UNIVERSITÄT ZU LÜBECK

Module Guide for the Study Path

Bachelor Computer Science 2019

Version from 1. October 2025

1st semester

2nd semester

3rd semester

4th semester

5th semester

6th semester

Arbitrary semester

CS1000-KP10, CS1000SJ14 - Introduction to Programming (EinfProg14)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	10

Course of study, specific field and term:

- Bachelor Media Informatics 2020 (compulsory: aptitude test), computer science, 1st semester
- Bachelor Computer Science 2019 (compulsory: aptitude test), foundations of computer science, 1st semester
- Bachelor Robotics and Autonomous Systems 2020 (compulsory), foundations of computer science, 1st semester
- Bachelor Computer Science 2016 (compulsory: aptitude test), foundations of computer science, 1st semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory), computer science, 1st semester
- Bachelor IT-Security 2016 (compulsory: aptitude test), computer science, 1st semester
- Bachelor Media Informatics 2014 (compulsory: aptitude test), computer science, 1st semester
- Bachelor Computer Science 2014 (compulsory: aptitude test), foundations of computer science, 1st semester

Classes and lectures:

- Introduction to Programming (lecture, 2 SWS)
- Lab course Java (lecture, 2 SWS)
- Lab course Java (exercise, 2 SWS)
- Java project (programming project, 2 SWS)

Workload:

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

Contents of teaching:

- Basic concepts of computer science: representation of information and numbers, hardware, software, operating systems, applications
- Algorithm, Specification, Program
- Syntax und Semantics of Programming Languages
- Basic concepts of imperative and OO programming
- Techniques of secure programming
- Programming in Java including term-long project
- Development environment for Java

Qualification-goals/Competencies:

- Students can easily calculate in 2, 8 and 16 number systems and convert numbers into each other in these systems.
- Students can convert rational and real numbers into floating point numbers and vice versa.
- Students can explain the principles of text encoding in ASCII, Unicode, and UTF-8.
- Students can independently represent the term 'algorithm' and important properties.
- Students can explain the structure and semantics of imperative programs.
- Students master the technique of reading and understanding imperative algorithms and writing them down for simple problems.
- Students can apply basic algorithmic techniques such as iteration and recursion.
- Students are basically able to apply safe programming techniques.
- Students can design, implement and test simple simple programs
- Students can develop and implement solutions satisfying commonly accepted quality standards
- Students can implement limited, but no longer small software development projects in a team.

Grading through:

- written exam
- successful addressing of the project goals

Is requisite for:

- Lab Course Software Engineering (CS2301-KP06, CS2301)
- Software Engineering (CS2300-KP06, CS2300SJ14)
- Algorithms and Data Structures (CS1001-KP08, CS1001)

Responsible for this module:

- Prof. Dr. Stefan Fischer

Teacher:

- Institute of Telematics

- Prof. Dr. Stefan Fischer

Literature:

- H. P. Gumm and M. Sommer: Einführung in die Informatik - Oldenbourg, 10. Auflage, 2012
- G. Goos und W. Zimmermann: Vorlesungen über Informatik (Band 1 und 2) - Springer-Verlag, 2006
- D. J. Barnes und M. Kölling: Java lernen mit BlueJ - Objects first - eine Einführung in Java - 6. Auflage, Pearson Studium, 2017
- T. Stark und G. Krüger: Handbuch der Java-Programmierung - 5. Auflage, Addison-Wesley, 2007
- R. Sedgewick und K. Wayne: Einführung in die Programmierung mit Java - Pearson Studium

Language:

- offered only in German

Notes:

From WS2019 / 20:
Partial Examination CS1000-L1: Introduction to Programming and Programming Course (graded exam, 8 credits)
Partial exam CS1000-L2: Java project (ungraded internship, 2 credits)

Prerequisites for attending the module:
- None

Prerequisites for the exam in CS1000-L1:
- Successful completion of homework assignments during the semester.

Prerequisites for the exam in CS1000-L2:
- None

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

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written exam

Responsible for this module:

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

Teacher:

- Institute of Medical Informatics

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

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

Literature:

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

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise slips as specified at the beginning of the semester
- Giving a short lecture as specified at the beginning of the semester

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

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

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- portfolio exam

Responsible for this module:

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

Teacher:

- Institute for Neuro- and Bioinformatics

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

Literature:

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

Language:

- offered only in German

Notes:

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

Prerequisites for attending the module:
- None

Computer Science students get a B certificate.

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

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written exam

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering

- Dr.-Ing. Kristian Ehlers

Literature:

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

Language:

- offered only in German

Notes:

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

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework assignments during the semester.

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

CS1700-KP04, CS1700 - Introduction to IT Security and Reliability (EinfSiZuv)

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

Course of study, specific field and term:

- Bachelor Computer Science 2019 (optional subject), Introductory Module Computer Science, 1st semester
- Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester
- Bachelor Computer Science 2016 (optional subject), Introductory Module Computer Science, 1st semester
- Bachelor IT-Security 2016 (compulsory), IT-Security, 1st semester
- Bachelor Medical Informatics 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2014 (compulsory), specialization field IT security and safety, 1st semester
- Bachelor Computer Science 2012 (compulsory), specialization field IT security and safety, 1st semester

Classes and lectures:

- Introduction to IT Security and Reliability (lecture, 2 SWS)
- Introduction to IT Security and Reliability (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- introduction and terms
- data protection and data security, informational self-determination
- classification of security, safety and reliability requirements and riscs
- insecure systems: examples, impacts and damages, causes
- unreliable systems: examples, impacts and damages, causes
- attack scenarios, safety-critical businesses and domains
- simple measures for enhancing safety, security and reliability, risk estimation
- legal, social and ethical aspects

Qualification-goals/Competencies:

- Students can explain the basic problems in the area of security and reliability of IT systems.
- They can use simple standard methods to analyze and classify such problems.
- They can evaluate social aspects of IT security and reliability issues.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr.-Ing. Thomas Eisenbarth

Teacher:

- Institute of Computer Engineering
- Institute for IT Security
- Institute of Software Technology and Programming Languages
- Institute for Theoretical Computer Science

- Prof. Dr.-Ing. Mladen Berekovic
- Prof. Dr. Martin Leucker
- Prof. Dr. rer. nat. Esfandiar Mohammadi
- Prof. Dr. Maciej Liskiewicz
- Prof. Dr.-Ing. Thomas Eisenbarth

Literature:

- : - current introductory literature will be introduced in the respective lectures

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise sheets as specified at the beginning of the semester.

Module Exam(s):
- CS1700 -L1 Introduction to IT Security and Reliability, written exam, 90min, 100% of the (non-existent) module grade.

(Proportion of exercise Institute for IT Security: 100%)

CS1800-KP04 - Introduction to Web and Data Science (EinfWebDat)

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

Course of study, specific field and term:

- Bachelor IT-Security 2016 (optional subject), interdisciplinary, Arbitrary semester
- Bachelor Computer Science 2019 (compulsory), Canonical Specialization Web and Data Science, 1st semester
- Bachelor Computer Science 2019 (optional subject), Introductory Module Computer Science, 1st semester
- Bachelor Computer Science 2016 (compulsory), Canonical Specialization Web and Data Science, 1st semester
- Bachelor Computer Science 2016 (optional subject), Introductory Module Computer Science, 1st semester

Classes and lectures:

- Introduction to Web and Data Science (lecture, 2 SWS)
- Introduction to Web and Data Science (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Classification vs. regression, parametric and non-parametric supervised learning
- Networks made up of differentiable modules (Neural networks), support vector machines
- Frequent item analysis, market basket analysis, recommendation generation
- Statistics: samples, optimal estimators, distributions, density functions, cumulative distributions, ordinal, nominal, interval and ratio scales, confidence intervals, Pearson correlation coefficient
- Stochastic basics, Bayesian networks for the specification of discrete distributions, queries, query response algorithms, learning methods for Bayesian networks with complete data
- Inductive learning: version space, information theory, decision trees, rule learning
- Ensemble methods: bagging, boosting, random forests
- Cluster formation, K-means, analysis of variation (ANOVA), t-test, inter-cluster variation, intra-cluster variation, F-statistics, Bonferroni correction, MANOVA
- Analysis of social structures
- Deep Learning, Embedding Spaces

Qualification-goals/Competencies:

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

Grading through:

- written exam

Responsible for this module:

- Prof. Dr. Diedrich Wolter

Teacher:

- Institute of Software Technology and Programming Languages

- Prof. Dr. Diedrich Wolter
- Dr. Gesina Schwalbe

Literature:

- J. Stanton: An Introduction to Data Science - Syracuse University, 2013
- Chr. Manning, P. Raghavan, H. Schütze: An Introduction to Information Retrieval - Online edition, Cambridge, UK, 2009
- M. Welling: A First Encounter with Machine Learning - 2011

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises as specified at the beginning of the semester.

Module Exam(s):
- CS1800-L1: Introduction to Web and Data Science, written exam, 90min, 100% of (non-existent) module grade

CS1900-KP04 - Introduction to Software Systems Engineering (EinfSSE)

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

Course of study, specific field and term:

- Bachelor IT-Security 2016 (optional subject), interdisciplinary, Arbitrary semester
- Bachelor Computer Science 2019 (compulsory), Canonical Specialization SSE, 1st semester
- Bachelor Computer Science 2019 (optional subject), Introductory Module Computer Science, 1st semester
- Bachelor Computer Science 2016 (compulsory), Canonical Specialization SSE, 1st semester
- Bachelor Computer Science 2016 (optional subject), Introductory Module Computer Science, 1st semester

Classes and lectures:

- Introduction to Software Systems Engineering (lecture, 2 SWS)
- Introduction to Software Systems Engineering (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Software Systems
- Computer Science: definition and topics
- Software Life Cycle
- Quality of Software
- Human factors in software development
- Programming Languages
- Formal languages and propositional logic
- Complexitiy and Computability

Qualification-goals/Competencies:

- The students can explain the basic terms of computer science and software systems engineering.
- They can give a survey of the process of software development including the role of human factors.
- They can enumerate and explain criterias for the evaluation of software.
- They can differentiate between different programming paradigms.
- They can motivate subjects of Software Systems Engineering including theoretical computer science and explain with examples.
- The students can assess the topics of software systems engineering and can explain why they are part of the specialization track on software systems engineering.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages

- Prof. Dr. Martin Leucker

Literature:

- : - current introductory literature will be introduced in the respective lectures

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises as sepcified at the beginning of the semester.

Module Exam(s):
- CS1900-L1: Introduction in Software Systems Engineering, written exam, 90min, 100% of the (non-existent) module grade.

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

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

Course of study, specific field and term:

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

Classes and lectures:	Workload:
• Linear Algebra and Discrete Structures 1 (lecture, 4 SWS) • Linear Algebra and Discrete Structures 1 (exercise, 2 SWS)	• 125 Hours private studies and exercises • 90 Hours in-classroom work • 25 Hours exam preparation

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written exam

Is requisite for:

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

Responsible for this module:

- Prof. Dr. rer. nat. Jan Modersitzki

Teacher:

- Institute of Mathematics and Image Computing

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

Literature:

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

Language:

- offered only in German

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework assignments during the semester
- Successful completion of e-tests during the semester
- Presentation of homework assignment

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

MA2000-KP08, MA2000 - Analysis 1 (Ana1KP08)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Sequences and series
- Functions and continuity
- Differentiability, Taylor series
- Metric and normalized spaces, basic topological concepts
- Multivariate differential calculus

Qualification-goals/Competencies:

- Students understand the basic terms of analysis, especially the concept of convergence.
- Students understand the basic thoughts and proof techniques and are able to use them for the analytical treatment of scientifially or technically motivated problems.
- Students can explain basic relationships in real analysis.
- Students can apply the basic concepts and proof techniques of differential calculus.
- Students have an understanding for abstract structures.
- Interdisciplinary qualifications:
- Students have a basic competence in modeling.
- Students can transfer theoretical concepts to similar applications.
- Students can work as a group on elementary mathematical problems.

Grading through:

- written exam

Is requisite for:

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

- Analysis 2 (MA2500-KP05, MA2500-MLS)
- Analysis 2 (MA2500-KP04, MA2500)

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Jürgen Prestin
- PD Dr. rer. nat. Jörn Schnieder

Literature:

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

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None

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

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

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

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Sorting, algorithm analysis, heaps
- Distribution sort
- Priority queues
- Sets
- Sets
- Sets of strings
- Disjoint sets
- Associating objects
- Graphs
- Search graph for game playing
- Dynamic Programming principle, greedy algorithms
- Optimization problems, sequence alignment (longest common subsequence), knapsack problem, planning and layout problems, determining change coins, notion of completeness of algorithms
- String matching
- Hard problems
- Pruning and subgraph isomorphism
- Approximation

Qualification-goals/Competencies:

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

Grading through:

- written exam

Is requisite for:

- Databases (CS2700-KP04, CS2700)
- Lab Course Software Engineering (CS2301-KP06, CS2301)

- Software Engineering (CS2300-KP06, CS2300SJ14)
- Theoretical Computer Science (CS2000-KP08, CS2000)
- Algorithm Design (CS3000-KP04, CS3000)

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Esfandiar Mohammadi

Teacher:

- Institute for IT Security
- Prof. Dr. rer. nat. Esfandiar Mohammadi

Literature:

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

Language:

- offered only in German

Notes:

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

Admission requirements for participation in module examination(s):
- Successful completion of exercise sheets as specified at the beginning of the semester.

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

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

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

Course of study, specific field and term:

- Bachelor MES 2014 (optional subject), computer science / electrical engineering, 3rd semester at the earliest
- Bachelor Media Informatics 2020 (compulsory), computer science, 2nd semester
- Bachelor Computer Science 2019 (compulsory), foundations of computer science, 2nd semester
- Bachelor Robotics and Autonomous Systems 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Medical Informatics 2019 (compulsory), computer science, 2nd semester
- Bachelor Media Informatics 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2016 (compulsory), foundations of computer science, 3rd semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), computer science, 5th or 6th semester
- Bachelor IT-Security 2016 (compulsory), computer science, 2nd semester
- Bachelor Medical Informatics 2014 (compulsory), computer science, 3rd semester
- Bachelor Computer Science 2014 (compulsory), foundations of computer science, 3rd semester
- Bachelor Medical Informatics 2011 (compulsory), computer science, 1st semester
- Bachelor MES 2011 (optional subject), computer science, 3rd semester
- Bachelor CLS 2010 (optional subject), computer science, 6th semester
- Bachelor Computer Science 2012 (compulsory), foundations of computer science, 1st semester
- Bachelor Biophysics 2024 (optional subject), computer science, 6th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written exam

Responsible for this module:

- Prof. Dr. rer. nat. Till Tantau

Teacher:

- Institute for Theoretical Computer Science

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

Literature:

- Uwe Schöning: Logik für Informatiker - Spektrum Verlag, 1995

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

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise slips as specified at the beginning of the semester.

