UNIVERSITÄT ZU LÜBECK

Module Guide for the Study Path

# Bachelor MES 2020

Version from 6. October 2023

## 1st and 2nd semester



## 1st semester



## 2nd semester



## 3rd semester



## 3rd semester at the earliest

## 4th semester



## 4th semester at the earliest



## 5th semester

## 6th semester



## Arbitrary semester

# MZ2160-KP12, MZ2160 - Introduction to Medicine (EMed)

| Duration: | Turnus of offer: | Credit points: |
|---|---|---|
| 2 Semester | each winter semester | 12 |

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

- Bachelor MES 2020 (compulsory), medicine, 1st and 2nd semester
- Bachelor Medical Informatics 2019 (compulsory), medical computer science, 1st to 3th semester
- Bachelor MES 2014 (compulsory), medicine, 1st and 2nd semester

**Classes and lectures:**

- MZ2100 A: Anatomie (course, 2 SWS)
- MZ2100 B: Pathologie (course, 2 SWS)
- MZ2100 D: Physiologie (course, 2 SWS)
- MZ2100 F: Radiologie, Nuklearmedizin, Strahlentherapie (course, 2 SWS)

**Workload:**

- 180 Hours private studies
- 120 Hours in-classroom work
- 60 Hours exam preparation

**Contents of teaching:**

- See individual module parts

**Qualification-goals/Competencies:**

- See individual module parts

**Grading through:**

- written exam

**Responsible for this module:**

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

**Teacher:**

-
-
- Institute of Neurobiology
- Department of Pathology
- Institute of Anatomy

- Prof. Dr. med. Hartmut Gehring

**Literature:**

- as described for the module parts:

**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, 25% of the module grade.
- MZ2160-L2: Physiology for technical courses, written exam, 90min, 25% of the module grade
- MZ2160-L3: Radiology, Nuclear Medicine, Radiotherapy, written exam, 90min, 25% of module grade
- MZ2160-L4: Pathology for technical courses, written exam, 30min, 25% of module grade

In the Bachelor Medical Informatics study plan, the recommended duration is 3 semesters. In the curriculum Medical Engineering Science the duration is 2 semesters.

This module used to be called "Introduction to Medicine for MIW".

(Consists of MZ2100 A, MZ2100 B, MZ2100 D, MZ2100 F)

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

## 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
- 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

## ME1010-KP08, ME1010 - Physics 1 (Phy1)

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

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

- Bachelor Biophysics 2024 (compulsory: aptitude test), physics, 1st semester
- Bachelor MES 2020 (compulsory: aptitude test), physics, 1st semester
- Bachelor Biophysics 2016 (compulsory: aptitude test), physics, 1st semester
- Bachelor MES 2014 (compulsory: aptitude test), physics, 1st semester
- Bachelor MES 2011 (compulsory), physics, 1st semester

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

- Physical values, units, accuracy, measurement errors
- Mathematical methods and notations
- Kinematics of point mass, Newton s Axioms, contact forces, modulus, virtual forces, Newton s equation of motion, differential equations
- Work and energy, power and efficiency, momentum, inertia, physical pendulum, momentum of rotation
- Conservation laws and symmetries
- Gravitation, oscillation, waves, acoustics, Doppler effect
- Resting and flowing gases and liquids, effects of surfaces and interfaces
- Temperature, thermometer, therm. expansion, state equations, kinetic gas theory
- Van-der-Waals state equation, heat capacity, heat conduction, 1st law of thermodynamics, volume work, p-V diagram
- Adiabatic processes, 2nd law of thermodynamics, thermal engines and Carnot cycle, efficiency, heat pump
- Entropy, disorder and probability, 3rd law of thermodynamics

**Qualification-goals/Competencies:**

- You can name the basic laws of physics
- You can measure according to physics rules
- You can explain physical laws based on observations
- You can formally analyze physical problems
- You can judge which concept is best suited to solve a certain problem
- You can design novel physical experiments on your own

**Grading through:**

- written exam

**Is requisite for:**

- Physics 2 (ME1020-KP08, ME1020)

**Responsible for this module:**

- Prof. Dr. rer. nat. Christian Hübner

**Teacher:**

- Institute of Biomedical Optics
- Institute of Physics
- Institute of Medical Engineering

- Prof. Dr. rer. nat. Thorsten Buzug
- Prof. Dr. rer. nat. Christian Hübner
- PD Dr. rer. nat. Hauke Paulsen
- Prof. Dr. rer. nat. Alfred Vogel
- Prof. Dr. rer. nat. Robert Huber

**Literature:**

- Giancoli: Physics

**Language:**

- offered only in German

**Notes:**

Prerequisites for attending the module:
- None

Prerequisites for admission to the written examination:
- 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.

Module exam:
- ME1010-L1: written exam, 120 min, 100 % 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)

## 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.

## 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-KP08 - Analysis 2 (Ana2KP08)

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

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

- Bachelor Biophysics 2024 (compulsory), mathematics, 2nd semester
- Bachelor IT-Security 2016 (optional subject), specific, Arbitrary semester
- Bachelor MES 2014 (compulsory), mathematics, 2nd semester
- Bachelor MES 2020 (compulsory), mathematics, 2nd semester
- Bachelor Biophysics 2016 (compulsory), mathematics, 2nd semester

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

- Advanced multivariate differential calculus
- Integral calculus for functions of one real variable (indefinite integrals, antiderivatives, substitution, partial fractions, definite integrals, fundamental theorem of calculus)
- Curvilinear integrals, bounded variation
- Function series, power series
- Fourier series (trigonometric polynomials, convergence)
- Linear operators in Hilbert spaces

**Qualification-goals/Competencies:**

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

**Grading through:**

- 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:**

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

**Language:**

- 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

Modul exam:
-MA2500-L1: Analysis 2, written exam, 90 min, 100 % module grade

## ME1020-KP08, ME1020 - Physics 2 (Physik2)

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

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

- Bachelor Biophysics 2024 (compulsory), physics, 2nd semester
- Bachelor MES 2020 (compulsory), physics, 2nd semester
- Bachelor Biophysics 2016 (compulsory), physics, 2nd semester
- Bachelor MES 2014 (compulsory), physics, 2nd semester
- Bachelor MES 2011 (compulsory), physics, 2nd semester

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

- Electric charge, Coulomb force, electric field, electric potential, capacity
- Stationary electric current, resistor, Kirchhoff s laws
- Magnetic field, magnetic dipole, electric current and magnetic field
- Electromagnetic induction, resonant circuit
- Nonstationary electric and magnetic fields, displacement current, Maxwell s equations
- Refraction, reflexion
- Geometrical optics, image generation, lenses, aberrations, optical instruments
- Interference, diffraction, resolution power
- Polarization, birefringence, Brewster s angle
- Relativity theory
- Bohr s atomic model, spectral lines, quantum mechanical atomic model
- Molecules and solid bodies

**Qualification-goals/Competencies:**

- You can name the basic laws of physics
- You can measure according to physics rules
- You can explain physical laws based on observations
- You can formally analyze physical problems
- You can judge which concept is best suited to solve a certain problem
- You can design novel physical experiments on your own

**Grading through:**

- Written or oral exam as announced by the examiner

**Requires:**

- Physics 1 (ME1010-KP08, ME1010)

**Responsible for this module:**

- Prof. Dr. rer. nat. Christian Hübner
- Prof. Dr. rer. nat. Thorsten Buzug
- Prof. Dr. rer. nat. Robert Huber

**Teacher:**

- Institute of Biomedical Optics
- Institute of Physics
- Institute of Medical Engineering

- Prof. Dr. rer. nat. Thorsten Buzug
- Prof. Dr. rer. nat. Christian Hübner
- Prof. Dr. rer. nat. Robert Huber

**Literature:**

- Giancoli: Physics

**Language:**

- offered only in German

**Notes:**

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

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

Modul exam:
- ME1020-L1: Physics 2, written exam, 90 min, 100 % 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, 90min, 100% of the submodule grade.

(Is module part of MZ2151, MZ2160)

## 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.

## 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++'.

## ME2053-KP04, ME2053 - Physics Lab Course (PhysPrakt)

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

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

- Bachelor Biophysics 2024 (compulsory), physics, 3rd semester
- Bachelor Molecular Life Science 2024 (compulsory), physics, 3rd semester
- Bachelor MES 2020 (compulsory), physics, 3rd semester
- Bachelor MLS 2018 (compulsory), life sciences, 3rd semester
- Bachelor Biophysics 2016 (compulsory), physics, 3rd semester
- Bachelor MES 2014 (compulsory), physics, 3rd semester
- Bachelor MLS 2009 (compulsory), life sciences, 3rd semester
- Bachelor MES 2011 (compulsory), physics, 3rd semester

**Classes and lectures:**

- Physics Lab Course (practical course, 3 SWS)

**Workload:**

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

**Contents of teaching:**

- Experiment 1: fluid dynamics
- Experiment 2: heat
- Experiment 3: non stationary current
- Experiment 4: stationary current
- Experiment 5: spectrometer
- Experiment 6: diffusion
- Experiment 7: wave optics
- Experiment 8: geometrical optics
- Experiment 9: radio activity
- Experiment 10: sound and ultrasound

**Qualification-goals/Competencies:**

- The students can practically work out the physical connections to the mentioned contents of the practical course with regard to the roles of GSP of the University of Lübeck and of the DFG-guidelines..
- They can use measuring instruments correctly.
- They can display measurement results graphically.
- They can analyze collected data quantitatively.
- They can estimate and evaluate the accuracy of the measurement data and the results of the analysis.
- They can document measurement results correctly.
- They can draw meaningful conclusions from measurement data.
- They can name the principles of occupational health and safety in physical laboratories and comply with them at work.

