



UNIVERSITÄT ZU LÜBECK

Module Guide for the Study Path

# Bachelor Robotics and Autonomous Systems 2020

Version from 4. April 2024



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**CS1000-KP10, CS1000SJ14 - Introduction to Programming (EinfProg14)**
**Duration:**

1 Semester

**Turnus of offer:**

each winter semester

**Credit points:**

10

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam
- successful addressing of the project goals

**Is requisite for:**

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

**Responsible for this module:**

- [Prof. Dr. Stefan Fischer](#)

**Teacher:**

- [Institute of Telematics](#)
- [Prof. Dr. Stefan Fischer](#)



**Literature:**

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

**Language:**

- offered only in German

**Notes:**

From WS2019 / 20:

Partial Examination CS1000-L1: Introduction to Programming and Programming Course (graded exam, 8 credits)

Partial exam CS1000-L2: Java project (ungraded internship, 2 credits)

Prerequisites for attending the module:

- None

Prerequisites for the exam in CS1000-L1:

- Successful completion of homework assignments during the semester.

Prerequisites for the exam in CS1000-L2:

- None

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

1 Semester

**Turnus of offer:**

each winter semester

**Credit points:**

4

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam

**Responsible for this module:**

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

**Teacher:**

- [Institute of Computer Engineering](#)



- Dr. rer. nat. Javad Ghofrani

**Literature:**

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

**Language:**

- offered only in German

**Notes:**

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

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

Prerequisites for attending the module:

- None

Prerequisites for the exam:

- Successful completion of homework assignments during the semester.

Written exam:

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

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

1 Semester

**Turnus of offer:**

each winter semester

**Credit points:**

8

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam



**Is requisite for:**

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

**Responsible for this module:**

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

**Teacher:**

- [Institute of Mathematics and Image Computing](#)
- [Prof. Dr. rer. nat. Jan Modersitzki](#)
- [Prof. Dr. rer. nat. Jan Lellmann](#)

**Literature:**

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

**Language:**

- offered only in German

**Notes:**

Prerequisites for attending the module:

- None

Prerequisites for the exam:

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

Module exam:

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

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

1 Semester

**Turnus of offer:**

each winter semester

**Credit points:**

8

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam

**Is requisite for:**

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



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

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**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](#)

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**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

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**Language:**

- offered only in German

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**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

<b>RO1500-KP08 - Technical Mechanics (TechMec)</b>		
<b>Duration:</b> 2 Semester	<b>Turnus of offer:</b> starts every summer semester	<b>Credit points:</b> 8
<b>Course of study, specific field and term:</b> <ul style="list-style-type: none"> <li>• Bachelor Robotics and Autonomous Systems 2020 (compulsory), Robotics and Autonomous Systems, 2nd and 3rd semester</li> <li>• Bachelor Robotics and Autonomous Systems 2016 (compulsory), Robotics and Autonomous Systems, 2nd and 3rd semester</li> </ul>		
<b>Classes and lectures:</b> <ul style="list-style-type: none"> <li>• Engineering Mechanics 2 (lecture, 2 SWS)</li> <li>• Engineering Mechanics 2 (exercise, 2 SWS)</li> <li>• Engineering Mechanics 1 (lecture, 2 SWS)</li> <li>• Engineering Mechanics 1 (exercise, 2 SWS)</li> </ul>	<b>Workload:</b> <ul style="list-style-type: none"> <li>• 120 Hours in-classroom work</li> <li>• 120 Hours private studies and exercises</li> </ul>	
<b>Contents of teaching:</b> <ul style="list-style-type: none"> <li>• Statics and Elastostatics</li> <li>• Systems and equilibria of forces and moments</li> <li>• Gravitational force and center of mass</li> <li>• Planar systems of forces</li> <li>• Bearings and support of multibody systems</li> <li>• Trusses</li> <li>• Principle of virtual displacements</li> <li>• Law of elasticity</li> <li>• Beam theory</li> <li>• Stability of elastic systems</li> <li>• Energy conservation and approximate methods</li> <li>• Torsion</li> <li>• Kinematics of point masses</li> <li>• Kinetics of point masses</li> <li>• Kinematics of rigid bodies</li> <li>• Kinetics of rigid bodies</li> <li>• Linearization</li> <li>• Vibration theory</li> <li>• Product development and construction process</li> <li>• Requirements and target specification</li> <li>• Methods for identifying solutions, selection and evaluation</li> <li>• Methods of verification and fault prevention</li> </ul>		
<b>Qualification-goals/Competencies:</b> <ul style="list-style-type: none"> <li>• Students can explain the structure and basic properties of static mechanical systems.</li> <li>• They can calculate static mechanical systems.</li> <li>• They can develop products methodically and possess the necessary knowledge and skills.</li> <li>• They are able to model dynamic mechanical systems using kinetics and kinematic relations.</li> </ul>		
<b>Grading through:</b> <ul style="list-style-type: none"> <li>• written examination</li> </ul>		
<b>Responsible for this module:</b> <ul style="list-style-type: none"> <li>• Prof. Dr. Georg Schildbach</li> </ul>		
<b>Teacher:</b> <ul style="list-style-type: none"> <li>• <a href="#">Institute for Electrical Engineering in Medicine</a></li> <li>• <a href="#">Prof. Dr.-Ing. Christian Herzog</a></li> <li>• Prof. Dr. Georg Schildbach</li> </ul>		
<b>Literature:</b> <ul style="list-style-type: none"> <li>• Dankert, Jürgen; Dankert, Helga: Technische Mechanik. Statik, Festigkeitslehre, Kinematik/Kinetik - 7. Aufl. Wiesbaden: Springer Vieweg</li> </ul>		



