

1 Semester

Turnus of offer:

irregularly

Credit points:

4

Course of study, specific field and term:

- Master Computer Science 2012 (optional subject), specialization field medical informatics, 3rd semester
- Master CLS 2010 (optional subject), mathematics, 1st or 3rd semester
- Bachelor CLS 2010 (optional subject), mathematics, 5th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written exam

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Ziegler

Teacher:

- [Institute of Medical Biometry and Statistics](#)
- Prof. Dr. rer. nat. Andreas Ziegler

Literature:

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

Language:

- offered only in German

ME2053-MML - Physics Lab Course (PhysPrakt)		
Duration: 1 Semester	Turnus of offer: each winter semester	Credit points: 3
Course of study, specific field and term: <ul style="list-style-type: none"> Bachelor CLS 2010 (compulsory), physics, 5th semester 		
Classes and lectures: <ul style="list-style-type: none"> Physics Lab Course (practical course, 2 SWS) 		Workload: <ul style="list-style-type: none"> 45 Hours written report 30 Hours in-classroom work 15 Hours exam preparation
Contents of teaching: <ul style="list-style-type: none"> Experiment 1: fluid dynamics Experiment 2: heat Experiment 3: non stationary current Experiment 4: stationary current Experiment 5: sound and ultrasound Experiment 6: statistics Experiment 7: geometrical optics Experiment 8: spectrometer Experiment 9: diffusion Experiment 10: radio activity 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> Hands-on access to physical relations Graphical representation of experimental data Excellence in interpreting data 		
Grading through: <ul style="list-style-type: none"> Written or oral exam as announced by the examiner 		
Responsible for this module: <ul style="list-style-type: none"> Prof. Dr. rer. nat. Christian Hübner 		
Teacher: <ul style="list-style-type: none"> Institute of Biomedical Optics Institute of Physics Institute of Medical Engineering Prof. Dr. rer. nat. Christian Hübner 		
Literature: <ul style="list-style-type: none"> Giancoli: Physik 		
Language: <ul style="list-style-type: none"> offered only in German 		

CS1002-KP04, CS1002 - Introduction to Logics (Logik)		
Duration: 1 Semester	Turnus of offer: each summer semester	Credit points: 4
Course of study, specific field and term:		
<ul style="list-style-type: none"> • Bachelor MES 2014 (optional subject), computer science / electrical engineering, 3rd semester at the earliest • Bachelor Media Informatics 2020 (compulsory), computer science, 2nd semester • Bachelor Computer Science 2019 (compulsory), foundations of computer science, 2nd semester • Bachelor Robotics and Autonomous Systems 2020 (optional subject), computer science, 5th or 6th semester • Bachelor Medical Informatics 2019 (compulsory), computer science, 2nd semester • Bachelor Media Informatics 2014 (optional subject), computer science, 5th or 6th semester • Bachelor Computer Science 2016 (compulsory), foundations of computer science, 3rd semester • Bachelor Robotics and Autonomous Systems 2016 (optional subject), computer science, 5th or 6th semester • Bachelor IT-Security 2016 (compulsory), computer science, 2nd semester • Bachelor Medical Informatics 2014 (compulsory), computer science, 3rd semester • Bachelor Computer Science 2014 (compulsory), foundations of computer science, 3rd semester • Bachelor Medical Informatics 2011 (compulsory), computer science, 1st semester • Bachelor MES 2011 (optional subject), computer science, 3rd semester • Bachelor CLS 2010 (optional subject), computer science, 6th semester • Bachelor Computer Science 2012 (compulsory), foundations of computer science, 1st semester • Bachelor Biophysics 2024 (optional subject), computer science, 6th semester 		
Classes and lectures:		Workload:
<ul style="list-style-type: none"> • Introduction to Logic (lecture, 2 SWS) • Introduction to Logic (exercise, 1 SWS) 		<ul style="list-style-type: none"> • 65 Hours private studies and exercises • 45 Hours in-classroom work • 10 Hours exam preparation
Contents of teaching:		
<ul style="list-style-type: none"> • Key concepts of syntax: alphabet, string, term, formula • Key concepts of semantics: assignment, structure, model • Key concepts of proof calculus: axioms, proofs • Formlization and coding of problems • Validating correctness and satisfiability of formalizations • Syntax and semantics of propositional logic • Syntax and semantics of predicate logig • Proof caculi 		
Qualification-goals/Competencies:		
<ul style="list-style-type: none"> • Students are abel to explain the concepts of syntax and semantics for the examples of prepositional and predicate logic • They are able to apply formal systems and proof systems • They are able to transfer methods of mathematical logic to simple practical problems • They are abel to formalize discrete problems • They are able to modify proof templates in order to create simple proofs 		
Grading through:		
<ul style="list-style-type: none"> • written exam 		
Responsible for this module:		
<ul style="list-style-type: none"> • Prof. Dr. rer. nat. Till Tantau 		
Teacher:		
<ul style="list-style-type: none"> • Institute for Theoretical Computer Science • Prof. Dr. rer. nat. Till Tantau • Prof. Dr. Rüdiger Reischuk 		
Literature:		
<ul style="list-style-type: none"> • Uwe Schöning: Logik für Informatiker - Spektrum Verlag, 1995 		



