UNIVERSITÄT ZU LÜBECK

Module Guide for the Study Path

# Bachelor Medical Informatics 2014

Version from 14. April 2025

## 1st and 2nd semester

Introduction to Medicine for MI 1 (MZ2151-KP06, MZ2151, EMedMI1) 1

## 1st semester

Introduction to Programming (CS1000-KP08, CS1000SJ14-MML/MI, CS1000SJ14-MIW, EinfProg14) 2
Introduction to Medical Informatics (CS1300-KP04, CS1300, EMI) 4
Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000, LADS1) 6
Analysis 1 (MA2000-KP08, MA2000, Ana1KP08) 8
Module Part: Course Anatomy (MZ2100 A, Anatomie) 10

## 2nd semester

Algorithms and Data Structures (CS1001-KP08, CS1001, AuD) 12
Fundamentals of Computer Engineering 1 (CS1200-KP06, CS1200SJ14, TGI1) 14
Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500, LADS2) 16
Analysis 2 (MA2500-KP04, MA2500, Ana2KP04) 18
Module Part: Course Physiology (MZ2100 D, Physio) 20

## 3rd and 4th semester

Introduction to Medicine for MI 2 (MZ2152-KP08, MZ2152, EMedMI2) 22

## 3rd semester

Introduction to Logics (CS1002-KP04, CS1002, Logik) 23
Introduction to Bioinformatics (CS1400-KP04, CS1400, EinBioinfo) 25
Theoretical Computer Science (CS2000-KP08, CS2000, TI) 27
Software Engineering (CS2300-KP06, CS2300SJ14, SWEng14) 29
Introduction to Medical Engineering (ME2151-KP04, ME2151, EMedTecMI) 31
Module Part: Course Pathology (MZ2100 B, Patho) 33

## 4th and 5th semester

Informatics in Health Care - eHealth (CS3300-KP08, CS3300SJ14, eHealth14) 35

## 4th semester

Operating Systems and Networks (CS2150-KP08, CS2150SJ14, BSNetze14) 37
Lab Course Software Engineering (CS2301-KP06, CS2301, SWEngPrakt) 39
Databases (CS2700-KP04, CS2700, DB) 41

Biostatistics 1 (MA1600-KP04, MA1600, MA1600-MML, BioStat1) 43
Module Part: Course Cell Biology and Genetics (MZ2100 E, Zellbio) 45
Module Part: Radiology, Nuclearmedicine, Radiotherapy (MZ2100 F, RNSSJ14) 46

## 5th or 6th semester

Fundamentals of Computer Engineering 2 (CS1202-KP06, CS1202, TGI2) 48
Introduction to Robotics and Automation (CS1500-KP04, CS1500, ERA) 50
Introduction to IT Security and Reliability (CS1700-KP04, CS1700, EinfSiZuv) 52
Computer Architecture (CS2100-KP04, CS2100SJ14, RA14) 54
Embedded Systems (CS2101-KP04, CS2101, ES) 56
Robotics (CS2500-KP04, CS2500, Robotik) 58
Algorithm Design (CS3000-KP04, CS3000, AlgoDesign) 60
Human-Computer-Interaction (CS3010-KP04, CS3010, MCI) 62
Coding and Security (CS3050-KP04, CS3050, CodeSich) 64
Nonstandard Database Systems (CS3202-KP04, CS3202, NDB) 66
Artificial Intelligence 1 (CS3204-KP04, CS3204, KI1) 68
Computer Graphics (CS3205-KP04, CS3205, CompGrafik) 70
Medical Data Science and Artificial Intelligence (CS3350-KP06, MDS) 72
Cryptology (CS3420-KP04, CS3420, Krypto14) 74
Programming for Medical Image Processing in C++ (CS3830-KP04, CS3830, PmBV) 76
Security in Networks and Distributed Systems (CS4180-KP04, CS4180, SicherNet) 78
General Chemistry (LS1100-KP04, ACKP04) 80
Molecular Genetics (LS3100-KP04, LS3100SJ14, MolGen) 82
Clinical Studies (MA2214-KP04, MA2214, KlinStud) 84
Stochastics 1 (MA2510-KP04, MA2510, Stoch1) 86
Numerics 1 (MA3110-KP04, MA3110, Num1KP04) 88
Biomathematics (MA3400-KP04, MA3400, Biomathe) 90
Graph Theory (MA3445-KP04, MA3445, Graphen) 92
Introduction into Biomedical Optics (ME2100-KP04, ME2100SJ14, EinfBMO14) 94
Medical Imaging (ME3100-KP04, ME3100SJ14, MBG14) 96
Medical Quality Management (MZ3100-KP04, MZ3100, MedizQM) 98
Humanoid Robotics (RO5300-KP06, HumRob) 100

## 5th semester

Signal Processing (CS3100-KP08, CS3100SJ14, SignalV14) 102
Medical Image Computing (CS3310-KP08, CS3310SJ14, MBV14) 104
Bachelor Seminar Medical Informatics (CS3703-KP04, CS3703, BachSemMI) 106
Clinical Epidemiology (MZ4010-KP04, MZ4010, KlinEpi) 107

## 6th semester

Social Aspects of Medical Informatics (CS3800-KP03, CS3800, GesellMI) 109

Bachelor Thesis Medical Informatics (CS3991-KP15, CS3991, BScMI) 111

## Arbitrary semester

Tools for scientific practice (CS2450-KP02, CS2450, Werkzeuge) 112

# MZ2151-KP06, MZ2151 - Introduction to Medicine for MI 1 (EMedMI1)

| Duration: | Turnus of offer: | Credit points: |
|---|---|---|
| 2 Semester | each winter semester | 6 |

**Course of study, specific field and term:**

- Bachelor Medical Informatics 2014 (compulsory), medical computer science, 1st and 2nd semester

**Classes and lectures:**

- MZ2100 A: Anatomie (course, 2 SWS)
- MZ2100 D: Physiologie (course, 2 SWS)

**Workload:**

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

**Contents of teaching:**

- See individual module parts

**Grading through:**

- written exam

**Responsible for this module:**

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

**Teacher:**

- Institute of Neurobiology
- Institute of Anatomy

**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):
- MZ2160-L1: Anatomy for technical studies, written exam, 30min, 50% of the module grade.
- MZ2160-L2: Physiology for technical courses, written exam, 90min, 50% of module grade

(Consists of MZ2100 A, MZ2100 D)

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

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

**Course of study, specific field and term:**

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam

**Is requisite for:**

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

**Responsible for this module:**

- Prof. Dr. Stefan Fischer

**Teacher:**

- Institute of Telematics
- Prof. Dr. Stefan Fischer

**Literature:**


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

**Language:**

- offered only in German

**Notes:**

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- CS1000-L1: Successful completion of exercise assignments as specified at the beginning of the semester

Module Exam(s):
- CS1000-L1: Introduction to programming and programming course, written exam, 90min, 100% of module grade