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

CS1200-KP06, CS1200SJ14 - Fundamentals of Computer Engineering 1 (TGI1)

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

Course of study, specific field and term:

- Bachelor MES 2020 (compulsory), computer science, 4th semester
- Bachelor Media Informatics 2020 (compulsory), computer science, 2nd semester
- Bachelor Computer Science 2019 (compulsory), foundations of computer science, 2nd semester
- Bachelor Robotics and Autonomous Systems 2020 (compulsory: aptitude test), computer science, 2nd semester
- Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester
- Bachelor Computer Science 2016 (compulsory), foundations of computer science, 2nd semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory: aptitude test), computer science, 2nd semester
- Bachelor IT-Security 2016 (compulsory), computer science, 2nd semester
- Bachelor Biophysics 2016 (optional subject), computer science, 6th semester
- Bachelor Medical Informatics 2014 (compulsory), computer science, 2nd semester
- Bachelor Media Informatics 2014 (compulsory), computer science, 2nd semester
- Bachelor MES 2014 (compulsory), foundations of computer science, 4th semester
- Bachelor Computer Science 2014 (compulsory), foundations of computer science, 2nd semester
- Bachelor Biophysics 2024 (optional subject), computer science, 6th semester

Classes and lectures:

- Fundamentals of Computer Engineering 1 (lecture, 2 SWS)
- Fundamentals of Computer Engineering 1 (exercise, 2 SWS)

Workload:

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

Contents of teaching:

- Von-Neumann computer
- Switching algebra and switching functions
- Technological realization
- Combinatorial and sequential circuits
- Memories
- Microprocessors
- Assembler programming
- Microcontrollers
- Input/Output programming
- Basic processor architectures

Qualification-goals/Competencies:

- The students can explain the principal organization of a computer and the execution of a program according to the Von-Neumann principle.
- They can elucidate the principal functioning of combinatorial and sequential circuits and describe them formally using switching algebra.
- They can demonstrate the basic circuits for the technological realization of logic gates with bipolar and MOS transistors.
- They can explain the structure and operation of registers and memories.
- They can elucidate the instruction set of a microprocessor exemplarily and to be able to use it for assembly programming.
- Sie können die Ein/Ausgabe-Schnittstellen eines Mikrocontrollers beschreiben und in Assemblersprache programmieren (mit Polling bzw. Interrupt).
- They can program microcontrollers for simple applications in assembly language.
- They can discuss and compare basic processor architectures and their instruction sets.

Grading through:

- written exam

Is requisite for:

- Embedded Systems (CS2101-KP04, CS2101)
- Computer Architecture (CS2100-KP04, CS2100SJ14)
- Fundamentals of Computer Engineering 2 (CS1202-KP06, CS1202)

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering
- Dr.-Ing. Kristian Ehlers

Literature:

- C. Hamacher, Z. Vranesic, S. Zaky, N. Manjikian: Computer Organisation and Embedded Systems - McGraw-Hill 2012
- M. M. Mano, C. R. Kime: Logic and Computer Design Fundamentals - Pearson 2007
- D. A. Patterson, J. L. Hennessy: Computer Organisation & Design - The Hardware/Software Interface - Morgan Kaufmann 2011
- T. Ungerer, U. Brinkschulte: Mikrocontroller und Mikroprozessoren - Springer 2010

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of practical exercises as specified at the beginning of the semester.

Module examination(s):
- CS1200-L1: Technical Foundations of Computer Science 1, written exam 120min, 100% of module grade.

CS3050-KP04, CS3050 - Coding and Security (CodeSich)

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

Course of study, specific field and term:

- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2019 (compulsory), Canonical Specialization Web and Data Science, 2nd semester
- Bachelor Computer Science 2019 (optional subject), Canonical Specialization SSE, 2nd semester
- Bachelor Media Informatics 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Robotics and Autonomous Systems 2020 (optional subject), computer science, 6th semester
- Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester
- Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2016 (optional subject), Canonical Specialization Web and Data Science, 2nd semester
- Bachelor Computer Science 2016 (optional subject), Canonical Specialization SSE, 2nd semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), computer science, 6th semester
- Bachelor IT-Security 2016 (compulsory), IT-Security, 4th semester
- Bachelor Medical Informatics 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor Media Informatics 2014 (optional subject), computer science, 5th or 6th semester
- Master CLS 2010 (optional suject), computer science, Arbitrary semester

Classes and lectures:

- Coding and Security (lecture, 2 SWS)
- Coding and Security (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- information, entropie
- discrete sources and channels
- coding systems, error-tolerant codes
- codes for digital media, compression
- threats to IT-systems
- formal definition of security properties
- security primitives

Qualification-goals/Competencies:

- The students can explain and apply the basics of information and coding theory
- They can explain the concept of information.
- They are able to model information sources and communication networks.
- They know the most important codes and are familiar with their specific design principles and properties.
- They know basic scenarios of attacks and protection methods.

Grading through:

- written exam

Requires:

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

Responsible for this module:

- Prof. Dr. Rüdiger Reischuk

Teacher:

- Institute for Theoretical Computer Science

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

Literature:

- D. Hoffmann: Einführung in die Informations- und Codierungstheorie - Springer Vieweg 2014

- D. Salomon: Coding for Data and Computer Communications - Springer 2005
- D. Salomon: Data Privacy and Security - Springer 2003
- M. Stamp: Information Security: Principles and Practice - Wiley 2006
- R. Roth: Introduction to Coding Theory - Cambridge Univ. Press 2006

Language:

- German and English skills required

Notes:

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

LS2500-KP04, LS2500 - Biology (Bio)

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

Course of study, specific field and term:

- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester
- Bachelor Computer Science 2019 (compulsory), Canonical Specialization Bioinformatics and Systems Biology, 2nd semester
- Bachelor Medical Informatics 2019 (optional subject), medical computer science, 4th to 6th semester
- Bachelor Computer Science 2016 (optional subject), advanced curriculum, Arbitrary semester
- Bachelor Computer Science 2016 (compulsory), Canonical Specialization Bioinformatics, 2nd semester
- Bachelor Computer Science 2014 (compulsory), specialization field bioinformatics, 2nd semester
- Bachelor MES 2011 (optional subject), medical engineering science (expiring), 4th semester
- Bachelor Computer Science 2012 (compulsory), specialization field bioinformatics, 4th semester

Classes and lectures:

- Biology for computer scientists (lecture, 2 SWS)
- Biology for computer scientists (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Structure and function of biological macromolecules
- structure of cells
- cytoskeleton
- chromosomes
- epigenetics
- replication
- transcription
- translation
- cell cycle
- mitosis
- formal genetics
- mutation and inherited disease
- multifactorial hereditary diseases
- viruses

Qualification-goals/Competencies:

- Students can explain and compare the construction principles of procaryotic and eukariotic cells.
- The can explain the function of cellular compartments of the cytoskeleton of eukariotic cells and deduce the evolutionary advantages.
- They can denote the molecular mechanisms of replication, transcription and translation and make the connections to cell physiology.
- The basic understanding of the cell cycle and formal genetics enalbles the students to comprehend the emergence of hereditary diseases and to explain concrete diseases.
- With their knowledge of basic biological relations the student can analyse biological data with algorithmic methods.

Grading through:

- written exam

Is requisite for:

- Molecular Genetics (LS3100-KP04, LS3100SJ14)

Responsible for this module:

- Prof. Dr. rer. nat. Enno Hartmann

Teacher:

- Institute for Biology

- Prof. Dr. rer. nat. Enno Hartmann
- PD Dr. rer. nat. Bärbel Kunze
- Prof. Dr. rer nat. Rainer Duden
- Dr. rer. nat. Nicole Sommer

Literature:

- Campbell & Reece: Biologie - Pearson
- Purves, Sadava, Orians, Heller: Biologie - Spektrum
- Markl: - Klett

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- For the preparation of the practical exercise, it is urgently required that participants register in the corresponding Moodle course by the beginning of the semester on 1 April.

Admission requirements for participation in module examination(s):
- Regular participation in the exercises as specified at the beginning of the semester.

Module Exam(s):
- LS2500-L1: Fundamentals of Biology, written exam, 60min, 100% of module grade.

Passing this module is a prerequisite for participation in the module LS3100-KP04 Molecular Genetics.

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

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written exam

Is requisite for:

- Image Registration (MA5030-KP05)
- Image Registration (MA5030-KP04, MA5030)
- Mathematical Methods of Image Processing (MA4500-KP05)
- Mathematical Methods in Image Processing (MA4500-KP04, MA4500)
- Optimization (Advanced Mathematics) (MA4031-KP08)

- Module part: Optimization (MA4030 T)
- Optimization (MA4030-KP08, MA4030)

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Jan Modersitzki

Teacher:

- Institute of Mathematics and Image Computing

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

Literature:

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

Language:

- offered only in German

Notes:

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

Prerequisites for the exam:
- Successful completion of homework assignments during the semester
- Successful completion of e-tests during the semester
- Presentation of homework assignment

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

CS1202-KP06, CS1202 - Fundamentals of Computer Engineering 2 (TGI2)

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

Course of study, specific field and term:

- Bachelor MES 2020 (compulsory), computer science, 5th semester
- Bachelor Media Informatics 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2019 (compulsory), foundations of computer science, 3rd semester
- Bachelor Robotics and Autonomous Systems 2020 (compulsory), computer science, 3rd semester
- Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester
- Bachelor Computer Science 2016 (compulsory), foundations of computer science, 3rd semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory), computer science, 3rd semester
- Bachelor Medical Informatics 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor Media Informatics 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor MES 2014 (compulsory), foundations of computer science, 5th semester
- Bachelor Computer Science 2014 (compulsory), foundations of computer science, 3rd semester
- Bachelor IT-Security 2016 (optional subject), specific, Arbitrary semester

Classes and lectures:

- Fundamentals of Computer Engineering 2 (lecture, 2 SWS)
- Fundamentals of Computer Engineering 2 (exercise, 2 SWS)

Workload:

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

Contents of teaching:

- Design of combinatorial circuits
- Design of sequential circuits
- Hardware description languages
- Register-transfer languages
- Data paths
- Control units
- Microprogramming
- CPUs
- Semiconductor components and circuit families
- Integrated circuits
- Programmable logic (CPLDs, FPGAs)
- CAD-tools for circuit design

Qualification-goals/Competencies:

- The students can formally describe and design combinatorial and sequential circuits on gate level.
- They can use hardware description languages, particularly VHDL, for the modelling of simple circuits.
- They can formally describe and design sequential circuits with control unit and data path on register-transfer level.
- They can exploit microprogramming for the realization of control units.
- They can design simple processors (CPUs).
- They can elucidate and judge the most important technologies for the realization of simple digital circuits (bipolar, MOS, CMOS).
- They can describe and judge integrated circuits, in particular programmable logic like FPGAs.
- They can use CAD-tools to design, to simulate and to implement digital circuits on FPGAs.

Grading through:

- written exam

Is requisite for:

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

Requires:

- Fundamentals of Computer Engineering 1 (CS1200-KP06, CS1200SJ14)

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering

- Dr.-Ing. Kristian Ehlers
- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- T.L. Floyd: Digital Fundamentals - A Systems Approach - Pearson 2012
- M. M. Mano, C. R. Kime: Logic and Computer Design Fundamentals - Pearson 2007
- C. H. Roth, L.L. Kinney: Fundamentals of Logic Design - Cengage Learning 2009

Language:

- offered only in German

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework assignments during the semester
- continuous, successful participation in practical course

CS2000-KP08, CS2000 - Theoretical Computer Science (TI)

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

Course of study, specific field and term:

- Bachelor Media Informatics 2020 (compulsory), computer science, 3rd semester
- Bachelor Computer Science 2019 (compulsory), foundations of computer science, 3rd semester
- Bachelor Robotics and Autonomous Systems 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Medical Informatics 2019 (compulsory), computer science, 3rd semester
- Bachelor Computer Science 2016 (compulsory), foundations of computer science, 3rd semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), computer science, 5th or 6th semester
- Bachelor IT-Security 2016 (compulsory), computer science, 3rd semester
- Bachelor MES 2011 (optional subject), computer science, 5th semester
- Bachelor Medical Informatics 2014 (compulsory), computer science, 3rd semester
- Bachelor Computer Science 2014 (compulsory), foundations of computer science, 3rd semester
- Bachelor Media Informatics 2014 (compulsory), computer science, 3rd semester
- Bachelor Medical Informatics 2011 (compulsory), computer science, 3rd semester
- Bachelor Computer Science 2012 (compulsory), foundations of computer science, 3rd semester

Classes and lectures:

- Theoretical Computer Science (lecture, 4 SWS)
- Theoretical Computer Science (exercise, 2 SWS)

Workload:

- 135 Hours private studies and exercises
- 90 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Formalization of problems using languages
- formal grammars
- regular languages, finite automata
- context free language, push down automata
- sequential computational models: Turing machines, register machines
- sequential complexity classes
- simulations, reductions, completeness
- satisfiability problem, NP-completeness
- (In-)decidability and enumerability
- halting problem and Church-Turing thesis

Qualification-goals/Competencies:

- Students are able to present the theoretical foundation of syntax and operational semantics of programming languages
- They are able to transform formalizations using theorems of theoretical computer science.
- They can classify problems according to their computational complexity
- They are able to model algorithmic problems and solve them using appropriate tools
- They can judge what computer science can and cannot achieve in principle

Grading through:

- written exam and course achievements

Is requisite for:

- Parallel Computing (CS3051-KP04, CS3051)

Requires:

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

Responsible for this module:

- Prof. Dr. Rüdiger Reischuk

Teacher:

- Institute for Theoretical Computer Science

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

Literature:

- J. Hopcroft, R. Motwani, J. Ullman: Introduction to Automata Theory, Languages and Computation - Addison Wesley, 2001

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None (the competences of the modules indicated under

CS2300-KP06, CS2300SJ14 - Software Engineering (SWEng14)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	each winter semester	6	12

Course of study, specific field and term:

- Bachelor Biophysics 2024 (optional subject), computer science, 5th semester
- Bachelor Media Informatics 2020 (compulsory), computer science, 3rd semester
- Bachelor Computer Science 2019 (compulsory), foundations of computer science, 3rd semester
- Bachelor Robotics and Autonomous Systems 2020 (compulsory), computer science, 3rd semester
- Bachelor Medical Informatics 2019 (compulsory), computer science, 3rd semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory), computer science, 3rd semester
- Bachelor IT-Security 2016 (compulsory), computer science, 3rd semester
- Bachelor Biophysics 2016 (optional subject), computer science, 5th semester
- Bachelor Computer Science 2016 (compulsory), foundations of computer science, 3rd semester
- Bachelor Media Informatics 2014 (compulsory), foundations of computer science, 3rd semester
- Bachelor Medical Informatics 2014 (compulsory), computer science, 3rd semester
- Bachelor Computer Science 2014 (compulsory), foundations of computer science, 3rd semester

Classes and lectures:

- Software Engineering (lecture, 3 SWS)
- Software Engineering (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- overview on major fields of software engineering
- Software development, software process models
- Project plan and workload estimation
- Software management and quality assurance
- System Analysis and requirements analysis
- Basics of UML
- Software architectures and design patterns
- Validation and verification
- Legal aspects: copyright, standards, liability, licenses

Qualification-goals/Competencies:

- The students understand software design as an engineering process.
- They can argue about major software process models.
- They can explain important techniques and factors of software management.
- They can describe and evaluate measures for quality ensurance.
- They are able to model software systemson different levels of abtraction.
- They can apply the basic concepts of object-oriented modelling and design.
- They are able to apply design patterns in a useful way.
- They can discuss about legal aspects of software development.

Grading through:

- Written or oral exam as announced by the examiner

Is requisite for:

- Safe Software (CS3250-KP08)
- Lab Course Software Engineering (CS2301-KP06, CS2301)

Requires:

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

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages

- Prof. Dr. Martin Leucker
- Prof. Dr. Diedrich Wolter

Literature:

- H. Balzert: Lehrbuch der Software-Technik: Software-Entwicklung - Spektrum Akademischer Verlag 2001
- B. Brügge, A. H. Dutoit: Objektorientierte Softwaretechnik mit UML, Entwurfsmustern und Java - Pearson Studium 2004
- I. Sommerville: Software Engineering - Addison-Wesley 2006
- B. Oestereich: Analyse und Design mit der UML 2.1 - Objektorientierte Softwareentwicklung - Oldenbourg 2006
- D. Bjorner: Software Engineering 1-3 - Springer 2006

Language:

- offered only in German

Notes:

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

Admission requirements for participation in module examination(s):
- Successful completion of exercises as specified at the beginning of the semester.

Module exam(s):
- CS2300-L1: Software Engineering, written exam, 90min, 100% of the module grade.

Passing this module is a formal requirement for participation in the module CS2301-KP06 Lab Course Software Engineering. It is recommended to do the internship directly in the following semester.