**Grading through:**

- certificates and protocols

**Responsible for this module:**

- Prof. Dr. rer. nat. Christian Hübner

**Teacher:**

- Institute of Biomedical Optics
- Institute of Medical Engineering
- Institute of Physics

- Prof. Dr. rer. nat. Christian Hübner
- Prof. Dr. rer. nat. Thorsten Buzug
- PD Dr. rer. nat. Hauke Paulsen
- Prof. Dr. rer. nat. Alfred Vogel
- MitarbeiterInnen des Instituts

**Literature:**

- Giancoli: Physik

**Language:**

- offered only in German

**Notes:**

Prerequisites for attending the module:
- Prerequisite for participation in the internship is physics 1 or 2.

Prerequisites for the exam:
- Certificates and protocols

Modul exam:
- ME2053-L1: Practical Course Physics, course, ungraded practical course, 0 % module grade, has to be passed

## ME2150-KP06, ME2150 - Introduction to Medical Engineering (EMedTec)

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

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

- Bachelor MES 2020 (compulsory), medical engineering science, 3rd semester
- Bachelor MES 2014 (compulsory), medical engineering science, 3rd semester

**Classes and lectures:**

- ME2151 T: Module part: Introduction to Medical Engineering (course, 3 SWS)
- ME2152 T: Module part: Lecture Series Industrial Medical Engineering (course, 1 SWS)
- ME2153 T: Module part: Introduction to scientific programming (course, 1 SWS)

**Workload:**

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

**Contents of teaching:**

- as described for the module parts

**Qualification-goals/Competencies:**

- as described for the module parts

**Grading through:**

- Written or oral exam as announced by the examiner

**Responsible for this module:**

- Prof. Dr.-Ing. Matthias Gräser

**Teacher:**

- Institute of Medical Engineering
- MitarbeiterInnen des Instituts
- Prof. Dr. rer. nat. Thorsten Buzug
- Prof. Dr.-Ing. Matthias Gräser

**Literature:**

- as described for the module parts:

**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.

## ME2151 T - Module part: Introduction to Medical Engineering (EMedTec1)

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

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

- Bachelor MES 2020 (Module part of a compulsory module), medical engineering science, 3rd semester
- Bachelor Medical Informatics 2019 (Module part of a compulsory module), medical computer science, 3rd semester
- Bachelor MES 2014 (Module part of a compulsory module), medical engineering 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:**

- Siehe Hauptmodul

**Teacher:**

- Institute of Medical Engineering
- Prof. Dr.-Ing. Matthias Gräser

**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:
- 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.

## ME2152 T - Module part: Lecture series Industrial Medical Engineering (EMedTec2)

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

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

- Bachelor MES 2020 (Module part of a compulsory module), medical engineering science, 3rd semester
- Bachelor MES 2014 (Module part of a compulsory module), medical engineering science, 3rd semester

**Classes and lectures:**

- Lecture series History of Medical Engineering (lecture, 1 SWS)
- Lecture series Industrial Medical Technology (lecture, 0,5 SWS)

**Workload:**

- 15 Hours in-classroom work
- 15 Hours written report

**Contents of teaching:**

- History and philosophy of technology in general
- Theories of technolution (how and when do innovations emerge?)
- Critique and assessment of technology, technology assessment
- Fields of medical engineering and their historical development

**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 technology and medical engineering.
- They have an understanding of the philosophical and cultural implications of the production and application of technology, and are able to apply this knowledge to case studies.
- They are capable to identify questions of social acceptability of technology, to carve out their different implications, and to discuss them critically.
- 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 written form.

**Grading through:**

- continuous, successful participation in course

**Responsible for this module:**

- Siehe Hauptmodul

**Teacher:**

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

- Prof. Dr. rer. nat. Thorsten Buzug
- Prof. Dr. med. Cornelius Borck
- Prof. Dr. rer. nat. Burghard Weiss

**Literature:**


- 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
- Kramme R (Hrsg.): Medizintechnik: Verfahren Systeme Informationsverarbeitung - 4. Aufl. Berlin, Heidelberg, New York: Springer 2011


**Language:**

- German and English skills required

**Notes:**

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Regular and successful participation

## ME2153 T - Module part: Introduction to scientific programming (EMedTec3)

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

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

- Bachelor MES 2020 (Module part of a compulsory module), medical engineering science, 3rd semester
- Bachelor Medical Informatics 2019 (Module part of a compulsory module), medical computer science, 3rd semester
- Bachelor MES 2014 (Module part of a compulsory module), medical engineering science, 3rd semester

**Classes and lectures:**

- ME2153-P: Introduction to scientific programming (practical course, 1 SWS)

**Workload:**

- 15 Hours private studies
- 15 Hours in-classroom work

**Contents of teaching:**

- Basics of scientific programming
- Basics of digital signal processing
- Basics of signal analysis and evaluation
- Image processing (local image operators, filtering in frequency space)
- Scientific visualization

**Qualification-goals/Competencies:**

- Students will be able to analyze syntax of a scientific programming language.
- Students will be able to use the help and documentation of scientific programming languages.
- Students can implement basic structures (e.g. loops and conditions).
- Students will be able to create matrices of any dimension and locate values within the matrices.
- Students will be able to apply and visualize signal filtering.
- Students will be able to demonstrate medically relevant visualization issues using external libraries.

**Grading through:**

- as announced by examiner

**Responsible for this module:**

- Siehe Hauptmodul

**Teacher:**

- Institute of Medical Engineering
- Prof. Dr.-Ing. Matthias Gräser

**Literature:**

- Julia Tutorial (1):
- Julia Tutorial (2):
- Think Julia: How to Think Like a Computer Scientist (benlauwens.github.io):

**Language:**

- German and English skills required

**Notes:**

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Regular and successful participation

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

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

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam

**Is requisite for:**

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

**Requires:**

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

**Responsible for this module:**

- Prof. Dr. Philipp Rostalski

**Teacher:**

- Institute for Electrical Engineering in Medicine

- Prof. Dr. Philipp Rostalski

**Literature:**

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

**Language:**

- offered only in German

**Notes:**

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

Admission requirements for taking the module:
- None

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

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

## 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.

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

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

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam

**Is requisite for:**

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

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

**Requires:**

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

**Responsible for this module:**

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

**Teacher:**

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

**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.

## 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.

## 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

## CS2250-KP04 - Cybersecurity (CyberSec04)

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

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- Written or oral exam as announced by the examiner

**Responsible for this module:**

- Prof. Dr. Thomas Eisenbarth

**Teacher:**

- Institute for IT Security
- Prof. Dr. Thomas Eisenbarth

**Literature:**

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

**Language:**

- offered only in German

**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):
- CS2250-L1 Cybersecurity, written exam, 90min, 100% of module grade.

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

## 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 of: 70 points in the form of a written examination at the end of the semester, 15 points in the form of programming tasks during the semester, 15 points in the form of e-tests during the semester, 100% of the 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 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
- Bachelor Biophysics 2024 (optional subject), computer science, 6th 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. rer. nat. habil. Ralf Möller

**Teacher:**

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

**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.

## 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 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
- Bachelor Biophysics 2024 (optional subject), computer science, 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:**

- written 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, written exam, 90min, 100% of the module grade

## 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

## CS3831-KP04 - Programming for machine learning and image processing in medicine (PMBV4)

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

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

- Bachelor MES 2020 (optional subject), medical engineering science, 3rd semester at the earliest

**Classes and lectures:**

- Programming for machine learning and image processing in medicine (lecture, 1 SWS)
- Programming for machine learning and image processing in medicine (exercise, 2 SWS)

**Workload:**

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

**Contents of teaching:**

- Introduction to C++ programming for medical image processing
- Basic data structures for medical data (arrays, lists)
- Branches, loops, functions, arguments and recursion
- Classes and Objects
- Efficient and parallel programming for medical image data
- Use of the Eigen- and LibTorch program libraries
- Implementation of filters for medical image processing
- Medical image analysis with machine learning in pytorch
- Convolutional filters and neural network classifiers
- Implementation of prototype algorithms in python

**Qualification-goals/Competencies:**

- Students have a good overview of the special requirements of medical image processing for programming.
- They have an understanding of the basics of object-oriented programming.
- They will acquire the skills to integrate and use external libraries.
- They learn good C++ and python knowledge.
- They are enabled to design, implement and test programs independently.
- They will learn to implement new informatics or mathematical methods in solutions for practical applications in medical image processing with machine learning.