- Kreuzer, Kühlig: Logik für Informatiker - Pearson Studium, 2006

Language:

- offered only in German

Notes:

Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s):

- Successful completion of exercise slips as specified at the beginning of the semester.

Module Exam(s):

- CS1002-L1: Introduction to Logic, portfolio exam: a total of 70 points for written exercises down during the course of the semester, 30 points for the written exam at the end. The grade is calculated as follows: 50 to 54 points for a 4.0, then 55 to 59 points for a 3.7 and so on until the end 95 to 100 points for a 1.0.

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

1 Semester

Turnus of offer:

each winter semester

Credit points:

4

Course of study, specific field and term:

- Bachelor Biophysics 2016 (optional subject), computer science, 5th semester
- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Media Informatics 2020 (compulsory), media informatics, 3rd semester
- Bachelor Robotics and Autonomous Systems 2020 (optional subject), media informatics, 5th or 6th semester
- Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), computer science, 4th or 6th semester
- Bachelor IT-Security 2016 (optional subject), computer science, Arbitrary semester
- Bachelor Media Informatics 2014 (compulsory), media informatics, 3rd semester
- Bachelor Computer Science 2014 (optional subject), central topics of computer science, 5th semester
- Bachelor Computer Science 2012 (optional subject), central topics of computer science, 6th semester
- Bachelor CLS 2010 (optional subject), computer science, 6th semester
- Bachelor Computer Science 2012 (compulsory), specialization field media informatics, 2nd semester
- Bachelor Biophysics 2024 (optional subject), computer science, 5th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Sensation and Perception
- Analog Media Technology
- Digitalisation
- Digital Audio, Image and Video Technology
- Media storage (compression / formats)
- Media Transmission (Broadcast / Streaming)

Qualification-goals/Competencies:

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

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- [Prof. Dr.-Ing. Andreas Schrader](#)

Teacher:

- [Institute of Telematics](#)
- [Prof. Dr.-Ing. Andreas Schrader](#)

Literature:

- Thomas Görne: Tontechnik - 4. Auflage, Hanser 2014
- Ulrich Schmidt: Professionelle Videotechnik - 6. Auflage, Springer 2013

Language:

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

Notes:



Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s):

- Successful completion of exercise slips as specified at the beginning of the semester.

Module Exam(s):

- CS1601-L1 Fundamentals of Multimedia Technology, as determined by the instructor: Written exam, 90min, 100% of module grade OR oral exam, 100% of module grade.

CS2700-KP04, CS2700 - Databases (DB)
Duration:

1 Semester

Turnus of offer:

each winter semester

Credit points:

4

Course of study, specific field and term:

- Bachelor Biophysics 2024 (optional subject), computer science, 6th semester
- Bachelor MES 2020 (optional subject), computer science / electrical engineering, 3rd semester at the earliest
- Bachelor Media Informatics 2020 (compulsory), computer science, 5th semester
- Bachelor Computer Science 2019 (compulsory), foundations of computer science, 3rd semester
- Bachelor Robotics and Autonomous Systems 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Medical Informatics 2019 (compulsory), computer science, 3rd semester
- Bachelor Computer Science 2016 (compulsory), foundations of computer science, 4th semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), computer science, 5th or 6th semester
- Bachelor IT-Security 2016 (compulsory), computer science, 3rd semester
- Bachelor Biophysics 2016 (optional subject), computer science, 6th semester
- Bachelor MES 2011 (optional subject), computer science, 4th or 6th semester
- Bachelor Medical Informatics 2014 (compulsory), computer science, 4th semester
- Bachelor MES 2014 (optional subject), computer science / electrical engineering, 4th or 6th semester
- Bachelor Media Informatics 2014 (compulsory), foundations of computer science, 4th semester
- Bachelor Computer Science 2014 (compulsory), foundations of computer science, 4th semester
- Bachelor Medical Informatics 2011 (compulsory), computer science, 2nd semester
- Master CLS 2010 (optional subject), computer science, 2nd semester
- Bachelor CLS 2010 (optional subject), computer science, 6th semester
- Bachelor Computer Science 2012 (compulsory), foundations of computer science, 4th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

- For all subjects mentioned in the course contents under the indents students should name the central ideas, which can define relevant terms and explain the functioning of algorithms by means of application examples.

