UNIVERSITÄT ZU LÜBECK

Module Guide for the Study Path

Master CLS starting 2016

Version from 1. April 2019

mathematics

mathematics / computer science

computer science

Interdisciplinary modules

MML with specialization in Life Science

MML with specialization in Image Processing

MML with specialization in Genetic Statistics

CS3100-KP08, CS3100SJ14 - Signal Processing (SignalV14)

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

Course of study, specific field and term:

- Bachelor Medical Informatics since 2019 in planning (optional subject), computer science, 4th to 6th semester
- Bachelor Computer Science 2014 and 2015 (compulsory), specialization field robotics and automation, 5th semester
- Bachelor Computer Science 2014 and 2015 (compulsory), specialization field bioinformatics, 5th semester
- Bachelor Computer Science since 2016 (compulsory), Canonical Specialization Bioinformatics, 5th semester
- Bachelor Computer Science since 2016 (optional subject), major subject informatics, arbitrary semester
- Bachelor Computer Science since 2016 (compulsory), Canonical Specialization Web and Data Science WS16-SS19, 5th semester
- Master CLS starting 2016 (compulsory), mathematics, 1st semester
- Bachelor Robotics and Autonomous Systems (compulsory), Robotics and Autonomous Systems, 5th semester
- Bachelor IT-Security (optional subject), computer science, arbitrary semester
- Bachelor Biophysics (compulsory), computer science, 5th semester
- Bachelor Medical Informatics since 2014 (compulsory), computer science, 5th semester
- Bachelor MES since 2014 (compulsory), computer science, 5th semester
- Bachelor Media Informatics (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2014 and 2015 (optional subject), central topics of computer science, 5th semester

Classes and lectures:

- Signal Processing (lecture, 2 SWS)
- Signal Processing (exercise, 1 SWS)
- Image Processing (lecture, 2 SWS)
- Image Processing (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Linear time-invariant systems
- Impulse response
- Convolution
- Fourier transform
- Transfer function
- Correlation and energy density of deterministic signals
- Sampling
- Discrete-time signals and systems
- Discrete-time Fourier transform
- z-Transform
- FIR and IIR filters
- Block diagrams
- FIR filter design
- Discrete Fourier transform (DFT)
- Fast Fourier transform (FFT)
- Characterization and processing of random signals
- Introduction, interest of visual information
- Fourier transformatio
- 2D Sampling
- Image enhancement
- Edge detection
- Multiresolution concepts: Gaussian and Laplacian Pyramid, wavelets
- Principles of image compression
- Segmentation
- Morphological image processing

Qualification-goals/Competencies:

- Students are able to explain the fundamentals of linear system theory.
- They are able to define and competently explain the essential elements of signal processing mathematically.
- They will have a command of mathematical methods for the description and analysis of continuous-time and discrete-time signals and systems.

- They are able to design digital filters and know various structures for their implementation.
- They are able to explain the basic techniques for describing and processing of random signals.
- They will have basic knowledge of two-dimensional system theory.
- They are able to describe the main techniques for image analysis and image enhancement.
- They are able to apply the learned principles in practice.

Grading through:

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

Requires:

- Analysis 1 (MA2000-KP08, MA2000)

Responsible for this module:

- Prof. Dr.-Ing. Alfred Mertins

Teacher:

- Institute for Signal Processing
- Prof. Dr.-Ing. Alfred Mertins

Literature:

- A. Mertins: Signaltheorie: Grundlagen der Signalbeschreibung, Filterbänke, Wavelets, Zeit-Frequenz-Analyse, Parameter- und Signalschätzung - Springer-Vieweg, 3. Auflage, 2013
- A. K. Jain: Fundamentals of Digital Image Processing - Prentice Hall, 1989
- Rafael C. Gonzalez, Richard E. Woods: Digital Image Processing - Prentice Hall 2003

Language:

- offered only in German

CS4220-KP04, CS4220 - Pattern Recognition (Muster)

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

Course of study, specific field and term:

- Master MES since 2014 (optional subject), Medical Engineering Science, arbitrary semester
- Master Robotics and Autonomous Systems (optional subject), computer science, 1st or 2nd semester
- Master CLS starting 2016 (compulsory), mathematics, 2nd semester
- Master Medical Informatics since 2019 in planing (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester
- Master Medical Informatics (optional subject), medical image processing, 1st or 2nd semester

Classes and lectures:

- Pattern Recognition (lecture, 2 SWS)
- Pattern Recognition (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Introduction to probability theory
- Principles of feature extraction and pattern recognition
- Bayes decision theory
- Discriminance functions
- Neyman-Pearson test
- Receiver Operating Characteristic
- Parametric and nonparametric density estimation
- kNN classifiers
- Linear classifiers
- Support vector machines and kernel trick
- Random Forest
- Neural Nets
- Feature reduction and feature transforms
- Validation of classifiers
- Selected application scenarios: acoustic scene classification for the selection of hearing-aid algorithms, acoustic event recognition, attention classification based on EEG data, speaker and emotion recognition

Qualification-goals/Competencies:

- Students are able to describe the main elements of feature extraction and pattern recognition.
- They are able to explain the basic elements of statistical modeling.
- They are able to use feature extraction, feature reduction and pattern classification techniques in practice.

Grading through:

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

Responsible for this module:

- Prof. Dr.-Ing. Alfred Mertins

Teacher:

- Institute for Signal Processing

- Prof. Dr.-Ing. Alfred Mertins

Literature:

- R. O. Duda, P. E. Hart, D. G. Storck: Pattern Classification - New York: Wiley

Language:

- offered only in German

CS5204-KP05 - Artificial Intelligence 2 (KI2MML)

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

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), mathematics, arbitrary semester

Classes and lectures:

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

Workload:

- 70 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Machine Learning
- Support Vector Machines
- Classification
- Regression
- Prediction

Qualification-goals/Competencies:

- The students are able to choose a method for machine learning for a given application amongst a variety of such methods.
- The chosen method can be customized to the needs of the application. The process of customization goes well beyond straightforward search of parameters and involves adjustments to the basic mathematical techniques.This leads to innovative applications for machine learning, designed and implemented by the students.The starting point are support vector machines.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Achim Schweikard

Teacher:

- Institute for Robotics and Cognitive Systems

- Prof. Dr. rer. nat. Floris Ernst

Literature:

- P. Norvig, S. Russell: Künstliche Intelligenz - München: Pearson 2004

Language:

- offered only in English

CS5275-KP05 - Selected Topics of Signal Analysis and Enhancement (AMSAV5)

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

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), mathematics, 2nd or 4th semester

Classes and lectures:

- Selected Topics of Signal Analysis and Enhancement (lecture, 2 SWS)
- Selected Topics of Signal Analysis and Enhancement (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Introduction to statistical signal analysis
- Autocorrelation and spectral estimation
- Linear estimators
- Linear optimal filters
- Adaptive filters
- Multichannel signal processing, beamforming, and source separation
- Compressed sensing
- Basic concepts of multirate signal processing
- Nonlinear signal processing algorithms
- Application scenarios in auditory technology, enhancement, and restauration of one- and higher-dimensional signals, Sound-field measurement, noise reduction, deconvolution (listening-room compensation), inpainting

Qualification-goals/Competencies:

- Students are able to explain the basic elements of stochastic signal processing and optimum filtering.
- They are able to describe and apply linear estimation theory.
- Students are able to describe the concepts of adaptive signal processing.
- They are able to describe and apply the concepts of multichannel signal processing.
- They are able to describe the concept of compressed sensing.
- They are able to analyze and design multirate systems.
- Students are able to explain various applications of nonlinear and adaptive signal processing.
- They are able to create and implement linear optimum filters and nonlinear signal enhancement techniques on their own.

Grading through:

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

Responsible for this module:

- Prof. Dr.-Ing. Alfred Mertins

Teacher:

- Institute for Signal Processing

- Prof. Dr.-Ing. Alfred Mertins

Literature:

- A. Mertins: Signaltheorie: Grundlagen der Signalbeschreibung, Filterbänke, Wavelets, Zeit-Frequenz-Analyse, Parameter- und Signalschätzung - Springer-Vieweg, 3. Auflage, 2013
- S. Haykin: Adaptive Filter Theory - Prentice Hall, 1995

Language:

- German and English skills required

Notes:

According to the PVO the only exam in this module is a written test. Prerequisites are exercises and an assignment.

MA3445-KP05 - Graph Theory (GraphTKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

- Ability to solve discrete problems using graph theoretical methods
- Knowledge of proof techniques and ideas of discrete mathematics
- Knowledge of fundamental and selected recent research results
- Ability to learn independently by studying relevant literature

Grading through:

- Exercises
- Oral examination

Requires:

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

Responsible for this module:

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

Teacher:

- Institute for Mathematics

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

Literature:

- F. Harary: Graph Theory - Reading, MA:.Addison-Wesley 1969
- R. Diestel: Graphentheorie - Berlin: Springer 2010 (4th edition)
- D. Jungnickel: Graphen, Netzwerke und Algorithmen - Mannheim: BI-Wissenschaftsverlag1994
- J. Bang-Jensen, G. Gutin: Digraphs: Theory, Algorithms and Applications - London: Springer 2001
- B. Bollobas: Modern Graph Theory - Berlin: Springer 1998

Language:

- offered only in German

Notes:

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

MA4100-KP05 - Survival Analysis (UebAnaKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- project work
- Viva Voce or test

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Ziegler

Teacher:

- Institute of Medical Biometry and Statistics

- Prof. Dr. rer. nat. Andreas Ziegler

Literature:

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

Language:

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

Notes:

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

MA4330-KP05 - Biosignal analysis (BioSAKP05)		
Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	each summer semester	5

Course of study, specific field and term:

- Master CLS starting 2016 (compulsory), mathematics, 2nd semester

Classes and lectures:

- Biosignal analysis (lecture, 2 SWS)
- Biosignal analysis (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Hilbert spaces
- Fourier series and Fourier transformation
- generalized functions
- discrete wavelet tranformation
- least square techniques
- application to biological and medical data

Qualification-goals/Competencies:

- Students have deepened knowledges of the mathematical background of signal analysis
- They master different methodsof one-dimensional signal analysis
- They have practical skills in the application of these methods
- They have skills in working with Mathematica or MatLab

Grading through:

- Exercises
- written exam

Requires:

- Analysis 2 (MA2500-KP04, MA2500)

Responsible for this module:

- Prof. Dr. rer. nat. Karsten Keller

Teacher:

- Institute for Mathematics

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

Literature:

- S. Mallat: A wavelet tour of signal processing - Academic Press, 1998
- A. N. Kolmogorov, S.V. Fomin: Reelle Funktionen und Funktionalanalysis - Deutscher Verlag der Wissenschaften 1975

Language:

- offered only in German

MA4341-KP05 - Time series analysis (ZeitAnKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Exercises
- Oral examination
- written exam

Requires:

- Stochastics 2 (MA4020-KP05)

Responsible for this module:

- Prof. Dr. rer. nat. Karsten Keller

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Karsten Keller

Literature:

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

Language:

- offered only in German

Notes:

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

MA4345-KP05 - Functional Analysis (AKFunkKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Exercises
- Oral examination
- written exam

Requires:

- Analysis 2 (MA2500-KP04, MA2500)

Responsible for this module:

- Prof. Dr. rer. nat. Karsten Keller

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Karsten Keller

Literature:

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

Language:

- offered only in German

Notes:

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

MA4400-KP05 - Chaos and Complexity (ChaKomKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

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

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Karsten Keller

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Karsten Keller

Literature:

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

Language:

- depends on the chosen courses

Notes:

lecture notes in English

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

MA4410-KP05 - Approximation Theory (ApproxKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- exercises, project, oral or written exam

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

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

Literature:

- P. L. Butzer, R. J. Nessel: Fourier Analysis and Approximation - Birkhäuser Verlag 1971
- R. A. Devore, G. G. Lorentz: Constructive Approximation - Springer 1993

Language:

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

Notes:

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

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

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Exercises
- project work
- Oral examination

Responsible for this module:

- Prof. Dr. Arne Traulsen

Teacher:

- Institute for Mathematics

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

Literature:

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

Language:

- offered only in English

Notes:

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

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

MA4454-KP05 - Evolutionary Dynamics: Game Theory (EvDyGTKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Exercises
- project work
- Oral examination

Responsible for this module:

- Prof. Dr. Arne Traulsen

Teacher:

- Institute for Mathematics

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

Literature:

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

Language:

- offered only in English

Notes:

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

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

MA4500-KP05 - Mathematical Methods in Image Processing (MMBVKP05)

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

Course of study, specific field and term:

- Master CLS starting 2016 (compulsory), mathematics, 1st or 3rd semester

Classes and lectures:

- Mathematical Methods in Image Processing (lecture, 2 SWS)
- Mathematical Methods in Image Processing (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Image processing
- Digital images
- Operators in the spatial domain
- Operators in the Fourier domain
- Deblurring
- Total variation
- Segmentation
- Level set methods

Qualification-goals/Competencies:

- Students have a solid mathematical understanding of typical image processing methods.
- They can compare and assess typical mathematical image processing methods.
- They can derive typical mathematical methods for image processing.
- They understand fundamental operators in image processing.
- They understand fundamental discretization techniques.
- They understand typical numerical methods for image processing.
- They are able to implement fundamental numerical methods for image processing.
- Interdisciplinary qualifications:
- Students have advanced skills in modeling.
- They can translate theoretical concepts into practical solutions.
- They are experienced in implementation.
- They can think abstractly about practical problems.

Grading through:

- exercises, project, oral or written exam
- Presentation of one´s own solution of an exercise

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Jan Modersitzki

Teacher:

- Institute of Mathematics and Image Computing

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

Literature:

- Gonzales/Woods: Digital Image Processing - Prentice Hall
- Russ: The Image Processing Handbook - CRC Press
- Handels: Medizinische Bildverarbeitung - Vieweg+Teubner

Language:

- German and English skills required

Notes:

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

MA4510-KP05 - Wavelet Theory (WaveThKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- exercises, project, oral or written exam

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Jürgen Prestin

Literature:

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

Language:

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

Notes:

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

MA4610-KP05 - Stochastic processes (StoProKP05)

Duration:	Turnus of offer:	Credit points:
1 Semester	normally each year in the winter semester	5

Course of study, specific field and term:

- Master CLS starting 2016 (compulsory), mathematics, 1st or 3rd semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Conditional expectation
- Stochastic processes
- Filtrations
- Martingales
- Brownian motion

Qualification-goals/Competencies:

- To develop some insight into stochastic processes based on selected classes of processes
- Training of a stochastic way of thinking
- Application of basic ideas and concepts of stochastic analysis

Grading through:

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

Requires:

- Stochastics 2 (MA4020-KP05)
- 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:

- L. C. G. Rogers, D. Williams: Diffusions, Markov Processes, and Martingales, Vol. 1, Foundations - 2nd edition, Cambridge University Press, 2000
- L. C. G. Rogers, D. Williams: Diffusions, Markov Processes, and Martingales, Vol. 2, Ito Calculus - 2nd edition, Cambridge University Press, 2014
- Ioannis Karatzas, Steven E. Shreve: Brownian Motion and Stochastic Calculus - Springer Verlag, 2nd edition, 1991

Language:

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

Notes:

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

MA4611-KP05 - Markov-Prozesse (MarkPrKP05)		
Duration: 1 Semester	**Turnus of offer:** irregularly	**Credit points:** 5

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

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

Responsible for this module:

- Prof. Dr. rer. nat. Karsten Keller

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Karsten Keller

Language:

- offered only in German

Notes:

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

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

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

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

Requires:

- Numerics 2 (MA4040-KP06)
- Numerics 1 (MA3110-KP06)
- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)
- Analysis 2 (MA2500-KP09)
- Analysis 1 (MA2000-KP08, MA2000)

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Rößler

Teacher:

- Institute for Mathematics

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

Language:

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

Notes:

Literature will be announced in the lecture.

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

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

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

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

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Rößler

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Andreas Rößler

Literature:

- P. E. Kloeden, E. Platen: Numerical Solution of Stochastic Differential Equations - Springer-Verlag, Berlin, 1999
- P. E. Kloeden, E. Platen, H. Schurz: Numerical Solution of SDE Through Computer Experiments - Springer-Verlag, Berlin, 2003
- G. N. Milstein, M. V. Tretyakov: Stochastic Numerics for Mathematical Physics - Springer-Verlag, Berlin, 2004

Language:

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

Notes:

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

MA4616-KP05 - Advanced Numerics (HoeNumKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

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

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Rößler

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Andreas Rößler

Language:

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

Notes:

Literature will be announced in the lecture.

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

MA4617-KP05 - Stochastic differential equations (StDiGlKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

- Stochastic differential equations (lecture, 2 SWS)
- Stochastic differential equations (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Stochastic processes, Brownian motion
- Stochastic integration
- Ito formula
- Stochastic differential equations

Qualification-goals/Competencies:

- To impart basic principles of stochastic processes and stochastic differential equations
- To learn methods of proof as well as the application of results from stochastic analysis
- Accomplished handling of essential concepts and results as well as of selected advanced topics

Grading through:

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

Requires:

- Stochastic processes (MA4610-KP05)
- Stochastics 2 (MA4020-KP05)
- 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:

- Bernt Oksendal: Stochastic Differential Equations: An Introduction with Applications - Springer Verlag, 6th edition, 2013
- Ioannis Karatzas, Steven E. Shreve: Brownian Motion and Stochastic Calculus - Springer Verlag, 2nd edition, 1991
- Philip Protter: Stochastic Integration and Differential Equations - Springer Verlag, 2005
- K. L. Chung, R. J. Williams: Introduction to Stochastic Integration - Birkhäuser, 2nd edition, 1990

Language:

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

Notes:

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

MA4618-KP05 - Introduction to stochastic partial differential equations (EinSPDKP05)		
Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	irregularly	5

Course of study, specific field and term:

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

Classes and lectures:

- Introduction to stochastic partial differential equations (lecture, 2 SWS)
- Introduction to stochastic partial differential equations (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Gaussian measures on Hilbert spaces
- Infinite-dimensional Brownian motion
- Martingales on Banach spaces
- Stochastic integration in Hilbert spaces
- Existence of solutions for SPDEs

Qualification-goals/Competencies:

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

Grading through:

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

Requires:

- Stochastic processes (MA4610-KP05)
- Stochastics 2 (MA4020-KP05)
- 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
- MitarbeiterInnen des Instituts

Language:

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

Notes:

Literature will be announced in the lecture.

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

MA4630-KP05 - Fourier Analysis (FouAnaKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- exercises, project, oral or written exam

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Jürgen Prestin

Literature:

- Chandrasekharan, K.: Classical Fourier Transforms - Springer 1989
- Pinsky, M. A.: Introduction to Fourier Analysis and Wavelets - Brooks/Cole 2002

Language:

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

Notes:

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

MA4650-KP05 - Matrix algebra (MatAlgKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- project work
- written exam

Requires:

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

Responsible for this module:

- Dr. Reinhard Vonthein

Teacher:

- Institute of Medical Biometry and Statistics

- Dr. Reinhard Vonthein
- MitarbeiterInnen des Instituts

Literature:

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

Language:

- offered only in German

Notes:

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

MA4660-KP05 - Prognostic models (ProMoKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- project work
- Viva Voce or test

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Ziegler

Teacher:

- Institute of Medical Biometry and Statistics

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

Literature:

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

Language:

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

Notes:

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

MA4665-KP05 - Statistical Learning (StaLerKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Viva Voce or test

Requires:

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

Responsible for this module:

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

Teacher:

- Institute of Medical Biometry and Statistics

- Damian Gola, M.Sc.

Literature:

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

Language:

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

Notes:

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

MA4670-KP05 - Combinatorics (KombiKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

- Learning the basics of combinatorics
- Knowledge of different proof techniques and combinatorial approaches
- Teaching fundamental results and deepening some selected aspects of combinatorics
- Ability to learn independently by studying relevant literature

Grading through:

- Exercises
- Oral examination

Requires:

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

Responsible for this module:

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

Teacher:

- Institute for Mathematics

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

Literature:

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

Language:

- offered only in German

Notes:

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

MA4675-KP05 - Algebra (AlgebrKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

- Learning the basics of algebra
- Knowledge of different proof techniques and algebraic approaches
- Teaching fundamental results and deepening some selected aspects of algebra
- Ability to learn independently by studying relevant literature

Grading through:

- Exercises
- Oral examination

Requires:

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

Responsible for this module:

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

Teacher:

- Institute for Mathematics

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

Literature:

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

Language:

- offered only in German

Notes:

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

MA4735-KP05 - Geometry (GeoKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

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

Requires:

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

Responsible for this module:

- PD Dr. rer. nat. Christian Bey

Teacher:

- Institute for Mathematics

- PD Dr. rer. nat. Christian Bey

Literature:

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

Language:

- offered only in German

Notes:

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

MA4740-KP05 - Fractal Geometry (FraGeoKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Exercises
- Oral examination

Responsible for this module:

- Dr. Sabrina Kombrink

Teacher:

- Institute for Mathematics

- Dr. Sabrina Kombrink

Literature:

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

Language:

- offered only in German

Notes:

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

MA4750-KP05 - Topology (TopoKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

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

Requires:

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

Responsible for this module:

- PD Dr. rer. nat. Christian Bey

Teacher:

- Institute for Mathematics

- PD Dr. rer. nat. Christian Bey

Language:

- offered only in German

Notes:

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

MA4760-KP05 - Integral Theorems in Analysis (IntAnaKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

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

Requires:

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

Responsible for this module:

- PD Dr. rer. nat. Christian Bey

Teacher:

- Institute for Mathematics

- PD Dr. rer. nat. Christian Bey

Language:

- offered only in German

Notes:

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

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

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- exercises, project, oral or written exam

Responsible for this module:

- Prof. Dr. Reinhard Schuster

Teacher:

- Institute for Mathematics

- Prof. Dr. Reinhard Schuster

Literature:

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

Language:

- offered only in German

Notes:

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

MA4802-KP05 - Theory of Relativity (RelaThKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- exercises, project, oral or written exam

Responsible for this module:

- Prof. Dr. Reinhard Schuster

Teacher:

- Institute for Mathematics

- Prof. Dr. Reinhard Schuster

Literature:

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

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

Language:

- offered only in German

Notes:

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

MA4803-KP05 - Number Theory (ZahlThKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- exercises, project, oral or written exam

Responsible for this module:

- Prof. Dr. Reinhard Schuster

Teacher:

- Institute for Mathematics

- Prof. Dr. Reinhard Schuster

Literature:

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

- Winogradow: Elemente der Zahlentheorie - Prestel-Verlag 1956

Language:

- offered only in German

Notes:

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

MA4804-KP05 - Special Functions (SpFunkKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- exercises, project, oral or written exam

Responsible for this module:

- Prof. Dr. Reinhard Schuster

Teacher:

- Institute for Mathematics

- Prof. Dr. Reinhard Schuster

Literature:

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

- Fichtenholz, G.M.: Differential- und Integralrechnung, Band 1-3 - H. Deutsch 1997
- Hurwitz, A., Courant, R.: Vorlesungen über Allgemeine Funktionentheorie und Elliptische Funktionen - Springer 2000
- Stegun, I. A., Abramowitz, M.: Handbook of Mathematical Functions - Dover Press
- Strampp, W., Ganzha, V., Vorozhtsov, E.: Höhere Mathematik mit Mathematica, Bd.4, Funktionentheorie, Fouriertransformationen und Laplacetransformationen: Funktionentheorie, Fourier- und Laplacetransformation - Vieweg 1997
- Wawrzynczyk, A.: Group Representations and Special Functions - Reidel Publishing Company 1983
- Whittaker, E. T., Watson, G. N.: A Cource of Modern Analysis - Cambridge University Press 1902 ... 1999

Language:

- offered only in German

Notes:

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

MA4940-KP05 - Test and estimation theory (TSchThKP05)

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

Course of study, specific field and term:

- Master CLS starting 2016 (compulsory), mathematics, 2nd semester

Classes and lectures:

- Test and estimation theory (lecture, 2 SWS)
- Test and estimation theory (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Parametric theory and nonparametric hints about point and interval estimation, and statistical tests
- Properties of estimators: consistency, unbiasedness, sufficiency, efficiency
- Construction of estimators: score function, maximum likelihood, bias correction, theorems of Rao-Crámer, Rao-Blackwell, and Lehmann-Schefé, multi-parametric exponential family
- Properties of confidence intervals: exact, coverage probability, pivot statistics
- Construction of Wald, score, and ML confidence intervalls; delta method
- Properties of statistical tests: power function, unbiasedness, best tests, Lemma of Neyman and Pearson, consistency and asymptotic relative efficiency
- Construction of likelihood ratio, Wald, score, MLR, and conditional tests

Qualification-goals/Competencies:

- Students know the definitions of central theoretical concepts in the theory of estimation and testing.
- They have understood properties and construction principles.
- They apply construction principles to problems with one or more parameters.
- They prove properties of estimators and tests.
- They assess tests and estimators by their properties.
- They construe statistical tests and confidence intervals for problems with distributions they did now know before.

Grading through:

- project work
- written exam

Requires:

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

Responsible for this module:

- Dr. Reinhard Vonthein

Teacher:

- Institute of Medical Biometry and Statistics

- Dr. Reinhard Vonthein

Literature:

- Lehmann, E.L., Romano, Joseph P.: Testing Statistical Hypotheses - ISBN-13 9780387988641
- Lehmann, E.L., Casella, George: Theory of Point Estimation - ISBN-13 9780387985022
- Held, L.: Methoden der statistischen Inferenz - Spektrum 2008 - ISBN 978-3-8274-1939-2
- Rüger, B.: Test- und Schätztheorie: Band I: Grundlagen - Oldenbourg 1999 - ISBN 3 486-23650-4
- Rüger, B.: Test- und Schätztheorie: Band II: Statistische Tests - Oldenbourg 2002 - ISBN 3 486-25130-9

Language:

- offered only in German

Notes:

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

MA4944-KP05 - Multivariate Statistics (MulStaKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- project work
- written exam

Requires:

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

Responsible for this module:

- Dr. Reinhard Vonthein

Teacher:

- Institute of Medical Biometry and Statistics

- Dr. Reinhard Vonthein
- MitarbeiterInnen des Instituts

Literature:

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

Language:

- offered only in German

Notes:

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

MA4947-KP05 - Nonparametric statistics (NpStatKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- project work
- Viva Voce or test

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Ziegler

Teacher:

- Institute of Medical Biometry and Statistics

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

Literature:

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

Language:

- offered only in German

Notes:

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

MA4955-KP05 - Applied Multiple Regression (AMuRegKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written examination
- continuous, successful participation in course

Requires:

- Biostatistics 2 (MA2600-KP07)

Responsible for this module:

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

Teacher:

- Institute of Medical Biometry and Statistics

- Dr. Sandeep Grover

Literature:

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

Language:

- offered only in English

MA4962-KP05 - Generalized Linear Models (VLModKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Viva Voce or test
- project work

Requires:

- Biostatistics 2 (MA2600-KP07)

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Ziegler

Teacher:

- Institute of Medical Biometry and Statistics

- Prof. Dr. rer. nat. Andreas Ziegler

Literature:

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

Language:

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

Notes:

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

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

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- project work
- Viva Voce or test

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Ziegler

Teacher:

- Institute of Medical Biometry and Statistics

- Prof. Dr. rer. nat. Andreas Ziegler

Literature:

- Kursbuch: Montgomery, Douglas C. 2012: Design and Analysis of Experiments. 8th ed. International Student Version - John Wiley & Sons, New York. ISBN 978-1-118-09793-9
- Supplementary literature: Mason, Robert L., Gunst, Richard F., Hess, James L. 2003: Statistical Design and Analysis of Experiments. 2nd ed. - John Wiley & Sons, New York. ISBN 0-471-37216-1

Language:

- offered only in German

Notes:

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

MA5008-KP05 - Mathematical course (PrakMaKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

- Mathematical course (practical course, 5 SWS)

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Written report

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institutes of the Department of Computer Science/ Engineering

Language:

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

MA5030-KP05 - Image Registration (BildreKP05)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

- Students know the fundamental concepts of image registration.
- They are able to translate concrete problems into adequate models.
- They have experience with parametric registration and can determine optimal parameters.
- They understand nonparametric image registration.
- Interdisciplinary qualifications:
- Students have advanced skills in modeling.
- They can translate theoretical concepts into practical solutions.
- They are experienced in implementation.
- They can think abstractly about practical problems.

Grading through:

- exercises, project, oral or written exam
- Presentation of one´s own solution of an exercise

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Jan Modersitzki

Teacher:

- Institute of Mathematics and Image Computing

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

Literature:

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

Language:

- German and English skills required

Notes:

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

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

- The students are familiar with fundamental numerical concepts in image computing.
- They have experience in realizing practical solutions.
- They can implement numerical algorithms on a computer.
- They understand selected methods for solving large linear systems.
- They can implement selected methods for solving large linear systems.
- Interdisciplinary qualifications:
- Students have advanced skills in modeling.
- They can translate theoretical concepts into practical solutions.
- They are experienced in implementation.
- They can think abstractly about practical problems.

Grading through:

- exercises, project, oral or written exam
- Presentation of one´s own solution of an exercise

Responsible for this module:

- Prof. Dr. rer. nat. Jan Modersitzki

Teacher:

- Institute of Mathematics and Image Computing

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

Literature:

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

Language:

- German and English skills required

Notes:

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

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

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- exercises, project, oral or written exam
- Presentation of one´s own solution of an exercise

Responsible for this module:

- Prof. Dr. rer. nat. Jan Modersitzki

Teacher:

- Institute of Mathematics and Image Computing

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

Literature:

- Chan & Shen: Image Processing and Analysis - SIAM
- Modersitzki: Flexible Algorithms for Image Registration - SIAM
- Vogel: Computational Methods for Inverse Methods - SIAM
- Aubert, Kornprobst: Mathematical Problems in Image Processing: Partial Differential Equations and the Calculus of Variations - Springer
- Scherzer, Grasmair, Grossauer, Haltmeier, Lenzen: Variational Methods in Imaging - Springer

Language:

- German and English skills required

Notes:

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

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

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

- The students understand the strengths of non-smooth models.
- They can devise and analyse models for simple problems.
- They understand the advantages, disadvantages, and application areas of each optimization method.
- They know how to select and specialize a suitable optimization method for a given model.
- Interdisciplinary qualifications:
- Students have advanced skills in modeling.
- They can translate theoretical concepts into practical solutions.
- They are experienced in implementation.
- They can think abstractly about practical problems.

Grading through:

- exercises, project, oral or written exam
- Presentation of one´s own solution of an exercise

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Jan Lellmann

Teacher:

- Institute of Mathematics and Image Computing

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

Literature:

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

Language:

- German and English skills required

Notes:

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

MA5036-KP05 - Multi- and High-Dimensional Data Processing (MeHoDVKP05)		
Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	irregularly	5

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

- The students understand the difficulties when moving from scalar to higher-dimensional data.
- They are confident in selecting and implementing a suitable model for a given problem from a set of known models.
- They understand the special issues when solving manifold-constrained problems.
- They are familiar with selected methods for manifold-constrained optimizationand are confident in their implementation.
- They are familiar with selected methods for linear and non-linear dimensionality reduction.
- Interdisciplinary qualifications:
- Students have advanced skills in modeling.
- They can translate theoretical concepts into practical solutions.
- They are experienced in implementation.
- They can think abstractly about practical problems.