**Grading through:**

- continuous, successful participation in practical course

**Responsible for this module:**

- Prof. Dr. Mattias Heinrich

**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

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.

## CS4340-KP04, CS4340SJ14 - Health Economy (GOEK14)

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

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

- Bachelor MES 2020 (optional subject), medical engineering science, 3rd semester at the earliest
- Master Medical Informatics 2019 (advanced module), medical computer science, 1st or 2nd semester
- Bachelor Biophysics 2016 (optional subject), no specific field, 6th semester
- Bachelor MES 2014 (optional subject), medical engineering science, 4th or 6th semester
- Master Medical Informatics 2014 (compulsory), medical computer science, 1st or 2nd semester

**Classes and lectures:**

- Health Economy (lecture, 2 SWS)
- Health Economy (exercise, 1 SWS)

**Workload:**

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

**Contents of teaching:**

- Healthcare systems (international comparison)
- PART 1: MACRO-ECONOMICS ASPECTS
- Health Technology Assessment (HTA) as an instrument of evidence-based decision support
- Medical cost-benefit assessment
- Health economic evaluations
- Resource allocation and priority setting
- PART 2: BUSINESS ECONOMICS ASPECTS
- Players in the health care system, social legislation and health care reforms
- Hospital organization and service provision
- Payment modalities in the outpatient and inpatient sector, especially the G-DRG system
- Internal and external accounting: cost & service allocation
- DRG-related cost unit accounting and analysis tools
- Innovation financing for medical technology products and processes

**Qualification-goals/Competencies:**

- Students can assess the necessity of doing business from the perspective of single actors in the health care market as well as from the perspective of solidarity communities of all insured persons - in the statutory health insurance (GKV).
- They can name and discuss variants of national health systems with alternative control principles and financing models.
- PART 1: MACRO-ECONOMIC PERSPECTIVE
- They can explain the relevance and working methods of the Federal Joint Committee (G-BA) for the approval of procedures and products, including their eligibility for reimbursement in health care in the context of statutory health insurances (GKV).
- They can explain HTA as an instrument to support health-related decisions at system level.
- They can explain clinically relevant endpoints and surrogate parameters, as well as appropriate measures of morbidity.
- They can discuss suitable study forms, their validity (evidence levels) and applications as well as variants and quality criteria of meta-analyses for the demonstration of benefits.
- They can explain cost types and measurement approaches for their determination in health economic studies.
- In addition to the benefit (efficacy), they can also include clinical safety (undesired efficacy).
- They can assess the suitability of data sources for health economic studies and perform sensitivity analysis by changing assumptions and data sources.
- They can apply the acquired knowledge to analyze and critically evaluate concrete HTA reports on the efficacy and cost-effectiveness of medical products and procedures.
- They can identify ethical requirements for approval and reimbursability issues, including the tension between the health care of a population and that of an individual.
- PART 2: BUSINESS ECONOMIC PERSPECTIVE
- They can name variants and conditions for the reimbursement of investment costs and operating costs in outpatient and inpatient care in standard care, including new selective forms of care.
- They can explain the functions and effects of G-DRGs for case-mix-based reimbursement of inpatient treatment cases and calculate and discuss the case mix (index) for specific case constellations.
- They can explain the role of internal accounting (including the delimitation of operational costs and services from expenses and income from financial accounting in accordance with KHBV) for the economic assessment of operational events.
- They can explain the terms fixed/variable and direct/indirect costs, as well as cost type, cost center and cost unit accounting, incl. the

relevance of contribution margin analysis.
- They can outline the analysis of costs and activities in the hospital on the basis of DRG-related cost unit accounting according to the national calculation handbook (InEK Institute).
- In particular, they can carry out internal cost allocation of indirect costs.
- They can interpret the national G-DRG cost modules published annually by the InEK and define their role for benchmarking economical projects of individual hospitals.
- They can perform case mix (profit) optimization with respect to resource constraints using the Simplex algorithm.
- They can explain the mechanisms and conditions of NUBs for innovation financing and the delay of several years for introducing them into the reimbursement catalogues of the statutory health insurance (GKV).

**Grading through:**

- Written or oral exam as announced by the examiner

**Responsible for this module:**

- Prof. Dr. rer. nat. habil. Josef Ingenerf

**Teacher:**

- Institute for Social Medicine and Epidemiology - Section for Research and Teaching in Nursing
- Institute of Medical Informatics

- Prof. Dr. Katrin Balzer
- Prof. Dr. rer. nat. habil. Josef Ingenerf

**Literature:**


- Roeder N., Hensen P., Franz D. (Hrsg): Gesundheitsökonomie, Gesundheitssystem und öffentliche Gesundheitspflege Ein praxisorientiertes Kurzlehrbuch - 2. aktualisierte Auflage. Köln: Deutscher Ärzte-Verlag 2013 (ISBN 978-3-769-13514-5)
- Fleßa S., Greiner W.: Grundlagen der Gesundheitsökonomie Eine Einführung in das wirtschaftliche Denken im Gesundheitswesen - 3. aktualisierte Auflage. Berlin: Springer Gabler 2013 (ISBN 978-3-642-30918-2)
- Graumann M., Schmidt-Graumann A.: Rechnungslegung und Finanzierung der Krankenhäuser - 2. aktualisierte Auflage. Herne/Berlin: NWB 2011 (ISBN: 978-3-482-57572-3)
- Perleth M., Busse R., Gerhardus A., Gibis B., Lühmann D. (Hrsg): Health Technology Assessment : Konzepte, Methoden, Praxis für Wissenschaft und Entscheidungsfindung - Berlin: MWV, 1. Aufl. 2007 (ISBN: 978-3-939069-22-5)


**Language:**

- offered only in German

**Notes:**

Admission requirements for taking the module:
- None

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

Module Exam(s):
- CS4340-L1: Health Economics, written exam, 90min, 100% of module grade

## 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

## LS2200-KP04, LS2200 - Introduction into Biophysics (EinBiophy)

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

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

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

**Classes and lectures:**

- Introduction into Biophysics (lecture, 2 SWS)
- Biophysics (Excercise or practical course, 1 SWS)

**Workload:**

- 50 Hours private studies
- 45 Hours in-classroom work
- 15 Hours written report
- 10 Hours exam preparation

**Contents of teaching:**

- Biological macro molecules, structure, forces
- Proteins, structure, properties
- Biomembranes, structure, properties
- Mechanical properties of cells
- Thermo dynamics of biological processes

**Qualification-goals/Competencies:**

- You can assign forces in biological systems
- You become familiar with the basic aspects of living matter
- You gain the expertise to simplify complex living systems
- You can choose and apply appropriate experimental methods for the study of living matter

**Grading through:**

- written exam

**Responsible for this module:**

- Dr. Young-Hwa Song

**Teacher:**

- Institute of Physics

- Dr. Young-Hwa Song
- Prof. Dr. rer. nat. Christian Hübner

**Literature:**

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

**Language:**

- offered only in German

**Notes:**

Prerequisites for the module:
- None

Prerequisites for admission to the written examination:
- Successful participation in the exercises as specified at the beginning of the semester

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

The lecture and exercises take place in the winter semester, the practical course in the summer semester.
Whether exercises or a practical course take place is specified in the SGO of the respective study program.
Prerequisite for the understanding of the lecture is the knowledge of the basics of inorganic and organic chemistry.

## 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

## MA4040-KP04, MA4040 - Numerics 2 (Num2)

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

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

- Bachelor MES 2020 (optional subject), mathematics / natural sciences, 3rd semester at the earliest
- Bachelor MES 2014 (optional subject), mathematics / natural sciences, 4th or 6th semester
- Bachelor MES 2011 (optional subject), medical engineering science, 6th semester
- Master Computer Science 2012 (optional subject), advanced curriculum analysis, 2nd or 3rd semester
- Minor in Teaching Mathematics, Master of Education 2023 (compulsory), mathematics, 2nd semester

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

- Polynomial interpolation
- Hermite interpolation
- Approximation
- Numerical quadrature

**Qualification-goals/Competencies:**

- Students know basic numerical techniques.
- They can transform a continuous problem into a discrete one.
- They can handle both stable and robust numerical algorithms competently.
- They can competently work on practical tasks.

**Grading through:**

- written exam

**Requires:**

- Numerics 1 (MA3110-KP04, MA3110)
- 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
- 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 MA4040-MML/Numerics 2

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.