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

## 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

## 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:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam

**Is requisite for:**

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

**Responsible for this module:**

- Prof. Dr. rer. nat. Jan Modersitzki

**Teacher:**

- Institute of Mathematics and Image Computing
- Prof. Dr. rer. nat. Jan Modersitzki
- Prof. Dr. rer. nat. Jan Lellmann

**Literature:**

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

**Language:**

- offered only in German

**Notes:**

Prerequisites for attending the module:
- None

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

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

## MA2000-KP08, MA2000 - Analysis 1 (Ana1KP08)

| Duration: | 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

## MZ2100 A - Module Part: Course Anatomy (Anatomie)

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

**Course of study, specific field and term:**

- Bachelor MES 2020 (Module part of a compulsory module), medicine, 1st semester
- Bachelor Medical Informatics 2019 (Module part of a compulsory module), medical computer science, 1st semester
- Bachelor MES 2014 (Module part of a compulsory module), medicine, 1st semester
- Bachelor Medical Informatics 2014 (Module part of a compulsory module), medical computer science, 1st semester
- Bachelor Medical Informatics 2011 (Module part of a compulsory module), medical computer science, 1st semester
- Bachelor MES 2011 (Module part of a compulsory module), medicine, 1st semester
- Bachelor Computer Science 2012 (Module part of a compulsory module), specialization field medical informatics, 3rd semester

**Classes and lectures:**

- Anatomy (lecture, 2 SWS)

**Workload:**

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

**Contents of teaching:**

- Cytology
- Microscopic anatomy
- Anatomical regions of the human body using medical terms, to describe anatomical position relationships and their principle functions
- Musculoskeletal system
- Respiratory tract, digestive system and cardiovascular system
- Kidney and urinary system
- Spinal cord, brain and peripheral nerves
- Blood, immune system and endocrine system

**Qualification-goals/Competencies:**

- Students know the cell organelles and can describe their principle functions.
- Students are able to describe the basic function of the main body tissues: epithelial tissue, connective tissue, muscle tissue and nervous tissues.
- Students are able to name the anatomical regions of the human body using medical terms, to describe anatomical position relationships and their principle functions.
- Students are able to link main bones with respective body regions.
- Students are able to describe the structures and the principal functions of individual organ systems.
- Students have the competency to use the main medical terms.

**Grading through:**

- written exam

**Responsible for this module:**

- Prof. Dr. med. Jürgen Westermann

**Teacher:**

- Institute of Anatomy
- Prof. Dr. rer. nat. Kathrin Kalies

**Literature:**

- R. Eggers, O. Schmitt: Anatomie I + II - Skript zur Pflicht-Lehreinheit im Nebenfach Medizinische Informatik im Diplom-Studiengang Informatik. Hagen: Fern-Universität Hagen 2000
- A. Faller, M. Schünke: Der Körper des Menschen. Einführung in Bau und Funktion - Thieme: Stuttgart 2012

**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):
- MZ2160-L1: Anatomy for technical courses, written exam, 30min, 100% of the submodule grade.

(Is module part of MZ2151, MZ2160)

## 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.-Ing. Thomas Eisenbarth

**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.

## 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.

## 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

## 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

## MZ2100 D - Module Part: Course Physiology (Physio)

| Duration: | Turnus of offer: | Credit points: |
|---|---|---|
| 1 Semester | each summer semester | 3 |

**Course of study, specific field and term:**

- Bachelor MES 2020 (Module part of a compulsory module), medicine, 2nd semester
- Bachelor Medical Informatics 2019 (Module part of a compulsory module), medical computer science, 2nd semester
- Bachelor Medical Informatics 2014 (Module part of a compulsory module), medical computer science, 2nd semester
- Bachelor MES 2014 (Module part of a compulsory module), medicine, 2nd semester
- Bachelor MES 2011 (Module part of a compulsory module), medicine, 2nd semester
- Bachelor Medical Informatics 2011 (Module part of a compulsory module), medical computer science, 2nd semester

**Classes and lectures:**

- Physiology (lecture, 2 SWS)

**Workload:**

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

**Contents of teaching:**

- Basic cell physiology
- Blood & immune system
- Heart & circulation
- Respiration
- Nutrition, intestinal tract, liver
- Energy and heat metabolism
- Water and electrolyte balance, kidney function
- Endocrine system
- Central and autonomous nervous system
- Muscle physiology
- Sensory physiology

**Qualification-goals/Competencies:**

- Students are able to explain the concepts of interaction of different cells and tissues of the human body.
- Students are able to formalize and interpret the principles of cellular communication in selected organ systems.
- Students are able to transfer principles of cellular communication and tissue homeostasis to new systems.
- Students are able to define physiological problems and transfer them to experimental approaches.
- Students are able to interpret assay patterns in physiological sciences and apply them to new systems/problems.

**Grading through:**

- written exam

**Responsible for this module:**

- Prof. Dr. rer. nat. Henrik Oster

**Teacher:**

- Institute of Neurobiology
- Prof. Dr. rer. nat. Henrik Oster
- Dr. rer. nat. Violetta Pilorz

**Literature:**

- C. & A. Hick: Kurzlehrbuch Physiologie - München: Urban & Fischer (Elsevier)
- L.S. Costanzo: BRS Physiology - Philadelphia: Lippincott Williams & Wilki

**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):
- MZ2160-L2: Physiology for technical courses, written exam, 60min, 100% of the submodule grade.

(Is module part of MZ2151, MZ2160)

(Share of Institute of Neurobiology in V is 100%)

## MZ2152-KP08, MZ2152 - Introduction to Medicine for MI 2 (EMedMI2)

| Duration: | Turnus of offer: | Credit points: |
|---|---|---|
| 2 Semester | each winter semester | 8 |

**Course of study, specific field and term:**

- Bachelor Medical Informatics 2014 (compulsory), medical computer science, 3rd and 4th semester

**Classes and lectures:**

- MZ2100 B: Pathologie (course, 2 SWS)
- MZ2100 E: Zellbiologie und Genetik (course, 2 SWS)
- MZ2100 F: Radiologie, Nuklearmedizin, Strahlentherapie (course, 2 SWS)

**Workload:**

- 105 Hours private studies
- 90 Hours in-classroom work
- 45 Hours exam preparation

**Contents of teaching:**

- See individual module parts

**Grading through:**

- written exam

**Responsible for this module:**

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

**Teacher:**

-
-
- Institute for Biology
- Department of Pathology

- Prof. Dr. med. Hartmut Gehring

**Language:**

- offered only in German

## 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.

## 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.

## 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.

## ME2151-KP04, ME2151 - Introduction to Medical Engineering (EMedTecMI)

| 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 (optional subject), Robotics and Autonomous Systems, 5th or 6th semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory), Robotics and Autonomous Systems, 5th semester
- Bachelor Medical Informatics 2014 (compulsory), medical computer science, 3rd semester

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

- Fundamentals of medical measurement technology
- Methods of functional diagnostics
- Imaging systems
- Therapy systems
- Monitoring
- Medical informatics
- Important legal requirements
- Medical applications

**Qualification-goals/Competencies:**

- Students know how different signals in the body are formed and can be measured.
- They understand the complex mechanisms involved in the metrology of physiological parameters.
- Students are able to explain the physical phenomena of relevant biological processes and methods of measurement.
- The students are able to transfer basic problems and solutions within the medical industry.
- Students will be able to understand basic signal processing processes and implement them using a simulation environment.
- Students are able to assess the advantages and disadvantages, as well as the limitations of each method.
- Students are able to explain the applications of different medical measuring systems.
- Students will have an overview of the current state of medical technology.