CS2450-KP02, CS2450 - Tools for scientific practice (Werkzeuge)

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

Course of study, specific field and term:

- Bachelor Interdisciplinary Courses for health sciences (optional subject), interdisciplinary competence, Arbitrary semester
- Bachelor Computer Science 2019 (compulsory), interdisciplinary competence, 3rd semester
- Bachelor Medical Informatics 2014 (optional subject), interdisciplinary competence, Arbitrary semester
- Bachelor Medical Informatics 2019 (optional subject), interdisciplinary competence, Arbitrary semester
- Bachelor Computer Science 2016 (compulsory), interdisciplinary competence, 3rd semester
- Bachelor Interdisciplinary Courses (optional subject), Interdisciplinary modules, Arbitrary semester
- Bachelor Media Informatics 2014 (optional subject), interdisciplinary competence, 5th or 6th semester
- Bachelor Computer Science 2014 (compulsory), interdisciplinary competence, 3rd semester

Classes and lectures:

- Tools for scientific practice (seminar-style lectures, 2 SWS)

Workload:

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

Contents of teaching:

- Programming language Python
- Markup languages (LaTeX, Markdown)
- User Interfaces and Integrated Development Environments (Jupyter Notebook)
- Software for version control (git)
- digital libraries search (DBLP, ACM, IEEE)Scientific Computing (NumPy, SciPy)
- Data processing and visualization (Pandas, matplotlib, NLTK)
- Machine Learning (scikit-learn)
- DeepLearning (Tensorflow, PyTorch)

Qualification-goals/Competencies:

- The students know diverse technical tools for scientific work.
- They can apply important technical tools from the Python Ecosystem.
- They can handle version control and markup languages.
- They are able to select appropriate tools.

Grading through:

- exercises and project assignments

Is requisite for:

- Bachelor Thesis Computer Science (CS3990-KP15, CS3990)
- Bachelor Project Computer Science (CS3701-KP05, CS3701SJ14)
- Bachelor Seminar Informatics (CS3702-KP04, CS3702)

Responsible for this module:

- Studiengangsleitung Informatik

Teacher:

- Institute of Computer Engineering

- Alle prüfungsberechtigten Dozentinnen/Dozenten des Studienganges

Language:

- German and English skills required

Notes:

Prerequisites for attending the module:
- None

CS2700-KP04, CS2700 - Databases (DB)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written exam

Is requisite for:

- Nonstandard Databases and Data Mining (CS3130-KP08)

- Nonstandard Database Systems (CS3202-KP04, CS3202)

Requires:

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

Responsible for this module:

- Prof. Dr. Sven Groppe

Teacher:

- Institute of Information Systems
- Prof. Dr. Sven Groppe

Literature:

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

Language:

- offered only in German

Notes:

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

Admission requirements for participation in module examination(s):
- Successful completion of exercise sheets as specified at the beginning of the semester.

Module Exam(s):
- CS2700-L1: Databases, written exam, 90min, 100% of the module grade.

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

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Written or oral exam as announced by the examiner

Requires:

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

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages

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

Literature:

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

Language:

- German and English skills required

Notes:

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

LS1100-KP04 - General Chemistry (ACKP04)

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

Course of study, specific field and term:

- Bachelor CLS 2023 (compulsory), life sciences, 3rd semester
- Bachelor Biophysics 2024 (compulsory), life sciences, 1st semester
- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester
- Bachelor Computer Science 2019 (optional subject), Canonical Specialization Bioinformatics and Systems Biology, 3rd semester
- Bachelor MES 2020 (optional subject), mathematics / natural sciences, 3rd semester at the earliest
- Bachelor Medical Informatics 2019 (optional subject), medical computer science, 4th to 6th semester
- Bachelor Computer Science 2016 (optional subject), advanced curriculum, Arbitrary semester
- Bachelor Medical Informatics 2014 (optional subject), medical computer science, 5th or 6th semester
- Bachelor Computer Science 2016 (optional subject), Canonical Specialization Bioinformatics, 3rd semester
- Bachelor CLS 2016 (compulsory), life sciences, 3rd semester
- Bachelor Biophysics 2016 (compulsory), life sciences, 1st semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Lectures:
- The structure of atoms and the periodic table of the elements
- Chemical bonds, molecules and Ions
- Reaction equations and stoichiometry
- The threedimensional structure of molecules: From the VSEPR model to molecular orbitals
- Special properties of water
- Chemical equilibrium
- Acids and bases
- Redox reactions and electrochemistry
- Complexes and metal-ligand bonds
- Interactions between mater and radiation - Molecular spectroscopy
- Thermodynamics
- Chemical kinetics
- Roles of Environmental and occupational health and safety in the handling of hazardous materials (Globally Harmonized System of Classification and Labeling of Chemicals (GHS)) and of GSP of the University of Lübeck and of the DFG-guidelines
- Exercises:
- Students discuss problems covering all topics of the lectures on the black board

Qualification-goals/Competencies:

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

Grading through:

- written exam

Is requisite for:

- Practical Course Chemistry (LS1610-KP04)
- Organic Chemistry (LS1600-KP04)

Responsible for this module:

- PD Dr. phil. nat. Thomas Weimar

Teacher:

- Institute of Chemistry and Metabolomics

- PD Dr. phil. nat. Thomas Weimar

Literature:

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

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of homework assignments as specified at the beginning of the semester

Modul exam(s):
- LS1100-L1: General Chemistry, written exam, 90 min, 100% of module grade

LS3100-KP04, LS3100SJ14 - Molecular Genetics (MolGen)

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

Course of study, specific field and term:

- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester
- Bachelor Computer Science 2019 (compulsory), Canonical Specialization Bioinformatics and Systems Biology, 3rd semester
- Bachelor Medical Informatics 2019 (optional subject), medical computer science, 4th to 6th semester
- Bachelor Computer Science 2016 (optional subject), advanced curriculum, Arbitrary semester
- Bachelor Computer Science 2016 (optional subject), advanced curriculum, Arbitrary semester
- Bachelor Computer Science 2016 (compulsory), Canonical Specialization Bioinformatics, 6th semester
- Bachelor Medical Informatics 2014 (optional subject), medical computer science, 5th or 6th semester
- Bachelor Computer Science 2014 (compulsory), specialization field bioinformatics, 5th semester

Classes and lectures:

- Molecular genetics for computer scientists (lecture, 1 SWS)
- Molecular genetics for computer scientists (exercise, 2 SWS)

Workload:

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

Contents of teaching:

- Structure of DNA
- Causes of mutations
- Generation of genetically modified bacteria (Designs of the experiment at the computer, isolation of DNA, restriction cutting of DNA, PCR, ligation of DNA into plasmids, transformation of bacteria, restriction analysis, sequencing of DNA)
- Molecular evolution of DNA and its analysis by bioinformatical methods

Qualification-goals/Competencies:

- Students can pan a cloning experiment unassisted.
- They can conduct basic molecular-genetic process steps unassisted.
- They can evaluate the single steps of an experiment, prepare necessary control steps and analyse errors.
- They can prepare a scientific protocol.
- They can explain the structure of DNA, its molecular evolution, the cause of mutations and cellular repair mechanisms in a detailed way.
- They can explain the origin of biological data and analyse these data with methods from bioinformatics.

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Biology (LS2500-KP04, LS2500)

Responsible for this module:

- PD Dr. rer. nat. Bärbel Kunze

Teacher:

- Institute for Biology

- PD Dr. rer. nat. Bärbel Kunze
- Prof. Dr. rer. nat. Enno Hartmann
- Dr. rer. nat. Nicole Sommer

Literature:

- Campbell & Reece: Biologie - Pearson
- Purves, Sadava, Orians, Heller: Biologie - Spektrum
- Markl: Biologie - Klett
- T.A. Brown: Gentechnologie für Einsteiger - Spektrum

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- LS2500-KP04 Fundamentals of Biology successfully completed

Admission requirements for participation in module examination(s):
- Regular participation in the exercise sessions as specified at the beginning of the course
- Submission of a complete experimental protocol as specified at the beginning of the course

Module Exam(s):
- LS3100-L1: Molecular Genetics, written exam, 90min, 100% of module grade.

Block course at the end of the winter semester. Registration for the module by 15 January, limited number of participants.

For students in the study programme Medical Informatics according to older regulations, the submodule MZ2100E 'Cell Biology and Genetics' is a prerequisite for taking this module instead of LS2500-KP04.

Translated with www.DeepL.com/Translator (free version)

CS2100-KP04, CS2100SJ14 - Computer Architecture (RA14)

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

Course of study, specific field and term:

- Bachelor Media Informatics 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2019 (compulsory), foundations of computer science, 4th semester
- Bachelor Robotics and Autonomous Systems 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester
- Bachelor Computer Science 2016 (compulsory), foundations of computer science, 4th semester
- Bachelor Robotics and Autonomous Systems 2016 (optional suject), computer science, 4th semester
- Bachelor IT-Security 2016 (compulsory), computer science, 4th semester
- Bachelor Medical Informatics 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2014 (compulsory), foundations of computer science, 4th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Basic terms and concepts
- Processor architectures
- Computer components
- Parallel computer architectures
- Multiprocessors, multicomputer
- Vector processors, array processors
- Performance evaluation

Qualification-goals/Competencies:

- The students are able to elucidate the microarchitecture of modern processors and the corresponding methods for performance enhancement (caches, pipelining, VLIW, multi/manycore, virtualization etc.).
- They are able to explain important computer components (busses, storage hierachies, I/O-units).
- They are able to discuss and compare the most important parallel computer architectures (multiprocessors, multicomputers, vector computers, array computers etc.).
- They are able to judge and make use of methods for performance evaluation (benchmarks, monitoring, queuing models etc.).

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Fundamentals of Computer Engineering 1 (CS1200-KP06, CS1200SJ14)

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering

- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- J.L. Hennessy, D.A. Patterson: Computer Architecture - A Quantitative Approach - Morgan Kaufmann 2011
- D.A. Patterson, J.L. Hennessy: Rechnerorganisation und -entwurf - Die Hardware/Software-Schnittstelle - Pearson Studium 2012
- W. Stallings: Computer Organization and Architecture - Pearson Education 2012
- A.S. Tanenbaum, T. Austin: Structured Computer Organization - Pearson Education 2012

Language:

- offered only in German

Notes:

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

CS2150-KP08, CS2150SJ14 - Operating Systems and Networks (BSNetze14)

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

Course of study, specific field and term:

- Bachelor Media Informatics 2020 (compulsory), computer science, 4th semester
- Bachelor Computer Science 2019 (compulsory), foundations of computer science, 4th semester
- Bachelor Robotics and Autonomous Systems 2020 (compulsory), computer science, 4th semester
- Bachelor Medical Informatics 2019 (compulsory), computer science, 4th semester
- Bachelor Computer Science 2016 (compulsory), foundations of computer science, 4th semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory), computer science, 4th semester
- Bachelor IT-Security 2016 (compulsory), computer science, 4th semester
- Bachelor Media Informatics 2014 (compulsory), foundations of computer science, 4th semester
- Bachelor Medical Informatics 2014 (compulsory), computer science, 4th semester
- Bachelor Computer Science 2014 (compulsory), foundations of computer science, 4th semester

Classes and lectures:

- Operating Systems and Networks (lecture, 4 SWS)
- Operating Systems and Networks (exercise, 2 SWS)

Workload:

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

Contents of teaching:

- Tasks and Structure
- Historical Overview of Computer and Operating Systems
- Coding of Symbols and Numbers
- Foundations of Operating Systems
- Processes, Inter-Process Communication and Process Management
- Storage Management
- Input / Output
- Files and File Systems
- Examples (UNIX, Windows, mobile OS)
- Computer Networks and the Internet
- Application Layer
- Transport Layer
- Network Layer
- Link and Physical Layer

Qualification-goals/Competencies:

- Students know about the main concepts of operating systems.
- Students are able to judge, which OS concepts can be appropriately applied to novel computing architectures.
- Students are able to apply the most important strategies and algorithms for operating systems.
- At the end of the course, students know the most important concepts ofcomputer networks
- Students know the importance of the different layers of the OSI andInternet protocol suite along with the most important protocols and services of each layer
- The students are able decide which network technologies to use to meetthe requirements of any given application scenario
- The students know how the Internet works and are able to program smallapplications
- Students can apply the most important methods and algorithms from thefield of networks

Grading through:

- written exam

Responsible for this module:

- Prof. Dr. Stefan Fischer

Teacher:

- Institute of Telematics

- Prof. Dr. Stefan Fischer

- Dr. rer. nat. Florian-Lennert Lau

Literature:

- Andrew S. Tanenbaum: Moderne Betriebssysteme - 3., aktualisierte Auflage, Pearson, April 2009
- James Kurose, Keith Ross: Computer Networking - Der Top-Down-Ansatz - Pearson Studim, 2012
- Andrew S. Tanenbaum: Computernetzwerke - Pearson Studium, 2012

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise assignments as specified at the beginning of the semester.

Module Exam(s):
- CS2150-L1: Operating Systems and Networks, written exam, 90min, 100% of the module grade.

CS2250-KP04 - Cybersecurity (CyberSec04)

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

Course of study, specific field and term:

- Bachelor MES 2020 (optional subject), computer science / electrical engineering, 3rd semester at the earliest
- Bachelor Media Informatics 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2019 (compulsory), foundations of computer science, 4th semester
- Bachelor Robotics and Autonomous Systems 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Security problems in IT systems
- Security threats, risk analysis and defense mechanisms
- Software and application security
- Security of operating systems
- Security of databases and web applications
- Privacy
- Security oriented development, evaluation and penetration testing
- Legal, etical and economic aspects

Qualification-goals/Competencies:

- Students can independently identify security risks of software systems and explain the common security solutions from the areas discussed in the course.
- They can explain the basic methods in the area of cybersecurity and apply them to case studies.
- They can independently perform security analyses for simple scenarios.
- They are able to identify methods for eliminating weak points and implement concrete solutions.

Grading through:

- portfolio exam

Responsible for this module:

- Prof. Dr.-Ing. Thomas Eisenbarth

Teacher:

- Institute for IT Security

- Prof. Dr.-Ing. Thomas Eisenbarth

Literature:

- C. Paar, J. Pelzl: Understanding Cryptography - Springer, 2008
- D. Gollmann: Computer Security - Third Edition, Wiley, 2011
- R. Anderson: Security Engineering - Second Edition, Wiley, 2008
- M. Bishop: Introduction to Computer Security - Addison-Wesley, 2005

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- See portfolio

Module Exam(s):
- CS2250-L1 Cybersecurity, Portfolio examination, the specific examination elements and their weighting will be announced at the beginning of the semester, 100% of the module grade

The courses of this module are also part of CS2250-KP08.

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CS2251-KP04 - Cybersecurity Internship (CyberSecPr)

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

Course of study, specific field and term:

- Bachelor Robotics and Autonomous Systems 2016 (optional subject), Additionally recognized elective module, 4th or 6th semester
- Bachelor Robotics and Autonomous Systems 2020 (optional subject), Additionally recognized elective module, 4th or 6th semester
- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, 4th semester
- Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester

Classes and lectures:

- Practical Course Cybersecurity (practical course, 3 SWS)

Workload:

- 50 Hours work on project
- 40 Hours in-classroom work
- 30 Hours group work

Contents of teaching:

- Practical exploitation of security vulnerabilities in various fields of application
- Conduct of risk analyses and implementation of defensive measures
- Analysis of security requirements in a complex use case
- Design, realization, and analysis of a state-of-the-art security solution
- Discussion about attacker motivation, protective measures, and impact of attacks
- Getting acquainted with penetration testing tools

Qualification-goals/Competencies:

- Students can explain the basic methods in the field of cybersecurity and apply them to case studies.
- They can independently perform security analyses for simple scenarios.
- They are able to identify weak points and develop concrete solutions to eliminate them.