Grading through:

- exercises, project, oral or written exam
- Presentation of one´s own solution of an exercise

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Jan Lellmann

Teacher:

- Institute of Mathematics and Image Computing

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

Literature:

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

Language:

- German and English skills required

Notes:

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

MA5008-KP04 - Mathematical course (PrakMaKP04)		
Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	on request	4 (Typ B)

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), mathematics / computer science, 2nd or 3rd semester

Classes and lectures:

- Mathematical course (practical course, 4 SWS)

Workload:

- 100 Hours in-classroom work
- 20 Hours written report

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Written report

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institutes of the Department of Computer Science/ Engineering

Language:

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

CS3000-KP04, CS3000 - Algorithm Design (AlgoDesign)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- exercises and project assignments
- written exam

Requires:

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

Responsible for this module:

- Prof. Dr. Rüdiger Reischuk

Teacher:

- Institute for Theoretical Computer Science

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

Literature:

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

Language:

- offered only in German

CS3420-KP04, CS3420 - Cryptology (Krypto14)

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

Course of study, specific field and term:

- Bachelor Medical Informatics since 2019 in planning (optional subject), computer science, 4th to 6th semester
- Bachelor Computer Science 2014 and 2015 (compulsory), specialization field IT security and safety, 5th semester
- Bachelor Computer Science since 2016 (optional subject), major subject informatics, arbitrary semester
- Master CLS starting 2016 (optional subject), computer science, 3rd semester
- Bachelor Robotics and Autonomous Systems (optional subject), computer science, 5th or 6th semester
- Bachelor IT-Security (compulsory), IT-Security, 3rd or 5th semester
- Bachelor Medical Informatics since 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2014 and 2015 (optional subject), central topics of computer science, 5th or 6th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- history of cryptography, classical systems
- mathematical and algorithmic basics
- design principles for cryptographic applications
- symmetric crypto systems
- public key crypto systems, digital signatures
- efficient implementation of crypto systems
- methods in cryptoanalysis
- cryptographic protocols

Qualification-goals/Competencies:

- being to able to model and analyze IT security
- knowledge of cryptographic primitives and protocols
- being able to recognize cryptographic weakness
- good knowledge of standard techniques in cryptology
- understanding historical and social significance of encrypting information

Grading through:

- exercises and project assignments
- Viva Voce or test

Responsible for this module:

- Prof. Dr. Rüdiger Reischuk

Teacher:

- Institute for Theoretical Computer Science

- Prof. Dr. Rüdiger Reischuk
- Prof. Dr. Maciej Liskiewicz

Literature:

- A. Menezes, P. Oorschot, S. Vanstone: Handbook of Applied Cryptography - CRC Press 1997
- A. Beutelspacher, H. Neumann, T. Schwarzpaul: Kryptopgrafie in Theorie und Praxis - Vieweg 2005
- W. Trappe, L. Washington: Introduction to Cryptography with Coding Theory - Pearson 2006
- J. Katz, Y. Lindell: Introduction to Modern Cryptography - Chapman & Hall, 2008
- F. Bauer: Entzifferte Geheimnisse - Springer 1997
- B. Schneier: Applied Cryptography - J. Wiley 1996

Language:

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

CS4250-KP04, CS4250 - Computer Vision (CompVision)

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

Course of study, specific field and term:

- Master Biomedical Engineering (optional subject), advanced curriculum, 2nd semester
- Master CLS starting 2016 (optional subject), computer science, 2nd or 3rd semester
- Master MES since 2014 (optional subject), computer science and electrical engineering, 1st or 2nd semester
- Master Media Informatics (optional subject), computer science, arbitrary semester
- Master Computer Science before 2014 (optional subject), advanced curriculum imaging systems, 2nd or 3rd semester
- Master CLS (compulsory), computational life science / imaging, 2nd semester
- Master MES before 2014 (advanced curriculum), imaging systems, signal and image processing, 2nd semester
- Master Computer Science before 2014 (optional subject), advanced curriculum signal and image processing, 2nd or 3rd semester
- Master Computer Science before 2014 (compulsory), specialization field robotics and automation, 2nd semester
- Master Computer Science before 2014 (compulsory), specialization field bioinformatics, 2nd semester
- Master Computer Science before 2014 (optional subject), advanced curriculum intelligent embedded systems, 2nd semester
- Master Biophysics (optional subject), Elective, 2nd semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Introduction to human and computer vision
- Sensors, cameras, optics and projections
- Image features: edges, intrinsic dimension, Hough transform, Fourier descriptors, snakes
- Range imaging and 3-D cameras
- Motion and optical flow
- Object recognition
- Example applications

Qualification-goals/Competencies:

- Students can understand the basics of computer vision.
- They can explain and perform camera choice and calibration.
- They can explain and apply the basic methods for feature extraction, motion estimation, and object recognition.
- They can indicate appropriate methods for different kinds of computer-vision applications.

Grading through:

- Exercises
- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Erhardt Barth

Teacher:

- Institute for Neuro- and Bioinformatics

- Prof. Dr.-Ing. Erhardt Barth

Literature:

- Richard Szeliski: Computer Vision: Algorithms and Applications - Springer, Boston, 2011
- David Forsyth and Jean Ponce: Computer Vision: A Modern Approach - Prentice Hall, 2003

Language:

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

Notes:

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

Prerequisites for admission to the examination:
Successful participation in the exercises,
minimum pass percentage: 70 %

CS4405-KP04, CS4405 - Neuroinformatics (NeuroInf)

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

Course of study, specific field and term:

- Master CLS starting 2016 (compulsory), computer science, 2nd semester
- Master Robotics and Autonomous Systems (optional subject), computer science, 1st or 2nd semester
- Master MES since 2014 (optional subject), computer science and electrical engineering, arbitrary semester
- Master MES before 2014 (optional subject), mathematics, 2nd semester
- Bachelor MES before 2014 (optional subject), optional subject medical engineering science, 6th semester
- Master Computer Science before 2014 (optional subject), advanced curriculum organic computing, 2nd or 3rd semester
- Master MES before 2014 (advanced curriculum), imaging systems, signal and image processing, 2nd semester
- Master Computer Science before 2014 (optional subject), advanced curriculum intelligent embedded systems, 2nd or 3rd semester
- Master Computer Science before 2014 (compulsory), specialization field robotics and automation, 2nd semester
- Master Computer Science before 2014 (compulsory), specialization field bioinformatics, 2nd semester
- Master CLS (compulsory), computer science, 2nd semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- The human brain and abstract neuron models
- Learning with a single neuron:* Perceptrons* Max-Margin Classification* LDA and logistic Regression
- Network architectures:* Hopfield-Networks* Multilayer-Perceptrons* Deep Learning
- Unxupervised Learning:* k-means, Neural Gas and SOMs* PCA & ICA* Sparse Coding

Qualification-goals/Competencies:

- The students are able to understand the principle function of a single neuron and the brain as a whole.
- They know abstract neuronal models and they are able to name practical applications for the different variants.
- They are able to derive a learning rule from a given error function.
- They are able to apply (and implement) the proposed learning rules and approaches to solve unknown practical problems.

Grading through:

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

Responsible for this module:

- Prof. Dr. rer. nat. Thomas Martinetz

Teacher:

- Institute for Neuro- and Bioinformatics

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

Literature:

- S. Haykin: Neural Networks - London: Prentice Hall, 1999
- J. Hertz, A. Krogh, R. Palmer: Introduction to the Theory of Neural Computation - Addison Wesley, 1991
- T. Kohonen: Self-Organizing Maps - Berlin: Springer, 1995
- H. Ritter, T. Martinetz, K. Schulten: Neuronale Netze: Eine Einführung in die Neuroinformatik selbstorganisierender Netzwerke - Bonn: Addison Wesley, 1991

Language:

- offered only in German

CS4440-KP04, CS4440 - Molecular Bioinformatics (MolBioInfo)

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

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), computer science, 3rd semester
- Master MES before 2014 (advanced curriculum), biophysics and biomedical optics, 2nd semester
- Master CLS (optional subject), computer science, 1st or 3rd semester
- Master Computer Science before 2014 (compulsory), specialization field bioinformatics, 1st semester

Classes and lectures:

- Molecular Bioinformatics (lecture, 2 SWS)
- Molecular Bioinformatics (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Methods for fast genome comparison
- Analysis of data describing gene expression profiles and sequence variation
- Advanced usage of biological databases (for sequences, motifs, structures, gene regulation and interactions)

Qualification-goals/Competencies:

- The students can apply indexing based software to Next Generation sequence data.
- They can use and design databases for molecularbiological research.
- They are able to detect statistically significant changes in Microarray data.

Grading through:

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

Requires:

- Introduction to Bioinformatics (CS1400-KP04, CS1400)

Responsible for this module:

- Prof. Dr. rer. nat. Thomas Martinetz

Teacher:

- Institute for Neuro- and Bioinformatics

- Prof. Dr. Bernhard Haubold
- Prof. Dr. rer. nat. Thomas Martinetz
- MitarbeiterInnen des Instituts

Literature:

- M. S. Waterman: Introduction to Computational Biology - London: Chapman and Hall 1995
- B. Haubold, T. Wiehe: Introduction to Computational Biology - Birkhäuser 2007
- R. Durbin, S. Eddy, A. Krogh, G. Mitchison: Biological sequence analysis. Probabilistic models - Cambridge, MA: Cambridge University Press
- J. Setubal, J. Meidanis: Introduction to computational molecular - Pacific Grove: PWS Publishing Company
- D. M. Mount: Bioinformatics - Sequence and Genome - New York: Cold Spring Harbor Press

Language:

- offered only in German

CS5204-KP04, CS5204 - Artificial Intelligence 2 (KI2)

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

Course of study, specific field and term:

- Master MES since 2014 (optional subject), computer science and electrical engineering, arbitrary semester
- Master Biomedical Engineering (optional subject), Interdisciplinary modules, 2nd semester
- Master CLS starting 2016 (optional subject), computer science, 3rd semester
- Master Computer Science before 2014 (optional subject), advanced curriculum intelligent embedded systems, 2nd or 3rd semester
- Master Computer Science before 2014 (optional subject), specialization field robotics and automation, 3rd semester
- Master Biophysics (optional subject), Elective, 1st semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Support Vector Machines and Dualization
- Classification
- Regression
- Time-Series Prediction
- Lagrange Multipliers
- Sequential Minimal Optimization
- Geometric Reasoning

Qualification-goals/Competencies:

- The students are able to choose a method for machine learning for a given application amongst a variety of such methods.
- The chosen method can be customized to the needs of the application. The process of customization goes well beyond straightforward search of parameters and involves adjustments to the basic mathematical techniques.This leads to innovative applications for machine learning, designed and implemented by the students.The starting point are support vector machines.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Achim Schweikard

Teacher:

- Institute for Robotics and Cognitive Systems

- Prof. Dr.-Ing. Achim Schweikard

Literature:

- P. Norvig, S. Russell: Künstliche Intelligenz - München: Pearson 2004

Language:

- offered only in English

CS5450-KP04, CS5450 - Machine Learning (MaschLern)

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

Course of study, specific field and term:

- Master Auditory Technology (optional subject), computer science, 1st semester
- Master CLS starting 2016 (optional subject), computer science, 3rd semester
- Master MES since 2014 (optional subject), computer science and electrical engineering, arbitrary semester
- Master MES before 2014 (optional subject), mathematics, 1st or 2nd semester
- Master MES before 2014 (advanced curriculum), imaging systems, signal and image processing, 1st or 2nd semester
- Master Medical Informatics (optional subject), computer science, 1st or 2nd semester
- Master CLS (optional suject), computer science, arbitrary semester
- Master Computer Science before 2014 (optional subject), specialization field robotics and automation, 3rd semester
- Master Computer Science before 2014 (optional subject), specialization field bioinformatics, 3rd semester
- Master Medical Informatics since 2019 in planing (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Representation learning, including manifold learning
- Statistical learning theory
- VC dimension and support vector machines
- Boosting
- Deep learning
- Limits of induction and importance of data ponderation

Qualification-goals/Competencies:

- Students can understand and explain various machine-learning problems.
- They can explain and apply different machine learning methods and algorithms.
- They can chose and then evaluate an appropriate method for a particular learning problem.
- They can understand and explain the limits of automatic data analysis.