**Grading through:**

- written exam

**Responsible for this module:**

- Prof. Dr. rer. nat. Thorsten Buzug

**Teacher:**

- Institute of Medical Engineering
- Dr.-Ing. Ksenija Gräfe

**Literature:**

- R. Kramme (Hrsg.): Medizintechnik: Verfahren Systeme Informationsverarbeitung - Springer Verlag, 2011
- J. D. Enderle, J. D. Bronzino: Introduction to Biomedical Engineering - Elsevier, 2011

**Language:**

- German and English skills required

**Notes:**

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of exercise sheets as specified at the beginning of the semester

Module examination(s):
- ME2151-L1: Introduction to medical technology, written exam, 90 min, 100 % of the module grade

## MZ2100 B - Module Part: Course Pathology (Patho)

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

**Course of study, specific field and term:**

- Bachelor MES 2020 (Module part of a compulsory module), medicine, 1st semester
- Bachelor Medical Informatics 2019 (Module part of a compulsory module), medical computer science, 3rd semester
- Bachelor Medical Informatics 2014 (Module part of a compulsory module), medical computer science, 3rd semester
- Bachelor MES 2014 (Module part of a compulsory module), medicine, 1st semester
- Bachelor Medical Informatics 2011 (Module part of a compulsory module), medical computer science, 1st semester
- Bachelor MES 2011 (Module part of a compulsory module), medicine, 1st semester
- Bachelor Computer Science 2012 (Module part of a compulsory module), specialization field medical informatics, 3rd semester

**Classes and lectures:**

- Pathology (lecture, 2 SWS)

**Workload:**

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

**Contents of teaching:**

- To place the specialty of pathology in the context of medicine as a whole (looking to history and future)
- Specific methods of investigation in pathology
- To define terms like health, illness, death, aetiology, pathogenesis
- To define typical terms of medical statistics
- Description of morphological changes of cells and tissue with implications to diagnosis
- Basic mechanisms of pathogenesis, typical clinical progression of disease in different organ systems
- IT- applications in the area of pathology which support diagnostic work (Lab-devices, interfaces to connect lab and clinical systems as well as a private doctor s office, tele pathology)

**Qualification-goals/Competencies:**

- Students are able to relate important historical dates and persons of pathology to diagnostic methods. They can describe methods like descriptive pathology, gross section, immunohistochemistry and molecular pathology.
- They are able to define terms like health, illness, death, aetiology and pathogenesis. Evaluating a case report, they will recognize the right definition.
- They are able to evaluate a given problem and determine approptiate descriptive terms like incidence or mortality.
- They are able to to analyse a small case report. They will recognize and explain different changes of cells and tissues in connection to a limited number of given diagnoses.
- They are able to name and describe different informatics application which are used in the pathology lab.
- They can specify the needs a pathologist will have to the technology. This will cover the benefit and the usability for the diagnostic work.

**Grading through:**

- written exam

**Responsible for this module:**

- Prof. Dr. med. Sven Perner

**Teacher:**

- Department of Pathology
- MitarbeiterInnen des Instituts
- Dipl.-Ing. Harald Hatje

**Literature:**

- W. Böcker, H. Denk, P. U. Heitz, H. Moch: Pathologie - Urban & Fischer Verlag/Elsevier GmbH, 2012
- M. Krams, S. O. Frahm, U. Kellner, C. Mawrin: Kurzlehrbuch Pathologie - Thieme 2013
- R. Kramme: Medizintechnik, Verfahren - Systeme Informationsverarbeitung - Springer 2011

**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):
- MZ2160-L4: Pathology for technical courses, written exam, 30min, 100% of the submodule grade.

(Is module part of MZ2152, MZ2160)

Harald Hatje supports Prof. Perner in the pathology course and should therefore always be addressed.

## CS3300-KP08, CS3300SJ14 - Informatics in Health Care - eHealth (eHealth14)

| Duration: | Turnus of offer: | Credit points: |
|---|---|---|
| 2 Semester | each summer semester | 8 |

**Course of study, specific field and term:**

- Bachelor Medical Informatics 2014 (compulsory), medical computer science, 4th and 5th semester

**Classes and lectures:**

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

**Workload:**

- 60 Hours in-classroom work
- 55 Hours private studies
- 50 Hours work on project
- 30 Hours group work
- 20 Hours exam preparation
- 15 Hours written report
- 10 Hours oral presentation (including 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, ...
- PRACTICAL:
- Introduction to the methods and software tools required for the project internship.
- Planning and implementation of a software project in a division of labour group work.
- Practice-relevant project topics from the field of "hospital IT" in general database design and implementation of "simple" distributed application systems with HL7 V2 - based communication interfaces for realistic scenarios.

**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 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.
- You 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.
- INTERNSHIP:
- They can create a suitable data model for a more complex application scenario and implement it using relational DB software.
- They can create a simple GUI, that is, generally adapt a GUI template with CRUD functionality to your database.
- They can create adequate program and project documentations.

- They can solve the tasks in the team and apply the learned procedures from the modules 'Databases' and 'Software Engineering' and reach the goal of the internship on time.

**Grading through:**

- programming project
- written exam

**Requires:**

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

**Responsible for this module:**

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

**Teacher:**

- Institute of Medical Informatics
- Prof. Dr. rer. nat. habil. Josef Ingenerf

**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:**

Modulbeschreibung wird noch überarbeitet!

## 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.

## 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.

## 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.

## 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

## MZ2100 E - Module Part: Course Cell Biology and Genetics (Zellbio)

| Duration: | Turnus of offer: | Credit points: |
|---|---|---|
| 1 Semester | each summer semester | 3 |

**Course of study, specific field and term:**

- Bachelor Medical Informatics 2014 (Module part of a compulsory module), medical computer science, 4th semester
- Bachelor MES 2011 (Module part of a compulsory module), medical engineering science, 2nd semester
- Bachelor Medical Informatics 2011 (Module part of a compulsory module), medical computer science, 2nd semester

**Classes and lectures:**

- Cell Biology and Genetics (lecture, 2 SWS)

**Workload:**

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

**Contents of teaching:**

- Structure and functions of biological macromolecules
- Internal organization and functioning of cells
- Molecular genetics and gene regulation, epigenetics
- Flow of genetic information; genotype vs. phenotype
- Cell cycle
- Classical genetics
- Human genetics and inheritable diseases
- Ecological aspects of medicine (Interactions of humans, microbes, & environment)

**Qualification-goals/Competencies:**

- Ability, to understand and reproduce the basics in the areas listed under content of teaching and to use them in the further studies