## ME2101-KP04, ME2101 - Lasers in Medicine (Lasermed)

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

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

- Bachelor MES 2020 (optional subject), medical engineering science, 3rd semester at the earliest
- Bachelor MES 2014 (optional subject), medical engineering science, 4th or 6th semester
- Bachelor MES 2011 (optional subject), medical engineering science, 6th semester

**Classes and lectures:**

- Interdisciplinary Lectures on Laser Medicine (lecture, 2 SWS)
- Interdisciplinary Lectures on Laser Medicine/Excercises & Clinic Visits (exercise, 1 SWS)

**Workload:**

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

**Contents of teaching:**

- Fundamentals of laser technology and application systems
- Tissue optics
- Photo-physics
- Photodynamic therapy
- Laser coagulation
- Laser ablation
- Laser disruption
- Optical diagnostics
- Dermatology (clinical aspects)
- Gynaecology (clinical aspects)
- Ophthalmology (clinical aspects)
- Urology (clinical aspects)
- Gastroenterology (clinical aspects)

**Qualification-goals/Competencies:**

- The students acquire an overview of therapeutic techniques in the field of laser medicine and can list, describe and compare them.
- They can describe the interaction of light and tissue and are able to explain the underlying physical, biological and chemical principles.
- They are able to assess the capabilities of therapeutic techniques and their limits.
- They are able to transfer and apply their knowledge to clinical issues and problems.

**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
- Dr. rer. nat. Ralf Brinkmann
- Prof. Dr. rer. nat. Gereon Hüttmann
- Dr. rer. nat. Ramtin Rahmanzadeh
- PD Dr. med. Michael Bohlmann
- Dr. med. Mariella Fleischer

**Literature:**


- M. H. Niemz: Laser-Tissue Interactions - Springer Nature Switzerland AG, 2019
- H.-Peter Berlien, Gerhard Müller (Hrsg.): Applied Laser Medicine - Springer, Heidelberg, 2003
- A. Vogel, V. Venugopalan: Pulsed laser ablation of tissue - In: Welch A.J. und van Gemert M. (Hrsg.) Optical Thermal Response of Laser-Irradiated Tissue, 2nd. Ed., Springer, Heidelberg, New York, pp. 551-615, 2011. Available as Pdf file.


**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.

## ME2200-KP04, ME2200 - Introduction to biological laboratory techniques for engineers (EBL)

| Duration: | Turnus of offer: | Credit points: | Max. group size: |
|---|---|---|---|
| 1 Semester | each winter semester | 4 | 12 |

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

- Bachelor MES 2020 (optional subject), medical engineering science, 3rd semester at the earliest
- Bachelor MES 2014 (optional subject), medical engineering science, 3rd or 5th semester
- Bachelor MES 2011 (optional subject), optional subject medical engineering science, 3rd or 5th semester

**Classes and lectures:**

- Introduction to biological laboratory techniques for engineers (lecture, 2 SWS)
- Introduction to biological laboratory techniques for engineers (exercise, 1 SWS)

**Workload:**

- 50 Hours private studies
- 45 Hours in-classroom work
- 25 Hours exam preparation

**Contents of teaching:**

- Cell culture, antibody fluorescence labelling, protein quantification, immune staining, fluorescence microscopy, flow cytometry
- Techniques: sterile working, centrifugation, plating of cells, cell culture media, freezing/thawing of cells, use of liquid nitrogen, pH-meter, protein purification with sephadex columns, cell fixation, cell permeabilisation, absorbance- and fluorescence spectometry

**Qualification-goals/Competencies:**

- Students are able to conduct basic biological experiments in the laboratory.
- They are able to record laboratory experiments in written reports.
- They are able to associate applications with different biological tasks.

**Grading through:**

- continuous, successful participation in course

**Responsible for this module:**

- Dr. rer. nat. Ramtin Rahmanzadeh

**Teacher:**

- Institute of Biomedical Optics
- Dr. rer. nat. Ramtin Rahmanzadeh

**Literature:**

- Gstraunthaler G., Lindl T.: Zell- und Gewebekultur: Allgemeine Grundlagen und spezielle Anwendungen - Spektrum, 2013
- Schmitz S., Desel C.: Der Experimentator Zellbiologie - Springer, 2018

**Language:**

- offered only in German

**Notes:**

This module is a block course.

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Regular and successful participation

## ME3220-KP04, ME3220 - Therapeutische Laseranwendungen (TLA)

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

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

- Bachelor MES 2020 (optional subject), medical engineering science, 3rd semester at the earliest
- Master MES 2014 (optional subject), medical engineering science, Arbitrary semester
- Bachelor MES 2014 (optional subject), medical engineering science, 5th semester
- Bachelor Biophysics 2024 (optional subject), medical engineering science, 5th semester

**Classes and lectures:**

- Therapeutische Laseranwendungen (lecture, 3 SWS)

**Workload:**

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

**Contents of teaching:**

- Theory of microscopic imaging: from geometrical optics via Fourier optics to quantum mechanical description for solid angles up to 4p
- Determination and display of phase information in microscopy: darkfield, phase contrast, DIC, Hoffman contrast, PlasDIC, generalized phase contrast, quantitative phase contrast by OCT, holography, phase-shifting interferometry
- Marker and targeting techniques: chromophores, fluorescent dyes, reporter genes of the GFP family and luciferases, quantum dots, molecular beacons, nanogold
- Modern microscopy techniques: FRET, TIRF, structured illumination
- Nonlinear microscopy, imaging and damage thresholds: Multiphoton excitation, 2nd harmonic, CARS, STED and related techniques
- Image composition, improvement and analysis techniques: Deconvolution, Adaptive Optics, 3D Stacks, Advanced Spectral Analysis
- Optical methods in analytics: flow cytometry, fluorescence-activated cell sorting (FACS), DNA and protein chips, fiber-assisted sensor technology
- Advanced methods of multifocal optical manipulation with laser tweezers

**Qualification-goals/Competencies:**

- Students learn laser light distribution in tissue as a function of absorption and scattering.
- The students learn the different mechanisms of action of laser light on tissue as a function of pulse duration and irradiance.
- The students learn the therapeutic possibilities in the different efficacy classes.
- The students learn the photocoagulation of the retina of the eye and the thermal coagulation of tissue as examples of thermal modes of action.
- The students learn selective retina therapy and tissue dissection as examples of vaporization effects.
- The students learn the laser-induced disintegration of hard concrements (ureter stones) as an example of photoablative mechanisms.
- The students learn refractive surgery and presbyopia prophylaxis as examples of plasma-mediated effects.
- The students learn different methods for real-time measurement of the laser effect on tissue, e.g. photoacoustics, spectroscopy, light reflection.
- Based on this, the students learn the real-time feedback to the treatment laser for intelligent, feedback laser therapy (Theragnostics).
- The students learn the application of all procedures in the wet lab in the laboratory on models.

**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. Ralf Brinkmann
- Dr. rer. nat. Fred Reinholz
- Dr. rer. nat. Norbert Linz

**Literature:**

- Brinkmann R, Knipper A, Dröge G, Schroer F, Gromoll B, Birngruber R.: Fundamental Studies of Fiber-Guided Soft Tissue Cutting by Means of Pulsed Midinfrared IR lasers and their Application in Ureterotomy - J Biomed Optics 1998; 3(1):85-95

- Theisen-Kunde D, Ott V, Brinkmann R, Keller R.: Potential of a new cw 2µm laser scalpel for laparoscopic surgery - Medical laser application 2007; 22:139-145
- Brinkmann R, Birngruber R.: Selektive Retina-Therapie (SRT) - Z Med Phys 2007; 17:6-22
- Brinkmann R, Koinzer S, Schlott K, Ptaszynski L, Bever M, Baade A, Luft S, Miura Y, Roider J, Birngruber R.: Real-time temperature determination during retinal photocoagulation on patients - J Biomed Opt 2012; 17(6): 061219
- Lange B, Cordes J, Brinkmann R.: Stone/Tissue Differentiation for Holmium Laser Lithotripsy using Autofluorescence - Las Surg Med 2015; 47(9):737-744
- König, K.: Handbook of Biological Confocal Microscopy - Third Edition, edited by James B. Pawley, Springer Science+Business Media, LLC, New York, 2006


**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.

## ME3300-KP04, ME3300 - Measurement Technology (MTech)

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

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

- Bachelor MES 2020 (optional subject), computer science / electrical engineering, 3rd semester at the earliest
- Bachelor IT-Security 2016 (optional subject), mathematics, Arbitrary semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), electrical engineering, 6th semester
- Bachelor MES 2014 (optional subject), computer science / electrical engineering, 4th or 6th semester
- Bachelor Robotics and Autonomous Systems 2020 (optional subject), Additionally recognized elective module, 6th semester

**Classes and lectures:**

- Measurement Technology (lecture, 2 SWS)
- Measurement Technology (exercise, 0,5 SWS)
- Measurement Technology (project work, 0,5 SWS)

**Workload:**

- 60 Hours work on project
- 30 Hours in-classroom work
- 20 Hours exam preparation
- 10 Hours oral presentation and discussion (including preparation)

**Contents of teaching:**

- Measuring systems and measuring errors
- Application areas of measurement technology: temperature sensors, displacement and velocity measurement, electrical potential measurement, biosignal measurement, capacitance measurement, impedance measurement, humidity measurement, concentration measurements
- Electrotechnical measuring circuits
- Non-ideal amplifiers and filter circuits
- Probability theory
- Measurement of stochastic signals
- Description of measured signals
- Acquisition of analog signals
- Practical measurement data acquisition
- Requirements of medical technology for measurement technology
- Observation of non-measurable conditions

**Qualification-goals/Competencies:**

- The students know the elements of the measurement chain in detail, how they can be characterized and their possible characteristics.
- The students are able to describe and evaluate requirements for measurement technology.
- They are able to design and characterize basic electrical measurement circuits.
- The students are familiar with essential measuring instruments and methods, especially with a focus on medical metrology and mechatronics.
- The students know the essential connections between measuring element and control loop.