Grading through:

- Exercises
- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Erhardt Barth

Teacher:

- Institute for Neuro- and Bioinformatics

- Prof. Dr.-Ing. Erhardt Barth
- Prof. Dr. rer. nat. Thomas Martinetz

Literature:

- Chris Bishop: Pattern Recognition and Machine Learning - Springer ISBN 0-387-31073-8
- Vladimir Vapnik: Statistical Learning Theory - Wiley-Interscience, ISBN 0471030031

Language:

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

Notes:

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

ME2451-KP04, ME2451 - Control Systems (RegTech)

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

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), computer science, 2nd or 4th semester
- Master MES since 2014 (optional subject), computer science and electrical engineering, 2nd or 4th semester
- Master MES before 2014 (optional subject), advanced curriculum, 2nd or 4th semester

Classes and lectures:

- Control Systems (lecture with exercises, 3 SWS)

Workload:

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

Contents of teaching:

- Modeling of dynamic systems
- Dynamic behavior of systems
- Feedback concepts
- Controller design in time domain
- System representation in frequency domain
- Stability
- Controller design in frequency domain

Qualification-goals/Competencies:

- Students can model physical systems mathematically as well as describe and analyze their dynamic behavior.
- Students know the fundamental tools and can formulate requirements with respect to systems in the time and frequency domain. Students are able to design control loops using time and frequency domain-based tools.
- Students are able to analyze stability of feedback systems and can evaluate the resulting dynamic properties with respect to control performance and robustness.

Grading through:

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

Responsible for this module:

- Prof. Dr. Philipp Rostalski

Teacher:

- Institute for Electrical Engineering in Medicine

- Prof. Dr. Philipp Rostalski

Literature:

- G.F. Franklin, J.D. Powell, A. Emami-Naeini: Feedback Control of Dynamic Systems - Pearson Verlag - 2014
- J. Lunze: Regelungstechnik 1 - Springer Verlag 2012
- J. Lunze: Regelungstechnik 2 - Springer Verlag 2012

Language:

- German and English skills required

RO5501-KP04 - Graphical Models in Systems and Control (GMSC)

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

Course of study, specific field and term:

- Master Robotics and Autonomous Systems (module part), computer science, 2nd or 4th semester
- Master MES since 2014 (optional subject), computer science and electrical engineering, 1st or 2nd semester
- Master CLS starting 2016 (optional subject), computer science, 3rd semester

Classes and lectures:

- Lecture Graphical Models in Systems and Control (lecture, 2 SWS)
- Exercise Graphical Models in Systems and Control (Excercises with project, 1 SWS)

Workload:

- 60 Hours in-classroom work
- 30 Hours in-classroom exercises
- 30 Hours private studies and exercises

Contents of teaching:

- Introduction to Probability Theory, Discretely and Continuously Distributed Random Variables
- Fundamentals on Probabilistic Graphical Models
- Forney-Style Factor Graphs as a Probabilistic Graphical Model
- Message Passing via Sum- and Max-Produkt Algorithms
- Gaussian Message Passing
- State Estimation (Kalman Filtering and Smoothing including Nonlinear Extensions)
- Parameter Estimation via Expectation Maximization
- Expectation Propagation
- Control on Factor Graphs

Qualification-goals/Competencies:

- Students develop and extend their fundamental knowledge on probability theory and the transformation of discretely as well as continuously distributed random variables.
- Students can understand simple linear algorithms, such as the Kalman filter, with the help of graphical probabilistic models.
- Students can combine elements of probabilistic algorithms to novel ones with the help of graphical probabilistic models.
- Students can understand, extend and apply advanced algorithms in signal processing, parameter and state estimation as well as control to relevant problems with the help of graphical probabilistic models.

Grading through:

- exercises and project assignments
- written exam, oral exam and/or presentation as announced by the examiner

Responsible for this module:

- Prof. Dr. Philipp Rostalski

Teacher:

- Institute for Electrical Engineering in Medicine

- Dr.-Ing. Christian Herzog, geb. Hoffmann
- Prof. Dr. Philipp Rostalski

Literature:

- Loeliger, Hans-Andrea; Dauwels, Justin; Hu, Junli; Korl, Sascha; Ping, Li; Kschischang, Frank R.: The Factor Graph Approach to Model-Based Signal Processing - Proc. IEEE, Vol. 95, No. 6, 2007
- Loeliger, Hans-Andrea: An Introduction to factor graphs - IEEE Signal Process. Mag., Vol. 21, No. 1, 2004
- Hoffmann, Christian; Rostalski, Philipp: Current Publications from Research at the IME
- Miscellaneous: Current Publications from Research

Language:

- offered only in English

MA5009-KP04, MA5009 - Master's Seminar mathematics (MSMathe)		
Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	each semester	4

Course of study, specific field and term:

- Minor in Teaching Mathematics, Master of Education (compulsory), mathematics, 3rd semester
- Master CLS starting 2016 (optional subject), Interdisciplinary modules, 3rd semester
- Master CLS (optional subject), mathematics, 3rd semester

Classes and lectures:

- Advanced Master's Seminar mathematics (seminar, 2 SWS)

Workload:

- 30 Hours oral presentation (including preparation)
- 30 Hours in-classroom work
- 30 Hours private studies
- 30 Hours written report

Contents of teaching:

- The students study a scientific topic of their specialization.
- They present the topic in written form.

Qualification-goals/Competencies:

- The students have gained experience of familiarizing themselves with the details of a given scientific topic.
- They are able to present the result of their studies in comprehensible written form.
- They are able to supply a coherent overview of a complex scientific area in a comprehensive oral presentation.
- They have gained experience of holding scientific discussions.
- They understand scientific presentations and know how to critically examine them in open discussions.

Grading through:

- oral presentation
- term paper

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

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

- Prof. Dr. rer. nat. Jürgen Prestin
- Prof. Dr. rer. nat. Jan Modersitzki
- Prof. Dr. rer. nat. Andreas Rößler
- Prof. Dr. rer. nat. Karsten Keller
- Prof. Dr. rer. nat. Jan Lellmann
- Prof. Dr. rer. biol. hum. Inke König
- Prof. Dr. rer. nat. Andreas Ziegler

Language:

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

MA5990-KP30, MA5990 - Master's thesis in Computational Life Science (MaArbMML)		
Duration: 1 Semester	**Turnus of offer:** each semester	**Credit points:** 30

Course of study, specific field and term:

- Master CLS starting 2016 (compulsory), Interdisciplinary modules, 4th semester
- Master CLS (compulsory), mathematics, 4th semester

Classes and lectures:

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

Workload:

- 870 Hours private studies
- 30 Hours oral presentation (including preparation)

Contents of teaching:

- Individual studies under supervision

Qualification-goals/Competencies:

- Ability to solve a complex scientific problem with state-of-the-art methods
- Experience in writing a scientific thesis within a given time period
- Becoming an expert in a special subfield of mathematics
- Experience in working with scientific literature
- Presentation skills

Grading through:

- oral presentation
- Written report

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institutes of the Department of Computer Science/ Engineering

- Alle prüfungsberechtigten Dozentinnen/Dozenten des Studienganges

Language:

- thesis can be written in German or English

Notes:

The basic prerequisite for starting the Master's thesis is the successful completion of 75 credits.

PS5810-KP04, PS5810 - Scientific Teaching and Tutoring (WLehrKP04)		
Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	each semester	4 (Typ B)

Course of study, specific field and term:

- Master Interdisciplinary Courses (optional subject), Interdisciplinary modules, arbitrary semester
- Bachelor Interdisciplinary Courses (optional subject), Interdisciplinary modules, arbitrary semester
- Master CLS starting 2016 (optional subject), Interdisciplinary modules, 3rd semester
- Master Robotics and Autonomous Systems (optional subject), interdisciplinary competence, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies (optional subject), interdisciplinary competence, arbitrary semester
- Master Media Informatics (optional subject), interdisciplinary competence, arbitrary semester
- Master MES since 2014 (optional subject), no specific field, 1st or 2nd semester
- Bachelor MES since 2014 (optional subject), no specific field, arbitrary semester
- Master Computer Science since 2014 (optional subject), interdisciplinary competence, arbitrary semester
- Master CLS (optional suject), interdisciplinary competence, 3rd semester
- Master Computer Science before 2014 (optional subject), interdisciplinary competence, arbitrary semester

Classes and lectures:

- Theory and Practice of Good Teaching (seminar, 1 SWS)
- Work as a tutor in a lecture (practical course, 2 SWS)

Workload:

- 60 Hours private studies and exercises
- 45 Hours oral presentation (including preparation)
- 15 Hours in-classroom work

Contents of teaching:

- Organizing and running a scientific lecture
- Basic didactics of scientific teaching
- Practical work in tutorials

Qualification-goals/Competencies:

- Ability to run a tutorial and to explain topics of the relevant subfield of informatics.
- Basic pedagogical and didactical skills

Grading through:

- continuous participation in all courses of the module

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institute for Mathematics

- Dr. Jörn Schnieder

Language:

- depends on the chosen courses

LS2300-KP08, LS2301 - Biophysical Chemistry (BPCKP08)

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

Course of study, specific field and term:

- Bachelor MLS starting 2016 (compulsory), life sciences, 4th semester
- Master CLS starting 2016 (compulsory), MML with specialization in Life Science, 2nd semester
- Bachelor Biophysics (compulsory), biophysics, 4th semester
- Master CLS (optional subject), computational life science / life sciences, 2nd semester
- Bachelor MLS (compulsory), life sciences, 4th semester
- Bachelor MLS starting 2018 (compulsory), life sciences, 4th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Lecture topics:
- What is Biophysical Chemistry?
- Basics of NMR spectroscopy
- Basics of mass spectrometry
- Theoretical calculation of molecules - Quantum mechanics or molecular mechanics?
- Basics of chemical thermodynamics
- Thermodynamics of ligand binding
- Basics of chemical kinetics
- Basics of enzyme kinetics
- Practical:
- NMR, Molecular Modeling, experiments with a focus on thermodynamics and kinetics

Qualification-goals/Competencies:

- Acquire basic knowledge on spectroscopic techniques to analyze (bio)molecules. Focus is on NMR and mass spectrometry techniques
- Insight into properties (e.g. structure, dynamics, spectroscopic properties) of molecules employing theoretical models. Acquisition of basic knowledge to compute molecules
- Application of laws of thermodynamics to describe chemical reactions and biological processes with a focus on binding and recognition reactions in biological systems
- Acquire basic knowledge to analyze time courses of chemical reactions and biological processes
- Acquisition of skills to work independently and self-determined in the laboratory

Grading through:

- written exam

Requires:

- Biological Chemistry (LS2600-KP06, LS2601)
- General Chemistry (LS1100-KP04)
- Organic Chemistry (LS1600-KP10, LS1600-MLS)

Responsible for this module:

- Prof. Dr. rer. nat. Thomas Peters

Teacher:

- Institute of Chemistry and Metabolomics

- Prof. Dr. rer. nat. Thomas Peters
- PD Dr. phil. nat. Thomas Weimar

Literature:

- Peter Atkins and Julio de Paula: Physical Chemistry for the Life Sciences - Oxford, University Press, Freeman and Company, 2006, ISBN

0-1992-8095-9
- Thomas Engel und Philip Reid: Physikalische Chemie - Pearson Studium, 2006, ISBN 13: 978-3-8273-7200-0
- van Holde, Johnson & HoPrentice Hall: Principles of Physical Biochemistry - New Jersey, 1998, 2006, ISBN 0-13-720459-0
- Atkins: Physical Chemistry - Oxford University Press, Oxford Mel-bourne Tokyo, 1998, ISBN 0-19-850101-3 Paperback, Deutsche Ausgabe (dritte Auflage) bei Wiley VCH, 2002: ISBN 3-527-30236-0 Wiley-VCH, Weinheim
- Fersht, W. H.: Structure and Mechanism in Protein Science - New York, 1999, ISBN 0-7167-3268-8
- Cantor & Schimmel: Biophysical Chemistry, Parts I-III - Freeman and Company, New York, 1980, ISBN 0-71671188-5 Paperback
- H. Friebolin: Ein- und zweidimensionale NMR-Spektroskopie - Wiley-VCH

Language:

- offered only in German

Notes:

Prerequisite for examination is the successful participation in the excercises and oral presentation.
The practical course takes place in September as compact course. Prerequisite LS1600 and LS2600.

LS2600-KP06, LS2601 - Biological Chemistry (BiolChem06)

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

Course of study, specific field and term:

- Bachelor MLS starting 2016 (compulsory), life sciences, 3rd semester
- Master CLS starting 2016 (compulsory), MML with specialization in Life Science, 1st semester
- Bachelor MLS (compulsory), life sciences, 3rd semester
- Bachelor MLS starting 2018 (compulsory), life sciences, 1st semester

Classes and lectures:

- Biological Chemistry (lecture, 4 SWS)

Workload:

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

Contents of teaching:

- Lecture topics:
- What is Biological Chemistry?
- The nature of chemical bonds
- Chemical reactions to modify proteins
- Synthesis of peptides
- Chemical analytics - MS and NMR
- Metabolic labeling
- Chemical reactions to follow the fate of molecules in cells and whole organisms

Qualification-goals/Competencies:

- The nature of chemical bonds - an in depth treatment based on quantum mechanical principles
- How to use synthetic organic chemistry to solve biological questions
- In-depth treatment of reaction mechanisms of chemical reactions important in biological systems
- Analytical techniques to identify and characterize compounds

Grading through:

- exercises during lecture
- written exam

Responsible for this module:

- Prof. Dr. rer. nat. Thomas Peters

Teacher:

- Institute of Chemistry and Metabolomics

- Prof. Dr. rer. nat. Thomas Peters

Literature:

- Paula Y. Bruice: Organic Chemistry - Pearson Verlag

Language:

- offered only in German

LS4020 A - Module part LS4020A: Crystallography (StrAnaKris)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	each winter semester	3	60

Course of study, specific field and term:

- Master MLS starting 2018 (module part), structure biology, 1st semester
- Master Infection Biology ab 2018 (module part), Interdisciplinary modules, 1st semester
- Master Biophysics (module part), biophysics, 1st semester
- Master CLS starting 2016 (module part), MML with specialization in Life Science, 3rd semester
- Master MLS starting 2016 (module part), structure biology, 1st semester
- Master Infection Biology (module part), Interdisciplinary modules, 1st semester
- Master CLS (module part), computational life science / life sciences, 3rd semester
- Master MLS (module part), structure biology, 1st semester

Classes and lectures:

- Crystallography (lecture, 2 SWS)

Workload:

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

Contents of teaching:

- Crystal growth, precipitant and phase diagram, crystal morphology, symmetry and space groups, crystallogenesis
- X-rays, X-ray sources, X-ray diffraction, Bragg's law, reciprocal lattice and Ewald-sphere construction
- X-ray diffraction by electrons, Fourier analysis and synthesis
- Protein structure determination by X-ray diffraction, crystallographic phase problem, Patterson map, molecular replacement (MR), multiple isomorphous replacement (MIR), multi-wavelength anomalous diffraction (MAD)
- Crystallography and the drug discovery process: studying protein-ligand interactions
- Practical exercises employing an X-ray generator (collection of a diffraction image) and the computer (MR; calculation and interpretation of electron density maps)
- Site visit at the Synchrotron DESY (Hamburg)

Qualification-goals/Competencies:

- They have a general scientific competence in macromolecular X-ray diffraction analysis
- They have the methodological competence to grow protein crystals by hanging or sitting drops
- They have the methodological competence to correctly interpret (salt or protein) the diffraction image of a crystal using the Ewald Sphere construction
- They have the methodological competence to tackle the phase problem either by MR, MIR or MAD
- They can calculate and interprete electron density maps
- They have the methodological competence, to apply structure- or fragment-based techniques for lead compound identification
- They have the communication competency to convey the principles of X-ray diffraction theory

Grading through:

- see Notes

Responsible for this module:

- Prof. Dr. rer. nat. Christian Hübner
- Prof. Dr. rer. nat. Thomas Peters

Teacher:

- Institute of Biochemistry

- Dr. math. et dis. nat. Jeroen Mesters
- Prof. Dr. rer. nat. Rolf Hilgenfeld

Literature:

- Jan Drenth: Principles of Protein X-ray Crystallography - Science+Business Media, LLC, New York

Language:

- offered only in English

Notes:

Is part of Module:
- LS4021-KP06 (former LS4020-IB) -> Prof. Hübner
- LS4020-KP06 (former LS4020-MLS) and LS4020-KP12 -> Prof. Peters

4 exercises, 2 hours each, are offered in addition to the lecture. Dates are given at the start of the semester.

For Master MLS with specialization Structure Biology the module is mandatory.

LS4020 B - Module part LS4020B: NMR Spectroscopy (StrAnaNMR)

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

Course of study, specific field and term:

- Master Infection Biology ab 2018 (module part), Interdisciplinary modules, 1st semester
- Master Biophysics (module part), biophysics, 1st semester
- Master CLS starting 2016 (module part), MML with specialization in Life Science, 3rd semester
- Master MLS starting 2016 (module part), structure biology, 1st semester
- Master Infection Biology (module part), Interdisciplinary modules, 1st semester
- Master CLS (module part), computational life science / life sciences, 3rd semester
- Master MLS (module part), structure biology, 1st semester
- Master MLS starting 2018 (module part), structure biology, 1st semester

Classes and lectures:

- NMR-Spectroscopy (lecture, 2 SWS)

Workload:

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

Contents of teaching:

- Lecture topics:
- Assignment of NMR spectra
- Description of the NOESY experiment using the vector model
- Chemical Exchange and Transfer-NOEs
- Multidimensional NMR spectroscopy
- Assignment strategy for peptides
- Introduction into the product operator formalism (POF)
- Description of the COSY and of the HSQC experiment using POF
- NMR experiments for the assignment of proteins
- NMR structural analysis of proteins
- Experiments to probe the motions of protein

Qualification-goals/Competencies:

- Advanced techniques to assign and analyze NMR spectra
- Understanding of NMR experiments based on the product operator formalism
- Basic knowledge about NMR experiments to analyze structure and dynamics of proteins

Grading through:

- see Notes

Responsible for this module:

- Prof. Dr. rer. nat. Thomas Peters

Teacher:

- Institute of Chemistry and Metabolomics

- Prof. Dr. rer. nat. Thomas Peters
- PD Dr. rer. nat. Karsten Seeger

Literature:

- James Keeler: Understanding NMR Spectroscopy - Wiley
- :
- Malcolm H. Levitt: Spin Dynamics - Basics of Nuclear Magnetic Resonance - Wiley-VCH
- D. Neuhaus & M. P. Williamson: The Nuclear Overhauser Effect in Structural and Conformational Analysis - Wiley-VCH
- Timothy Claridge: High-Resolution NMR Techniques in Organic Chemistry - Pergamon Press
- : Current scientific literature

Language:

- offered only in English

Notes:

This lecture is a part of modules:
- LS4021-KP06 (former LS4020-IB) -> Prof. Hübner
- LS4020-KP06 (former LS4020-MLS) and LS4020-KP12 -> Prof. Peters

Exercises are integrated into the lectures.
It is a compulsory module part for the Master MLS with a focus on structural biology.