2013

- Gross, Dietmar; Hauger, Werner; Schröder, Jörg; Wall, Wolfgang A.: Technische Mechanik 1. Statik - With assistance of Dietmar Gross. 12., aktualisierte. Aufl. Berlin [u.a.]: Springer Vieweg (Springer-Lehrbuch) 2013
- 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
- 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

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**Language:**

- offered only in German

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**Notes:**

Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s):

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

Module Exam(s):

- RO1500-L1: Technical Mechanics, written exam, 90min, 100% of the module grade

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

1 Semester

**Turnus of offer:**

each summer semester

**Credit points:**

8

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam

**Is requisite for:**

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

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

**Requires:**

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

**Responsible for this module:**

- [Prof. Dr. Thomas Eisenbarth](#)

**Teacher:**

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

**Literature:**

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

**Language:**

- offered only in German

**Notes:**

Admission requirements for taking the module:

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

Admission requirements for participation in module examination(s):

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

Module exam(s):

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

**CS1200-KP06, CS1200SJ14 - Fundamentals of Computer Engineering 1 (TG11)**
**Duration:**

1 Semester

**Turnus of offer:**

each summer semester

**Credit points:**

6

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam

**Is requisite for:**

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





**Responsible for this module:**

- Prof. Dr.-Ing. Mladen Berekovic

**Teacher:**

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

**Literature:**

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

**Language:**

- offered only in German

**Notes:**

Admission requirements for taking the module:  
- None

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

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

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

1 Semester

**Turnus of offer:**

each summer semester

**Credit points:**

8

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam

**Is requisite for:**

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

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

**Requires:**

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

**Responsible for this module:**

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

**Teacher:**

- [Institute of Mathematics and Image Computing](#)
- [Prof. Dr. rer. nat. Jan Modersitzki](#)
- [Prof. Dr. rer. nat. Jan Lellmann](#)

**Literature:**

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

**Language:**

- offered only in German

**Notes:**

Prerequisites for attending the module:

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

Prerequisites for the exam:

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

Module exam:

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

<b>MA2500-KP04, MA2500 - Analysis 2 (Ana2KP04)</b>		
<b>Duration:</b>	<b>Turnus of offer:</b>	<b>Credit points:</b>
1 Semester	each summer semester	4
<b>Course of study, specific field and term:</b>		
<ul style="list-style-type: none"> <li>• Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester</li> <li>• Bachelor Robotics and Autonomous Systems 2020 (compulsory), mathematics, 2nd semester</li> <li>• Bachelor Medical Informatics 2019 (compulsory), mathematics, 2nd semester</li> <li>• Bachelor IT-Security 2016 (optional subject), mathematics, Arbitrary semester</li> <li>• Bachelor Computer Science 2016 (compulsory), mathematics, 2nd semester</li> <li>• Bachelor Robotics and Autonomous Systems 2016 (compulsory), mathematics, 2nd semester</li> <li>• Bachelor Medical Informatics 2014 (compulsory), mathematics, 2nd semester</li> <li>• Bachelor Computer Science 2014 (compulsory), mathematics, 2nd semester</li> <li>• Bachelor Medical Informatics 2011 (compulsory), mathematics, 4th semester</li> <li>• Bachelor MES 2011 (compulsory), mathematics, 2nd semester</li> <li>• Bachelor Computer Science 2012 (compulsory), mathematics, 4th semester</li> </ul>		
<b>Classes and lectures:</b>		<b>Workload:</b>
<ul style="list-style-type: none"> <li>• Analysis 2 (lecture, 2 SWS)</li> <li>• Analysis 2 (exercise, 1 SWS)</li> </ul>		<ul style="list-style-type: none"> <li>• 60 Hours private studies</li> <li>• 45 Hours in-classroom work</li> <li>• 15 Hours exam preparation</li> </ul>
<b>Contents of teaching:</b>		
<ul style="list-style-type: none"> <li>• Integral calculus for functions of one real variable (indefinite integrals, antiderivatives, substitution, partial fractions, definite integrals, fundamental theorem of calculus)</li> <li>• Sequences and series of functions</li> <li>• Fourier series (trigonometric polynomials, convergence)</li> </ul>		
<b>Qualification-goals/Competencies:</b>		
<ul style="list-style-type: none"> <li>• Students understand the advanced terms of analysis, such as even convergence.</li> <li>• Students understand the advanced thoughts and proof techniques.</li> <li>• Students can explain advanced relationships in analysis.</li> <li>• Interdisciplinary qualifications:</li> <li>• Students can transfer advanced theoretical concepts to similar applications.</li> <li>• Students can work as a group on complex mathematical problems.</li> </ul>		
<b>Grading through:</b>		
<ul style="list-style-type: none"> <li>• written exam</li> </ul>		
<b>Requires:</b>		
<ul style="list-style-type: none"> <li>• Analysis 1 (MA2000-KP09)</li> <li>• Analysis 1 (MA2000-KP08, MA2000)</li> </ul>		
<b>Responsible for this module:</b>		
<ul style="list-style-type: none"> <li>• <a href="#">Prof. Dr. rer. nat. Jürgen Prestin</a></li> </ul>		
<b>Teacher:</b>		
<ul style="list-style-type: none"> <li>• <a href="#">Institute for Mathematics</a></li> <li>• <a href="#">Prof. Dr. rer. nat. Jürgen Prestin</a></li> </ul>		
<b>Literature:</b>		
<ul style="list-style-type: none"> <li>• K. Fritzsche: Grundkurs Analysis 1 + 2</li> <li>• H. Heuser: Lehrbuch der Analysis 1 + 2</li> <li>• K. Burg, H. Haf, F. Wille, A. Meister: Höhere Mathematik für Ingenieure</li> <li>• R. Lasser, F. Hofmaier: Analysis 1 + 2</li> </ul>		
<b>Language:</b>		



- offered only in German

**Notes:**

Admission requirements for taking the module:

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

Admission requirements for the examination:

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

Module Exam(s):

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

**CS1202-KP06, CS1202 - Fundamentals of Computer Engineering 2 (TG12)**

**Duration:**

1 Semester

**Turnus of offer:**

each winter semester

**Credit points:**

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

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**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

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**Language:**

- offered only in German

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**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

**CS2300-KP06, CS2300SJ14 - Software Engineering (SWEng14)**

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

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- Written or oral exam as announced by the examiner

**Is requisite for:**

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

**Requires:**

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

**Responsible for this module:**

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



**Teacher:**

- Institute of Software Technology and Programming Languages
- Prof. Dr. Martin Leucker
- Prof. Dr. Diedrich Wolter

**Literature:**

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

**Language:**

- offered only in German

**Notes:**

Admission requirements for taking the module:

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

Admission requirements for participation in module examination(s):

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

Module exam(s):