**Grading through:**

- written exam

**Is requisite for:**

- Molecular Genetics (LS3100)

**Responsible for this module:**

- Prof. Dr. rer. nat. Enno Hartmann

**Teacher:**

- Institute for Biology
- Prof. Dr. rer nat. Rainer Duden
- PD Dr. rer. nat. Bärbel Kunze
- Dr. rer. nat. Nicole Sommer

**Literature:**

- Markl (Hrsg.): Biologie - Klett 2010 (ISBN: 978-3-12-150010-9)

**Language:**

- offered only in German

## MZ2100 F - Module Part: Radiology, Nuclearmedicine, Radiotherapy (RNSSJ14)

| Duration: | Turnus of offer: | Credit points: |
|---|---|---|
| 1 Semester | each summer semester | 3 |

**Course of study, specific field and term:**

- Bachelor MES 2020 (Module part of a compulsory module), medicine, 2nd semester
- Bachelor Medical Informatics 2019 (Module part of a compulsory module), medical computer science, 2nd semester
- Bachelor Medical Informatics 2014 (Module part of a compulsory module), medical computer science, 4th semester
- Bachelor MES 2014 (Module part of a compulsory module), medicine, 2nd semester

**Classes and lectures:**

- Radiology, Nuclearmedicine, Radiotherapy (lecture, 2 SWS)

**Workload:**

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

**Contents of teaching:**

- Fundamentals of the use of radiological equipment (x-ray, computed tomography, magnetic resonance imaging, sonography)
- Radiological examination and treatment methods
- Basics of clinical radiobiology and radiotherapy
- Medical Physics
- irradiation planning
- dosimetry
- Technical basics of planar scintigraphy, SPECT and PET including tomographic algorithms
- Nuclear medicine therapy methods with beta radiating radionuclides

**Qualification-goals/Competencies:**

- Students can explain the different techniques, applications and indications of radiological and radionuclide-based examinations and treatments.
- They can present the basics of X-ray anatomy and pathology.
- They can classify pathological and healthy metabolic processes.
- They can discuss basic questions of medical physics, radiation biology and radiation planning.

**Grading through:**

- written exam

**Responsible for this module:**

- Prof. Dr. med. Jörg Barkhausen

**Teacher:**

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- Prof. Dr. med. Jörg Barkhausen
- Prof. Dr. med. Alex Frydrychowicz
- Prof. Dr. med. Peter Schramm
- PD Dr. med. Inga Buchmann
- PD Dr. med. Dirk Rades
- Dr. Lutz Schelper
- Dr. med. Tobias Boppel
- Dr. Corinna Melchert
- Dr. Florian Cremers
- Dr. med. Malte Sieren
- Dr. med. Franz Wegner
- Dr. med. Nikolaos Panagiotopoulos

**Literature:**

- :
- :
- :
- :

**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):
- MZ2160-L3: Radiology, Nuclear Medicine, Radiotherapy, written exam, 90min, 100% of the submodule grade.

(Is module part of MZ2152, MZ2160)
(Is equal to MZ3160)

Replaces the independent module MZ3160.

## 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

## 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%)

## 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

## 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

## 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)

## 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.-Ing. Nicole Jochems

**Teacher:**

- Institute for Multimedia and Interactive Systems
- Prof. Dr.-Ing. Nicole Jochems

**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

## 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

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

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

**Course of study, specific field and term:**

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- Written or oral exam as announced by the examiner

**Requires:**

- Databases (CS2700-KP04, CS2700)

**Responsible for this module:**

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

**Teacher:**

- Institute of Information Systems

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

**Literature:**

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

**Language:**

- offered only in German

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

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

**Course of study, specific field and term:**

- 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

## CS3350-KP06 - Medical Data Science and Artificial Intelligence (MDS)

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

**Course of study, specific field and term:**

- Bachelor Medical Informatics 2014 (optional subject), medical computer science, 5th or 6th semester
- Bachelor Medical Informatics 2019 (compulsory), Medical Data Science / Artificial Intelligence, 5th semester

**Classes and lectures:**

- Medical Data Science and Artificial Intelligence (lecture, 2 SWS)
- Medical Data Science and Artificial Intelligence (exercise, 2 SWS)
- Medical Data Science and Artificial Intelligence (practical course, 1 SWS)

**Workload:**

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

**Contents of teaching:**

- Introduction
- General Approach to Information Retrieval (Scenario 1: Medical Information Retrieval)
- Annotation-based Approach to Information Retrieval (Scenario 1: Medical Information Retrieval)
- Content-based Approach to Information Retrieval (Scenario 1: Medical Information Retrieval)
- Performance of Systems for Information Retrieval (Scenario 1: Medical Information Retrieval)
- General Approach to Supervised Classification (Scenario 2: Voice-based Early Diagnosis)
- Extraction, Selection and Transformation of Features (Scenario 2: Voice-based Early Diagnosis)
- Linear Classification (Scenario 2: Voice-based Early Diagnosis)
- Statistical Classification (Scenario 2: Voice-based Early Diagnosis)
- General Approach to Unsupervised Classification (Scenario 3: Population Medicine)
- Sequential Clustering (Scenario 3: Population Medicine)
- Hierarchical Clustering (Scenario 3: Population Medicine)
- Fuzzy Clustering (Scenario 3: Population Medicine)
- Demonstrators from Current Research Projects
- Summary and Conclusions

**Qualification-goals/Competencies:**

- Students know the term Medical Data Science and are able to define and clearly distinguish it from other related terms.
- Students know the concept of the automated information retrieval.
- Students know the annotation-based approach to information retrieval and are able to implement it in the medical context using a programming language.
- Students know the content-based approach to information retrieval and are able to implement it in the medical context using a programming language.
- Students know evaluation strategies for information retrieval platforms and are able to assess the performance of such systems.
- Students know the concept of supervised classification.
- Students know selected approaches to feature extraction, selection, and transformation and are able to implement it in the medical context using a programming language.
- Students know the linear classification approach and are able to implement it in the medical context using a programming language.
- Students know the statistical classification approach and are able to implement it in the medical context using a programming language.
- Students know the concept of unsupervised learning (clustering).
- Students know the sequential clustering approach and are able to implement it in the medical context using a programming language.
- Students know the hierarchical clustering approach and are able to implement it in the medical context using a programming language.
- Students know the fuzzy clustering approach and are able to implement it in the medical context using a programming language.
- Students know the objectives and function of software systems from selected current medical data science research projects.
- Students know the societal relevance of methods for automated data analysis in the medicine.

**Grading through:**

- Written or oral exam as announced by the examiner

**Responsible for this module:**

- Prof. Dr.-Ing. Marcin Grzegorzek

**Teacher:**

- Institute of Medical Informatics

- Prof. Dr.-Ing. Marcin Grzegorzek
- PD Dr. rer. nat. habil. Sebastian Fudickar

**Literature:**

- Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze: Introduction to Information Retrieval - ISBN: 9780521865715
- Sergios Theodoridis and Konstantinos Koutroumbas: Pattern Recognition - ISBN: 9781597492720

**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 smaller programming projects as specified at the beginning of the semester.