**Grading through:**

- Written or oral exam as announced by the examiner

**Requires:**

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

**Responsible for this module:**

- Prof. Dr. Georg Schildbach

**Teacher:**

- Institute for Electrical Engineering in Medicine
- Prof. Dr. Georg Schildbach

**Literature:**

- Lerch: Elektrische Messtechnik: Analoge, digitale und computergestützte Verfahren - 6. Auflage, Springer Verlag 2012
- Schrüfer, Reindl, Zagar: Elektrische Messtechnik: Messung elektrischer und nichtelektrischer Größen - 11. Auflage, Carl Hanser Verlag

2014
- Parthier: Messtechnik: Grundlagen und Anwendungen der elektrischen Messtechnik - 8. Auflage, Springer Vieweg Verlag 2016
- Webster: Medical Instrumentation: Application and Design - 4th edition, John Wiley & Sons 2010

**Language:**
- German and English skills required

**Notes:**

currently suspended

## ME3600-KP04, ME3600 - Visualisierungstechnologie (VT)

| Duration: | Turnus of offer: | Credit points: | Max. group size: |
|---|---|---|---|
| 1 Semester | each winter semester | 4 | 12 |

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

- Bachelor MES 2020 (optional subject), medical engineering science, 3rd semester at the earliest
- Bachelor MES 2014 (optional subject), medical engineering science, 5th semester

**Classes and lectures:**

- Visualisierungstechnologie (lecture, 1 SWS)
- Visualisierungstechnologie (seminar, 1 SWS)
- Visualisierungstechnologie (practical course, 1 SWS)

**Workload:**

- 45 Hours written report
- 45 Hours in-classroom work
- 30 Hours private studies

**Contents of teaching:**

- Overview of important imaging methods in biomedical engineering (including CT, MRI, MPI)
- Mathematical and physical-technological principles of image formation
- Applications in fundamental and applied research as well as in clinical diagnosis

**Qualification-goals/Competencies:**

- The students have basic knowledge of the functioning, areas of application and imaging properties of imaging methods in biomedical technology.
- They have the ability to assess the possibilities and limitations of modern visualization technologies.
- They have theoretical and practical knowledge in the use of various imaging modalities.
- They have practical experience in the field of medical imaging.
- They have the ability to present complex issues (oral and written).

**Grading through:**

- Oral examination

**Responsible for this module:**

- Prof. Dr. rer. nat. Thorsten Buzug

**Teacher:**

- Institute of Medical Engineering

- Prof. Dr. rer. nat. Thorsten Buzug
- MitarbeiterInnen des Instituts

**Literature:**


- Olaf Dössel, Thorsten M. Buzug: Biomedizinische Technik: Band 7: Medizinische Bildgebung - De Gruyter, 2013
- Olaf Dössel: Bildgebende Verfahren in der Medizin: Von der Technik zur medizinischen Anwendung - Springer, 1999
- Thorsten M. Buzug: Computed Tomography: From Photon Statistics to Modern Cone-Beam CT - Springer, 2008
- Zhi-Pei Liang, Paul C. Lauterbur: Principles of magnetic resonance imaging: a signal processing perspective - SPIE Optical Engineering Press, 2000
- Tobias Knopp, Thorsten M. Buzug: Magnetic Particle Imaging: An Introduction to Imaging Principles and Scanner Instrumentation - Springer, 2012


**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.

## ME4141-KP04, ME4141 - Human ocular system and ophthalmic instruments (AMOI)

| Duration: | Turnus of offer: | Credit points: | Max. group size: |
|---|---|---|---|
| 1 Semester | each summer semester | 4 | 12 |

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

- Bachelor MES 2020 (optional subject), medical engineering science, 3rd semester at the earliest
- Master MES 2014 (optional subject), medical engineering science, 2nd or 4th semester
- Bachelor MES 2014 (optional subject), medical engineering science, 4th or 6th semester
- Master MES 2011 (advanced curriculum), biophysics and biomedical optics, 2nd semester

**Classes and lectures:**

- Human ophthalmic system (lecture, 1 SWS)
- Construction and function of optical ophthalmic instruments (exercise, 1,5 SWS)

**Workload:**

- 50 Hours private studies
- 40 Hours in-classroom work
- 30 Hours oral presentation (including preparation)

**Contents of teaching:**

- Structure and function of the eye components
- Fundamentals of geometric and wave optical processes within the human ocular system
- Demonstrations and laboratory exercises using optical experimental set-ups and ophthalmic instruments
- Biological and anatomical facts are presented in a way that students can comprehend physics and engineering based diagnostic and therapeutic techniques.

**Qualification-goals/Competencies:**

- Students will be able to combine biomedical and technical concepts of optical sciences.
- They will develop practical skills in the areas of operating, adjusting, maintaining, and servicing optical systems.
- They will have the competency to judge the diagnostic merits of images and other data obtained with ophthalmic instruments as well as testing and modifying such instruments.

**Grading through:**

- continuous participation in lecture and exercises

**Responsible for this module:**

- Dr. rer. nat. Fred Reinholz

**Teacher:**

- Institute of Biomedical Optics

- Dr. rer. nat. Fred Reinholz
- Prof. Dr. rer. nat. Gereon Hüttmann
- Dr. med. Yoko Miura

**Literature:**

- M. Kaschke, K.-H. Donnerhacke, M.S. Rill: Optical Devices in Ophthalmology and Optometry - Willey-VCH Verlag GmbH, Weinheim, 2014

**Language:**

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

**Notes:**

Block scheduling
Held as a one-week intensive course

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Continuous participation in lecture and exercises

## PY4210-KP05 - Engineering Psychology (IngPsy5)

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

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

- Master MES 2020 (optional subject), interdisciplinary, Arbitrary semester
- Bachelor MES 2020 (optional subject), interdisciplinary, 3rd semester at the earliest
- Master Media Informatics 2020 (compulsory), psychology, 1st to 3th semester

**Classes and lectures:**

- Engineering Psychology (lecture, 2 SWS)
- Engineering Psychology (seminar, 1 SWS)

**Workload:**

- 105 Hours private studies and exercises
- 45 Hours in-classroom work

**Contents of teaching:**

- Fundamentals of Engineering Psychology
- human-machine systems
- Information Processing in Human-Technology Interaction
- Selective attention in interface interaction
- Situation awareness and mental models
- Situation assessment and action selection
- Manual control and election response tasks
- Errors
- Workload and stress
- Multitasking and Resource Management
- Automation (levels, automation trust)
- User diversity

**Qualification-goals/Competencies:**

- Students can receive, classify and use psychological engineering research contributions.
- The students can explain central theories and findings of engineering psychology with reference to relevant questions of human-technology interaction and interface conception.
- Students can derive design guidelines for man-machine systems from concepts and findings in engineering psychology.

**Grading through:**

- portfolio exam
- written exam

**Responsible for this module:**

- Prof. Dr. rer. nat. Thomas Franke

**Teacher:**

- Institute for Multimedia and Interactive Systems
- Prof. Dr. rer. nat. Thomas Franke

**Literature:**

- Wickens, C., Hollands, J., Banbury, S., & Parasuraman, R. (2013): Engineering psychology and human performance. - Boston: Pearson
- Proctor, R., & van Zandt, T. (2018): Human Factors in Simple and Complex Systems - Boca Raton: CRC Press.