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

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

**CS2500-KP04, CS2500 - Robotics (Robotik)**
**Duration:**

1 Semester

**Turnus of offer:**

each winter semester

**Credit points:**

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

<b>ME2400-KP08, ME2400 - Fundamentals of Electrical Engineering 1 (ETechnik1)</b>		
<b>Duration:</b>	<b>Turnus of offer:</b>	<b>Credit points:</b>
1 Semester	each winter semester	8
<b>Course of study, specific field and term:</b>		
<ul style="list-style-type: none"> <li>• Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester</li> <li>• Bachelor MES 2020 (compulsory), electrical engineering, 3rd semester</li> <li>• Bachelor Robotics and Autonomous Systems 2020 (compulsory), electrical engineering, 3rd semester</li> <li>• Bachelor MES 2011 (optional subject), electrical engineering, 4th to 6th semester</li> <li>• Bachelor Computer Science 2016 (optional subject), advanced curriculum, Arbitrary semester</li> <li>• Bachelor Robotics and Autonomous Systems 2016 (compulsory), Robotics and Autonomous Systems, 3rd semester</li> <li>• Bachelor MES 2014 (compulsory), electrical engineering, 3rd semester</li> <li>• Bachelor IT-Security 2016 (optional subject), specific, Arbitrary semester</li> </ul>		
<b>Classes and lectures:</b>		<b>Workload:</b>
<ul style="list-style-type: none"> <li>• Fundamentals of Electrical Engineering 1 (lecture, 4 SWS)</li> <li>• Fundamentals of Electrical Engineering 1 (exercise, 2 SWS)</li> </ul>		<ul style="list-style-type: none"> <li>• 125 Hours private studies</li> <li>• 90 Hours in-classroom work</li> <li>• 25 Hours exam preparation</li> </ul>
<b>Contents of teaching:</b>		
<ul style="list-style-type: none"> <li>• Maxwell's Equations and electrical circuits</li> <li>• Circuit Abstraction</li> <li>• Passive electrical circuit elements</li> <li>• Methods of linear and nonlinear circuit analysis</li> <li>• Measuring voltages and currents</li> <li>• Equivalent circuit diagram (ideal/nonideal sources, MOSFETs, BJTs)</li> <li>• MOSFET Switch</li> <li>• Digital Abstraction</li> <li>• MOSFET Amplifier</li> </ul>		
<b>Qualification-goals/Competencies:</b>		
<ul style="list-style-type: none"> <li>• Students understand how electrical circuits are derived from Maxwell's equations and which simplifications are accepted in this process.</li> <li>• Students can calculate and analyze electrical circuits with passive elements.</li> <li>• 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.</li> <li>• 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.</li> <li>• Students know the difference between large and small signal analysis and are able to use this to analyze electrical circuits.</li> </ul>		
<b>Grading through:</b>		
<ul style="list-style-type: none"> <li>• written exam</li> </ul>		
<b>Is requisite for:</b>		
<ul style="list-style-type: none"> <li>• Fundamentals of Electrical Engineering 2 (ME2700-KP08, ME2700)</li> </ul>		
<b>Requires:</b>		
<ul style="list-style-type: none"> <li>• Analysis 2 (MA2500-KP04, MA2500)</li> <li>• Analysis 1 (MA2000-KP08, MA2000)</li> <li>• Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)</li> <li>• Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)</li> </ul>		
<b>Responsible for this module:</b>		
<ul style="list-style-type: none"> <li>• <a href="#">Prof. Dr. Philipp Rostalski</a></li> </ul>		
<b>Teacher:</b>		
<ul style="list-style-type: none"> <li>• <a href="#">Institute for Electrical Engineering in Medicine</a></li> </ul>		

- [Prof. Dr. Philipp Rostalski](#)

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**Literature:**

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

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**Language:**

- offered only in German

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**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.

<b>PS4640-KP04 - Technikethik (TE)</b>		
<b>Duration:</b> 1 Semester	<b>Turnus of offer:</b> each winter semester	<b>Credit points:</b> 4
<b>Course of study, specific field and term:</b> <ul style="list-style-type: none"> <li>• Bachelor Robotics and Autonomous Systems 2020 (compulsory), interdisciplinary competence, 3rd semester</li> </ul>		
<b>Classes and lectures:</b> <ul style="list-style-type: none"> <li>• Ethics of Technology (lecture, 2 SWS)</li> <li>• Ethics of Technology (seminar, 1 SWS)</li> </ul>		<b>Workload:</b> <ul style="list-style-type: none"> <li>• 60 Hours private studies</li> <li>• 30 Hours in-classroom work</li> <li>• 30 Hours work on project</li> </ul>
<b>Contents of teaching:</b> <ul style="list-style-type: none"> <li>• Fundamental ethical theories and methods</li> <li>• Responsible Research &amp; Innovation</li> <li>• Trustworthiness of technologies</li> <li>• Aspects of privacy</li> <li>• Justice and Eco-social Inequality</li> <li>• transparency, technological opacity, interpretability and explainability</li> <li>• Ironies of automation</li> <li>• Approaches to ethical decision-making</li> <li>• Autonomous systems in the context of societal transformation</li> <li>• Novel and unsolved cases in ethical discourse on the basis of modern and innovative technologies</li> </ul>		
<b>Qualification-goals/Competencies:</b> <ul style="list-style-type: none"> <li>• The students know ethical and societal challenges of innovative technologies and are able to articulate these precisely.</li> <li>• The students are able to evaluate and analyze future and existing technologies with regard to associated ethical debates.</li> <li>• The students are able to decide in case studies on the basis of different normative ethical theories.</li> <li>• The students are able to present precise ethical arguments to defend their opinions in discourse.</li> <li>• The students know fundamental future ethical debates with regard to automation and the development of autonomous systems and artificial intelligence.</li> <li>• The students are able to comprehensibly express their findings in interdisciplinary exchange.</li> <li>• Students are able to systematically develop solution proposals based on ethical criteria and present them with arguments.</li> </ul>		
<b>Grading through:</b> <ul style="list-style-type: none"> <li>• portfolio exam</li> </ul>		
<b>Responsible for this module:</b> <ul style="list-style-type: none"> <li>• <a href="#">Prof. Dr.-Ing. Christian Herzog</a></li> </ul>		
<b>Teacher:</b> <ul style="list-style-type: none"> <li>• <a href="#">Institute for Electrical Engineering in Medicine</a></li> <li>• <a href="#">Prof. Dr.-Ing. Christian Herzog</a></li> </ul>		
<b>Literature:</b> <ul style="list-style-type: none"> <li>• van de Poel, Ibo; Royackers, Lambèr: Ethics, Technology, and Engineering - An Introduction - Wiley-Blackwell</li> <li>• :</li> </ul>		
<b>Language:</b> <ul style="list-style-type: none"> <li>• offered only in German</li> </ul>		
<b>Notes:</b>		



Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s):

- None

Module Exam(s):

- Submissions in groups will be required periodically during the semester, accounting for 20% of the final grade.
- At the end of the semester a report (80%) is required, whereby the respective individual performance must be identified and will be evaluated separately.
- The grade of the report is calculated from: 70% individual performance + 30% overall grade of the report (= average grade of the individual performances of the report).