Grading through:

- written exam

Is requisite for:

- Nonstandard Databases and Data Mining (CS3130-KP08)

- Nonstandard Database Systems (CS3202-KP04, CS3202)

Requires:

- Algorithms and Data Structures (CS1001-KP08, CS1001)
- Introduction to Programming (CS1000-KP08, CS1000SJ14-MML/MI, CS1000SJ14-MIW)
- Introduction to Programming (CS1000-KP10, CS1000SJ14)

Responsible for this module:

- [Prof. Dr. Sven Groppe](#)

Teacher:

- [Institute of Information Systems](#)
- [Prof. Dr. Sven Groppe](#)

Literature:

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

Language:

- offered only in German

Notes:

Admission requirements for taking the module:

- None (the competences of the modules mentioned under "requires" are needed for this module, but are not a formal prerequisite).

Admission requirements for participation in module examination(s):

- Successful completion of exercise sheets as specified at the beginning of the semester.

Module Exam(s):

- CS2700-L1: Databases, written exam, 90min, 100% of the module grade.

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

1 Semester

Turnus of offer:

not available anymore

Credit points:

4

Course of study, specific field and term:

- Bachelor Medical Informatics 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor Media Informatics 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2014 (optional subject), central topics of computer science, 5th or 6th semester
- Bachelor Medical Informatics 2011 (optional subject), Applied computer science, 4th to 6th semester
- Master Computer Science 2012 (optional subject), specialization field media informatics, 2nd or 3rd semester
- Master CLS 2010 (optional subject), computer science, Arbitrary semester
- Bachelor CLS 2010 (optional subject), computer science, 6th semester
- Master Computer Science 2012 (optional subject), advanced curriculum distributed information systems, 2nd or 3rd semester
- Bachelor Computer Science 2012 (optional subject), central topics of computer science, 5th or 6th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Databases (CS2700-KP04, CS2700)

Responsible for this module:

- [Prof. Dr. rer. nat. habil. Ralf Möller](#)

Teacher:

- [Institute of Information Systems](#)



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

Literature:

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

Language:

- offered only in German

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

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4
Course of study, specific field and term:		
<ul style="list-style-type: none"> • Bachelor Biophysics 2024 (optional subject), computer science, 6th semester • Bachelor Robotics and Autonomous Systems 2020 (compulsory), Robotics and Autonomous Systems, 6th semester • Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester • Bachelor MES 2020 (optional subject), computer science / electrical engineering, 3rd semester at the earliest • Bachelor Media Informatics 2020 (optional subject), computer science, 5th or 6th semester • Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester • Bachelor MES 2014 (optional subject), computer science / electrical engineering, 3rd semester at the earliest • Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester • Bachelor Computer Science 2016 (compulsory), Canonical Specialization Web and Data Science, 6th semester • Bachelor Robotics and Autonomous Systems 2016 (compulsory), Robotics and Autonomous Systems, 6th semester • Bachelor IT-Security 2016 (optional subject), computer science, Arbitrary semester • Bachelor Biophysics 2016 (optional subject), computer science, 6th semester • Bachelor Medical Informatics 2014 (optional subject), computer science, 5th or 6th semester • Bachelor Media Informatics 2014 (optional subject), computer science, 5th or 6th semester • Bachelor Computer Science 2014 (optional subject), central topics of computer science, 6th semester • Bachelor Computer Science 2014 (compulsory), specialization field robotics and automation, 6th semester • Bachelor Medical Informatics 2011 (optional subject), Applied computer science, 4th to 6th semester • Bachelor CLS 2010 (optional subject), computer science, 6th semester • Bachelor MES 2011 (optional subject), medical engineering science, 6th semester • Bachelor Computer Science 2012 (compulsory), specialization field robotics and automation, 4th semester • Bachelor Computer Science 2012 (optional subject), central topics of computer science, 5th or 6th semester 		
Classes and lectures:	Workload:	
<ul style="list-style-type: none"> • Artificial Intelligence (lecture, 2 SWS) • Artificial Intelligence (exercise, 2 SWS) 	<ul style="list-style-type: none"> • 55 Hours private studies • 45 Hours in-classroom work • 20 Hours exam preparation 	
Contents of teaching:		
<ul style="list-style-type: none"> • Part 1: Search strategies As 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, adversarial search as well as heuristic search. The concept of agents will be presented. • Part 2: Learning and reasoning Revision 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 intelligence Typical applications in the fields of 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:		
<ul style="list-style-type: none"> • 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:		
<ul style="list-style-type: none"> • portfolio exam 		
Requires:		
<ul style="list-style-type: none"> • Analysis 2 (MA2500-KP04, MA2500) • Algorithms and Data Structures (CS1001-KP08, CS1001) 		

Responsible for this module:

- Prof. Dr. rer. nat. Floris Ernst

Teacher:

- [Institute for Robotics and Cognitive Systems](#)
- 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:

Admission requirements for taking the module

- None (the competences of the modules mentioned under **Requires** are needed for this module, but are not a formal prerequisite).