Grading through:

- continuous, successful participation in practical course
- project work

Responsible for this module:

- Prof. Dr.-Ing. Thomas Eisenbarth

Teacher:

- Institute for IT Security

- Dr.-Ing. Jan Wichelmann

Literature:

- D. Gollmann: Computer Security, Third Edition, Wiley, 2011 - Third Edition, Wiley, 2011
- R. Anderson: Security Engineering - Second Edition, Wiley, 2008
- C. Kaufman, R. Perlman, and M. Speciner: Network security: private communication in a public world - Second Edition, Prentice Hall, 2002
- W. Du: W. Du: Computer Security: A Hands-on Approach - First Edition, CreateSpace Independent Publishing Platform, 2017

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- None

Module Exam(s):
- CS2251-L1 Practical Cybersecurity, ungraded practical, 100% of (non-existent) module grade.

The course is limited to 60 places; compulsory participants will be given priority; allocation of further places according to registration order in Moodle;

Participation is only possible if CS2250-KP04 Cybersecurity is taken in parallel or has already been taken. Parallel enrollment is recommended.

The courses of this module are also part of CS2250-KP08.

(Share of Institute for IT Security in P is 100%)

CS2301-KP06, CS2301 - Lab Course Software Engineering (SWEngPrakt)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	each summer semester	6 (Typ A)	12

Course of study, specific field and term:

- Bachelor Media Informatics 2020 (compulsory), computer science, 4th semester
- Bachelor Computer Science 2019 (compulsory), foundations of computer science, 4th semester
- Bachelor Robotics and Autonomous Systems 2020 (compulsory), computer science, 4th semester
- Bachelor Medical Informatics 2019 (compulsory), computer science, 4th semester
- Bachelor Computer Science 2016 (compulsory), foundations of computer science, 4th semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory), computer science, 4th semester
- Bachelor IT-Security 2016 (compulsory), computer science, 4th semester
- Bachelor Media Informatics 2014 (compulsory), foundations of computer science, 4th semester
- Bachelor Medical Informatics 2014 (compulsory), computer science, 4th semester
- Bachelor Computer Science 2014 (compulsory), foundations of computer science, 4th semester

Classes and lectures:

- Lab Course Software Engineering (practical course, 4 SWS)

Workload:

- 60 Hours in-classroom work
- 60 Hours group work
- 50 Hours work on project
- 10 Hours oral presentation and discussion (including preparation)

Contents of teaching:

- Realization of a software system
- Project management and team work
- Design, implementation and testing

Qualification-goals/Competencies:

- The students are able to systematically design software systems whose implemention meets the requirements, using object oriented techniques.
- They can use UML and CASE tools.
- They can decide how to advance their software in a sensible way.
- They can contribute their experience in the realization of a software development project in further projects.
- They have the qualification to present artefacts, to comply tostandards and to observe time limits.
- They are qualified to work in a team and to reflect their social skills.

Grading through:

- continuous, successful participation in practical course
- presentation
- successful addressing of the project goals
- documentation

Requires:

- Introduction to Programming (CS1000-KP10, CS1000SJ14)
- Algorithms and Data Structures (CS1001-KP08, CS1001)
- Software Engineering (CS2300-KP06, CS2300SJ14)

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages

- Prof. Dr. Martin Leucker

Literature:

- H. Balzert: Lehrbuch der Softwaretechnik: Softwaremanagement - Spektrum Akademischer Verlag 2008

- B. Brügge, A. H. Dutoit: Objektorientierte Softwaretechnik mit UML, Entwurfsmustern und Java - Pearson Studium 2004
- I. Sommerville: Software Engineering - Addison-Wesley 2012
- B. Oestereich: Analyse und Design mit der UML 2.3 - Objektorientierte Softwareentwicklung - Oldenbourg 2009

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- Passing the module CS2300-KP06 Software Engineering is a prerequisite for taking this module.

It is recommended to take this practical course directly after CS2300-KP06 Software Engineering.

Admission requirements for participation in module examination(s):
- Successful participation in the internship as specified at the beginning of the semester.

Module Exam(s):
- CS2301-L1: Internship Software Engineering, graded internship, 100% of module grade.

CS3051-KP04, CS3051 - Parallel Computing (ParallelVa)

Duration:	Turnus of offer:	Credit points:
1 Semester	normally each year in the summer semester	4

Course of study, specific field and term:

- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2019 (optional subject), Canonical Specialization SSE, 4th semester
- Bachelor Media Informatics 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Robotics and Autonomous Systems 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2016 (optional subject), Canonical Specialization Web and Data Science, 4th semester
- Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2016 (optional subject), Canonical Specialization SSE, 4th semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), computer science, 5th or 6th semester
- Bachelor IT-Security 2016 (optional subject), computer science, Arbitrary semester
- Master Medical Informatics 2014 (optional subject), computer science, 1st or 2nd semester
- Bachelor Computer Science 2014 (optional subject), central topics of computer science, 5th or 6th semester
- Master Computer Science 2012 (optional subject), advanced curriculum programming, 2nd and 3rd semester
- Bachelor Computer Science 2012 (optional subject), central topics of computer science, 5th or 6th semester
- Master Computer Science 2012 (optional subject), advanced curriculum algorithmics and complexity theory, 2nd or 3rd semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Parallel architectures
- Programming language support for parallel programming
- Design methodologies for parallel algorithms
- Implementation of parallel algorithms
- Parallel search and sorting
- Parallel graph algorithms
- Parallel formula evaluation
- Speedup, efficiency, parallel complexity classes
- Limits of parallelism and lower bounds

Qualification-goals/Competencies:

- Studentes are able to describe the design and function of parallel systems.
- They are able to design and implement parallel algorithms.
- They are able to analyze parallel systems and programs.
- They are able to describe the limits of parallel systems.

Grading through:

- Viva Voce or test

Requires:

- Theoretical Computer Science (CS2000-KP08, CS2000)

Responsible for this module:

- Prof. Dr. rer. nat. Till Tantau

Teacher:

- Institute for Theoretical Computer Science

- Prof. Dr. rer. nat. Till Tantau

Literature:

- Jaja: An Introduction to Parallel Algorithms - Addison Wesley, 1992

- Quinn: Parallel Programming in C with MPI and OpenMP - McGraw Hill, 2004

Language:

- offered only in German

Notes:

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

CS3055-KP04 - Logic Programming (LoPro)

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

Course of study, specific field and term:

- Bachelor IT-Security 2016 (optional subject), specific, Arbitrary semester
- Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2014 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2019 (compulsory), Canonical Specialization Web and Data Science, 4th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Logical foundations: First-order logic (syntax, semantics, resolution, ...),Datalog (syntax, semantics, evaluation strategies, magic-sets)
- Logic programming in Prolog:syntax,semantics,recursive data structures,difference lists,DCGs,Application: natural language processing (NLP)
- Answer Set Programming (ASP):syntax,semantics (sable models),applications
- Constraint programming:Theoretical foundations,Constraint Programming in Prolog and ASP
- Outlook: Probabilistic Logic programming,Prolog and ASP for Data Science: Generating relational annotations:Relational learning

Qualification-goals/Competencies:

- For each of the mentioned themes in the contents of teaching the students are able to explain the central ideas, are able to define the relevant concepts and are able to explain how the learned algorithms work in concrete application scenarios.

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Databases (CS2700-KP04, CS2700)
- Introduction to Logics (CS1002-KP04, CS1002)
- Algorithms and Data Structures (CS1001-KP08, CS1001)

Responsible for this module:

- Prof. Dr. Diedrich Wolter

Teacher:

- Institute of Software Technology and Programming Languages

- Prof. Dr. Diedrich Wolter

Literature:

- Bratko: Prolog programming for artificial intelligence - Addison Wesley, 2011
- Clocksin, Mellish: Programming in Prolog - Springer, 2003
- Baral: Knowledge representation reasoning and declarative problem solving - CUP, 2003
- Gebser, Kaminski, Kaufmann, Schaub: Answer Set Solving in Practice - Morgan/Claypool Publishers, 2012
- Apt: Principles of constraint programming - Cambridge, 2003
- De Raedt: Logical relational learning - Springer, 2008

Language:

- offered only in German

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework assignments during the semester.

MA2510-KP04, MA2510 - Stochastics 1 (Stoch1)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written exam

Is requisite for:

- Stochastic processes (MA4610-KP05)
- Stochastic processes and modeling (MA4610-KP04, MA4610)
- Modeling Biological Systems (MA4450-KP08, MA4450-MML)
- Modeling Biological Systems (MA4450-KP07)
- Module part: Modeling Biological Systems (MA4450 T-INF)
- Module part: Modeling Biological Systems (MA4450 T)
- Modeling Biological Systems (MA4450)
- Modeling (MA4449-KP07)

- Module part: Stochastics 2 (MA4020 T)
- Stochastics 2 (MA4020-KP05)
- Stochastics 2 (MA4020-MML)
- Stochastics 2 (MA4020-KP04, MA4020)

Responsible for this module:

- Nachfolge von Prof. Dr. rer. nat. Karsten Keller

Teacher:

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

Literature:

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

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None

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

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

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:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written exam

Requires:

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

Responsible for this module:

- Prof. Dr. Rüdiger Reischuk

Teacher:

- Institute for Theoretical Computer Science

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

Literature:

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

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

Language:

- offered only in German

Notes:

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

Prerequisites for the exam:
- Successful completion of homework and project assignments as specified at the beginning of the semester.

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

CS3010-KP04, CS3010 - Human-Computer-Interaction (MCI)

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

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (optional subject), interdisciplinary competence, Arbitrary semester
- Bachelor Computer Science 2019 (compulsory), foundations of computer science, 5th semester
- Bachelor Robotics and Autonomous Systems 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester
- Master Biophysics 2019 (optional subject), Elective, 1st semester
- Master Psychology 2016 (optional subject), interdisciplinary competence, 3rd semester at the earliest
- Bachelor Computer Science 2016 (compulsory), foundations of computer science, 5th semester
- Bachelor IT-Security 2016 (compulsory), computer science, 3rd semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), computer science, 5th or 6th semester
- Master Entrepreneurship in Digital Technologies 2014 (optional subject), interdisciplinary competence, Arbitrary semester
- Master psychology 2013 (optional subject), interdisciplinary competence, 3rd semester
- Master Medical Informatics 2014 (optional subject), computer science, 1st or 2nd semester
- Bachelor Computer Science 2014 (compulsory), foundations of computer science, 5th semester
- Bachelor Medical Informatics 2014 (optional subject), computer science, 5th or 6th semester

Classes and lectures:

- Human-Computer-Interaction (lecture, 2 SWS)
- Human-Computer-Interaction (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Introduction and overview of the topic area
- Norms and legal foundations
- Human information processing and processes of actions
- Models for human-computer systems and interactive media
- Input/Output devices and interaction technologies
- User-centered development process and special groups of users
- Usability Engineering
- System paradigms and corresponding system examples
- Evaluation and impact analyzes
- Innovative concepts and systems

Qualification-goals/Competencies:

- The students know the principles and methods of the context-, task- and user-centered development of interactive systems.
- They have basic knowledge about human information processing and can introduce it into the design process.
- They know the basic models of interactive systems und can apply them for their analysis and evaluation.
- They have the ability to analyze and review interative systems based on criteria.

Grading through:

- written exam

Responsible for this module:

- Prof. Dr. phil. André Calero Valdez

Teacher:

- Institute for Multimedia and Interactive Systems

- Prof. Dr. phil. André Calero Valdez

Literature:

- M. Dahm: Grundlagen der Mensch-Computer-Interaktion - Pearson Studium, 2006
- J.A. Jacko: The Human-Computer Interaction Handbook - CRC Press, 2012

Language:

- offered only in German

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework assignments as stated in the beginning of the course

Exam(s):
- CS3010-L1 Mensch-Computer-Interaktion, Klausur, 90min, 100% der Modulnote

CS3060-KP04 - Extension of the Bachelor Project Computer Science (ExtBacProj)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	each winter semester	4 (Typ B)	12

Course of study, specific field and term:

- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, 5th semester
- Bachelor Computer Science 2019 (compulsory), Canonical Specialization SSE, 5th semester
- Bachelor Computer Science 2016 (optional subject), advanced curriculum, 5th semester
- Bachelor Computer Science 2016 (compulsory), Canonical Specialization SSE, 5th semester

Classes and lectures:

- Extension of the Bachelor Project Computer Science (programming project, 4 SWS)

Workload:

- 60 Hours in-classroom work
- 30 Hours work on project
- 20 Hours group work
- 5 Hours written report
- 5 Hours oral presentation (including preparation)

Contents of teaching:

- In addition to CS3701-KP05 Bachelor project Computer Science
- Risk management
- Applying measures for quality enhancement

Qualification-goals/Competencies:

- In addition to CS3701-KP05 Bachelor project Computer Science
- The students can master the complexity of hardware / software projects.
- They can assess additional challanges for complex projects and can apply adequate measures to cade these challenges.
- They can motivate and apply procedures for quality enhancement.

Grading through:

- oral presentation
- Written report
- successful addressing of the project goals

Requires:

- Lab Course Software Engineering (CS2301-KP06, CS2301)
- Software Engineering (CS2300-KP06, CS2300SJ14)
- Theoretical Computer Science (CS2000-KP08, CS2000)
- Algorithms and Data Structures (CS1001-KP08, CS1001)
- Introduction to Programming (CS1000-KP10, CS1000SJ14)

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages

- Prof. Dr. Martin Leucker

Literature:

- In addition to the literature from CS3701-KP05 Bachelor project Computer Science::
- H. Balzert: Lehrbuch der Software-Technik: Software-Management, Software Qualitätssicherung
- B. Boehm: Software Engineering Economics - Prentice Hall 1981
- T. DeMarco: Controlling Software Projects - Prentice Hall 1986
- M. Burhardt: Einführung in das Projektmanagement - Publicis 2002

Language:

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

Notes:

This extension module can only be undertaken in combination with the module CS3701-KP05 Bachelor project Computer Science.

Prerequisites for attending the module:
- s. CS3701-KP05 Bachelor Project Computer Science

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:

- Master CLS 2023 (compulsory), mathematics, 1st semester
- Bachelor Biophysics 2024 (compulsory), computer science, 5th semester
- Bachelor Robotics and Autonomous Systems 2020 (compulsory), Robotics and Autonomous Systems, 5th semester
- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2019 (compulsory), Canonical Specialization Bioinformatics and Systems Biology, 5th semester
- Bachelor MES 2020 (compulsory), computer science, 5th semester
- Bachelor Media Informatics 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester
- Bachelor Computer Science 2014 (compulsory), specialization field robotics and automation, 5th semester
- Bachelor Computer Science 2014 (compulsory), specialization field bioinformatics, 5th semester
- Bachelor Computer Science 2016 (compulsory), Canonical Specialization Bioinformatics, 5th semester
- Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2016 (compulsory), Canonical Specialization Web and Data Science, 5th semester
- Master CLS 2016 (compulsory), mathematics, 1st semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory), Robotics and Autonomous Systems, 5th semester
- Bachelor IT-Security 2016 (optional subject), computer science, Arbitrary semester
- Bachelor Biophysics 2016 (compulsory), computer science, 5th semester
- Bachelor Medical Informatics 2014 (compulsory), computer science, 5th semester
- Bachelor MES 2014 (compulsory), computer science, 5th semester
- Bachelor Media Informatics 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2014 (optional subject), central topics of computer science, 5th 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
- 2D Sampling
- Image enhancement
- Edge detection
- Multiresolution concepts: Gaussian and Laplacian Pyramid, wavelets
- Principles of image compression
- Segmentation
- Morphological image processing

- Students work self-actingly and independently with regard to the roles of GSP of the University of Lübeck.

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:

- written exam

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

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework assignments during the semester (at least 50% of max. points).