Module Exam(s):
- CS3350-L1: Medical Data Science and Artificial Intelligence, written exam, 120min, 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

## CS3830-KP04, CS3830 - Programming for Medical Image Processing in C++ (PmBV)

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

**Course of study, specific field and term:**

- Bachelor MES 2014 (optional subject), medical engineering science, 4th or 6th semester
- Master Medical Informatics 2014 (optional subject), medical image processing, 1st or 2nd semester
- Bachelor Medical Informatics 2014 (optional subject), medical computer science, 5th or 6th semester
- Bachelor Medical Informatics 2011 (optional subject), medical computer science, 4th to 6th semester

**Classes and lectures:**

- Programming for Medical Image Processing in C++ (lecture, 1 SWS)
- Programming for Medical Image Processing in C++ (practical course, 2 SWS)

**Workload:**

- 70 Hours private studies
- 45 Hours in-classroom work
- 5 Hours oral presentation and discussion (including preparation)

**Contents of teaching:**

- Introduction to C++ programming for medical image processing
- File formats of medical data and data structure/types
- Vectors, Standard Template Library, Pairs and Tuples
- Class objects, functions and methods
- Loops, also in C++11, lambda functions
- Use of programming libraries (Eigen)
- Implementation of filters for medical image processing
- Dimensionality reduction using PCA
- Search and cluster trees for image processing
- Patch-based non-local means segmentation
- Fast-Fourier transform for template matching
- Integration of C++ in MATLAB (mex)
- Efficient programming for 3d medical images
- Parallel and SIMD programming techniques in C++
- Solve practical project in a team

**Qualification-goals/Competencies:**

- Students understand the specific challenges of programming for medical image processing.
- They know the basics of object orientated programming.
- They are able to implement local and regional pixel operators (filter, etc) independently.
- They know functions from STL and current trends in C++.
- They are proficient in solving large problems in limited time.
- They can design, implement and test programme code independently.
- They are able to develop practical algorithms for medical image processing based on theoretical concepts.
- They can tackle large scale problems together in teams.

**Grading through:**

- continuous, successful participation in practical course

**Responsible for this module:**

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

**Teacher:**

- Institute of Medical Informatics
- Prof. Dr. Mattias Heinrich

**Literature:**

- Lippman: C++ Primer - Addison-Wesley Longman, Amsterdam

**Language:**

- German and English skills required

**Notes:**

taught as compact course in spring term break (project during term)

## CS4180-KP04, CS4180 - Security in Networks and Distributed Systems (SicherNet)

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

**Course of study, specific field and term:**

- Bachelor Medical 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 IT security and safety, 4th 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), advanced curriculum enterprise IT, 2nd or 3rd semester

**Classes and lectures:**

- Security in Networks and Distributed Systems (lecture, 2 SWS)
- Security in Networks and Distributed Systems (exercise, 1 SWS)

**Workload:**

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

**Contents of teaching:**

- Fundamentals of network security
- Attacks
- Cryptology
- Acquire a basic understanding of formals and organizational aspects of network security (IT-Grundschutz, ITIL security)
- 
- Integrity & Authentication, Authorization, and Accountability
- Key Distribution
- Certificates and Digital Signatures
- Protocols (Physical & Data-Link, Network & Transport, Application Layer)
- Firewalls
- IT Grundschutz & ITIL
- Societal aspects

**Qualification-goals/Competencies:**

- Acquire a basic understanding of security issues (important terms, security objectives, communication models, network security models, attacker models, difference between safety and security)
- Understand the different security risks in networks and distributed systems
- Learn about the different types of attacks and their classification
- Understand the basics of cryptography: substitution ciphers (Caesar, Vigenère, etc.), Enigma, One-Time Pad, stream ciphers (structure, RC4), block ciphers (Feistel Networks, DES, AES), operation modes (ECB, CBC, PCBC, CFB, OFB, Counter), padding, asymmetric systems (Diffie-Hellmann, RSA)
- Understand integrity, authentication, authorization, and accountability
- Understanding of digital certificates, public key infrastructures and learn about important standards such as X.509
- Lean about important security solutions on different layers of the ISO/OSI stack
- Understand firewalls
- 

**Grading through:**

- Written or oral exam as announced by the examiner

**Responsible for this module:**

- Prof. Dr. Stefan Fischer

**Teacher:**

- Institute of Telematics
- Prof. Dr. Stefan Fischer

**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

**Language:**

- offered only in German

## 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)

## MA2214-KP04, MA2214 - Clinical Studies (KlinStud)

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

**Course of study, specific field and term:**

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- portfolio exam

**Requires:**

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

**Responsible for this module:**

- PD Dr. rer. pol. Reinhard Vonthein
- Prof. Dr. rer. biol. hum. Inke König

**Teacher:**

- Institute of Medical Biometry and Statistics

- PD Dr. rer. pol. Reinhard Vonthein
- Prof. Dr. rer. biol. hum. Inke König

**Literature:**

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

**Language:**

- German and English skills required

**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):
- None

Module exam(s):
- MA2214-L1: Clinical Studies, portfolio exam, 100 % of module grade, with a total of 200 points, distributed as follows:
+ 145 points for project work with documentation and presentations
+ 55 points for 5 short term papers

The course is held annually in German and English alternately. Languages Englisch or German may be chosen for homework and project with
documentation and presentation.

## 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

## 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.

## MA3400-KP04, MA3400 - Biomathematics (Biomathe)

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

**Course of study, specific field and term:**

- Master Molecular Life Science 2023 (optional subject), mathematics / computer science, 1st 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 2014 (optional subject), medical computer science, 5th or 6th semester
- Bachelor MES 2014 (optional subject), mathematics / natural sciences, 3rd or 5th semester
- Bachelor Computer Science 2014 (compulsory), specialization field bioinformatics, 5th semester
- Master MES 2011 (optional subject), mathematics, 1st semester
- Bachelor Medical Informatics 2011 (optional subject), bioinformatics, 4th to 6th semester
- Master Computer Science 2012 (optional subject), specialization field medical informatics, 3rd semester
- Bachelor MES 2011 (optional subject), mathematics, 5th semester
- Bachelor Computer Science 2012 (compulsory), specialization field bioinformatics, 5th semester

**Classes and lectures:**

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

**Workload:**

- 55 Hours private studies and exercises
- 45 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
- In accordance to the rules of GSP of UzL

**Qualification-goals/Competencies:**

- Students are able to explain basic notions from the theory of ordinarydifferential equations.
- Based on examples, students are able to explain
- Based on theorems, students are able to give conditions under which
- 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:**

Prerequisites for the module:
- nothing

Prerequisites for admission to the written examination:
- Successful completion of homework assignments during the semester

Module exam:
- MA3400-L1: Biomathematik, written exam, 90 min, 100 % module grade