<b>CS2251-KP04 - Cybersecurity Internship (CyberSecPr)</b>		
<b>Duration:</b> 1 Semester	<b>Turnus of offer:</b> each summer semester	<b>Credit points:</b> 4 (Typ B)
<b>Course of study, specific field and term:</b> <ul style="list-style-type: none"> <li>• Bachelor Robotics and Autonomous Systems 2016 (optional subject), Additionally recognized elective module, 4th or 6th semester</li> <li>• Bachelor Robotics and Autonomous Systems 2020 (optional subject), Additionally recognized elective module, 4th or 6th semester</li> <li>• Bachelor Computer Science 2019 (optional subject), Extended optional subjects, 4th semester</li> <li>• Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester</li> </ul>		
<b>Classes and lectures:</b> <ul style="list-style-type: none"> <li>• Practical Course Cybersecurity (practical course, 3 SWS)</li> </ul>		<b>Workload:</b> <ul style="list-style-type: none"> <li>• 50 Hours work on project</li> <li>• 40 Hours in-classroom work</li> <li>• 30 Hours group work</li> </ul>
<b>Contents of teaching:</b> <ul style="list-style-type: none"> <li>• Practical exploitation of security vulnerabilities in various fields of application</li> <li>• Conduct of risk analyses and implementation of defensive measures</li> <li>• Analysis of security requirements in a complex use case</li> <li>• Design, realization, and analysis of a state-of-the-art security solution</li> <li>• Discussion about attacker motivation, protective measures, and impact of attacks</li> <li>• Getting acquainted with penetration testing tools</li> </ul>		
<b>Qualification-goals/Competencies:</b> <ul style="list-style-type: none"> <li>• Students can explain the basic methods in the field of cybersecurity and apply them to case studies.</li> <li>• They can independently perform security analyses for simple scenarios.</li> <li>• They are able to identify weak points and develop concrete solutions to eliminate them.</li> </ul>		
<b>Grading through:</b> <ul style="list-style-type: none"> <li>• continuous, successful participation in practical course</li> <li>• project work</li> </ul>		
<b>Responsible for this module:</b> <ul style="list-style-type: none"> <li>• <a href="#">Prof. Dr. Thomas Eisenbarth</a></li> </ul> <b>Teacher:</b> <ul style="list-style-type: none"> <li>• <a href="#">Institute for IT Security</a></li> <li>• <a href="#">Prof. Dr. Thomas Eisenbarth</a></li> </ul>		
<b>Literature:</b> <ul style="list-style-type: none"> <li>• D. Gollmann: Computer Security, Third Edition, Wiley, 2011 - Third Edition, Wiley, 2011</li> <li>• R. Anderson: Security Engineering - Second Edition, Wiley, 2008</li> <li>• C. Kaufman, R. Perlman, and M. Speciner: Network security: private communication in a public world - Second Edition, Prentice Hall, 2002</li> <li>• W. Du: W. Du: Computer Security: A Hands-on Approach - First Edition, CreateSpace Independent Publishing Platform, 2017</li> </ul>		
<b>Language:</b> <ul style="list-style-type: none"> <li>• offered only in German</li> </ul>		
<b>Notes:</b>		





Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s):

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

Module Exam(s):

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

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

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

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

**CS2110-KP04, CS2110 - Mobile Robots (MobilRob14)**
**Duration:**

1 Semester

**Turnus of offer:**

each summer semester

**Credit points:**

4

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- Written or oral exam as announced by the examiner

**Responsible for this module:**

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

**Teacher:**

- [Institute of Computer Engineering](#)
- Dr. rer. nat. Javad Ghofrani

**Literature:**

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

**Language:**

- offered only in German



**Notes:**

Prerequisites for attending the module:

- None

Prerequisites for the exam:

- continuous, successful participation in practical course

<b>CS2150-KP08, CS2150SJ14 - Operating Systems and Networks (BSNetze14)</b>		
<b>Duration:</b> 1 Semester	<b>Turnus of offer:</b> each summer semester	<b>Credit points:</b> 8
<b>Course of study, specific field and term:</b>		
<ul style="list-style-type: none"> <li>• Bachelor Media Informatics 2020 (compulsory), computer science, 4th semester</li> <li>• Bachelor Computer Science 2019 (compulsory), foundations of computer science, 4th semester</li> <li>• Bachelor Robotics and Autonomous Systems 2020 (compulsory), computer science, 4th semester</li> <li>• Bachelor Medical Informatics 2019 (compulsory), computer science, 4th semester</li> <li>• Bachelor Computer Science 2016 (compulsory), foundations of computer science, 4th semester</li> <li>• Bachelor Robotics and Autonomous Systems 2016 (compulsory), computer science, 4th semester</li> <li>• Bachelor IT-Security 2016 (compulsory), computer science, 4th semester</li> <li>• Bachelor Media Informatics 2014 (compulsory), foundations of computer science, 4th semester</li> <li>• Bachelor Medical Informatics 2014 (compulsory), computer science, 4th semester</li> <li>• Bachelor Computer Science 2014 (compulsory), foundations of computer science, 4th semester</li> </ul>		
<b>Classes and lectures:</b>		<b>Workload:</b>
<ul style="list-style-type: none"> <li>• Operating Systems and Networks (lecture, 4 SWS)</li> <li>• Operating Systems and Networks (exercise, 2 SWS)</li> </ul>		<ul style="list-style-type: none"> <li>• 130 Hours private studies</li> <li>• 90 Hours in-classroom work</li> <li>• 20 Hours exam preparation</li> </ul>
<b>Contents of teaching:</b>		
<ul style="list-style-type: none"> <li>• Tasks and Structure</li> <li>• Historical Overview of Computer and Operating Systems</li> <li>• Coding of Symbols and Numbers</li> <li>• Foundations of Operating Systems</li> <li>• Processes, Inter-Process Communication and Process Management</li> <li>• Storage Management</li> <li>• Input / Output</li> <li>• Files and File Systems</li> <li>• Examples (UNIX, Windows, mobile OS)</li> <li>• Computer Networks and the Internet</li> <li>• Application Layer</li> <li>• Transport Layer</li> <li>• Network Layer</li> <li>• Link and Physical Layer</li> </ul>		
<b>Qualification-goals/Competencies:</b>		
<ul style="list-style-type: none"> <li>• Students know about the main concepts of operating systems.</li> <li>• Students are able to judge, which OS concepts can be appropriately applied to novel computing architectures.</li> <li>• Students are able to apply the most important strategies and algorithms for operating systems.</li> <li>• At the end of the course, students know the most important concepts of computer networks</li> <li>• Students know the importance of the different layers of the OSI and Internet protocol suite along with the most important protocols and services of each layer</li> <li>• The students are able to decide which network technologies to use to meet the requirements of any given application scenario</li> <li>• The students know how the Internet works and are able to program small applications</li> <li>• Students can apply the most important methods and algorithms from the field of networks</li> </ul>		
<b>Grading through:</b>		
<ul style="list-style-type: none"> <li>• written exam</li> </ul>		
<b>Responsible for this module:</b>		
<ul style="list-style-type: none"> <li>• <a href="#">Prof. Dr. Stefan Fischer</a></li> </ul>		
<b>Teacher:</b>		
<ul style="list-style-type: none"> <li>• <a href="#">Institute of Telematics</a></li> <li>• <a href="#">Prof. Dr. Stefan Fischer</a></li> </ul>		



- [Dr. rer. nat. Florian-Lennert Lau](#)

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**Literature:**

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

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**Language:**

- offered only in German

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**Notes:**

Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s):

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

Module Exam(s):