Module exam:
- CS3100-L1: Signal Processing, written exam, 90 min, 100% of module grade

CS3130-KP08 - Nonstandard Databases and Data Mining (NDBDM)

Duration:	Turnus of offer:	Credit points:
1 Semester	not available anymore	8

Course of study, specific field and term:

- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2019 (compulsory), Canonical Specialization Web and Data Science, 5th semester
- Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester
- Bachelor Media Informatics 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor IT-Security 2016 (optional subject), computer science, Arbitrary semester
- Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2016 (compulsory), Canonical Specialization Web and Data Science, 5th semester

Classes and lectures:

- Nonstandard Databases and Data Mining (lecture, 4 SWS)
- Nonstandard Databases and Data Mining (exercise, 2 SWS)

Workload:

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

Contents of teaching:

- Semi-structured data models (JSON, XML) and full text queries
- Information Retrieval
- Multidimensional index structures
- Clustering
- Embedding techniques
- first-n, top-k, and skyline queries
- Probabilistic databases, query response, query transformation, safe plan query, top-k queries (Monte Carlo simulation, Luby-Karp method, multi-simulation), open-world acceptance
- Probabilistic modeling, Bayesian networks, query response algorithms, learning methods for models
- Temporal databases and the relational model
- Probabilistic Temporal Databases
- SQL: new developments (e.g. JSON structures and arrays), time series (e.g. TimescaleDB)
- Stream databases, principles of window-oriented incremental processing
- Approximation techniques for stream data processing, stream mining
- Probabilistic spatiotemporal databases and stream data processing systems: queries and index structures, spatiotemporal data mining, probabilistic skylines
- From NoSQL to NewSQL databases, graph data in SQL, CAP theorem, CALM theorem, blockchain databases

Qualification-goals/Competencies:

- Knowledge: Students can name the main features of standard databases and, in addition, can explain which nonstandard database models emerge if certain features are dropped. Students can describe the main ideas behind nonstandard databases presented in the course by explaining the main features of respective query languages (syntax and semantics) as well as the most important implementation techniques used for their practical realization.
- Skills: Students can apply query languages for nonstandard data models introduced in the course to retrieve desired structures from sample datasets for satisfying human information needs. Students will be enabled to represent data in the relational data model using encoding techniques presented in the course such that they can demonstrate how new formalisms relate to or can be implemented in SQL (SQL-2011). In case an SQL transformation cannot be found, students can explain and apply dedicated algorithms for query answering. Students can demonstrate how index structures help answering queries fast by showing how index structures are built, updated, and exploited for query answering. The participants of the course can derive query answers by evaluating queries step by step and by deriving optimized query execution plans.
- Social skills: Students work in teams to handle assignments, and they are encouraged to present their solution to other students in small presentations (in lab classes). In addition, self-dependence is fostered by giving pointers to query evaluation engines for various formalism presented in the lecture such that students get familiar with data models and query languages by self-controlled work.

Grading through:

- written exam

Requires:

- Databases (CS2700-KP04, CS2700)

Responsible for this module:

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

Teacher:

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

Literature:

- S. Abiteboul, P. Buneman, D. Suciu: Data on the Web - From Relations to Semistructured Data and XML - Morgan-Kaufmann, 1999
- Ch. Aggarwal: Data Mining - The Textbook - Springer, 2015
- S. Chakravarthy, Q. Jiang: Stream Data Processing - A Quality of Service Perspective - Springer, 2009
- J. Leskovec, A. Rajaraman: Mining of Massive Datasets - Cambridge University Press, 2012
- P. Revesz: Introduction to Databases: From Biological to Spatio-Temporal - Springer 2010
- P. Rigaux, M. Scholl, A. Voisard: Spatial Databases With Applications to GIS - Morgan-Kaufmann, 2001
- D. Suciu, D. Olteanu, Chr. Re, Chr. Koch: Probabilistic Databases - Morgan & Claypool, 2011

Language:

- offered only in German

Notes:

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

Admission requirements for participation in module examination(s):
- Successful completion of exercise assignments as specified at the beginning of the semester.

Module Exam(s):
- CS3130-L1: Non-Standard Databases and Data Mining, written exam, 90min, 100% of module grade.

Former name of the module: Algorithmic Data Analysis

CS3150-KP08 - Human and Machine Intelligence (HMI)

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

Course of study, specific field and term:

- Bachelor IT-Security 2016 (optional subject), computer science, Arbitrary semester
- Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester
- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2019 (compulsory), Canonical Specialization Web and Data Science, 5th semester

Classes and lectures:

- Human and Machine Intelligence (lecture, 2 SWS)
- Human and Machine Intelligence (exercise, 2 SWS)
- Human and Machine Intelligence (seminar, 1 SWS)

Workload:

- 125 Hours private studies
- 75 Hours in-classroom work
- 40 Hours exam preparation

Contents of teaching:

- Human intelligence and artificial intelligence
- Different types of intelligence
- Cognitive Systems
- Human Development & Developmental Robotics
- Hybrid Intelligence
- Different forms of learning in humans/ artificial systems
- Examples of problem-solving methods
- Challenges of real environments
- Embodied Systems
- Social Intelligence
- Human-robot Cooperation/Collaboration
- Negative side of intelligence (bias, manipulation, control, lying, etc.)

Qualification-goals/Competencies:

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

Grading through:

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

Responsible for this module:

- Prof. Dr.-Ing. Nele Rußwinkel

Teacher:

- Institute of Information Systems

- Prof. Dr.-Ing. Nele Rußwinkel

Literature:

- Lieto, A.: Cognitive Design for Artificial Minds - London/New York, Routledge (Taylor and Francis), 2021
- S.J. Russell: Human Compatible: Artificial Intelligence and the Problem of Control - Penguin Books, 2020
- S.J. Russell, P. Norvik: Artificial Intelligence: A Modern Approach - Upper Saddle River, N.J. :Prentice Hall, 2010

Language:

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

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise assignments as specified at the beginning of the semester
- Seminar lecture and elaboration according to the requirements at the beginning of the semester

Module Exam(s):
- CS3150-L1: Human and Machine Intelligence, written exam, 90min, 100% of module grade.

Students for whom this course is a compulsory module have priority.

CS3201-KP04, CS3201 - Usability Engineering (UsabUXEng)

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

Course of study, specific field and term:

- Bachelor Media Informatics 2020 (compulsory), media informatics, 5th semester
- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2019 (compulsory), Canonical Specialization SSE, 5th semester
- Bachelor Robotics and Autonomous Systems 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2016 (compulsory), Canonical Specialization SSE, 5th semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), computer science, 5th or 6th semester
- Bachelor IT-Security 2016 (optional subject), computer science, Arbitrary semester
- Bachelor Media Informatics 2014 (compulsory), media informatics, 5th semester
- Bachelor Computer Science 2014 (optional subject), central topics of computer science, 5th semester
- Bachelor Medical Informatics 2011 (optional subject), software engineering, 4th to 6th semester
- Bachelor Computer Science 2012 (compulsory), specialization field media informatics, 6th semester
- Bachelor Computer Science 2012 (optional subject), central topics of computer science, 6th semester

Classes and lectures:

- Usability Engineering (lecture, 2 SWS)
- Usability-Engineering (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Introduction and motivation
- Software- und Usability-Engineering
- Usability and UX target criteria for interactive systems
- Cost-benefit analysis
- Design and conception methods for user experience
- Organizational and context analysis
- User analyses
- Task analyses
- Modeling and design of interactive systems
- Evaluation of interactive systems: planning, implementation and evaluation
- Statistical methods of usability and UX evaluation
- Interdisciplinary teams and social processes
- Embedding usability and UX in business processes

Qualification-goals/Competencies:

- Students can explain and implement the basic human-centered development processes for multimedia interactive systems.
- You can adapt and apply the basic processes for development projects to suit the problem.
- They can apply usability and user experience engineering methods in a targeted manner and evaluate, reflect on and communicate their results.
- They can justify the influence of formal and informal requirements as well as complex social structures and behaviors on human-centered development processes.
- The exercise trains team skills, structured work, time management and presentation skills.

Grading through:

- written exam

Requires:

- Software Ergonomics (CS2200-KP04, CS2200)

Responsible for this module:

- Prof. Dr. phil. André Calero Valdez

Teacher:

- Institute for Multimedia and Interactive Systems
- Prof. Dr. phil. André Calero Valdez

Literature:

- Deborah J. Mayhew: The Usability Engineering Lifecycle - Morgan Kaufmann Publ., 1999
- Jeff Sauro, James R. Lewis: Quantifying the User Experience - Morgan Kaufmann Publ., 2016
- Karen Holtzblatt, Hugh Beyer: Contextual Design. Defining Customer-Centered Systems - Morgan Kaufmann Publ., 1997

Language:

- offered only in German

Notes:

Replaces CS3201-KP04 Usability-Engineering.

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework assignments as stated at the beginning of the course

Exam(s):
- CS3201-L1 Usability- und UX-Engineering, Klausur, 90min, 100% der Modulnote

CS3250-KP08 - Safe Software (SichereSW)

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

Course of study, specific field and term:

- Bachelor Computer Science 2019 (optional subject), Canonical Specialization Web and Data Science, 5th semester
- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2019 (compulsory), Canonical Specialization SSE, 5th semester
- Bachelor Media Informatics 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2016 (compulsory), Canonical Specialization SSE, 5th semester
- Bachelor IT-Security 2016 (compulsory), IT-Security, 5th semester

Classes and lectures:

- Safe Software (lecture, 4 SWS)
- Safe Software (exercise, 2 SWS)

Workload:

- 120 Hours private studies
- 90 Hours in-classroom work
- 30 Hours exam preparation

Contents of teaching:

- Measures for improving software safety
- Definition of central techniques such as static analysis, model checking, testing, runtime verification
- Techniques for program analysis
- Operation of model checkers
- Test procedures
- Verification at runtime
- Application of the techniques
- Theorem proving
- Tools

Qualification-goals/Competencies:

- The students can describe and classify measures for the improvement of software safety.
- They can explain the principles of central verification techniques.
- They can compare various methods for software testing.
- They can motivate the use of various techniques for improving software safety.
- They can assess the effect of these techniques on the safety of certain software.
- They are familiar with common tools for the verification of software and they can familiarize themselves with new developments.

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Theoretical Computer Science (CS2000-KP08, CS2000)
- Introduction to Logics (CS1002-KP04, CS1002)
- Software Engineering (CS2300-KP06, CS2300SJ14)

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages

- Prof. Dr. Martin Leucker

Literature:

- A.R. Bradley, Z. Manna: The Calculus of Computation - Springer, 2007
- F. Nielson, H.R. Nielson, C. Hankin: Principles of Program Analysis - Springer 2010
- C. Baier, J.-P. Katoen: Principles of Model Checking - MIT Press, 2008
- D. Peled: Software Reliability Methods - Springer, 2001

Language:

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

Notes:

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

CS3701-KP05, CS3701SJ14 - Bachelor Project Computer Science (BacProjl14)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	each winter semester	5 (Typ B)	12

Course of study, specific field and term:

- Bachelor Computer Science 2019 (compulsory), interdisciplinary competence, 5th semester
- Bachelor Computer Science 2016 (compulsory), interdisciplinary competence, 5th semester
- Bachelor Computer Science 2014 (compulsory), interdisciplinary competence, 5th semester

Classes and lectures:

- Bachelor Project Computer Science (programming project, 4 SWS)

Workload:

- 65 Hours group work
- 60 Hours in-classroom work
- 15 Hours written report
- 10 Hours oral presentation (including preparation)

Contents of teaching:

- Team-based planning and realization of a complete software/hardware project ranging from requirement engineering to installation while observing standards and deadlines

Qualification-goals/Competencies:

- Students have the communication competency to elucidate the system requirements with customers.
- They have the methodological competency to analyse complex tasks, to structure them into subtasks, and to implement them in teams.
- They have the management competency to estimate the costs, to plan the activities, and to allocate the resources needed for meeting the project goals.
- They are able to integrate components into an overall application while ensuring quality.
- They have the methodological competency to manage created artefacts and to document implementations.
- They have the communication competency to write down and present (partial) results.

Grading through:

- oral presentation
- Written report
- successful addressing of the project goals

Requires:

- Tools for scientific practice (CS2450-KP02, CS2450)
- Lab Course Software Engineering (CS2301-KP06, CS2301)
- Software Engineering (CS2300-KP06, CS2300SJ14)
- Theoretical Computer Science (CS2000-KP08, CS2000)
- Algorithms and Data Structures (CS1001-KP08, CS1001)
- Introduction to Programming (CS1000-KP10, CS1000SJ14)

Responsible for this module:

- Studiengangsleitung Informatik

Teacher:

- Institutes of the Department of Computer Science/ Engineering

- Alle prüfungsberechtigten Dozentinnen/Dozenten des Studienganges

Literature:

- :
- :
- :
- :

Language:

- German and English skills required

Notes:

Prerequisites for attending the module:
- None

CS3702-KP04, CS3702 - Bachelor Seminar Informatics (BachSemInf)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	each semester	4 (Typ B)	15

Course of study, specific field and term:

- Bachelor Computer Science 2019 (compulsory), interdisciplinary competence, 5th semester
- Bachelor Computer Science 2016 (compulsory), interdisciplinary competence, 5th semester
- Bachelor Computer Science 2014 (compulsory), interdisciplinary competence, 5th semester
- Bachelor Computer Science 2012 (compulsory), interdisciplinary competence, 5th semester

Classes and lectures:

- Bachelor Seminar (seminar, 2 SWS)

Workload:

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

Contents of teaching:

- Familiarization in a scientific topic
- Working on a scientific topic and its answers for problems
- Presentation and discussion of the topic in English

Qualification-goals/Competencies:

- The students are able to analyze, judge and develop a scientific topic.
- They are able to present the results in a written documentation and in a talk in an scientific way
- The are able to present and discuss a scientific topic in English.
- They are able to classify and differentiate the topic in the wider academic context.
- They improve their language competency.

Grading through:

- oral presentation
- term paper

Requires:

- Tools for scientific practice (CS2450-KP02, CS2450)

Responsible for this module:

- Studiengangsleitung Informatik

Teacher:

- Institutes of the Department of Computer Science/ Engineering

- Alle prüfungsberechtigten Dozentinnen/Dozenten des Studienganges

Literature:

- Topic and literature are chosen indiviually.:
- :

Language:

- offered only in English

Notes:

Prerequisites for attending the module:
- None

MA3400-KP05 - Biomathematics (BioMaKP05)

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

Course of study, specific field and term:

- Bachelor CLS 2023 (compulsory), mathematics, 3rd semester
- Bachelor Biophysics 2024 (compulsory), mathematics, 3rd semester
- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester
- Bachelor Computer Science 2019 (compulsory), Canonical Specialization Bioinformatics and Systems Biology, 5th semester
- Bachelor Medical Informatics 2019 (optional subject), medical computer science, 4th to 6th semester
- Master MLS 2018 (optional subject), interdisciplinary competence, 1st semester
- Bachelor Computer Science 2016 (optional subject), advanced curriculum, Arbitrary semester
- Bachelor Computer Science 2016 (compulsory), Canonical Specialization Bioinformatics, 5th semester
- Master MLS 2016 (optional subject), mathematics / computer science, 1st semester
- Bachelor CLS 2016 (compulsory), mathematics, 3rd semester
- Bachelor Biophysics 2016 (compulsory), mathematics, 3rd semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Examples and elementary solution methods for ordinary differential equations
- Existence and uniqueness theorems
- Dependence of solutions on initial conditions
- Linear systems (in particular with constant coefficients)
- Higher-Order linear differential equations
- Qualitative theory of nonlinear systems

Qualification-goals/Competencies:

- Students are able to explain basic notions from the theory of ordinarydifferential equations.
- Students can explain bad phenomena of solutions of differential equations using examples.
- Students can specify conditions under which good phenomena of solutions are guaranteed by applying theorems from the theory of ordinary differential equations.
- Students are able to find explicit solutions of simple differential equations.
- Students are able to explain how solutions of differential equations can beanalysed qualitatively.
- Students are able to present important models of the natural sciences which canbe analysed by differential equations.