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

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

**Course of study, specific field and term:**

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- Oral examination

**Requires:**

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

**Responsible for this module:**

- PD Dr. rer. nat. Christian Bey

**Teacher:**

- Institute for Mathematics
- PD Dr. rer. nat. Christian Bey

**Literature:**


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

**Language:**

- offered only in German

**Notes:**

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

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

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

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

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

**Course of study, specific field and term:**

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- Written or oral exam as announced by the examiner

**Responsible for this module:**

- Prof. Dr. rer. nat. Robert Huber

**Teacher:**

- Institute of Biomedical Optics
- Dr. rer. nat. Norbert Linz

**Literature:**

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

**Language:**

- offered only in German

**Notes:**

Prerequisites for attending the module:
- None

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

## ME3100-KP04, ME3100SJ14 - Medical Imaging (MBG14)

| 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 (optional subject), Additionally recognized elective module, 5th semester
- Master Auditory Technology 2022 (optional subject), Auditory Technology, 1st semester
- Master Auditory Technology 2017 (optional subject), Auditory Technology, 1st semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), medical image processing, 5th or 6th semester
- Bachelor Medical Informatics 2019 (optional subject), medical computer science, 4th to 6th semester
- Bachelor Medical Informatics 2014 (optional subject), medical computer science, 5th or 6th semester

**Classes and lectures:**

- Medical Imaging (lecture, 2 SWS)
- Medical Imaging (exercise, 1 SWS)

**Workload:**

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

**Contents of teaching:**

- Introduction to the theory of imaging systems
- Ultrasound imaging
- Conventional X-ray imaging, Computed Tomography
- Magnetic Resonance Imaging

**Qualification-goals/Competencies:**

- The students can characterise linear translation-invariant imaging systems by means of impulse response and transfer function.
- They can explain the Nyquist-Shannon theorem and justify its validity.
- They can describe what is meant by spatial resolution of an imaging system.
- They can give an overview of important medical imaging techniques.
- They can explain the physical foundations of ultrasound imaging.
- They can describe the behaviour of ultrasound waves at tissue borders.
- They can reason the fundamental limit to spatial resolution in US.
- They can list the interdependence between ultrasound frequency, spatial resolution, and penetration depth.
- They can elucidate how technical parameters are chosen for a given target to be imaged.
- They can discuss aim and realisation of beam forming in US imaging.
- They can explain how Doppler US works.
- They can describe why important US image artefacts occur.
- They can explain the physical and technical foundations of X-ray generation.
- They can sketch the typical spectrum of a technical X-ray source.
- They can list and describe the most important interaction processes between X-rays and matter.
- They can mention possible sources of hazard in X-ray imaging and discuss strategies for avoiding them.
- They can describe the influence of technical parameters in X-ray imaging systems.
- They can describe and justify important reconstruction principles in CT and their mathematical foundations.
- They can explain the physical foundations of nuclear magnetic resonance (NMR).
- They can describe how spatial resolution is achieved in NMR imaging.
- They can justify the occurrence of different types of radio frequency echoes in NMR.
- They can explain the concept of k-space.
- They can describe how different weightings are achieved in MR images.
- They can list sources of hazard in MRI and explain their causes.
- They can describe the technical components of an MR imaging system.
- They can implement important algorithms used in imaging systems.

**Grading through:**

- written exam

**Responsible for this module:**

- Prof. Dr. rer. nat. Martin Koch

**Teacher:**

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

**Literature:**

- O. Dössel: Bildgebende Verfahren in der Medizin - Springer, Berlin 2000
- H. Morneburg (Hrsg.): Bildgebende Systeme für die medizinische Diagnostik. 3. Aufl. - Publicis MCD Verlag, München 1995

**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 assignments as specified at the beginning of the semester.

Module Exam(s):
- ME3100-L1: Medical Imaging, written exam, 60min, 100% of the module grade.

## MZ3100-KP04, MZ3100 - Medical Quality Management (MedizQM)

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

**Course of study, specific field and term:**

- Bachelor MES 2020 (compulsory), medicine, 3rd semester
- Bachelor Medical Informatics 2019 (optional subject), medical computer science, 4th to 6th semester
- Bachelor Medical Informatics 2014 (optional subject), medical computer science, 5th or 6th semester
- Bachelor MES 2014 (compulsory), medicine, 3rd semester
- Master Computer Science 2012 (optional subject), specialization field medical informatics, 3rd semester
- Bachelor MES 2011 (compulsory), medicine, 5th semester

**Classes and lectures:**

- Medical Quality Management (lecture, 2 SWS)
- Medical Quality Management (exercise, 1 SWS)

**Workload:**

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

**Contents of teaching:**

- Part I: Medical Qualtity Management
- Part II: Gauging, testing and engineer standards
- Part III: Industrial Qualtiy Management

**Qualification-goals/Competencies:**

- Part I: The students can classify the importance of quality management in the medical sector (procedural knowledge), they know the basic terms of this subject area and the contents of the EC Directives and the Medical Devices Act (factual knowledge). They have the expertise for independet evaluations of clinical studies (empowerment) and the have factual knowledge sectors of quality assurance an psychometric tests.
- Part II: The students can identify the important physiological signals from the area of anesthesiology an they know the important parameters to describe the measured signal quality (factual knowledge). They have acquired knowledge in signal recording an processing (factual knowledge) and they can analyze a invasive blood preasure system (second-prder system) independently unter supervision. They know the contents of relevant safety, quality and testing standards (factual knowledge).
- Part III: The students kno the basic components and requirements of a industrial quality management system in the medical technology branch (factual knowledge). They are able to point out the difference between corporate objetives and quality objectives (procedural knowledge). They know the specific qulity requirements for medical software, hardware (MRI) and in-virto diagnostics (factual knowledge).

**Grading through:**

- written exam

**Responsible for this module:**

- Prof. Dr. med. Hartmut Gehring

**Teacher:**

- Institute of Medical Engineering
-
- Prof. Dr. med. Hartmut Gehring

**Literature:**


- Böckmann, Frankenberger, und Wille: MPG und Co. - 7. akt. Auflage 2015, TÜV-Verlag GmbH Köln, ISBN: 978-3-8429-1843-0
- Jahnke, I., Friedrich, H.-J. & Hüppe, M. (2002): Die Lübecker Fragebogen-Doppelkarte zur Erfassung der Patientenzufriedenheit: Wie differenziert sollte eine Auswertung für das Qualitätsmanagement erfolgen? - FOCUS MUL, 19,/ 82-91
- Lauterbach, Lüngen, Schrappe: Gesundheitsökonomie, Management und Evidence-based Medicine. - 3. Auflage 2010, Schattauer GmbH, ISBN 978-3-7945-2576-8
- Frodel: BWL für Mediziner - 2008, Walter de Gruyter & Co. KG, ISBN: 978-3-11-020112-3
- Lauterbach, Stock, Brunner: Gesundheitsökonomie - 2. Auflage 2009, Verlag Hans Huber, ISBN 978-3-456-84695-8