Admission requirements for participation in module examination(s):

- Successful completion of exercises as specified at the beginning of the semester.

Moduel Exam(s):

- CS3204-L1: Artificial Intelligence, Portfolio examination, 100% of the module grade

Note: The portfolio examination consists of: 70 points in the form of a written examination at the end of the semester, 15 points in the form of semester-accompanying programming tasks (group and individual performance), 15 points in the form of semester-accompanying e-tests (individual performance)

CS3205-KP04, CS3205 - Computer Graphics (CompGrafik)
Duration:

1 Semester

Turnus of offer:

each summer semester

Credit points:

4

Course of study, specific field and term:

- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Bachelor MES 2020 (optional subject), computer science / electrical engineering, 3rd semester at the earliest
- Bachelor Media Informatics 2020 (compulsory), media informatics, 6th semester
- Bachelor Robotics and Autonomous Systems 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester
- Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), computer science, 5th or 6th semester
- Bachelor IT-Security 2016 (optional subject), computer science, Arbitrary semester
- Bachelor Medical Informatics 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor MES 2014 (optional subject), computer science / electrical engineering, 4th or 6th semester
- Bachelor Media Informatics 2014 (compulsory), media informatics, 6th semester
- Bachelor Computer Science 2014 (optional subject), central topics of computer science, 5th or 6th semester
- Bachelor Medical Informatics 2011 (optional subject), computer science, 4th to 6th semester
- Master Computer Science 2012 (optional subject), advanced curriculum imaging systems, 2nd or 3rd semester
- Bachelor CLS 2010 (optional subject), mathematics, 6th semester
- Bachelor Computer Science 2012 (optional subject), central topics of computer science, 5th or 6th semester
- Master CLS 2010 (optional subject), mathematics, 2nd semester
- Bachelor Computer Science 2012 (compulsory), specialization field media informatics, 5th or 6th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Geometric transformations in 2D and 3D
- Homogeneous coordinates
- Transformations between Cartesian coordinate systems
- Planar and perspective projections
- Polygonal models
- Illumination models and shading methods
- Texture Mapping
- Culling and clipping
- Hidden line and surface removal
- Raster graphics algorithms
- Ray tracing
- Shadows, reflections and transparency
- Basics of graphics programming with OpenGL and GLSL

Qualification-goals/Competencies:

- Students know the basic concepts, algorithms and methods in computer graphics
- They are able to implement and apply principle algorithms
- They are able to explain the learned techniques and to assess their possibilities and limitations

Grading through:

- written exam

Requires:

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

Responsible for this module:



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

Teacher:

- Institute of Medical Informatics
- Dr. rer. nat. Jan Ehrhardt

Literature:

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

Language:

- offered only in German

Notes:

Admission requirements for taking the module:

- None (the competences of the modules listed under "requires" are needed for this module, but are not a formal prerequisite)

Admission requirements for participation in module examination(s):

- Successful completion of exercise slips and programming projects as specified at the beginning of the semester

Module exam(s):

- CS3205-L1: Computer Graphics, written exam, 90 min, 100 % of module grade

CS5010 - Wissenschaftliches Rechnen (ScienComp)		
Duration: 1 Semester	Turnus of offer: not available anymore	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master Computer Science 2012 (optional subject), advanced curriculum algorithmics and complexity theory, 2nd or 3rd semester • Bachelor MES 2011 (optional subject), medical engineering science, 3rd, 5th, or 6th semester • Bachelor CLS 2010 (optional subject), computer science, 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Scientific Computing (lecture, 2 SWS) • Scientific Computing (exercise, 1 SWS) 		Workload: <ul style="list-style-type: none"> • 65 Hours private studies and exercises • 45 Hours in-classroom work • 10 Hours exam preparation
Contents of teaching: <ul style="list-style-type: none"> • lineare und nichtlineare Gleichungssysteme, Eigenwertberechnungen • High-Performance Computing (Parallelsierungstechniken) • Modellierungsaspekte 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • Numerische Simulation von naturwissenschaftlichen Vorgängen • Anwendung auf praxisrelevante Fragestellungen 		
Grading through: <ul style="list-style-type: none"> • written exam 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. Rüdiger Reischuk 		
Teacher: <ul style="list-style-type: none"> • Institute for Theoretical Computer Science • Prof. Dr. Rüdiger Reischuk 		
Language: <ul style="list-style-type: none"> • offered only in German 		