LS4020 C - Module part LS4020C: Single Molecule Methods (Einzelstru)

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

Course of study, specific field and term:

- Master MLS starting 2018 (module part), structure biology, 1st semester
- Master Infection Biology ab 2018 (module part), Interdisciplinary modules, 1st semester
- Master Biophysics (module part), biophysics, 1st semester
- Master CLS starting 2016 (module part), MML with specialization in Life Science, 3rd semester
- Master MLS starting 2016 (module part), structure biology, 1st semester
- Master Infection Biology (module part), Interdisciplinary modules, 1st semester
- Master CLS (module part), computational life science / life sciences, 3rd semester
- Master MLS (module part), structure biology, 1st semester

Classes and lectures:

- Single Molecule Methods (lecture, 2 SWS)

Workload:

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

Contents of teaching:

- Physical basics of fluorescence
- Photo physics
- Microscopy techniques
- Protein labeling
- Fluorescence resonance energy transfer
- Single molecule enzymology
- Single molecule protein folding
- Physical basics of optical tweezers
- Protein folding with optical tweezers

Qualification-goals/Competencies:

- Understanding of the physical basics of single molecule methods
- Understanding of the benefits of single molecule methods
- Understanding of the limits of single molecule methods

Grading through:

- see Notes

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Physics

- Prof. Dr. rer. nat. Christian Hübner

Literature:

- Lakowicz, Joseph R: Principles of Fluorescence Spectroscopy - ISBN 978-0-387-46312-4
- Markus Sauer, Johan Hofkens, Jörg Enderlein: Handbook of Fluorescence Spectroscopy and Imaging: From Ensemble to Single Molecules - ISBN: 978-3-527-31669-4

Language:

- offered only in English

Notes:

Is module part of:
- LS4021-KP06 (former LS4020-IB) -> Prof. Hübner
- LS4020-KP06 (former LS4020-MLS) and LS4020-KP12 -> Prof. Peters

This module part is identical to LS4020 C-MIW without seminar.
For Master MLS with specialization in structure biology the module is mandatory.

LS4020 D - Module part LS4020D: Microscopy: techniques and applications (StrAnaMikr)

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

Course of study, specific field and term:

- Master Infection Biology ab 2018 (module part), Interdisciplinary modules, 1st semester
- Master Biophysics (module part), biophysics, 1st semester
- Master CLS starting 2016 (module part), MML with specialization in Life Science, 3rd semester
- Master MLS starting 2016 (module part), structure biology, 1st semester
- Master Infection Biology (module part), Interdisciplinary modules, 1st semester
- Master CLS (module part), computational life science / life sciences, 3rd semester
- Master MLS (module part), structure biology, 1st semester
- Master MLS starting 2018 (module part), structure biology, 1st semester

Classes and lectures:

- Microscopy: techniques and applications (lecture, 2 SWS)

Workload:

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

Contents of teaching:

- Light microscopy
- Confocal microscopy
- 2-photon microscopy
- Light sources and detectors
- Fluorescent Dyes; GFP and genetically encoded fluorescence markers; Live Cell/tissue imaging: considerations/limitations
- Labelling/identifying cell components using fluorescence techniques
- Protein-protein Interactions in living cells: FRET, FLIM; Biosensors
- Photo-activatable/-switchable Fluorescent Proteins; Fluorescent Timers
- Advanced 3D-Fluoresence Microscopy, STED, PALM, STORM
- In vivo imaging in tissues and living animals
- Applications of Flow Cytometry & Fluorescence-activated Cell Sorting
- Electron Microscopy: TEM, Immunogold label; Survey of cell ultrastructure; Correlative EM/light microscopy; Scanning Electron Microscopy (SEM)
- Bioluminescence; high-content screening; outlook: emerging technologies
- Data storage/formats; Course discussion; and then: Cinema of the Cell

Qualification-goals/Competencies:

- Basics of light and fluorescence microscopy and electron microscopy
- Detailed knowledge of methods for labelling and visualization of proteins and subcellular compartments
- Applications of live cell imaging, in vivo imaging and quantitative fluorescence techniques

Grading through:

- see Notes

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Biology

- Prof. Dr. rer nat. Rainer Duden

Literature:

- -: http://micro.magnet.fsu.edu/primer/index.html
- -: http://www.microscopyu.com/smallworld/
- -: http://www.olympusmicro.com/

Language:

- offered only in English

Notes:

Is module part of:
- LS4021-KP06 (former LS4020-IB) -> Prof. Hübner
- LS4020-KP06 (former LS4020-MLS) and LS4020-KP12 -> Prof. Peters

For Master MLS with specialization in Structure Biology the module is mandatory.

(Contribution to lecture, Biology 60%)
(Contribution to lecture, Biomedical Optics 40%)

LS4020-KP08 - Advanced Topics in Life Science (VertLSKP08)

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

Course of study, specific field and term:

- Master CLS starting 2016 (compulsory), MML with specialization in Life Science, 3rd semester

Classes and lectures:

- See module part LS4020 A: Crystallography (lecture, 2 SWS)
- See module part LS4020 B: NMR-Spectroscopy (lecture, 2 SWS)
- See module part LS4020 C: Single Molecule Methods (lecture, 2 SWS)
- See module part LS4020 D: Microscopy: techniques and applications (lecture, 2 SWS)

Workload:

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

Contents of teaching:

- See module parts LS4020 A to D

Qualification-goals/Competencies:

- See module parts LS4020 A to D

Grading through:

- written exam

Responsible for this module:

- Prof. Dr. rer. nat. Thomas Peters

Teacher:

- Institute of Physics
- Institute for Biology
- Institute of Biochemistry
- Institute of Chemistry and Metabolomics

- Prof. Dr. rer. nat. Thomas Peters
- Prof. Dr. rer. nat. Rolf Hilgenfeld
- Dr. math. et dis. nat. Jeroen Mesters
- PD Dr. rer. nat. Karsten Seeger
- Prof. Dr. rer. nat. Christian Hübner
- Prof. Dr. rer nat. Rainer Duden

Language:

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

CS4335-KP08 - Image Analysis and Computer Graphics (BACGKP08)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	each summer semester	8	99

Course of study, specific field and term:

- Master CLS starting 2016 (compulsory), MML with specialization in Image Processing, 2nd semester

Classes and lectures:

- Image Analysis and Visualization Systems in Diagnostics and Therapy (lecture, 2 SWS)
- Image Analysis and Visualization Systems in Diagnostics and Therapy (exercise, 1 SWS)
- Computer Graphics (lecture, 2 SWS)
- Computer Graphics (exercise, 1 SWS)

Workload:

- 90 Hours private studies and exercises
- 75 Hours in-classroom work
- 40 Hours written report
- 20 Hours exam preparation
- 15 Hours oral presentation (including preparation)

Contents of teaching:

- Part A, Image Analysis:
- Methods and algorithms for the analysis and visualization of medical images including current research activities in the field of medical image computing. The following methods and algorithms are explained:
- Segmentation of multispectral image data
- Live wire segmentation
- Segmentation with active contour models and deformable models
- Level set segmentation
- Statistical shape models
- Image registration
- Atlas-based segmentation and motion field estimation using non-linear registration
- Visualization techniques in medicine
- 3D-Visualisierungsmethoden: Ray Casting, Volume Rendering etc.
- Haptic 3D interactions in virtual bodies
- Virtual reality techniques in medical applications
- Part B, Computer Graphics:
- Homogeneous coordinates and geometrical transformations
- Planar and perspective projections
- Polygon meshes
- Bezier curves and surfaces
- B-spline curves and surfaces
- Culling and Clipping
- Hidden surface removal
- Raster graphics algorithms
- Illumination and shading

Qualification-goals/Competencies:

- Part A, Image Analysis:
- Increase knowledge in the field of medical image processing and visualization
- Knowledge of the individual steps of pattern recognition
- Understanding of the underlying algorithms
- Ability to select appropriate methods for a given problem
- Implementation of the methods
- Application to practical problems
- Overview of medical image processing techniques with many examples
- Part B, Computer Graphics:
- Knowledge and understanding of the basic concepts, algorithms and methods of computer graphics
- Ability to implement the basic algorithms of computer graphics
- Ability to assess the possibilities and limitations of the learned techniques in computer graphics

Grading through:

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

Responsible for this module:

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

Teacher:

- Institute of Medical Informatics

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

Literature:

- H. Handels: Medizinische Bildverarbeitung - 2. Auflage, Vieweg u. Teubner 2009
- T. Lehmann: Handbuch der Medizinischen Informatik - München: Hanser 2005
- M. Sonka, V. Hlavac, R. Boyle: Image Processing, Analysis and Machine - 2nd edition. Pacific Grove: PWS Publishing 1998
- B. Preim, D. Bartz: Visualization in Medicine - Elsevier, 2007
- Foley et. al: Grundlagen der Computergrafik - Addison-Wesley, 1994

Language:

- offered only in German

Notes:

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

MA5038-KP08 - Advanced Topics in Image Processing (VertBVKP08)

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

Course of study, specific field and term:

- Master CLS starting 2016 (compulsory), MML with specialization in Image Processing, 3rd semester

Classes and lectures:

- Advanced Topics in Image Processing (depends on the chosen courses, 3 SWS)

Workload:

- 240 Hours overall workload, division depending on the chosen courses

Contents of teaching:

- Familiarization with advanced methods in image and signal processing
- Familiarization with the underlying mathematical models and methods
- Practical implementation, critical evaluation and interpretation of the results
- Details as in the description of the chosen courses

Qualification-goals/Competencies:

- Students have advanced knowledge in a special or application area within the field of image and signal processing.
- The have an improved overview of the diversity of the field.
- They can see their prior knowledge in a different context and build new connections.
- 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:

- see Notes

Responsible for this module:

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

Teacher:

- Institute of Mathematics and Image Computing

- N.N.

Language:

- German and English skills required

Notes:

The module comprises 8 ECTS credit points, which must be accounted for by combining courses within the area of advanced image and signal processing. The chosen combination must be agreed upon in advance by the person responsible for the module.

Grading: Generally by weighted average of the results of the chosen courses. Depending on the combination of courses, an overall exam is also possible.

ME4411 T - Module part: Computed Tomography (CT)

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

Course of study, specific field and term:

- Master IT-Security (module part), module part, arbitrary semester
- Master CLS starting 2016 (module part), MML with specialization in Image Processing, 1st semester
- Master Robotics and Autonomous Systems (module part), module part, 1st or 2nd semester
- Master Computer Science since 2014 (module part), module part, arbitrary semester
- Master Medical Informatics (module part), module part, arbitrary semester
- Master Entrepreneurship in Digital Technologies (module part), module part, arbitrary semester
- Master MES since 2014 (module part), Medical Engineering Science, 1st semester

Classes and lectures:

- Computed Tomography (lecture, 2 SWS)

Workload:

- 40 Hours private studies
- 35 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Signal processing (recapitulation of fundamental principles in signal processing)
- Mathematical methods in image reconstruction and signal processing
- X-Ray (fundamental principles, quantum statistics)
- Computed Tomography * devices, * current and past technology, * signal processing, * Fourier-based 2D and 3D image reconstruction, * algebraic and statistical image reconstruction, * image artifacts, * technical and clinical applications, * dose.

Qualification-goals/Competencies:

- Students are able to create an overview of the signal chain for medical imaging.
- They are able to explain the mathematical background for the reconstruction of CT images.
- They are able to explain the basics for the creation of X-ray.
- They are able to list all generations of CT devices and explain differences and advances.
- They are able to apply the Fourier transform.
- They are able to explain the mathematical basics for the two-dimensional image reconstruction.
- They are able to create and apply an algebraic approach for the reconstruction of CT images.
- They are able to create and apply an statistical approach for the reconstruction of CT images.
- They are able to outline the differences between two dimensional and three dimensional image reconstruction.
- They are able to transfer methods from two dimensional to three dimensional image reconstruction.