**Language:**

- offered only in German

**Notes:**

Prerequisites for attending the module:
- None

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

## RO1501-KP04 - Engineering Mechanics 1 (TechMec1)

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

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

- Bachelor MES 2020 (optional subject), computer science / electrical engineering, 3rd semester at the earliest
- Bachelor MES 2014 (optional subject), computer science / electrical engineering, 4th or 6th semester

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

- Statics and Elastostatics
- Systems and equilibria of forces and moments
- Gravitational force and center of mass
- Planar systems of forces
- Bearings and support of multibody systems
- Trusses
- Principle of virtual displacements
- Law of elasticity
- Beam theory
- Stability of elastic systems
- Energy conservation and approximate methods
- Torsion
- Product development and construction process
- Requirements and target specification
- Methods for identifying solutions, selection and evaluation
- Methods of verification and fault prevention

**Qualification-goals/Competencies:**

- Students can explain the structure and basic properties of static mechanical systems.
- They can calculate static mechanical systems.
- They can develop products methodically and possess the necessary knowledge and skills.
- They are able to model dynamic mechanical systems using kinetics and kinematic relations.

**Grading through:**

- written examination

**Responsible for this module:**

- Prof. Dr. Philipp Rostalski

**Teacher:**

- Institute for Electrical Engineering in Medicine

**Literature:**

- Pahl, Gerhard; Beitz, Wolfgang; Feldhusen, Jörg; Grote, Karl-H: Konstruktionslehre. Grundlagen erfolgreicher Produktentwicklung Methoden und Anwendung - 6. Aufl. Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg 2005

**Language:**

- offered only in German

**Notes:**

Admission requirements for taking the module:
- None

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

Module Exam(s):
- RO1501-L1: Engineering Mechanics 1, Oral exam, 100% of module grade.

## RO1502-KP04 - Engineering Mechanics 2 (TechMec2)

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

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

- Bachelor MES 2020 (optional subject), computer science / electrical engineering, 3rd semester at the earliest
- Bachelor MES 2014 (optional subject), computer science / electrical engineering, 3rd semester

**Classes and lectures:**

- Engineering Mechanics 2 (lecture, 2 SWS)
- Engineering Mechanics 2 (exercise, 2 SWS)

**Workload:**

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

**Contents of teaching:**

- Statics and Elastostatics
- Systems and equilibria of forces and moments
- Gravitational force and center of mass
- Planar systems of forces
- Bearings and support of multibody systems
- Trusses
- Principle of virtual displacements
- Law of elasticity
- Beam theory
- Stability of elastic systems
- Energy conservation and approximate methods
- Torsion
- Kinematics of point masses
- Kinetics of point masses
- Kinematics of rigid bodies
- Kinetics of rigid bodies
- Linearization
- Vibration theory

**Qualification-goals/Competencies:**

- They can calculate static mechanical systems.
- They are able to model dynamic mechanical systems using kinetics and kinematic relations.

**Grading through:**

- Oral examination

**Requires:**

- Engineering Mechanics 1 (RO1501-KP04)

**Responsible for this module:**

- Prof. Dr. Philipp Rostalski

**Teacher:**

- Institute for Electrical Engineering in Medicine
- Dr.-Ing. Christian Herzog

**Literature:**

- Gross, Dietmar; Hauger, Werner; Schröder, Jörg; Wall, Wolfgang A.: Technische Mechanik 2. Elastostatik - [Verschiedene Aufl.]. Berlin: Springer Vieweg (Springer-Lehrbuch) 2014
- Gross, Dietmar; Hauger, Werner; Schröder, Jörg; Wall, Wolfgang A.: Technische Mechanik 3. Kinetik - 13., überarb. Aufl. Berlin, Heidelberg: Springer Berlin Heidelberg (Springer-Lehrbuch) 2015

**Language:**

- offered only in German

**Notes:**

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

## 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.

## ME2060-KP04, ME2060 - Fields and Quanta (FQ)

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

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

- Bachelor MES 2020 (compulsory), physics, 4th semester
- Bachelor MES 2014 (compulsory), physics, 4th semester

**Classes and lectures:**

- Fields and Quanta (lecture, 2 SWS)
- Fields and Quanta (exercise, 1 SWS)

**Workload:**

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

**Contents of teaching:**

- Scalar and vector fields
- electric charge, electr. Potential, electr. field
- Current density, continuity equation
- magnetic field
- electromagnetic induction
- Maxwell equations
- Wave-particle duality
- Uncertainty
- Wave functions, operators and measurement
- Schrödinger equation

**Qualification-goals/Competencies:**

- Students are able to calculate the propagation of electromagnetic waves in homogeneous media.
- They can enumerate the main axioms of quantum mechanics.
- They can explain the terms operator, wave function, quantum numbers and measurements, and the relationships between them.
- They can calculate the eigenstates of simple quantum mechanical systems.
- They can describe the stationary states of the hydrogen atom and calculate the associated energy values.
- They are using the terms and concepts of theoretical physics such an extent that you can acquire further representations on their own.

**Grading through:**

- Written or oral exam as announced by the examiner

**Requires:**

- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)
- Analysis 2 (MA2500-KP08)
- Analysis 1 (MA2000-KP08, MA2000)
- Physics 2 (ME1020-KP08, ME1020)
- Physics 1 (ME1010-KP08, ME1010)

**Responsible for this module:**

- Prof. Dr. rer. nat. Magdalena Rafecas

**Teacher:**

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

**Literature:**

- D. J. Griffiths: Elektrodynamik: Eine Einführung - Pearson, Hallbergmoos 2011
- D. J. Griffiths: Quantenmechanik: Lehr- und Übungsbuch - Pearson, Hallbergmoos 2012

**Language:**

- offered only in German

**Notes:**

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

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

## ME2100 T - Module part: Introduction into Biomedical Optics (EinBMO)

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

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

- Bachelor Biophysics 2024 (Module part of a compulsory module), physics, 4th semester
- Bachelor MES 2020 (Module part of a compulsory module), medical engineering science, 4th semester
- Bachelor Biophysics 2016 (Module part of a compulsory module), physics, 4th semester
- Bachelor MES 2014 (Module part of a compulsory module), medical engineering science, 4th semester

**Classes and lectures:**

- Introduction into Biomedical Optics (lecture, 2 SWS)
- Biomedical Optics/Excercises (exercise, 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 cytometryof photophysics
- 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:**

- Siehe Hauptmodul

**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.

## ME2102 T - Module part: Photonics (Photonik)

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

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

- Bachelor MES 2020 (Module part of a compulsory module), medical engineering science, 4th semester
- Bachelor Biophysics 2016 (Module part of a compulsory module), physics, 4th semester
- Bachelor MES 2014 (Module part of a compulsory module), medical engineering science, 4th semester
- Bachelor Biophysics 2024 (Module part of a compulsory module), physics, 4th semester

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

- Historical introduction
- Light as EM wave, physical parameters of the light wave field
- Detection and detection of light
- Geometric optics, raytracing
- Optical Instruments
- Optics of the eye
- Polarization
- Diffraction
- Optical fibres
- Integrated optics
- Optoelectronics
- Laser
- Nonlinear Optics

**Qualification-goals/Competencies:**

- The students can name the essential concepts of optics (geometric optics, wave optics, quantum optics) and distinguish them from each other.
- The students can name and explain the essential optical phenomena.
- The students can explain the function and application of the most important photonic components.

**Grading through:**

- Written or oral exam as announced by the examiner

**Responsible for this module:**

- Siehe Hauptmodul

**Teacher:**

- Institute of Biomedical Optics
- Prof. Dr. rer. nat. Gereon Hüttmann

**Literature:**

- E. Hecht: Optics - Addison-Wesley, (dt: Optik, Oldenbourg)
- Frank L. Pedrotti, Leno S. Pedrotti: Introduction to optics - Prentice-Hall
- Frank Pedrotti: Optik eine Einführung - Prentice Hall
- B.E.A. Saleh, M.C. Teich: Fundamentals of Photonics - Wiley 2007 (dt.: Grundlagen der Photonik, Wiley-VCH)
- Matt Young: Optics and Lasers : Including Fibers and Optical Waveguides - Springer 2000

**Language:**

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

**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.

## ME2600-KP08, ME2600 - Introduction to Biomedical Optics and Photonics (EinfBMOPho)

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

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

- Bachelor Biophysics 2024 (compulsory), physics, 4th semester
- Bachelor MES 2020 (compulsory), medical engineering science, 4th semester
- Bachelor Biophysics 2016 (compulsory), physics, 4th semester
- Bachelor MES 2014 (compulsory), medical engineering science, 4th semester

**Classes and lectures:**

- ME2100 T: Module part: Introduction to Biomedical Optics (4 ECTS) (course, 3 SWS)
- ME2102 T: Module part: Photonics (4 ECTS) (course, 3 SWS)