Grading through:

- written exam

Requires:

- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)
- Analysis 2 (MA2500-KP04, MA2500)
- Analysis 1 (MA2000-KP08, MA2000)

Responsible for this module:

- PD Dr. rer. nat. Christian Bey

Teacher:

- Institute for Mathematics

- PD Dr. rer. nat. Christian Bey

Literature:

- G. Birkhoff, G.-C. Rota: Ordinary Differential Equations

- H. Heuser: Gewöhnliche Differentialgleichungen - Teubner Verlag 2009 (6. Auflage)
- M.W. Hirsch, S. Smale: Differential Equations, Dynamical Systems, and Linear Algebra
- J. D. Murray: Mathematical Biology - Springer
- J. Scheurle: Gewöhnliche Differentialgleichungen
- R. Schuster: Biomathematik - Vieweg + Teubner Studienbücher 2009
- W. Walter: Gewöhnliche Differentialgleichungen

Language:

- offered only in German

Notes:

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

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

Module exam(s):
- MA3400-L1: Biomathematics, written exam, 90 min, 100 % of module grade

ME1500-KP04 - Fundamentals of Physics (GrPhysKP04)

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

Course of study, specific field and term:

- Bachelor CLS 2023 (compulsory), life sciences, 5th semester
- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester
- Bachelor Computer Science 2019 (optional subject), Canonical Specialization Bioinformatics and Systems Biology, 5th semester
- Bachelor Computer Science 2016 (optional subject), advanced curriculum, Arbitrary semester
- Bachelor Computer Science 2016 (optional subject), Canonical Specialization Bioinformatics, 5th semester
- Bachelor CLS 2016 (compulsory), life sciences, 5th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written exam

Responsible for this module:

- Prof. Dr. rer. nat. Robert Huber

Teacher:

- Institute of Biomedical Optics

- Dr. rer. nat. Norbert Linz

Literature:

- Giancoli: Physik

Language:

- offered only in German

Notes:

Prerequisites for attending the module:
- None

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

Module exam(s):
- ME1500-L1: Fundamentals of Physics, written exam, 90 min, 100 % of module grade

CS2101-KP04, CS2101 - Embedded Systems (ES)

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

Course of study, specific field and term:

- Bachelor Robotics and Autonomous Systems 2020 (optional subject), Additionally recognized elective module, Arbitrary semester
- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2019 (optional subject), Canonical Specialization SSE, 6th semester
- Bachelor MES 2020 (optional subject), computer science / electrical engineering, 3rd semester at the earliest
- Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester
- Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2016 (optional subject), Canonical Specialization SSE, 6th semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), computer science, 5th or 6th semester
- Bachelor IT-Security 2016 (optional subject), computer science, Arbitrary semester
- Bachelor Biophysics 2016 (optional subject), computer science, 6th semester
- Bachelor Medical Informatics 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor MES 2014 (optional subject), computer science / electrical engineering, 4th or 6th semester
- Bachelor Computer Science 2014 (optional subject), central topics of computer science, 6th semester
- Bachelor Computer Science 2014 (compulsory), specialization field robotics and automation, 4th semester
- Bachelor Medical Informatics 2011 (optional subject), computer science, 4th to 6th semester
- Bachelor MES 2011 (compulsory), computer system science, 6th semester
- Bachelor Biophysics 2024 (optional subject), computer science, 6th semester

Classes and lectures:

- Embedded Systems (lecture, 2 SWS)
- Embedded Systems (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Target architectures (microcontrollers, FPGAs etc.)
- Conceptional models
- Peripheral buses
- Scheduling algorithms and real-time operating systems
- Specification languages
- Transformation from specification to implementation
- Development tools
- Programming of embedded systems using C

Qualification-goals/Competencies:

- Students are able to explain the differences between desktop systems and embedded systems.
- They are able to select an appropriate hardware architecture for an embedded system.
- They are able to select appropriate communication protocols for interfacing peripheral components.
- They are able to control peripheral components with a microcontroller.
- They are able to model embedded systems conceptually and to specify them formally.
- They are well acquainted with the model-based design and tool-based implementation and of simple embedded systems.
- They can independently implement the specifications of the embedded system through C programming
- They can use real-time operating systems to implement embedded systems with real-time capability and deterministic time behavior

Grading through:

- written exam

Requires:

- Introduction to Programming (CS1000-KP10, CS1000SJ14)
- Fundamentals of Computer Engineering 1 (CS1200-KP06, CS1200SJ14)

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering
- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- P. Marwedel: Eingebettete Systeme - Berlin: Springer 2007
- W. Wolf: Computers as Components - Principles of Embedded Computing System Design - San Francisco: Morgan Kaufmann 2012
- D.D. Gajski, F. Vahid, S. Narayan, J. Gong: Specification and Design of Embedded Systems - Englewood Cliffs: Prentice Hall 1994
- U. Brinkschulte, T. Ungerer: Mikrocontroller und Mikroprozessoren - Berlin: Springer 2010
- H. Woern, U. Brinkschulte: Echtzeitsysteme - Berlin: Springer 2005

Language:

- offered only in German

Notes:

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

CS3140-KP04 - Cloud and Web Technologies (WebTech)

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

Course of study, specific field and term:

- Bachelor Robotics and Autonomous Systems 2020 (optional subject), Additionally recognized elective module, 6th semester
- Bachelor Computer Science 2014 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2019 (compulsory), Canonical Specialization Web and Data Science, 6th semester
- Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester
- Bachelor IT-Security 2016 (optional subject), specific, Arbitrary semester

Classes and lectures:

- Cloud and Web Technologies (lecture, 2 SWS)
- Cloud and Web Technologies (exercise, 2 SWS)

Workload:

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

Contents of teaching:

- Web-technologies and web-engineering
- Client and server technologies
- Cloud Computing
- Architectures und middleware-technologies
- Web protocols
- Document languages
- Semantic Web

Qualification-goals/Competencies:

- Students can analyze problems of websites, evaluate with which web technologies they can be solved and implement the envisioned solution.
- They are able to explain the division of work between servers and clients in the web.
- They can model knowledge bases with the help of Semantic Web technologies.
- They can store, administer and process big data in the cloud.
- They can judge for which problems Semantic Web technologies are promising compared to traditional approaches.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Sven Groppe

Teacher:

- Institute of Information Systems

- Prof. Dr. Sven Groppe

Literature:

- R. W. Sebesta: Programming the World Wide Web - Pearson New International Edition - Pearson, 2014
- J. Domingue, D. Fensel, J.A. Hendler (Eds.): Handbook of Semantic Web Technologies
- R. Wartala: Hadoop: Zuverlässige, verteilte und skalierbare Big-Data-Anwendungen - Open Source Press, 2012
- S. Groppe: Data Management and Query Processing in Semantic Web Databases - Springer, 2011

Language:

- German and English skills required

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework and project assignments during the semester

CS3990-KP15, CS3990 - Bachelor Thesis Computer Science (BScInf)

Duration:	Turnus of offer:	Credit points:
1 Semester	each semester	15

Course of study, specific field and term:

- Bachelor Computer Science 2019 (compulsory), computer science, 6th semester
- Bachelor Computer Science 2016 (compulsory), computer science, 6th semester
- Bachelor Computer Science 2014 (compulsory), computer science, 6th semester
- Bachelor Computer Science 2012 (compulsory), computer science, 6th semester

Classes and lectures:

- Bachelor Thesis Computer Science (supervised self studies, 1 SWS)
- Colloquium (colloquium, 1 SWS)

Workload:

- 360 Hours research for and write up of a thesis
- 90 Hours oral presentation and discussion (including preparation)

Contents of teaching:

- investigating a given problem in informatics or application areas and developing a good solution
- colloquium to represent the results including a discussion with the referees

Qualification-goals/Competencies:

- The students can unassistedly solve a moderately difficult problem from the field of computer science with scientific methods based on the acquired professional knowledge.
- They are able to document their approach in a written thesis in a scientific style.
- They are able to present results in a scientific talk and defend them in a discussion.

Grading through:

- oral presentation
- Written report

Responsible for this module:

- Studiengangsleitung Informatik

Teacher:

- Institutes of the Department of Computer Science/ Engineering

- Alle prüfungsberechtigten Dozentinnen/Dozenten des Studienganges

Literature:

- : depends on subject

Language:

- thesis can be written in German or English

Notes:

Prerequisites for attending the module:
- see Academic Regulations and Procedures for Students

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

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

- With regard to the roles of GSP of the University of Lübeck and of the DFG-guidelines the student were able to work with the following statistical methods:The students are able to calculate descriptive statistics.
- They are able to calculate quantiles and surfaces of the normal distribution.
- They are able to explain terms of diagnostic testing, such as sensitivity or specificity.
- They are able to list the basic principles of statistical testing, sample size calculation and confidence interval construction.

- They are able to carry out a set of elementary statistical tests, such as t-test, test of proportions, X2 independence test, and to interpret the results.
- They are able to explain the basic principles of linear regression.
- They are able to apply the linear simple regression.
- They are able to explain the basic idea for the one-way analysis of variance (ANOVA).
- They are able to explain the results table for the one-way and two-way ANOVA.
- They are able to interpret the results of the ANOVA.
- They know the basic principles of clinical therapeutic studies.
- They know the assumptions that need to be fulfilled for the application of specific statistical tests.
- They are able to calculate simple adjustments for multiple comparisons.

Grading through:

- written exam

Is requisite for:

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

Responsible for this module:

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

Teacher:

- Institute of Medical Biometry and Statistics

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

Literature:

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

Language:

- offered only in German

Notes:

Prerequisites for attending the module:
- None

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

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

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

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr.-Ing. Andreas Schrader

Teacher:

- Institute of Telematics

- Prof. Dr.-Ing. Andreas Schrader

Literature:

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

Language:

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

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise slips as specified at the beginning of the semester.

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

CS2110-KP04, CS2110 - Mobile Robots (MobilRob14)

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

Course of study, specific field and term:

- Bachelor Robotics and Autonomous Systems 2020 (compulsory), Robotics and Autonomous Systems, 4th semester
- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Media Informatics 2020 (optional subject), Robotics and Autonomous Systems, 5th or 6th semester
- Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory), Robotics and Autonomous Systems, 4th semester
- Bachelor Computer Science 2014 (compulsory), specialization field robotics and automation, 5th semester
- Bachelor IT-Security 2016 (optional subject), specific, Arbitrary semester

Classes and lectures:

- Mobile Robots (lecture, 2 SWS)
- Mobile Robots (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Reactive behaviour
- Sensors
- Actuators, kinematics of the drives
- Hybrid deliberative/reactive behaviour
- Strategies of actions
- maps, self-localization
- Routing and navigation
- Robot learning
- Multi-robots
- Human-robot interaction
- Currentds trends, sample robots

Qualification-goals/Competencies:

- The students are able to describe and classify the various AI paradigms for mobile robots (reactive, deliberative, hybrid).
- They are able to explain and evaluate the most important sensors and actuators for mobile robots.
- They are able to describe and apply the basic methods of self-localization, planning and navigation in mobile robotics.
- They are able to iscuss the basic approaches for robot learning as well as multi-robot and human-robot interaction.
- They are able to elucidate the state of the art and current trends in mobile robotics by sample robots.
- They are able to design and program mobile robots.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering

- Dr. rer. nat. Javad Ghofrani

Literature:

- J. Hertzberg, K. Lingemann, A. Nüchter: Mobile Roboter - Springer Vieweg 2012
- R. R. Murphy: Introduction to AI Robotics - Cambridge, MA: The MIT Press 2000
- R. Siegwart, I. R. Nourbakhsh: Introduction to Autonomous Mobile Robots - Cambridge, MA: The MIT Press 2011

Language:

- offered only in German

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- continuous, successful participation in practical course

CS2500-KP04, CS2500 - Robotics (Robotik)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- portfolio exam

Is requisite for:

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

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Floris Ernst

Teacher:

- Institute for Robotics and Cognitive Systems

- Prof. Dr. rer. nat. Floris Ernst

Literature:

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

Language:

- offered only in German

Notes:

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

Admission requirements for participation in module examination(s):
- None

Module Exam(s):
- CS2500-L1: Robotics, portfolio examination consisting, 100% of the module grade

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

CS2550-KP08 - Security in Networks and Computer Forensics (SichereNCF)

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

Course of study, specific field and term:

- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester
- Bachelor IT-Security 2016 (compulsory), IT-Security, 5th semester

Classes and lectures:

- Security in Networks and Computer Forensics (lecture, 4 SWS)
- Security in Networks and Computer Forensics (exercise, 2 SWS)

Workload:

- 120 Hours private studies
- 90 Hours in-classroom work
- 30 Hours exam preparation

Contents of teaching:

- Fundamentals of network security
- Attacks
- Baisics of cryptography, confidentiality, integrity
- Authentication, Authorization, and Accountability
- Key Distribution, Certificates and Digital Signatures
- Protocols (Physical & Data-Link, Network & Transport, Application Layer)
- Firewalls, Intrusion Detection Systems and Penetration Testing
- IT Security Management with IT Grundschutz & ITIL
- Incident-Response technologies
- Computer forensic investigation processes
- post-mortem analysis
- Forensic Toolkits
- Cooperation with authorities

Qualification-goals/Competencies:

- The students have an in-depth understanding of the different security problems in networks (including terminology, security goals, security services, communication model, network security model, attacker model, difference between safety and security).
- They know the essential security risks in networks and distributed systems and can assess their significance.
- They have detailed knowledge about different types of attacks in networks and their classification.
- They know important encryption techniques and can apply them with the help of tools.
- They know the relevant security services such as confidentiality, integrity or authenticity and can describe them in detail.
- They understand the principle of electronic and digital signatures and public key infrastructures and know important standards (e.g. X.509).
- They know the different security solutions on the different layers of the ISO/OSI stack.
- They know firewalls and their deployment scenarios as well as the essential products. They have basic knowledge of how to configure firewalls.
- They know the basic organizational and regulatory measures to implement network security in a company (IT Baseline Security, ITIL Security).
- They know the basic processes of computer forensics.
- They are able to use incident-response tools to determine the cause and originator of a damage event.
- They are familiar with basic methods and tools for analyzing programs and malware.
- They can perform the essential steps necessary after a damage event.
- Students are able to hold subject-specific discussions in English and can follow subject-specific talks.

Grading through:

- portfolio exam

Responsible for this module:

- Prof. Dr.-Ing. Thomas Eisenbarth

Teacher:

- Institute for IT Security

- Dr.-Ing. Jan Wichelmann
- Prof. Dr.-Ing. Thomas Eisenbarth
- Prof. Dr. rer. nat. Esfandiar Mohammadi

Literature:

- William Stallings: Cryptography and Network Security: Principles and Practice - Prentice Hall, 2013
- William Stallings, Lawrie Brown: Computer Security: Principles and Practice - Prentice Hall, 2014
- Alexander Geschonneck: Computer Forensik - dpunkt, 6th ed., 2014

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- See portfolio

Module examination(s):
- CS2550-L1 Secure Networks and Computer Forensics, portfolio examination, the specific examination elements and their weightings will be announced at the beginning of the semester

Note on the discontinued module 'CS4180-KP04, CS4180 Security in Networks and Distributed Systems':
This module will not be offered in the future. Students who still need to take retakes or CS4180 as a compulsory module can now do so as part of this module ('CS2550-KP08 Secure Networks and Computer Forensics'). Further information on the procedure is available in the Moodle course and from the module supervisor.