LS2700-MML - Cell Biology (Zellbio)		
Duration: 1 Semester	Turnus of offer: each summer semester	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Bachelor CLS 2010 (optional subject), computational life science / life sciences, 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Cell Biology (lecture, 3 SWS) 		Workload: <ul style="list-style-type: none"> • 75 Hours private studies • 45 Hours in-classroom work
Contents of teaching: <ul style="list-style-type: none"> • Special structure of cells • Cell cycle and apoptosis • Introduction into developmental biology 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • Principle of the basic function of the eukaryotic cells • Detailed knowledge in all areas of cell biology covered by the lecture (see 		
Grading through: <ul style="list-style-type: none"> • written exam 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. rer. nat. Enno Hartmann 		
Teacher: <ul style="list-style-type: none"> • Institute of Medical and Marine Biotechnology • Institute for Biology • Prof. Dr. rer. nat. Enno Hartmann • PD Dr. rer. nat. Kai-Uwe Kalies • Prof. Dr. rer. nat. Charli Kruse 		
Literature: <ul style="list-style-type: none"> • Lodish: Molecular Cell Biology • Pollard: Cell Biology • Wolpert: Principles of Development • Alberts: Molecular Biology of the Cell 		
Language: <ul style="list-style-type: none"> • offered only in German 		

MA3990 - Bachelor thesis (BaArbMML)		
Duration: 1 Semester	Turnus of offer: each semester	Credit points: 12
Course of study, specific field and term: <ul style="list-style-type: none"> Bachelor CLS 2010 (compulsory), mathematics, 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> Bachelor Thesis CLS (supervised self studies, 1 SWS) Colloquium (presentation (incl. preparation), 1 SWS) 		Workload: <ul style="list-style-type: none"> 0 Hours
Contents of teaching:		
Grading through: <ul style="list-style-type: none"> Oral examination 		
Responsible for this module: <ul style="list-style-type: none"> Prof. Dr. rer. nat. Jürgen Prestin 		
Teacher: <ul style="list-style-type: none"> Institutes of the Department of Computer Science/ Engineering Alle prüfungsberechtigten Dozentinnen/Dozenten des Studienganges 		
Language: <ul style="list-style-type: none"> thesis can be written in German or English 		

MA4041 - Numerical Linear Algebra (NumLinAlg)		
Duration: 1 Semester	Turnus of offer: Currently not available	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Bachelor CLS 2010 (optional subject), mathematics, 6th semester • Master CLS 2010 (optional subject), mathematics, 2nd or 3rd semester 		
Classes and lectures: <ul style="list-style-type: none"> • Numerical Linear Algebra (lecture, 2 SWS) • Numerical Linear Algebra (exercise, 1 SWS) 		Workload: <ul style="list-style-type: none"> • 65 Hours private studies • 45 Hours in-classroom work • 10 Hours exam preparation
Contents of teaching: <ul style="list-style-type: none"> • Iterative solving of big linear equation systems • Numerics of eigenvalue problems 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • Students know the most important algorithms of scientific computing. • They know how to handle high-dimensional problems. • They are able to handle computer specific problems like Cache and BLAS. • They are able to implement practical problems originating from life sciences. • Interdisciplinary qualifications: • Students can transfer theoretical concepts to practical problems. • Students have experience in implementation. • Students can abstract practical problems. 		
Grading through: <ul style="list-style-type: none"> • Written or oral exam as announced by the examiner 		
Requires: <ul style="list-style-type: none"> • Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500) • Analysis 2 (MA2500-MML) 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. rer. nat. Jan Modersitzki 		
Teacher: <ul style="list-style-type: none"> • Institute of Mathematics and Image Computing • Prof. Dr. rer. nat. Jan Modersitzki • N.N. 		
Literature: <ul style="list-style-type: none"> • A. Meister: Numerik linearer Gleichungssysteme - Vieweg+Teubner, 2011 • G. Strang: Computational Science and Engineering - Wellesley-Cambridge Press, 2007 • P. Van Dooren, S. P. Bhattacharyya, V. Olshevsky, R. H. Chan, A. Routray: Numerical Linear Algebra in Signals, Systems and Control - Springer, 2011 		
Language: <ul style="list-style-type: none"> • German and English skills required 		