**Workload:**

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

**Contents of teaching:**

- as described for the module parts

**Qualification-goals/Competencies:**

- as described for the module parts

**Grading through:**

- written exam

**Responsible for this module:**

- Prof. Dr. rer. nat. Gereon Hüttmann

**Teacher:**

- Institute of Biomedical Optics

- Dr. rer. nat. Norbert Linz
- Prof. Dr. rer. nat. Gereon Hüttmann

**Literature:**

- Haferkorn, H.: Optik - Wiley-VCH
- P.N. Prasad: Introduction to Biophotonics - Wiley 2003
- M. Niemz: Laser-Tissue Interactions - 3rd Edition, Springer 2007
- D. B. Murphy: Fundamentals of Light Microscopy and Electronic Imaging - Wiley-Liss 2001
- E. Hecht: Optics - 5th Edition, 2016, Pearson
- Frank L. Pedrotti, Leno S. Pedrotti: Introduction to optics - Prentice Hall
- Paul A. Tipler, Gene Mosca: Physik: für Wissenschaftler und Ingenieure (Teil 5: Optik) - Springer 2000

**Language:**

- offered only in German

**Notes:**

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- None

Format of the module exam:
- ME2600-L1: Introduction to Biomedical Optics and Photonics, Written exam, 90 min, 100 % Module note

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

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

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- Written or oral exam as announced by the examiner

**Is requisite for:**

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

**Requires:**

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

**Responsible for this module:**

- Prof. Dr. Philipp Rostalski

**Teacher:**

- Institute for Electrical Engineering in Medicine
- Prof. Dr. Philipp Rostalski

**Literature:**

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

**Language:**

- offered only in German

**Notes:**

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

## ME2410-KP04 - Electronic circuit design and hardware design (ESuH)

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

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

- Bachelor MES 2020 (optional subject), computer science / electrical engineering, 4th semester at the earliest
- Bachelor MES 2014 (optional subject), computer science / electrical engineering, 4th semester at the earliest

**Classes and lectures:**

- ME2410-V: Electronic circuit design and hardware design (lecture, 2 SWS)
- ME2410: Electronic circuit design and hardware design (project work, 1 SWS)

**Workload:**

- 70 Hours work on project
- 30 Hours in-classroom work
- 20 Hours oral presentation and discussion (including preparation)

**Contents of teaching:**

- Frequency and power ranges of the electronics
- Behavior of real components in circuits
- Characteristics and designs of current components
- Coupling / decoupling of electrical circuits
- Circuit interaction with the human
- Methods for implementing electrical safety
- Development of complex electronic circuits
- PCB development
- Manufacturing processes of electronic assemblies

**Qualification-goals/Competencies:**

- Students will be able to characterize circuit problems and design their own solutions.
- Students understand the impact of environmental factors, such as linkage with humans.
- They can develop complex circuit topologies according to technical requirements.
- Students know the influence of real electronic components on circuit behavior and are able to select appropriate components accordingly.
- They can design printed circuit boards taking into account coupling effects.

**Grading through:**

- presentation
- project work

**Responsible for this module:**

- Prof. Dr. Philipp Rostalski

**Teacher:**

- Institute for Electrical Engineering in Medicine
- Dr.-Ing. Roman Kusche

**Literature:**

- U. Tietze, C. Schenk, E. Gamm: Halbleiter-Schaltungstechnik - 16. Auflage, Springer 2019

**Language:**

- offered only in German

## ME3702-KP04, ME3702 - Bachelor Seminar MIW (SemMIW)

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

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

- Bachelor MES 2020 (compulsory), medical engineering science, 4th semester at the earliest
- Bachelor MES 2014 (compulsory), medical engineering science, 4th and 5th semester
- Bachelor MES 2011 (compulsory), interdisciplinary competence, 6th semester

**Classes and lectures:**

- Bachelor Seminar (seminar, 2 SWS)

**Workload:**

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

**Contents of teaching:**

- Induction in a scientific topic
- Editing a scientific problem and its solution method
- 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 and written report

**Responsible for this module:**

- Studiengangsleitung MIW

**Teacher:**

- Institutes and hospitals of the University of Lübeck

**Literature:**

- selected individually:

**Language:**

- offered only in English

**Notes:**

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- None

## 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

## 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 T - Module part: Medical Image Computing (MBV)

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

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

- Bachelor MES 2020 (Module part of a compulsory module), medical engineering science, 5th semester
- Bachelor MES 2014 (Module part of a compulsory module), medical engineering science, 5th semester

**Classes and lectures:**

- Medical Image Computing (lecture, 2 SWS)
- Medical Image Computing (exercise, 2 SWS)

**Workload:**

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

**Contents of teaching:**

- Motivation, principles and applications of medical image computing
- Structure and formats of medical images
- Histograms and image transformations
- Image filtering using Fourier transform
- Image filtering with local operators
- Segmentation: thresholding, region growing
- Clusteranalysis and classifyer for image segmentation
- Introducing convolutional neural networks
- Morphological operators
- Application and evaluation of segmentation methods
- Image interpolation methods and transformataion of images
- Basic methods of image registration
- Combined signal and image analysis in 4D image processing

**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 and neural 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.

**Grading through:**

- written exam

**Is requisite for:**

- Model and AI-based image processing in medicine (CS4332-KP06)
- Advanced Techniques of Medical Image Processing (CS4370-KP04, CS4370)
- Image Analysis and Visualization in Diagnostics and Therapy (CS4330-KP08, CS4330SJ14)

**Requires:**

- Analysis 2 (MA2500-KP04, MA2500)

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

**Responsible for this module:**

- Siehe Hauptmodul

**Teacher:**

- Institute of Medical Informatics
- Prof. Dr. rer. nat. habil. Heinz Handels

**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 modules mentioned under "requires" are needed for this module, but are not a formal prerequisite).

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

Module Exam(s):
- CS3310-L1: Medical Image Processing, written exam, 90min, 100% of the submodule grade.

## ME3000-KP08, ME3000SJ14 - Medical Imaging and Medical Image Computing (MEDBGBV14)

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

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

- Bachelor MES 2020 (compulsory), medical engineering science, 5th semester
- Bachelor MES 2014 (compulsory), medical engineering science, 5th semester

**Classes and lectures:**

- Module part CS3310 T: Medical Image Computing (course, 3 SWS)
- Module part ME3100: Medical Imaging (course, 3 SWS)

**Workload:**

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

**Contents of teaching:**

- See description of module parts

**Qualification-goals/Competencies:**

- See description of module parts

**Grading through:**

- written exam

**Responsible for this module:**

- Prof. Dr. rer. nat. Thorsten Buzug

**Teacher:**

- Institute of Medical Engineering
- Institute of Medical Informatics

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

**Literature:**

- See description of module parts:

**Language:**

- German and English skills required

**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 T - Module part: Medical Imaging (MBGT)

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

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

- Bachelor MES 2020 (Module part of a compulsory module), medical engineering science, 5th semester
- Bachelor MES 2014 (Module part of a compulsory module), medical engineering science, 5th 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:**

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.

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

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

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

- Bachelor MES 2020 (compulsory), electrical engineering, 5th semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), electrical engineering, 5th or 6th semester
- Bachelor MES 2014 (compulsory), electrical engineering, 5th semester

**Classes and lectures:**

- Medical Electrical Engineering Lab Course (practical course, 3 SWS)

**Workload:**

- 65 Hours work on project
- 45 Hours in-classroom work
- 10 Hours oral presentation and discussion (including preparation)

**Contents of teaching:**

- Basics of electrical safety with focus on medical devices.
- Safety in the lab.
- Development, planning, creation and testing of an electrical circuit in the context of medical devices.
- Independent realization of a concrete project in a small team.

**Qualification-goals/Competencies:**

- Students can plan, design, specify and realize an electrical circuit.
- Students gain experience in the area of project management.
- Students know how to deliver and present results in a timely manner.

**Grading through:**

- presentation

**Requires:**

- Fundamentals of Electrical Engineering 2 (ME2700-KP08, ME2700)
- Fundamentals of Electrical Engineering 1 (ME2400-KP08, ME2400)

**Responsible for this module:**

- Prof. Dr. Philipp Rostalski

**Teacher:**

- Institute for Electrical Engineering in Medicine
- Prof. Dr. Philipp Rostalski

**Literature:**

- U. Tietze, C. Schenk, E. Gamm: Halbleiter-Schaltungstechnik - ISBN 978-3-642-31025-6

**Language:**

- offered only in German

**Notes:**

Admission requirements for taking the module:
- Fundamentals of Electrical Engineering 1 and 2 (ME2400 and ME2700)

Admission requirements for participation in module examination(s):
- Successful completion of the practical assignment and presentation.

Module Exam(s):
- ME3400-L1: Medical Electrical Engineering Lab Course, completion of internship assignment and presentation, 100% of module grade.