CS2602-KP08 - Interactive Systems (InterSys)

Duration:	Turnus of offer:	Credit points:
2 Semester	normally each term	8

Course of study, specific field and term:

- Bachelor IT-Security 2016 (optional subject), specific, Arbitrary semester
- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Media Informatics 2020 (compulsory), media informatics, 3rd and 4th semester

Classes and lectures:

- Interactive Systems (lecture, 4 SWS)
- Interactive Systems (exercise, 2 SWS)

Workload:

- 120 Hours private studies
- 90 Hours in-classroom work
- 30 Hours exam preparation

Contents of teaching:

- Introduction and overview: Development environments (e.g. VSCode), source code management (e.g. Git), developer tools (e.g. vite) and dependency management (e.g. npm & pnpm)
- Web: HTML and web standards, CSS layout, CSS frameworks (e.g. Tailwind) and TypeScript (DOM, event handling, asynchrony, callbacks, promises, HTTP requests)
- Web programming: client-server architecture, protocols, REST, JSON and Node.js
- - Web apps: Component-based development (e.g. React), TSX, component lifecycle, hooks and states, component libraries (e.g. daisyUI), icon libraries (e.g. TablerIcons) and progressive web apps
- Mobile apps: mobile operating systems, native app development and hybrid app development (e.g. React Native)
- Desktop apps: Desktop app development (e.g. Electron)
- Game programming: programming with an engine (e.g. Unity), concepts for game design and programming, control and input, graphics and sound, SDK and licenses, rendering pipelines, lighting, textures, shaders, materials, raycasting, terrain generation and game publishing

Qualification-goals/Competencies:

- Students will have a comprehensive overview of programming interactive systems for the Web, mobile devices, and desktop systems.
- Students have the theoretical foundations and practical experience to implement concepts for interactive multimedia computer applications.

Grading through:

- written exam

Responsible for this module:

- Prof. Dr. phil. André Calero Valdez

Teacher:

- Institute for Multimedia and Interactive Systems

- Prof. Dr. phil. André Calero Valdez
- MitarbeiterInnen des Instituts

Language:

- offered only in German

Notes:

The course only starts in the respective winter semester. The course examination only takes place at the end of the respective summer semester.

Literature will be announced during the lectures

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises as stated at the beginning of the semester

Exam(s):
- CS2602-L1 Interactive Systems, written exam, 90min, 100% of the module grade

CS3115-KP04, CS5156-KP04, CS5156 - System Architectures for Multimeda (SysArchMM)

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

Course of study, specific field and term:

- Bachelor IT-Security 2016 (optional subject), specific, Arbitrary semester
- Bachelor Media Informatics 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Master Medical Informatics 2014 (optional subject), computer science, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Computer Science 2012 (optional subject), advanced curriculum signal and image processing, 2nd or 3rd semester
- Master Computer Science 2012 (optional subject), specialization field software systems engineering, 3rd semester
- Master Computer Science 2012 (optional subject), advanced curriculum parallel and distributed system architecutres, 2nd or 3rd semester
- Master Computer Science 2012 (optional subject), specialization field media informatics, 2nd or 3rd semester

Classes and lectures:

- System Architectures for Multimedia (lecture, 2 SWS)
- System Architectures for Multimedia (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Performance requirements of multimedia systems on computer and systems
- Instruction set extensions for x86 processors
- System architecture of game consoles and multimedia systems
- Hardware structures for the realization of basic image and video processing operations
- System integration of hardware accelerators
- Programming of multimedia applications with OpenGL
- Protection and authentication of multimedia data

Qualification-goals/Competencies:

- Students are able to categorize instruction set extensions of processors for multimedia applications.
- They are able to discuss the characteristics of the system structure of game consoles and multimedia systems.
- They are able to implement image and video processing algorithms in software by making best use of instruction set extensions.
- They are able to evaluate the usefulness of specific processor architectures and system structures for the realization of multimedia systems.
- They are able to determine appropriate hardware structures for the implementation of image and video processing algorithms.
- They are able to write simple graphic applications with OpenGL.

Grading through:

- see Notes

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering

- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- P. A. Henning: Taschenbuch Multimedia - München: Fachbuchverlag Leipzig 2007
- A. S. Tanenbaum: Moderne Betriebssysteme - München: Pearson 2009
- D. G. Bailey: Design for Embedded Image Processing on FPGAs - Wiley & Sons 2011
- D. Kusswurm: Modern x86 Assembly Language Programming - Apress 2015
- A. Nischwitz, M. Fischer, P. Haberäcker, G. Socher: Computergrafik und Bildverarbeitung - Vieweg + Teubner, 2011

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise assignments as specified at the beginning of the semester

Module Exam(s):
- CS3115-L1: System Architectures for Multimeda, oral exam, 100% of the module grade

CS3125-KP04 - Hardware internship (HWPr)

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

Course of study, specific field and term:

- Bachelor MES 2020 (optional subject), Elective, 5th semester at the earliest
- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester
- Bachelor IT-Security 2016 (optional subject), computer science, Arbitrary semester

Classes and lectures:

- CS3125-P: Hardware Internship (practical course, 3 SWS)

Workload:

- 50 Hours work on project
- 40 Hours in-classroom work
- 30 Hours group work

Contents of teaching:

- Levels of abstraction in circuit design
- Design process and design strategies
- Introduction to the hardware description language VHDL
- Modelling of standard components in VHDL
- Creation of test environments and VHDL simulation cycle
- Circuit board design
- Hardware-based processing of sensor information
- Control of industrial equipment with the aid of an FPGA

Qualification-goals/Competencies:

- Students can design a digital circuit with VHDL based on a non-formal description of a digital system.design a digital circuit with VHDL
- They can simulate and test VHDL descriptions
- They can determine which VHDL constructs are converted into which hardware structures
- They can explain the VHDL simulation cycle
- They can create synthesis-compatible VHDL descriptions
- They can integrate sensors into a hardware design, address them and process data
- They can easily design and assemble circuit boards
- They can integrate and test modules in a larger system

Grading through:

- continuous, successful participation in practical course

Requires:

- Fundamentals of Computer Engineering 1 (CS1200-KP06, CS1200SJ14)

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering

- Dr.-Ing. Kristian Ehlers

Literature:

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

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of the internship

Module Exam(s):
CS3125-L1: Hardware Internship, ungraded internship, 100% of the (non existent) module grade

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

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

Course of study, specific field and term:

- Bachelor Biophysics 2024 (optional subject), computer science, 6th semester
- Bachelor Robotics and Autonomous Systems 2020 (compulsory), Robotics and Autonomous Systems, 6th semester
- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Bachelor MES 2020 (optional subject), computer science / electrical engineering, 3rd semester at the earliest
- Bachelor Media Informatics 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester
- Bachelor MES 2014 (optional subject), computer science / electrical engineering, 3rd semester at the earliest
- Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2016 (compulsory), Canonical Specialization Web and Data Science, 6th semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory), Robotics and Autonomous Systems, 6th semester
- Bachelor IT-Security 2016 (optional subject), computer science, Arbitrary semester
- Bachelor Biophysics 2016 (optional subject), computer science, 6th semester
- Bachelor Medical Informatics 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor Media Informatics 2014 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2014 (optional subject), central topics of computer science, 6th semester
- Bachelor Computer Science 2014 (compulsory), specialization field robotics and automation, 6th semester
- Bachelor Medical Informatics 2011 (optional subject), Applied computer science, 4th to 6th semester
- Bachelor CLS 2010 (optional subject), computer science, 6th semester
- Bachelor MES 2011 (optional subject), medical engineering science, 6th semester
- Bachelor Computer Science 2012 (compulsory), specialization field robotics and automation, 4th semester
- Bachelor Computer Science 2012 (optional subject), central topics of computer science, 5th or 6th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- portfolio exam

Requires:

- Analysis 2 (MA2500-KP04, MA2500)
- Algorithms and Data Structures (CS1001-KP08, CS1001)

Responsible for this module:

- Prof. Dr. rer. nat. Floris Ernst

Teacher:

- Institute for Robotics and Cognitive Systems

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

Literature:

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

Language:

- offered only in German

Notes:

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

Admission requirements for participation in module examination(s):
- Successful completion of exercises as specified at the beginning of the semester.

Moduel Exam(s):
- CS3204-L1: Artificial Intelligence, Portfolio examination, 100% of the module grade

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

CS3205-KP04, CS3205 - Computer Graphics (CompGrafik)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written exam

Requires:

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

Responsible for this module:

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

Teacher:

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

Literature:

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

Language:

- offered only in German

Notes:

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

Admission requirements for participation in module examination(s):
- Successful completion of exercise slips and programming projects as specified at the beginning of the semester

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

CS3206-KP04, CS3206 - Compiler Construction (Compiler)

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

Course of study, specific field and term:

- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), computer science, 5th or 6th semester
- Bachelor IT-Security 2016 (optional subject), computer science, Arbitrary semester
- Bachelor Computer Science 2014 (optional subject), central topics of computer science, 5th or 6th semester

Classes and lectures:

- Compiler Construction (lecture, 2 SWS)
- Compiler Construction (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- phases of translation and their interfaces
- lexical analysis
- syntactic analysis
- semantic analysis
- abstract machines
- translating expressions and statements
- storage management
- block structure and procedures
- translating object-oriented language elements
- code generration and optimization

Qualification-goals/Competencies:

- The students can illustrate the basic concepts and methods of compiler construction.
- They can explain the functional principles of the different phases of a compiler.
- They can apply tools for compiler construction.
- They can compare problem-oriented and machine-oriented languages.
- They can transfer methods of compiler construction for solving related tasks.

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Theoretical Computer Science (CS2000-KP08, CS2000)

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute for Theoretical Computer Science
- Institute of Software Technology and Programming Languages

- Prof. Dr. Martin Leucker

Literature:

- A.V. Aho, M.S. Lam, R. Sethi, J. Ullman: Compilers: Principles, Techniques, and Tools - Pearson Education 2013
- R. Wilhelm, H. Seidl, S. Hack: Übersetzerbau (4 Bände) - Springer, eXamen.press

Language:

- German and English skills required

Notes:

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

CS3207-KP04 - Reverse Engineering Lab (RevEngPr)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	every summer semester	4	60

Course of study, specific field and term:

- Bachelor IT-Security 2016 (optional subject), IT-Security, Arbitrary semester
- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester

Classes and lectures:

- Lab Reverse Engineering (practical course as compact course, 3 SWS)

Workload:

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

Contents of teaching:

- Introduction to Reverse Engineering (dynamic, static), Executables, Calling Conventions and API calls for a common OS like Windows
- Settting up a Reverse Engineering System and use of free Reverse Engineering tools
- Programing in Assembler
- Perform structured program analysis
- Add new functionality to existing programs
- Handling of anti-reverse-engineering techniques

Qualification-goals/Competencies:

- The students can explain basic reverse engineering methods and apply them to simple programs
- The students know different techniques to make reverse engineering harder and can spot these during analysis
- The students know commonly used API functions and are able to build simple applications in Assembler
- The students can make specific changes in or add functionality to existing programs
- The students can perform a structured analysis and document it appropiately

Grading through:

- B-Certificate (not graded)

Responsible for this module:

- Prof. Dr.-Ing. Thomas Eisenbarth

Teacher:

- Institute for IT Security

- Dr. Ralf Zimmermann

Literature:

- D. Andriesse: Practical Binary Analysis - No Starch Press, 2019
- B. Dang, A. Gazet, E. Bachaalany: Practical Reverse Engineering - Wiley, 2014
- C. Eagle: The Ghidra Book - No Starch Press, 2020
- E. Eilam: Reversing: Secrets of Reverse Engineering - Wiley, 2005
- M. Russinovich, D. Solomon, A. Ionescu: Windows Internals Part 2 - 6th Edition, Microsoft Press, 2012
- M. Sikorski, A. Honig: Practical Malware Analysis - No Starch Press, 2012
- P. Yosifovich, A. Ionescu, M. Russinovich, D. Solomon: Windows Internals Part 1 - 7th Edition, Microsoft Press, 2017

Language:

- offered only in German

Notes:

- Limited to 60 places; compulsory participants will be given priority; allocation of further places according to registration order in Moodle.

- Content will be presented using an operating system of the instructor's choice

- Knowledge of C is an advantage, but there will be a short introduction at the beginning of the course

Admission requirements for taking the module:
- None

Entry requirements for taking module examination(s):
- Successful completion of exercise slips as specified at the beginning of the semester, successful completion of a project assignment.

Module Exam(s):
- CS3207-L1 Practical Reverse Engineering, practical course, 100% of the (non-existent) module grade.

CS3300-KP04 - Informatics in Health Care - eHealth (eHealth04)

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

Course of study, specific field and term:

- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester
- Bachelor Computer Science 2016 (optional subject), advanced curriculum, Arbitrary semester

Classes and lectures:

- Informatics in Health Care - eHealth (lecture, 2 SWS)
- Informatics in Health Care - eHealth (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Health Care System (in Germany): organization, legislation and funding
- Medical Documentation and electronic patient records
- Coding of diagnoses and procedures, e.g. ICD-10 and OPS
- DRG-based compensation system and accounting of cases
- Hospital information system, clinical research IT, incl. data protection
- Distributed clinical systems and communication standards, including HL7 and DICOM
- Telematics in medicine: e.g. electronic health insurance card and health professional card
- Classifications and terminologies in medicine, including LOINC, SNOMED CT, MeSH, ...
- Decision support, e.g. knowledge-based systems, literature databases, ...

Qualification-goals/Competencies:

- Students can explain basic structures of the German health care system and possible consequences for health IT projects.
- They can explain the goals of medical documentation and the advantages and disadvantages of structured documentation.
- They can create a relational database model for use cases (e.g. laboratory documentation) and model and implement meaningful parts according to the EAV model (Entity-Attribute-Value).
- They can explain the relevance and functionality of the diagnosis and procedure classifications ICD-10 and OPS.
- They can explain the G-DRG system both as a case classification system and as a case-mix system.
- They can name the goals, structure, and functions of a hospital information system (HIS).
- They can outline the use of the most relevant communication standards (xDT, HL7, DICOM, IHE) and implement corresponding interfaces.
- They can explain and use a communications server as a middleware component in the HIS context.
- They can sketch typical telemedical applications including challenges of health telematics in Germany.
- They can explain relevant regulations regarding data protection and security in medicine.
- They can explain the concepts 'pseudonymisation' and 'anonymisation' and present suitable measures, especially in biobank-based research IT infrastructures.
- They can name simple fact information systems and knowledge-based systems for decision support in medicine and explain their chances and risks.
- They can explain terminologies like SNOMED CT that go beyond classifications with regard to their intended use, their structural structure and their expressiveness.
- They can explain and apply the function of MeSH as a controlled vocabulary (thesaurus) with reference to recall and precision of a literature search in MEDLINE.
- They can practically implement and test concrete tasks using web services to access knowledge ressources (incl. standardized) vocabularies, for example.

Grading through:

- Written or oral exam as announced by the examiner

Requires:

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

Responsible for this module:

- Prof. Dr.-Ing. Marcin Grzegorzek

Teacher:

- Institute of Medical Informatics
- Prof. Dr. rer. nat. habil. Sebastian Fudickar

Literature:

- T. Lehmann: Handbuch der Medizinischen Informatik - München: Hanser 2004 (ISBN 978-3-446-22701-9)
- P. Haas: Medizinische Informationssysteme und Elektronische Krankenakten - Berlin: Springer 2005 (ISBN 978-3540204251)
- M. Dugas, K. Schmidt.: Medizinische Informatik und Bioinformatik - Ein Kompendium für Studium und Praxis - Berlin: Springer 2003 (ISBN 978-3-540-42568-7)

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None (The competences of the prerequisite modules are required for this module, but the modules do not constitute admission requirements).

Admission requirements for participation in module examination(s):
- Successful completion of exercise assignments as specified at the beginning of the semester.

Module Exam(s):
- CS3300-L1: Informatics in Health Care - eHealth, written or oral examination (at the discretion of the lecturer), 90min, 100% of the module grade.

CS3420-KP04, CS3420 - Cryptology (Krypto14)

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

Course of study, specific field and term:

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

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:

- The students are able to model and analyze IT security.
- They know basic cryptographic primitives and protocols.
- They can recognize cryptographic weakness.
- They can apply standard techniques in cryptology.
- They can explain and assess the historical and social significance of encrypting information.