Grading through:

- Oral examination

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Medical Engineering
- Prof. Dr. rer. nat. Thorsten Buzug

Literature:

- T. M. Buzug: Computed Tomography, From Photon Statistics to Modern Cone Beam CT - Springer-Verlag, Berlin/Heidelberg, 2008
- T. M. Buzug: Einführung in die Computertomographie, Mathematisch-physikalische Grundlagen der Bildrekonstruktion - Springer-Verlag, Berlin/Heidelberg, 2004

Language:

- German and English skills required

ME4412 T - Module part: Magnetic Resonance Imaging (MRT)

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

Course of study, specific field and term:

- Master Medical Informatics since 2019 in planing (module part), module part, arbitrary semester
- Master IT-Security (module part), module part, arbitrary semester
- Master CLS starting 2016 (module part), MML with specialization in Image Processing, 1st semester
- Master Robotics and Autonomous Systems (module part), module part, 1st or 2nd semester
- Master Computer Science since 2014 (module part), module part, arbitrary semester
- Master Medical Informatics (module part), module part, arbitrary semester
- Master Entrepreneurship in Digital Technologies (module part), module part, arbitrary semester
- Master MES since 2014 (module part), Medical Engineering Science, 1st semester

Classes and lectures:

- Magnetic Resonance Imaging (lecture, 2 SWS)

Workload:

- 40 Hours private studies
- 30 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Physical fundamentals of magnetic resonance imaging: nuclear magnetic resonance, relaxation mechanisms, principles of position encodingprinciples of spatial encoding, relaxation)
- Construction of basic imaging sequences, weighting
- Concept of k-space
- Coherence pathways
- Hardware components of a clinical MR system
- Possible sources of hazard for patients
- Influence of measurement parameters on signal-to-noise ratio
- Causes of image artefacts

Qualification-goals/Competencies:

- The students can explain the physical principles of NMR and MRI.
- They can explain the idea behind important imaging sequences, using a pulse sequence diagram.
- They can recognise the causes of important image artefacts.
- The can list advantages and disadvantages of MRT, compared to other imaging techniques.
- They can list possible sources of hazard for patients, explain their causes and point out strategies for avoiding these.

Grading through:

- Oral examination

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Medical Engineering
- Prof. Dr. rer. nat. Martin Koch

Literature:

- Liang, Z.-P., Lauterbur, P. C.: Principles of Magnetic Resonance Imaging: A Signal Processing Perspective - IEEE Press, New York 2000

Language:

- German and English skills required

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

- as described for the module parts

Qualification-goals/Competencies:

- as described for the module parts

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. rer. nat. Thorsten Buzug

Teacher:

- Institute of Medical Engineering

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

Literature:

- T. M. Buzug:

Language:

- German and English skills required

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

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- continuous, successful participation in practical course
- written exam

Is requisite for:

- Seminar Genetic Epidemiology (MA5129-KP04, MA5129)

Requires:

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

Responsible for this module:

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

Teacher:

- Institute of Medical Biometry and Statistics

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

- MitarbeiterInnen des Instituts

Literature:

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

Language:

- offered only in German

Notes:

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

MA5129-KP04, MA5129 - Seminar Genetic Epidemiology (SemGenEpi)

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

Course of study, specific field and term:

- Master CLS starting 2016 (compulsory), MML with specialization in Genetic Statistics, 3rd semester
- Master CLS (optional suject), mathematics, 3rd semester
- Master CLS (compulsory), computational life science / biostatistics, 3rd semester

Classes and lectures:

- Seminar Genetic Epidemiology (seminar, 2 SWS)

Workload:

- 90 Hours work on an individual topic with written and oral presentation
- 30 Hours in-classroom work

Contents of teaching:

- Become acquainted with current topics in genetic epidemiology overall and in detail, typically using a current scientific publication, in written and oral form

Qualification-goals/Competencies:

- The students have the methodological competence to master the thorough analysis of a circumscribed scientific topic and to put it into scientific perspective.
- They are competent to present their results comprehensively in written form.
- They have the communication competence to orally present a scientifically complex topic in a coherent way.
- They have the communication competence to take an active part in a scientific discussion.

Grading through:

- Oral presentation and written report

Requires:

- Genetic Epidemiology 2 (MA4661-KP08, MA4661)
- Genetic Epidemiology 1 (MA3200-KP04, MA3200)

Responsible for this module:

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

Teacher:

- Institute of Medical Biometry and Statistics

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

Language:

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

Notes:

Specialized literature will be named in class.

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

MZ4010-KP04, MZ4010 - Clinical Epidemiology (KlinEpi)

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

Course of study, specific field and term:

- Bachelor Medical Informatics since 2019 in planning (optional subject), medical computer science, 4th to 6th semester
- Master CLS starting 2016 (compulsory), MML with specialization in Genetic Statistics, 3rd semester
- Bachelor Medical Informatics since 2014 (compulsory), medical computer science, 5th semester
- Bachelor Medical Informatics before 2014 (compulsory), medical computer science, 3rd semester
- Master CLS (compulsory), computational life science / biostatistics, 1st semester
- Master Computer Science before 2014 (compulsory), specialization field medical informatics, 3rd semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Introduction to epidemiology
- Diagnosis
- Frequencies
- Registers and data sources
- Geographical epidemiology
- Study designs (RCT, cohort study, case control study, cross sectional study)
- Effect measures
- Causality
- Chance, bias and confounding
- Control of errors
- Outbreak investigation

Qualification-goals/Competencies:

- Students are able to explain technical terms such as disease register, incidence, prevalence, mortality, lethality, standardization.
- They are able to explain and interpret epidemiological measures.
- They are able to assess which study design is appropriate for a certain research question.
- They are able to identify possible sources of error, bias and confounding and how they affect the study results.
- They are able to assess causal inferences in the context of different study types.
- They are able to critically appraise data, results, and epidemiological research methods as well as scientific literature in the context of medicine and epidemiology.

Grading through:

- Exercises
- written exam
- e-tests

Responsible for this module:

- Prof. Dr. med. Alexander Katalinic

Teacher:

- Institute for Social Medicine and Epidemiology

- Prof. Dr. med. Alexander Katalinic
- MitarbeiterInnen des Instituts

Literature:

- L. Gordis: Epidemiology - Oxford: Elsevier; 5th edition 2013
- R. H. Fletcher: Clinical Epidemiology. The Essentials. - Lippincott Williams & Wilki; 5th rev. edition 2012
- :

Language:

- offered only in German

MZ4373-KP03, MZ4373 - Human Genetics (HumGen)

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

Course of study, specific field and term:

- Master Medical Informatics (optional subject), bioinformatics, 1st or 2nd semester
- Master CLS starting 2016 (compulsory), MML with specialization in Genetic Statistics, 1st semester
- Master CLS (compulsory), computational life science / biostatistics, 1st semester
- Master CLS (optional suject), mathematics, arbitrary semester
- Master Medical Informatics since 2019 in planing (optional subject), bioinformatics, 1st or 2nd semester

Classes and lectures:

- Human Genetics for MML (lecture, 2 SWS)

Workload:

- 40 Hours private studies
- 30 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Human genome
- Heredity
- Genetics of mitochondria
- Mutations, detection and nomenclature of sequence variations
- Polymorphisms and SNP
- Linkage analyses
- Repetitive sequences
- Methods: isolation, amplification, screening, and analysis of nucleic acids
- Data bases
- Epigenetics

Qualification-goals/Competencies:

- Students are able to explain basic principles of heredity, the organization of the human genome, the relevance of sequence variations, and their application for medical biometrics.

Grading through:

- written exam

Responsible for this module:

- Prof. Dr. rer. nat. Christine Zühlke

Teacher:

- Institute of Human Genetics

- Prof. Dr. rer. nat. Christine Zühlke
- Dr. Andreas Dalski
- MitarbeiterInnen des Instituts

Literature:

- Tom Strachan & Andrew P. Read: Molekulare Humangenetik - 3. Auflage (2005)

Language:

- offered only in German

MZ4374-KP03, MZ4374 - Molecular Human Genetics (MolHumGen)		
Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	each winter semester	3 (Typ B)

Course of study, specific field and term:

- Master CLS starting 2016 (compulsory), MML with specialization in Genetic Statistics, 1st semester
- Master Medical Informatics (optional subject), bioinformatics, 1st or 2nd semester
- Master CLS (compulsory), computational life science / biostatistics, 1st semester
- Master Medical Informatics since 2019 in planing (optional subject), bioinformatics, 1st or 2nd semester

Classes and lectures:

- Molecular Human Genetics (practical course, 2 SWS)

Workload:

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

Contents of teaching:

- Safety instructions
- Isolation of nucleic acids
- Preparation and separation of nucleic acids
- Amplification of nucleic acids (PCR)
- Restriction of nucleic acids
- Theoretical consideration of pedigrees
- Data base search

Qualification-goals/Competencies:

- Students can perform fundamental molecular genetic experiments, they get basic knowledge in laboratory work

Grading through:

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

Requires:

- Human Genetics (MZ4373-KP03, MZ4373)

Responsible for this module:

- Prof. Dr. rer. nat. Christine Zühlke

Teacher:

- Institute of Human Genetics

- Prof. Dr. rer. nat. Christine Zühlke
- Dr. Andreas Dalski

Literature:

- Lecture notes: -

Language:

- offered only in German

MA3111-KP07 - Numerics (NumKP07)

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

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), 1st, 2nd, or 3rd semester

Classes and lectures:

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

Workload:

- 100 Hours private studies and exercises
- 60 Hours in-classroom work
- 30 Hours additional private studies computational life science
- 20 Hours exam preparation

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Exercises
- programming exercises
- Oral examination
- written exam

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Rößler

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Andreas Rößler

Literature:

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

Language:

- offered only in German

Notes:

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.

MA4031-KP08 - Optimization (OptiKP08)		
Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	each summer semester	8

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), 1st, 2nd, or 3rd semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

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

Is requisite for:

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

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Jan Modersitzki

Teacher:

- Institute of Mathematics and Image Computing

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

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:

Variant of MA4030, MA4030-KP08 for students who did not attend a course on optimization in their Bachelor s program.

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

MA4449-KP07 - Modeling (ModellKP07)

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

Course of study, specific field and term:

- Master CLS starting 2016 (optional subject), 1st, 2nd, or 3rd semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- exercises, project, oral or written exam

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Karsten Keller

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Karsten Keller

Literature:

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

Language:

- offered only in German