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

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

<b>Duration:</b> 1 Semester	<b>Turnus of offer:</b> each summer semester	<b>Credit points:</b> 6 (Typ A)	<b>Max. group size:</b> 12
<b>Course of study, specific field and term:</b>			
<ul style="list-style-type: none"> <li>• Bachelor Media Informatics 2020 (compulsory), computer science, 4th semester</li> <li>• Bachelor Computer Science 2019 (compulsory), foundations of computer science, 4th semester</li> <li>• Bachelor Robotics and Autonomous Systems 2020 (compulsory), computer science, 4th semester</li> <li>• Bachelor Medical Informatics 2019 (compulsory), computer science, 4th semester</li> <li>• Bachelor Computer Science 2016 (compulsory), foundations of computer science, 4th semester</li> <li>• Bachelor Robotics and Autonomous Systems 2016 (compulsory), computer science, 4th semester</li> <li>• Bachelor IT-Security 2016 (compulsory), computer science, 4th semester</li> <li>• Bachelor Media Informatics 2014 (compulsory), foundations of computer science, 4th semester</li> <li>• Bachelor Medical Informatics 2014 (compulsory), computer science, 4th semester</li> <li>• Bachelor Computer Science 2014 (compulsory), foundations of computer science, 4th semester</li> </ul>			
<b>Classes and lectures:</b>		<b>Workload:</b>	
<ul style="list-style-type: none"> <li>• Lab Course Software Engineering (practical course, 4 SWS)</li> </ul>		<ul style="list-style-type: none"> <li>• 60 Hours in-classroom work</li> <li>• 60 Hours group work</li> <li>• 50 Hours work on project</li> <li>• 10 Hours oral presentation and discussion (including preparation)</li> </ul>	
<b>Contents of teaching:</b>			
<ul style="list-style-type: none"> <li>• Realization of a software system</li> <li>• Project management and team work</li> <li>• Design, implementation and testing</li> </ul>			
<b>Qualification-goals/Competencies:</b>			
<ul style="list-style-type: none"> <li>• The students are able to systematically design software systems whose implementation meets the requirements, using object oriented techniques.</li> <li>• They can use UML and CASE tools.</li> <li>• They can decide how to advance their software in a sensible way.</li> <li>• They can contribute their experience in the realization of a software development project in further projects.</li> <li>• They have the qualification to present artefacts, to comply to standards and to observe time limits.</li> <li>• They are qualified to work in a team and to reflect their social skills.</li> </ul>			
<b>Grading through:</b>			
<ul style="list-style-type: none"> <li>• continuous, successful participation in practical course</li> <li>• presentation</li> <li>• successful addressing of the project goals</li> <li>• documentation</li> </ul>			
<b>Requires:</b>			
<ul style="list-style-type: none"> <li>• Introduction to Programming (CS1000-KP10, CS1000SJ14)</li> <li>• Algorithms and Data Structures (CS1001-KP08, CS1001)</li> <li>• Software Engineering (CS2300-KP06, CS2300SJ14)</li> </ul>			
<b>Responsible for this module:</b>			
<ul style="list-style-type: none"> <li>• <a href="#">Prof. Dr. Martin Leucker</a></li> </ul>			
<b>Teacher:</b>			
<ul style="list-style-type: none"> <li>• <a href="#">Institute of Software Technology and Programming Languages</a></li> <li>• <a href="#">Prof. Dr. Martin Leucker</a></li> </ul>			
<b>Literature:</b>			
<ul style="list-style-type: none"> <li>• H. Balzert: Lehrbuch der Softwaretechnik: Softwaremanagement - Spektrum Akademischer Verlag 2008</li> </ul>			



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

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**Language:**

- offered only in German

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**Notes:**

Admission requirements for taking the module:

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

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

Admission requirements for participation in module examination(s):

- Successful participation in the internship as specified at the beginning of the semester.

Module Exam(s):

- CS2301-L1: Internship Software Engineering, graded internship, 100% of module grade.

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

1 Semester

**Turnus of offer:**

each summer semester

**Credit points:**

4

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam

**Is requisite for:**

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





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

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**Responsible for this module:**

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

**Teacher:**

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

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**Literature:**

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

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**Language:**

- offered only in German

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**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

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

1 Semester

**Turnus of offer:**

each summer semester

**Credit points:**

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

**CS1002-KP04, CS1002 - Introduction to Logics (Logik)**
**Duration:**

1 Semester

**Turnus of offer:**

each summer semester

**Credit points:**

4

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam

**Responsible for this module:**

- [Prof. Dr. rer. nat. Till Tantau](#)

**Teacher:**

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

**Literature:**

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

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

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**Language:**

- offered only in German

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**Notes:**

Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s):

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

Module Exam(s):

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

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

1 Semester

**Turnus of offer:**

each winter semester

**Credit points:**

4

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam

**Responsible for this module:**

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

**Teacher:**

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



- Prof. Dr. rer. nat. habil. Josef Ingenerf
- Prof. Dr.-Ing. Marcin Grzegorzek

**Literature:**

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

**Language:**

- offered only in German

**Notes:**

Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s):

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

Module examinations:

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

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

**Duration:**

1 Semester

**Turnus of offer:**

each winter semester

**Credit points:**

4

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- Written or oral exam as announced by the examiner

**Responsible for this module:**

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

**Teacher:**

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

**Literature:**

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

**Language:**

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

**Notes:**





Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s):

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

Module Exam(s):

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

**CS2000-KP08, CS2000 - Theoretical Computer Science (TI)**
**Duration:**

1 Semester

**Turnus of offer:**

each winter semester

**Credit points:**

8

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam and course achievements

**Is requisite for:**

- Parallel Computing (CS3051-KP04, CS3051)

**Requires:**

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

**Responsible for this module:**

- [Prof. Dr. Rüdiger Reischuk](#)

**Teacher:**



- Institute for Theoretical Computer Science

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

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**Literature:**

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

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**Language:**

- offered only in German

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**Notes:**

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

**CS2100-KP04, CS2100SJ14 - Computer Architecture (RA14)**
**Duration:**

1 Semester

**Turnus of offer:**

each summer semester

**Credit points:**

4

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- Written or oral exam as announced by the examiner