Grading through:

- written exam

Responsible for this module:

- Prof. Dr. Maciej Liskiewicz

Teacher:

- Institute for Theoretical Computer Science

- Prof. Dr. Maciej Liskiewicz

Literature:

- J von zur Gathen: CryptoSchool - Springer 2015
- A. Beutelspacher, H. Neumann, T. Schwarzpaul: Kryptopgrafie in Theorie und Praxis - Vieweg 2005
- D. Wätjen: Kryptographie - Springer 2018
- J. Katz, Y. Lindell: Introduction to Modern Cryptography - Chapman & Hall, 2008
- C. Bauer: Secret History - The Story of Cryptology - CRC Press 2013
- B. Schneier: Applied Cryptography - J. Wiley 1996

Language:

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

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise sheets as specified at the beginning of the semester

Module exam(s):
- CS3420-L1: Cryptology, written exam, 90 minutes, 100% of module grade

CS4172-KP04, CS4172 - Dependability of Computing Systems (ZuverlRSys)

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

Course of study, specific field and term:

- Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Robotics and Autonomous Systems 2020 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), computer science, 5th or 6th semester
- Bachelor IT-Security 2016 (compulsory), IT-Security, 6th semester
- Bachelor Computer Science 2014 (optional subject), central topics of computer science, 6th semester
- Bachelor Computer Science 2014 (compulsory), specialization field IT security and safety, 6th semester
- Bachelor Computer Science 2012 (compulsory), specialization field IT security and safety, 6th semester
- Master Computer Science 2012 (optional subject), advanced curriculum security, 2nd or 3rd semester
- Master Computer Science 2012 (optional subject), specialization field software systems engineering, 3rd semester
- Master Computer Science 2012 (optional subject), advanced curriculum parallel and distributed system architecutres, 2nd or 3rd semester
- Master Computer Science 2012 (optional subject), specialization field robotics and automation, 3rd semester

Classes and lectures:

- Dependability of Computing Systems (lecture, 2 SWS)
- Dependability of Computing Systems (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Basic terms
- General redundancy techniques
- Fault diagnosis
- Reconfiguration and recovery
- Fault masking
- Examples for fault-tolerant systems

Qualification-goals/Competencies:

- The students are able to present the most important fault types in hardware and software and their abstraction to fault models.
- They are able to elucidate the basic redundancy techniques (static and dynamic redundancy, hybrid forms etc.).
- They are able to explain various methods for fault diagnosis, reconfiguration, recovery and fault masking.
- They are able to describe typical application examples and sample fault-tolerant computers.
- They are able to analyze fault tolerance techniques quantitatively by mathematical reliability models.
- They are able to valuate and compare suitable fault tolerance techniques and to select them for a given application area.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering

- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- E. Dubrova: Fault-Tolerant Design - Springer 2013
- K. Echtle: Fehlertoleranzverfahren - Springer 1990
- I. Koren, C. M. Krishna: Fault Tolerant Systems - Morgan-Kaufman 2007
- K. Trivedi: Probability and Statistics with Reliability, Queuing, and Computer Science Applications - Wiley 2001

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise assignments as specified at the beginning of the semester

Module Exam(s):
- CS4172-L1: Dependability of Computing Systems, written exam, 90min, 100% of the module grade

MA2500-KP04, MA2500 - Analysis 2 (Ana2KP04)

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

Course of study, specific field and term:

- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester
- Bachelor Robotics and Autonomous Systems 2020 (compulsory), mathematics, 2nd semester
- Bachelor Medical Informatics 2019 (compulsory), mathematics, 2nd semester
- Bachelor IT-Security 2016 (optional subject), mathematics, Arbitrary semester
- Bachelor Computer Science 2016 (compulsory), mathematics, 2nd semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory), mathematics, 2nd semester
- Bachelor Medical Informatics 2014 (compulsory), mathematics, 2nd semester
- Bachelor Computer Science 2014 (compulsory), mathematics, 2nd semester
- Bachelor Medical Informatics 2011 (compulsory), mathematics, 4th semester
- Bachelor MES 2011 (compulsory), mathematics, 2nd semester
- Bachelor Computer Science 2012 (compulsory), mathematics, 4th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Integral calculus for functions of one real variable (indefinite integrals, antiderivatives, substitution, partial fractions, definite integrals, fundamental theorem of calculus)
- Sequences and series of functions
- Fourier series (trigonometric polynomials, convergence)

Qualification-goals/Competencies:

- Students understand the advanced terms of analysis, such as even convergence.
- Students understand the advanced thoughts and proof techniques.
- Students can explain advanced relationships in analysis.
- Interdisciplinary qualifications:
- Students can transfer advanced theoretical concepts to similar applications.
- Students can work as a group on complex mathematical problems.

Grading through:

- written exam

Requires:

- Analysis 1 (MA2000-KP09)
- Analysis 1 (MA2000-KP08, MA2000)

Responsible for this module:

- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Jürgen Prestin

Literature:

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

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None (the competences of the modules mentioned under ''requires'' are needed for this module, but are not a formal prerequisite).

Admission requirements for the examination:
- Successful completion of exercises during the semester as specified at the beginning of the semester.
- Successful completion of e-tests as specified at the beginning of the semester.

Module Exam(s):
- MA2500-L1: Analysis 2, written exam, 90min, 100% of the module grade

MA3110-KP04, MA3110 - Numerics 1 (Num1KP04)

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

Course of study, specific field and term:

- Master Auditory Technology 2022 (optional subject), Elective, Arbitrary semester
- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester
- Bachelor MES 2020 (optional subject), mathematics / natural sciences, 3rd semester at the earliest
- Bachelor Robotics and Autonomous Systems 2020 (optional subject), mathematics, 5th or 6th semester
- Bachelor Medical Informatics 2019 (optional subject), mathematics, 4th to 6th semester
- Bachelor IT-Security 2016 (optional subject), mathematics, Arbitrary semester
- Master Auditory Technology 2017 (optional subject), compulsory module depending on previous knowledge , 1st semester
- Bachelor Computer Science 2016 (optional subject), advanced curriculum, Arbitrary semester
- Bachelor Computer Science 2016 (optional subject), Canonical Specialization Web and Data Science, 3rd semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), mathematics, 5th or 6th semester
- Bachelor Medical Informatics 2014 (optional subject), mathematics, 5th or 6th semester
- Bachelor MES 2014 (optional subject), mathematics / natural sciences, 3rd or 5th semester
- Bachelor Computer Science 2014 (optional subject), central topics of computer science, 5th semester
- Master MES 2011 (optional subject), mathematics, 1st semester
- Bachelor MES 2011 (optional subject), mathematics, 3rd semester
- Bachelor Computer Science 2012 (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

- Students understand basic numerical tasks.
- They are proficient in the modern programming language MATLAB.
- They can implement theoretical algorithms.
- They can assess the quality of a method (accuracy, stability, complexity).

Grading through:

- written exam

Requires:

- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)
- Analysis 2 (MA2500-KP04, MA2500)
- Analysis 1 (MA2000-KP08, MA2000)

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Rößler

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Andreas Rößler

Literature:

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

Language:

- offered only in German

Notes:

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

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

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

MA3445-KP05 - Graph Theory (GraphTKP05)

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

Course of study, specific field and term:

- Master CLS 2023 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS 2023 (optional subject), mathematics, 5th or 6th semester
- Minor in Teaching Mathematics, Master of Education 2023 (optional subject), mathematics, 2nd or 3rd semester
- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester
- Minor in Teaching Mathematics, Master of Education 2017 (optional subject), mathematics, 2nd or 3rd semester
- Bachelor Computer Science 2016 (optional subject), advanced curriculum, Arbitrary semester
- Master CLS 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS 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:

- Oral examination

Requires:

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

Responsible for this module:

- PD Dr. rer. nat. Christian Bey

Teacher:

- Institute for Mathematics

- PD Dr. rer. nat. Christian Bey

Literature:

- F. Harary: Graph Theory - Reading, MA:.Addison-Wesley 1969
- R. Diestel: Graphentheorie - Berlin: Springer 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:

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

Admission requirements for participation in module examination(s):
- Successful completion of homework assignments as specified at the beginning of the semester

Module exam(s):
- MA3445-L1: Graph Theory, oral exam, 30 min, 100 % of module grade

MA4020-KP05 - Stochastics 2 (Stoch2KP05)

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

Course of study, specific field and term:

- Minor in Teaching Mathematics, Master of Education 2023 (compulsory), mathematics, 1st semester
- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester
- Bachelor IT-Security 2016 (optional subject), mathematics, Arbitrary semester
- Minor in Teaching Mathematics, Master of Education 2017 (compulsory), mathematics, 1st semester
- Bachelor Computer Science 2016 (optional subject), advanced curriculum, Arbitrary semester
- Bachelor CLS 2016 (compulsory), mathematics, 3rd semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Exercises
- written exam

Requires:

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

Responsible for this module:

- Nachfolge von Prof. Dr. rer. nat. Karsten Keller

Teacher:

- Institute for Mathematics

- Nachfolge von Prof. Dr. rer. nat. Karsten Keller

Literature:

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

Language:

- offered only in German

Notes:

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

MA4030-KP08, MA4030 - Optimization (Opti)

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

Course of study, specific field and term:

- Minor in Teaching Mathematics, Bachelor of Arts 2023 (compulsory), mathematics, 8th semester
- Bachelor CLS 2023 (compulsory), mathematics, 4th semester
- Master Auditory Technology 2022 (optional subject), mathematics, 2nd semester
- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester
- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, Arbitrary semester
- Minor in Teaching Mathematics, Bachelor of Arts 2017 (compulsory), mathematics, 8th semester
- Master Auditory Technology 2017 (optional subject), mathematics, 1st or 2nd semester
- Bachelor Computer Science 2016 (optional subject), advanced curriculum, Arbitrary semester
- Bachelor CLS 2016 (compulsory), mathematics, 4th semester
- Master MES 2014 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master MES 2011 (optional subject), mathematics, 2nd semester
- Master Computer Science 2012 (optional subject), advanced curriculum numerical image processing, 2nd or 3rd semester
- Bachelor MES 2011 (optional subject), medical engineering science, 6th semester
- Master Computer Science 2012 (optional subject), advanced curriculum analysis, 2nd or 3rd semester
- Bachelor CLS 2010 (compulsory), mathematics, 4th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Linear optimization (simplex method)
- Unconstrained nonlinear optimization (gradient descent, conjugate gradients, Newton method, Quasi-Newton methods, globalization)
- Equality- and inquality-constrained nonlinear optimization (Lagrange multipliers, active set methods)
- Stochastic methods for machine learning

Qualification-goals/Competencies:

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

Grading through:

- Written or oral exam as announced by the examiner

Is requisite for:

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

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Jan Modersitzki

Teacher:

- Institute of Mathematics and Image Computing

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

Literature:

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

Language:

- offered only in German

Notes:

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

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

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

ME2400-KP08, ME2400 - Fundamentals of Electrical Engineering 1 (ETechnik1)

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

Course of study, specific field and term:

- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester
- Bachelor MES 2020 (compulsory), electrical engineering, 3rd semester
- Bachelor Robotics and Autonomous Systems 2020 (compulsory), electrical engineering, 3rd semester
- Bachelor MES 2011 (optional subject), electrical engineering, 4th to 6th semester
- Bachelor Computer Science 2016 (optional subject), advanced curriculum, Arbitrary semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory), Robotics and Autonomous Systems, 3rd semester
- Bachelor MES 2014 (compulsory), electrical engineering, 3rd semester
- Bachelor IT-Security 2016 (optional subject), specific, Arbitrary semester

Classes and lectures:

- Fundamentals of Electrical Engineering 1 (lecture, 4 SWS)
- Fundamentals of Electrical Engineering 1 (exercise, 2 SWS)

Workload:

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

Contents of teaching:

- Maxwell s Equations and electrical circuits
- Circuit Abstraction
- Passive electrical circuit elements
- Methods of linear and nonlinear circuit analysis
- Measuring voltages and currents
- Equivalent circuit diagram (ideal/nonideal sources, MOSFETs, BJTs)
- MOSFET Switch
- Digital Abstraction
- MOSFET Amplifier

Qualification-goals/Competencies:

- Students understand how electrical circuits are derived from Maxwell s equations and which simplifications are accepted in this process.
- Students can calculate and analyze electrical circuits with passive elements.
- Students understand how complicated circuits, e.g. with MOSFETs and BJTs can be expressed and analyzed by means of equivalent circuit diagrams with sources and passive elements.
- Students know and comprehend the basic physical structure and operation of a MOSFET device as a switch and as an amplifier and know how to describe and analyze its operation.
- Students know the difference between large and small signal analysis and are able to use this to analyze electrical circuits.

Grading through:

- written exam

Is requisite for:

- Fundamentals of Electrical Engineering 2 (ME2700-KP08, ME2700)

Requires:

- Analysis 2 (MA2500-KP04, MA2500)
- 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:

- Prof. Dr. Philipp Rostalski

Teacher:

- Institute for Electrical Engineering in Medicine

- Prof. Dr. Philipp Rostalski

Literature:

- Argawal, Lang: Foundations of Analog and Digital Circuits - Elsevier; ISBN: 1-55860-735-8
- M. Albach: Elektrotechnik - ISBN: 978-3-8689-4081-7

Language:

- offered only in German

Notes:

In the Bachelor of Computer Science CS3120-KP04 Electronics and Microsystems Engineering and ME2400-KP08 Fundamentals of Electrical Engineering 1
cannot be chosen in combination due to content overlap.

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises as specified at the beginning of the semester.

Module Exam(s):
- ME2400-L1: Fundamentals of Electrical Engineering 1, written exam, 90min, 100% of module grade.

ME2700-KP08, ME2700 - Fundamentals of Electrical Engineering 2 (ETechnik2)

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

Course of study, specific field and term:

- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester
- Bachelor MES 2020 (compulsory), electrical engineering, 4th semester
- Bachelor Robotics and Autonomous Systems 2020 (compulsory), electrical engineering, 4th semester
- Bachelor MES 2011 (optional subject), electrical engineering, 4th to 6th semester
- Bachelor Computer Science 2016 (optional subject), advanced curriculum, Arbitrary semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory), Robotics and Autonomous Systems, 4th semester
- Bachelor MES 2014 (compulsory), electrical engineering, 4th semester

Classes and lectures:

- Fundamentals of Electrical Engineering 2 (lecture, 4 SWS)
- Fundamentals of Electrical Engineering 2 (exercise, 2 SWS)

Workload:

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

Contents of teaching:

- Periodic and non-periodic waveforms
- Transient response of basic linear circuits
- AC circuit analysis
- Frequency responses and Nyquist plot
- Physical basics of semiconductors
- Diodes
- Bipolar Transistors
- Field-effect transistors
- Operational amplifier
- Integrated circuits
- AD and DA converter
- Basic electronic circuits
- Introduction into the simulation of electrical circuits

Qualification-goals/Competencies:

- Students know and understand the basics of AC circuit analysis and know how to apply it.
- Students can assess frequency response plots of electrical circuits and evaluate their consequences.
- Students can develop and analyze active and passive analog filters.
- Students know the main semiconductor elements and their basic circuits.
- Students recognize and understand the most relevant electronic circuits.
- Students can design and modify their own circuits by modifying and combining elementary circuits.
- Students are capable of simulating electrical circuits and know how to use basic features of the PSpice simulator.

Grading through:

- Written or oral exam as announced by the examiner

Is requisite for:

- Medical Electrical Engineering Lab Course (ME3400-KP04, ME3400)

Requires:

- Fundamentals of Electrical Engineering 1 (ME2400-KP08, ME2400)

Responsible for this module:

- Prof. Dr. Philipp Rostalski

Teacher:

- Institute for Electrical Engineering in Medicine

- Prof. Dr. Philipp Rostalski

Literature:

- Agarwal, Lang: Foundations of Analog and Digital Circuits - Elsevier; ISBN: 1-55860-735-8
- S. Goßner: Grundlagen der Elektronik. Halbleiter, Bauelemente und Schaltungen - ISBN: 3826588258

Language:

- offered only in German

Notes:

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