**Language:**

- offered only in German

**Notes:**

Prerequisites for attending the module:
- None

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

## RO5300-KP06 - Humanoid Robotics (HumRob)

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

**Course of study, specific field and term:**

- Master Biophysics 2019 (optional subject), Elective, 1st or 2nd semester
- Bachelor Media Informatics 2020 (optional subject), Robotics and Autonomous Systems, 5th or 6th semester
- Bachelor Robotics and Autonomous Systems 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 Medical Informatics 2014 (optional subject), Robotics and Autonomous Systems, 5th or 6th semester
- Bachelor Media Informatics 2014 (optional subject), Robotics and Autonomous Systems, 5th or 6th semester
- Bachelor IT-Security 2016 (optional subject), Robotics and Autonomous Systems, Arbitrary semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), Robotics and Autonomous Systems, 5th or 6th semester

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

- Development of humanoid robots: The special features of the kinematics of humanoid robots based on the human model are considered. Challenges and strategies for the design of humanoid robots are discussed. Mechatronic concepts for humanoid robot development are presented using examples.
- Control of humanoid walking robots: Basic concepts for the planning and control of walking movements are introduced. The characteristics of human locomotion are considered. Based on this, the motion planning and control of robotic walking is presented.
- Gripping with humanoid robot hands: Grip planning and grip synthesis with humanoid robot hands is presented. Basic characteristics of human grasping are considered. Analytical methods for planning and evaluating grasps are discussed and modern approaches for learning grasps are introduced.
- Modeling and planning: Basic concepts of modeling and planning tasks are discussed. The description of a goal-oriented action using modular actions is shown. Optimization methods for automated action planning are presented.

**Qualification-goals/Competencies:**

- Students acquire the ability to independently solve application-oriented exercises from robotics, with a focus on (humanoid) robots with a mathematical background
- You have a basic understanding of the kinematic properties of humanoid robots
- They know the requirements for the design of humanoid robots and understand mechatronic concepts for the development of human-inspired robot kinematics.
- They understand the complexity of controlling humanoid robots, especially with regard to bipedal walking and gripping with five-fingered hands, including the dynamic processes
- You have gained an insight into learning methods for planning the action sequences of humanoid robots, including the dynamic processes
- You have experience in programming humanoid robots

**Grading through:**

- Oral examination

**Responsible for this module:**

- Prof. Dr.-Ing. Julia Starke

**Teacher:**

- Institute for Robotics and Cognitive Systems
- Prof. Dr.-Ing. Julia Starke

**Literature:**

- Murray, Li and Sastry: A mathematical introduction to robotic manipulation - CRC Press 1994

**Language:**

- 

**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):
- RO5300-L1: Humanoid Robotics, oral exam, 100% of the module grade

## 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

## CS3310-KP08, CS3310SJ14 - Medical Image Computing (MBV14)

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

**Course of study, specific field and term:**

- Bachelor Medical Informatics 2014 (compulsory), medical computer science, 5th semester

**Classes and lectures:**

- Medical Image Computing (lecture, 2 SWS)
- Medical Image Computing (exercise, 1 SWS)
- Practical Medical Image Computing (lecture, 1 SWS)
- Practical Medical Image Computing (exercise, 1 SWS)
- Practical Medical Image Computing (practical course, 1 SWS)

**Workload:**

- 90 Hours in-classroom work
- 50 Hours work on project
- 40 Hours private studies
- 30 Hours group work
- 20 Hours exam preparation
- 10 Hours oral presentation (including preparation)

**Contents of teaching:**

- Motivation, principles and applications of medical image computing
- Structure and formats of medical images
- Fundamentals of pattern recognition (segmentation, feature extraction, classification, interpretation)
- Histograms and image transformations
- Image filtering using Fourier transform
- Image filtering with local operators
- Segmentation: thresholding, region growing
- Clusteranalysis and classifyer for image segmentation
- Morphological operators
- Application and evaluation of segmentation methods
- Image interpolation methods
- Transformataion of images
- Basic methods of image registration: rigid image registration
- Combined signal and image analysis in 4D image processing
- Application examples
- INTERNSHIP:
- Introduction to the methods and software tools required for the project internship
- Planning and implementation of a complete software project in group work based on division of labour while adhering to standards and deadlines
- The project topics to be worked on are chosen from the field of medical image processing using clinical image data

**Qualification-goals/Competencies:**

- Students are able to classify basic medical image processing methods, are able to characterize them and to apply them to concrete problems.
- They are able to select appropriate, problem-specific methods for image filtering, image segmentation, and morphological post-processing of segmentation results, to combine them in a processing pipeline and to use them for image enhancement or image segmentation of medical structures.
- They are able to distinguish between different methods of cluster analysis and statistical pattern recognition and can characterize them based on different implicitly used model assumptions and properties.
- They are able to evaluate segmentation results of different methods based on established quality measures and to carry out an objective comparison of the quality of different segmentation methods in practical use.
- They are able to distinguish between different image interpolation methods, to classify them according to their specific advantages and disadvantages and to select an appropriate method and apply it, depending on a specific problem.
- They are able to assess the characteristics of different rigid image registration methods. For a specific registration problem they are able to select problem specific similarity measures and regularization terms and to parameterize them.
- They are able to distinguish and to characterize different techniques for analyzing functional 4D fMRI image sequences, with whom neurally activated brain areas in 4D image sequences of the head can be made visible.
- They are able to implement basic image processing algorithms and to bring them to use in combination with medical image processing modules available from program libraries.
- They have the ability to develop problem-specfic medical image analysis systems by using various software tools.
- In this context, they are able to analyze complex tasks, to break them down into sub-tasks and to implement them in teams.
- They have the ability to estimate the project effort, to plan the project schedule and to use resources appropriately.

- They can document the developed solutions and present the results.

**Grading through:**

- successful addressing of the project goals

**Is requisite for:**

- Advanced Techniques of Medical Image Processing (CS4370-KP04, CS4370)
- Image Analysis and Visualization in Diagnostics and Therapy (CS4330-KP08, CS4330SJ14)

**Responsible for this module:**

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

**Teacher:**

- Institute of Medical Informatics

- Prof. Dr. rer. nat. habil. Heinz Handels
- Dr. rer. nat. Jan Ehrhardt
- PD Dr. rer. biol. hum. habil. Andre Mastmeyer

**Literature:**


- H. Handels: Medizinische Bildverarbeitung - Stuttgart: Vieweg & Teubner 2009
- T. Lehmann: Handbuch der Medizinischen Informatik - München: Hanser 2004
- M. Sonka, V. Hlavac, R. Boyle: Image Processing, Analysis and Machine Vision - 2nd edition. Pacific Grove: PWS Publishing 1998


**Language:**

- offered only in German

**Notes:**

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

Admission requirements for participation in module examination(s):
- Module part 'Medical Image Computing' (V+Ü): Successful completion of exercise sheets as specified at the beginning of the semester
- Module part 'Internship in Medical Image Computing': Regular participation in the practical course as specified at the beginning of the semester