MA4200 - Integralgleichungen (Integral)		
Duration: 1 Semester	Turnus of offer: every third semester	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Integralgleichungen (lecture, 2 SWS) • Integralgleichungen (exercise, 1 SWS) 	Workload: <ul style="list-style-type: none"> • 0 Hours 	
Contents of teaching: <ul style="list-style-type: none"> • Volterrasche Integralgleichungen • Fredholmsche Integralgleichungen • Numerische Lösungsverfahren 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • Modellierung praktischer Probleme der Life Sciences durch Integralgleichungen • Verständnis des Zusammenhangs zwischen Integralgleichungen und Differentialgleichungen • Klassifizierung von Integralgleichungen • Praktische Umsetzung theoretischer Algorithmen 		
Grading through: <ul style="list-style-type: none"> • written exam 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. rer. nat. Jürgen Prestin 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Prof. Dr. rer. nat. Jürgen Prestin 		
Language: <ul style="list-style-type: none"> • offered only in German 		

MA4341 - Time series analysis (Zeitreihen)		
Duration: 1 Semester	Turnus of offer: irregularly	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Time series analysis (lecture, 2 SWS) • Time series analysis (exercise, 1 SWS) 	Workload: <ul style="list-style-type: none"> • 65 Hours private studies and exercises • 45 Hours in-classroom work • 10 Hours exam preparation 	
Contents of teaching: <ul style="list-style-type: none"> • Simple descriptive 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Oral examination 		
Requires: <ul style="list-style-type: none"> • Stochastics 2 (MA4020-MML) 		
Responsible for this module: <ul style="list-style-type: none"> • Nachfolge von Prof. Dr. rer. nat. Karsten Keller 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Nachfolge von Prof. Dr. rer. nat. Karsten Keller 		
Literature: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • offered only in German 		
Notes: <p>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.</p>		

MA4612 - Numerik dynamischer Systeme (NumDynSyst)
Duration:

1 Semester

Turnus of offer:

not available anymore

Credit points:

4

Course of study, specific field and term:

- Master CLS 2010 (optional subject), mathematics, Arbitrary semester
- Master MES 2011 (optional subject), mathematics, 1st or 2nd semester
- Bachelor CLS 2010 (optional subject), mathematics, 6th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written exam

Responsible for this module:

- [Prof. Dr. rer. nat. Jan Modersitzki](#)

Teacher:

- [Institute for Mathematics](#)
- [Prof. Dr. rer. nat. Jan Modersitzki](#)

Language:

- offered only in German

MA4650 - Matrix algebra (MatrixAlg)

Duration: 1 Semester	Turnus of offer: every second year	Credit points: 4	Max. group size: 20
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Course of study, specific field and term:

- Master CLS 2010 (optional subject), mathematics, Arbitrary semester
- Master MES 2011 (optional subject), mathematics, 1st semester
- Bachelor CLS 2010 (optional subject), mathematics, 6th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written exam

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Ziegler

Teacher:

- [Institute of Medical Biometry and Statistics](#)
- Prof. Dr. rer. nat. Andreas Ziegler
- [PD Dr. rer. pol. Reinhard Vonthein](#)

Literature:

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

Language:

- offered only in German



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

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

Course of study, specific field and term:

- Master CLS 2023 (compulsory), MML with specialization in Genetic Statistics, 2nd semester
- Bachelor CLS 2023 (optional subject), mathematics, 6th semester
- Bachelor CLS 2016 (optional subject), mathematics, 6th semester
- Master CLS 2016 (compulsory), MML with specialization in Genetic Statistics, 2nd semester
- Bachelor CLS 2010 (optional subject), mathematics, 6th semester
- Master CLS 2010 (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:

- Classical methods of genetic epidemiology: - Familial aggregation and heritability - Model-based linkage analysis - Model-free linkage analysis - Linkage analysis for quantitative phenotypes - Linkage analyses for quantitative phenotypes - Family-based association tests
- Current topics in genetic epidemiology, e.g.: - Association tests for rare variants - Analysis of Omics data - Polygenic scores - Mendelian randomization
- Analysis of genetic data using specialized software packages (such as PLINK and MERLIN): - Genome-wide association studies - Family studies (linkage and association analyses)

Qualification-goals/Competencies:

- Students will be able to name and describe the most important procedures for linkage and association analysis in family studies.
- They know current analysis methods in genetic epidemiology.
- They can perform elementary tests by hand and interpret the results.
- They will be able to use software for more complex testing procedures and interpret the results.