## ME5050-KP04 - Biophysics of Ionizing Radiation and Radiation Safety (StrahlenS)

| Duration: | Turnus of offer: | Credit points: |
|---|---|---|
| 1 Semester | normally each term | 4 |

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

- Bachelor MES 2020 (compulsory), medical engineering science, 5th semester
- Bachelor MES 2014 (compulsory), medical engineering science, 5th semester
- Master MES 2011 (advanced curriculum), imaging systems, signal and image processing, 1st or 2nd semester

**Classes and lectures:**

- Biophysics of Ionizing Radiation and Radiation Safety (lecture, 2 SWS)
- Biophysics of Ionizing Radiation and Radiation Safety (practical course, 2 SWS)

**Workload:**

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

**Contents of teaching:**

- Physics of ionizing radiation
- Basic principles of dosimetry
- Introduction to methods of radiation measurement
- Radiation biology: principles of radiation damage, deterministic and stochastic effects, health risks caused by ionizing radiation
- Radiation chemistry, handling of open and enclosed radioactive materials
- Safety requirements in radionuclide laboratories
- Application of radionuclides in research and medicine
- German and international laws and regulations dealing with radiation safety
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**Qualification-goals/Competencies:**

- The students will have acquired in depth knowledge of the legal regulations concerning the work with radioactive materials and are able to implement these regulations in all relevant situations: Purchase, transport, storage, experimental use, disposal and decontamination
- They are able to safely handle open and enclosed radioactive compounds
- They are able to work in radiation protection areas in compliance with legal regulations
- They are able to measure radioactivity, calculate radiation doses and evaluate the results with respect to legal thresholds and biological impact
- They are able design experiments using radioactive materials, identify and meet the necessary safety precautions and establish a suitable workplace
- The students will acquire the requisite qualification (Fachkunde) according to German law (RöV and StrlSchV). This will qualify them (upon fulfillment of other regulatory requirements) to perform as a radiation safety officer according to German law.

**Grading through:**

- written exam

**Responsible for this module:**

- Prof. Dr. rer. nat.  Christian Schmidt

**Teacher:**

- Institute of Medical Engineering
- Institute of Biochemistry
- Institute for Biology
- Institute of Physics
- Isotopes laboratory

- Prof. Dr. rer. nat.  Christian Schmidt
- Prof. Dr. rer. nat. Christian Hübner
- Dipl.-Ing. Henning Schönwald
- Prof. Dr. rer. nat. Magdalena Rafecas
- Dr. math. et dis. nat. Jeroen Mesters

- Prof. Dr. Lars Redecke

**Literature:**

- Updated lecture materials on the basis of the current recommendations of the ICRP, the Radiation Protection Commission, other committees and the current standards:
- Radiation Protection Act in its current version:
- Radiation Protection Ordinance in its respective current version:
- : The following sources can be used for further consolidation:
- H. Reich (Hrsg.): Dosimetrie ionisierender Strahlung - B.G. Teubner, Stuttgart
- C. Grupen: Grundkurs Strahlenschutz - Springer Verlag (ab 3. Auflage)
- H. Krieger: Grundlagen der Strahlungsphysik und des Strahlenschutzes - B.G. Teubner, Stuttgart
- H.-G. Vogt, H. Schultz: Grundzüge des praktischen Strahlenschutzes - Carl Hanser Verlag München

**Language:**

- offered only in German

**Notes:**

Prerequisites for attending the module: None
Each winter semester preferential for students of Biophysics and MIW, every summer semester preferential for MLS students.
The module certificate will be graded.
The attendance of the radiation protection briefing is a prerequisite for the participation in the course.
The module certificate will be issued if a student has attended at least 90% of the practical training and achieved at least a score of 50% of the points in the written exam.
If the minimum score of 50% is not reached, a written or oral examination will be offered at the discretion of the module administrator.
The Fachkundebescheinigungen according to the German radiation safety regulations will be issued if a student has attended the entire course (a maximum absence during 10% of the lectures is permissible in exceptional cases) and has achieved a score of at least 70% in the written exam.
If a student has achieved less than 70% but more than 50% of the points in the written exam, a written or oral examination will be offered at the discretion of the module administrator.
Upon passing this examination the Fachkundebescheinigungen will be issued.
In this case, the decisive factor for the grade in the module certificate remains the result of the first examination.
Decisive for the realization of this course and the issuance of the Fachkundebescheinigungen are the Richtlinie über die im Strahlenschutz erforderliche Fachkunde (Fachkunde-Richtlinie Technik nach Strahlenschutzverordnung) in the currently valid version.

## ME3990-KP14, ME3990SJ14 - Bachelor Thesis Medical Engineering (BAMIW14)

| Duration: | Turnus of offer: | Credit points: |
|---|---|---|
| 1 Semester | each semester | 14 |

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

- Bachelor MES 2020 (compulsory), medical engineering science, 6th semester
- Bachelor MES 2014 (compulsory), medical engineering science, 6th semester

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

- Independent scientific work on a limited task of medical engineering sciences 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 MIW

**Teacher:**

- Scientific facilities at the Universität zu Lübeck or abroad with mandatory supervision by an university lecturer
- Medical technology companies at the Universität zu Lübeck or abroad with mandatory supervision by an university lecturer
- All Institutes and Clinics of the Universität zu Lübeck
- Alle prüfungsberechtigten Dozentinnen/Dozenten des Studienganges

**Literature:**

- is selected individually:

**Language:**

- thesis can be written in German or English

**Notes:**

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

Prerequisites for attending the module:
- see study programme regulations (e.g. certain minimum number of credit points reached)

## PS1030-KP04, PS1030 - English for Bachelor and Master students MLS (Engl)

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

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

- Bachelor Molecular Life Science 2024 (optional subject), interdisciplinary competence, Arbitrary semester
- Master MES 2020 (optional subject), interdisciplinary, Arbitrary semester
- Bachelor MES 2020 (optional subject), interdisciplinary, Arbitrary semester
- Bachelor MLS 2018 (optional subject), interdisciplinary competence, Arbitrary semester
- Bachelor MLS 2016 (optional suject), interdisciplinary competence, Arbitrary semester
- Bachelor Biophysics 2016 (optional subject), no specific field, 6th semester
- Master MES 2014 (optional subject), no specific field, 2nd semester
- Bachelor MES 2014 (optional subject), no specific field, 4th or 6th semester
- Master MLS 2009 (optional subject), interdisciplinary competence, Arbitrary semester
- Bachelor MES 2011 (optional subject), medical engineering science, Arbitrary semester
- Master CLS 2010 (optional subject), interdisciplinary competence, Arbitrary semester
- Bachelor MLS 2009 (optional subject), interdisciplinary competence, Arbitrary semester

**Classes and lectures:**

- English for Bachelor and Master students MLS (exercise, 4 SWS)

**Workload:**

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

**Contents of teaching:**

- Exercise:The content follows a curriculum, modified depending on the given skills and the thematic interests of the participants.
- Creating a CV in English

**Qualification-goals/Competencies:**

- Students acquire basic knowledge of the English language in word and writing.
- They improve their communication in English.
- They improve their skills in reading and writing English texts, including specialist literature.

**Grading through:**

- written exam

**Responsible for this module:**

- B. Sc. Sara Meitner

**Teacher:**

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- B. Sc. Sara Meitner

**Literature:**

- : - Up-to-date publications and articles

**Language:**

- offered only in English

**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.

## PY1200-KP04, PY1200-MIW - General Psychology 1 (APKP04)

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

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

- Bachelor MES 2014 (optional subject), no specific field, Arbitrary semester
- Master MES 2014 (optional subject), no specific field, 1st or 2nd semester
- Master MES 2020 (optional subject), interdisciplinary, Arbitrary semester
- Bachelor MES 2020 (optional subject), interdisciplinary, Arbitrary semester
- Bachelor Biophysics 2016 (optional subject), no specific field, 5th semester

**Classes and lectures:**

- General Psychology 1 (lecture, 2 SWS)

**Workload:**

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

**Contents of teaching:**

- Acquisition of basic knowledge in the topics perception, action, cognition and language
- Teaching of basic ideas, concepts and theories of perception and cognitive psychology
- Learning basic principles of experimental psychology work for planning and conducting experiments
- Understanding and judgment of basic ideas, theories and methods of perception, cognition and language

**Qualification-goals/Competencies:**

- Students can explain and apply psychological concepts in the areas of perception, action, cognition and language.
- They can translate psychological research questions into empirical research.
- They can use their knowledge in basic psychological research to scientifically reason, think and discuss.
- They have acquired social competence through discussion skills and knowledge transfer.
- They have acquired self-competence in the areas of concentrated absorption of knowledge, critical reflection and dealing with scientific literature.
- They can structure newly acquired knowledge themself.

**Grading through:**

- written exam

**Responsible for this module:**

- Prof. Dr. rer. nat. Ulrike Krämer

**Teacher:**

- Department of Neurology

- Prof. Dr. rer. nat. Ulrike Krämer
- Dr. rer. nat. Dipl.-Psych. Frederike Beyer

**Literature:**

- Goldstein: Wahrnehmungspsychologie - Spektrum, 2007
- Müsseler (Hrsg.): Allgemeine Psychologie - Spektrum, 2007
- Anderson: Kognitive Psychologie (7. Auflage) - Springer, 2013

**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.