Module Exam(s):
- CS3310-L1: Medical Image Computing, written exam, 60min, 50% of the module grade
-CS3310-L2: Internship Medical Image Computing, graded Internship, 50% of the module grade

## CS3703-KP04, CS3703 - Bachelor Seminar Medical Informatics (BachSemMI)

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

**Course of study, specific field and term:**

- Bachelor Medical Informatics 2019 (compulsory), interdisciplinary competence, 5th semester
- Bachelor Medical Informatics 2014 (compulsory), interdisciplinary competence, 5th semester
- Bachelor Medical Informatics 2011 (compulsory), interdisciplinary competence, 5th semester

**Classes and lectures:**

- 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:**

- Training in a scientific topic
- Processing a scientific problem and its solution methods
- 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

**Responsible for this module:**

- Studiengangsleitung Medizinische Informatik

**Teacher:**

- Institute of Medical Informatics

**Literature:**

- Subject and literature are determined individually:
- Participants should have the task in a timely manner, i. At least 1 MONTH before the beginning of the event, discuss with the lecturer:

**Language:**

- offered only in English

**Notes:**

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful participation in the seminar incl. elaboration, presentation, contributions to the discussion according to the requirements at the beginning of the semester.

Module Exam(s):
- CS3703-L1: Bachelor Seminar Medical Informatics, seminar, ungraded

## MZ4010-KP04, MZ4010 - Clinical Epidemiology (KlinEpi)

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

**Course of study, specific field and term:**

- Master CLS 2023 (compulsory), MML with specialization in Genetic Statistics, 3rd semester
- Bachelor Medical Informatics 2019 (optional subject), medical computer science, 4th to 6th semester
- Master CLS 2016 (compulsory), MML with specialization in Genetic Statistics, 3rd semester
- Bachelor Medical Informatics 2014 (compulsory), medical computer science, 5th semester
- Bachelor Medical Informatics 2011 (compulsory), medical computer science, 3rd semester
- Master CLS 2010 (compulsory), computational life science / biostatistics, 1st semester
- Master Computer Science 2012 (compulsory), specialization field medical informatics, 3rd semester

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam

**Responsible for this module:**

- Prof. Dr. med. Alexander Katalinic

**Teacher:**

- Institute for Social Medicine and Epidemiology
- Prof. Dr. med. Alexander Katalinic
- MitarbeiterInnen des Instituts

**Literature:**

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

**Language:**

- offered only in German

**Notes:**

Prerequisites for attending the module:
- None

Prerequisites for participation in the exam(s):
- None

Module exam(s):
- MZ4010-L1, Clinical Epidemiology, written exam, 90 min, 100 % of module grade

## CS3800-KP03, CS3800 - Social Aspects of Medical Informatics (GesellMI)

| Duration: | Turnus of offer: | Credit points: |
|---|---|---|
| 1 Semester | each summer semester | 3 (Typ B) |

**Course of study, specific field and term:**

- Bachelor Medical Informatics 2019 (compulsory), interdisciplinary competence, 6th semester
- Bachelor Medical Informatics 2014 (compulsory), interdisciplinary competence, 6th semester
- Bachelor Medical Informatics 2011 (compulsory), interdisciplinary competence, 6th semester

**Classes and lectures:**

- Social Aspects of Medical Informatics (lecture, 1 SWS)
- Social Aspects of Medical Informatics (seminar, 1 SWS)

**Workload:**

- 40 Hours written report
- 30 Hours in-classroom work
- 20 Hours private studies

**Contents of teaching:**

- History and philosophy of technology and informatics in general
- Theories of technolution (how and when do innovations emerge?)
- Critique and assessment of technology, technology assessment
- Fields of application of information technology in medicine
- Ethical and societal aspects of information technology
- Data security, cultural and aesthetical aspects of digital media

**Qualification-goals/Competencies:**

- Students are able to describe and explain basic concepts, theories, and methods of history of technology studies.
- They can depict pivotal stages and controversies in the historical development of medical informatics.
- They are capable to identify questions of social acceptability of information technology, to carve out their different implications, and to discuss them critically.
- They have an understanding of the philosophical and cultural implications of information technology, and are able to apply this knowledge to case studies.
- They master to research, interpret, and analyze critically scientific literature on the module's topics.
- They have the communication competency to analyze and present societal aspects of technological issues in oral and written form.

**Grading through:**

- presentation
- Written report
- continuous, successful participation in course

**Responsible for this module:**

- Prof. Dr. med. Cornelius Borck

**Teacher:**

- Institute of Medical Informatics
- Institute for History of Medicine and Science Studies

- Prof. Dr. med. Cornelius Borck
- Prof. Dr. rer. nat. Burghard Weiss
- Prof. Dr. rer. nat. habil. Heinz Handels
- Prof. Dr. phil. Christoph Rehmann-Sutter
- Dipl.-Inform. Dr. med. Jan-Hinrich Wrage
- Dr. phil. nat. Thorsten Kohl
- Dr. phil. Daniela Zetti

**Literature:**


- Kramme R (Hrsg.): Medizintechnik: Verfahren Systeme Informationsverarbeitung - 4. Aufl. Berlin, Heidelberg, New York: Springer 2011
- Orland B (Hrsg): Artifizielle Körper lebendige Technik: Technische Modellierungen des Körpers in historischer Perspektive - Zürich: Chronos 2005
- Horx M: Technolution. Wie unsere Zukunft sich entwickelt - Frankfurt: Campus 2008

**Language:**

- offered only in German

**Notes:**

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful and regular participation in the seminar incl. elaboration, presentation, contributions to the discussion as specified at the beginning of the semester.

Module Exam(s):
- CS3800-L1: Social Aspects of Medical Informatics, ungraded seminar

## CS3991-KP15, CS3991 - Bachelor Thesis Medical Informatics (BScMI)

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

**Course of study, specific field and term:**

- Bachelor Medical Informatics 2019 (compulsory), medical computer science, 6th semester
- Bachelor Medical Informatics 2014 (compulsory), medical computer science, 6th semester
- Bachelor Medical Informatics 2011 (compulsory), medical computer science, 6th semester

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

- Independent scientific work on a limited task of medical informatisc and its applications
- Scientific presentation about the problem and the solution developed

**Qualification-goals/Competencies:**

- Students are able to solve a limited task of a scientific problem with the means of their discipline.
- They have the expertise to plan, organize and carry out a project work.
- They can present complex information in written and oral form.
- They are experts for a clearly defined topic.

**Grading through:**

- Written report
- colloquium

**Responsible for this module:**

- Studiengangsleitung Medizinische Informatik

**Teacher:**

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

**Literature:**

- :

**Language:**

- thesis can be written in German or English

**Notes:**

Admission requirements for taking the module:
- see study programme regulations (e.g. certain minimum CP achieved).

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

Module Exam(s):
- CS3991-L1: Bachelor thesis with colloquium, 100% of the module grade.

Of the credit points of the module, 12 credit points are awarded for the actual thesis, the remaining credit points for the preparation and execution of the colloquium.

## 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