Grading through:

- Written or oral exam as announced by the examiner

Is requisite for:

- Seminar Genetic Epidemiology (MA5129-KP04, MA5129)

Requires:

- Biostatistics 2 (MA2600-KP07)
- Biostatistics 1 (MA1600-KP04, MA1600, MA1600-MML)
- Genetic Epidemiology 1 (MA3200-KP04, MA3200)

Responsible for this module:

- Prof. Dr. rer. nat. Silke Szymczak

Teacher:

- [Institute of Medical Biometry and Statistics](#)
- Prof. Dr. rer. nat. Silke Szymczak
- MitarbeiterInnen des Instituts

Literature:

- Ziegler, Andreas; König Inke R (2010): A Statistical Approach to Genetic Epidemiology. Concepts and Applications - 2nd ed., Wiley-VCH: Weinheim
- Bickeböller, Heike; Fischer, Christine (2007): Einführung in die Genetische Epidemiologie - Springer: New York
- Recent review articles: (to be announced in lecture)



Language:

- offered only in German

Notes:

Admission requirements for taking the module:

- None (The competencies of the modules listed under 'Requires' are needed for this module, but are not a formal prerequisite)

Admission requirements for participation in module examination(s):

- Examination prerequisites can be defined at the beginning of the semester. If preliminary work is defined, it must have been completed and positively evaluated before the first examination.

Module exam(s):

- MA4661-L1: Genetic Epidemiology 2, written exam (90 min) or oral exam (30 min), 100 % of module grade
- MA4661-L2: Practical Course Genetic Epidemiology 2, ungraded practical course, 0 % of module grade, must be passed

(Share of Institute of Medical Biometry and Statistics in V is 100%)

(Share of Institute of Medical Biometry and Statistics in Ü is 100%)

(Share of Institute of Medical Biometry and Statistics in P is 100%)

MA4700 - Angewandte Analysis (AngewAna)
Duration:

1 Semester

Turnus of offer:

each winter semester

Credit points:

4

Course of study, specific field and term:

- Master MES 2011 (optional subject), mathematics, 1st semester
- Master CLS 2010 (optional subject), mathematics, Arbitrary semester
- Bachelor CLS 2010 (optional subject), mathematics, 6th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written exam

Responsible for this module:

- [Prof. Dr. rer. nat. Jürgen Prestin](#)

Teacher:

- [Institute for Mathematics](#)
- [Prof. Dr. rer. nat. Jürgen Prestin](#)

Language:

- offered only in German

MA4800 - Differenzialgeometrie (Diffgeo)		
Duration: 1 Semester	Turnus of offer: every second year	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master MES 2011 (optional subject), mathematics, 1st or 2nd semester • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Differenzialgeometrie (lecture, 2 SWS) • Differenzialgeometrie (exercise, 1 SWS) 	Workload: <ul style="list-style-type: none"> • 60 Hours private studies • 45 Hours in-classroom work • 15 Hours exam preparation 	
Contents of teaching: <ul style="list-style-type: none"> • • • • • • • • • 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • • • • 		
Grading through: <ul style="list-style-type: none"> • Written or oral exam as announced by the examiner 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. Reinhard Schuster 		
Teacher: <ul style="list-style-type: none"> • Institute for Mathematics • Prof. Dr. Reinhard Schuster 		
Language: <ul style="list-style-type: none"> • offered only in German 		

MA4944 - Multivariate Statistics (MultivStat)
Duration:

1 Semester

Turnus of offer:

irregularly

Credit points:

4

Course of study, specific field and term:

- Bachelor CLS 2010 (optional subject), mathematics, 6th semester
- Master CLS 2010 (optional subject), mathematics, 2nd semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written exam

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Ziegler

Teacher:

- [Institute of Medical Biometry and Statistics](#)
- Prof. Dr. rer. nat. Andreas Ziegler
- [PD Dr. rer. pol. Reinhard Vonthein](#)

Literature:

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

Language:

- offered only in German

MA4960 - Linear Models (LinModelle)		
Duration: 1 Semester	Turnus of offer: irregularly	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Master CLS 2010 (optional subject), mathematics, Arbitrary semester • Bachelor CLS 2010 (optional subject), mathematics, 6th semester 		
Classes and lectures: <ul style="list-style-type: none"> • Linear models (lecture, 2 SWS) • Linear models (exercise, 1 SWS) 		Workload: <ul style="list-style-type: none"> • 65 Hours private studies • 45 Hours in-classroom work • 10 Hours exam preparation
Contents of teaching: <ul style="list-style-type: none"> • • • • • • • • 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • 		
Grading through: <ul style="list-style-type: none"> • Written or oral exam as announced by the examiner 		
Requires: <ul style="list-style-type: none"> • Biostatistics 1 (MA1600-KP04, MA1600, MA1600-MML) 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. rer. nat. Andreas Ziegler 		
Teacher: <ul style="list-style-type: none"> • Institute of Medical Biometry and Statistics • Prof. Dr. rer. nat. Andreas Ziegler 		
Literature: <ul style="list-style-type: none"> • : • : 		
Language: <ul style="list-style-type: none"> • offered only in German 		

MA5610 - Selected stochastic processes (StochPrz2)		
Duration: 1 Semester	Turnus of offer: not available anymore	Credit points: 4
Course of study, specific field and term: <ul style="list-style-type: none"> • Bachelor CLS 2010 (optional subject), mathematics, 6th semester • Master CLS 2010 (optional subject), mathematics, 2nd or 4th semester • Master Computer Science 2012 (optional subject), advanced curriculum stochastics, 2nd or 3rd semester 		
Classes and lectures: <ul style="list-style-type: none"> • Selected stochastic processes (lecture, 2 SWS) • Selected stochastic processes (exercise, 1 SWS) 	Workload: <ul style="list-style-type: none"> • 65 Hours private studies • 45 Hours in-classroom work • 10 Hours exam preparation 	
Contents of teaching: <ul style="list-style-type: none"> • branching processes • Poisson process • birth-and-death processes • renewal processes • Brownian and fractional Brownian motion • life science applications 		
Qualification-goals/Competencies: <ul style="list-style-type: none"> • Mastering some important classes of stochastic processes and understanding possible applications 		
Grading through: <ul style="list-style-type: none"> • Oral examination 		
Requires: <ul style="list-style-type: none"> • Stochastics 2 (MA4020-KP04, MA4020) 		
Responsible for this module: <ul style="list-style-type: none"> • Prof. Dr. rer. nat. Andreas Ziegler • Nachfolge von Prof. Dr. rer. nat. Karsten Keller Teacher: <ul style="list-style-type: none"> • Institute of Medical Biometry and Statistics • Institute for Mathematics • Nachfolge von Prof. Dr. rer. nat. Karsten Keller • Prof. Dr. rer. nat. Andreas Ziegler 		
Literature: <ul style="list-style-type: none"> • R. Durrett: Probability: Theory and Examples - 3rd. edition, Thomson, 2005 • S. Karlin und H.M. Taylor: A First Course in Stochastic Processes - 2rd. edition, Academic Press, 1975 		
Language: <ul style="list-style-type: none"> • offered only in German 		

ME2100-KP04, ME2100SJ14 - Introduction into Biomedical Optics (EinfBMO14)
Duration:

1 Semester

Turnus of offer:

each summer semester

Credit points:

4

Course of study, specific field and term:

- Bachelor CLS 2016 (optional subject), life sciences, 6th semester
- Bachelor CLS 2016 (optional subject), computer science, 6th semester
- Bachelor CLS 2010 (optional subject), life sciences, 6th semester
- Bachelor CLS 2010 (optional subject), computer science, 6th semester
- Bachelor Medical Informatics 2019 (optional subject), medical computer science, 4th to 6th semester
- Bachelor Medical Informatics 2014 (optional subject), medical computer science, 5th or 6th semester

Classes and lectures:

- Introduction into Biomedical Optics (lecture, 2 SWS)
- Biomedical Optics/Excercises (practical course, 1 SWS)

Workload:

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

Contents of teaching:

- Absorption and light scattering in biological tissues (Mie, Rayleigh)
- Measurement of optical tissue parameters, Mathematical description of light propagation
- Fundamentals of photophysics
- Spectroscopy, fluorescent markers, and flow cytometry
- Lasers for biomedicine
- Fundamentals of photochemistry and photobiology
- Thermal effects on biomolecules and tissue, photocoagulation
- Pulsed laser tissue ablation
- Nonlinear absorption and plasma-mediated dissection of transparent tissues
- Intraocular photodisruption, laser lithotripsy, refractive surgery, and cell surgery
- Fundamentals of light, fluorescence, and laser scanning microscopy

Qualification-goals/Competencies:

- The students are able to name and describe the fundamental physical phenomena and laws regarding light propagation and absorption in tissue.
- They can explain the interaction of light and tissue and describe it mathematically.
- They attain an overview of diagnostic and therapeutic techniques in the field of biomedical optics and can list, describe and compare them.
- They acquire an overview of optical instruments for biomedical applications and are able to explain their function.
- They are able to assess the capabilities and limits of microscopic imaging.
- They are able to transfer their knowledge to practical applications.
- The students have the professional, social and communication skills to discuss and solve Biomedical Optics exercises in tutorial groups.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- [Prof. Dr. rer. nat. Robert Huber](#)

Teacher:

- [Institute of Biomedical Optics](#)
- Dr. rer. nat. Norbert Linz

Literature:

- H.P. Berlien, G. Müller (eds): Applied Laser Medicine - Springer 2003
- M. Niemz: Laser-Tissue Interactions - 3rd Edition, Springer 2007

Language:

- offered only in German



Notes:

Prerequisites for attending the module:

- None

Prerequisites for the exam:

- Preliminary examinations can be determined at the beginning of the semester. If preliminary work has been defined, it must have been completed and positively assessed before the initial examination.