**Requires:**

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

**Responsible for this module:**

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

**Teacher:**

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

**Literature:**

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

**Language:**



- offered only in German

**Notes:**

Admission requirements for taking the module:

- None (the competencies of the modules listed under

<b>CS2250-KP04 - Cybersecurity (CyberSec04)</b>		
<b>Duration:</b> 1 Semester	<b>Turnus of offer:</b> each summer semester	<b>Credit points:</b> 4
<b>Course of study, specific field and term:</b> <ul style="list-style-type: none"> <li>• Bachelor MES 2020 (optional subject), computer science / electrical engineering, 3rd semester at the earliest</li> <li>• Bachelor Media Informatics 2020 (optional subject), computer science, 5th or 6th semester</li> <li>• Bachelor Computer Science 2019 (compulsory), foundations of computer science, 4th semester</li> <li>• Bachelor Robotics and Autonomous Systems 2020 (optional subject), computer science, 5th or 6th semester</li> <li>• Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester</li> </ul>		
<b>Classes and lectures:</b> <ul style="list-style-type: none"> <li>• Cybersecurity (lecture, 2 SWS)</li> <li>• Cybersecurity (exercise, 1 SWS)</li> </ul>	<b>Workload:</b> <ul style="list-style-type: none"> <li>• 60 Hours private studies and exercises</li> <li>• 40 Hours in-classroom work</li> <li>• 20 Hours exam preparation</li> </ul>	
<b>Contents of teaching:</b> <ul style="list-style-type: none"> <li>• Security problems in IT systems</li> <li>• Security threats, risk analysis and defense mechanisms</li> <li>• Software and application security</li> <li>• Security of operating systems</li> <li>• Security of databases and web applications</li> <li>• Privacy</li> <li>• Security oriented development, evaluation and penetration testing</li> <li>• Legal, etical and economic aspects</li> </ul>		
<b>Qualification-goals/Competencies:</b> <ul style="list-style-type: none"> <li>• Students can independently identify security risks of software systems and explain the common security solutions from the areas discussed in the course.</li> <li>• They can explain the basic methods in the area of cybersecurity and apply them to case studies.</li> <li>• They can independently perform security analyses for simple scenarios.</li> <li>• They are able to identify methods for eliminating weak points and implement concrete solutions.</li> </ul>		
<b>Grading through:</b> <ul style="list-style-type: none"> <li>• Written or oral exam as announced by the examiner</li> </ul>		
<b>Responsible for this module:</b> <ul style="list-style-type: none"> <li>• <a href="#">Prof. Dr. Thomas Eisenbarth</a></li> </ul>		
<b>Teacher:</b> <ul style="list-style-type: none"> <li>• <a href="#">Institute for IT Security</a></li> <li>• <a href="#">Prof. Dr. Thomas Eisenbarth</a></li> </ul>		
<b>Literature:</b> <ul style="list-style-type: none"> <li>• C. Paar, J. Pelzl: Understanding Cryptography - Springer, 2008</li> <li>• D. Gollmann: Computer Security - Third Edition, Wiley, 2011</li> <li>• R. Anderson: Security Engineering - Second Edition, Wiley, 2008</li> <li>• M. Bishop: Introduction to Computer Security - Addison-Wesley, 2005</li> </ul>		
<b>Language:</b> <ul style="list-style-type: none"> <li>• offered only in German</li> </ul>		
<b>Notes:</b>		



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.

<b>CS2600-KP08, CS2600SJ14 - Interaction Design and User Experience (IDE)</b>		
<b>Duration:</b> 1 Semester	<b>Turnus of offer:</b> each summer semester	<b>Credit points:</b> 8
<b>Course of study, specific field and term:</b>		
<ul style="list-style-type: none"> <li>• Bachelor Media Informatics 2020 (compulsory), design, 4th semester</li> <li>• Bachelor Robotics and Autonomous Systems 2020 (optional subject), computer science, 5th or 6th semester</li> <li>• Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester</li> <li>• Bachelor Robotics and Autonomous Systems 2016 (optional subject), computer science, 5th or 6th semester</li> <li>• Bachelor Computer Science 2014 (optional subject), central topics of computer science, 6th semester</li> <li>• Bachelor Media Informatics 2014 (compulsory), media informatics, 4th semester</li> </ul>		
<b>Classes and lectures:</b>		<b>Workload:</b>
<ul style="list-style-type: none"> <li>• Interaction Design (lecture, 4 SWS)</li> <li>• Interaction Design (exercise, 2 SWS)</li> </ul>		<ul style="list-style-type: none"> <li>• 120 Hours private studies</li> <li>• 90 Hours in-classroom work</li> <li>• 30 Hours exam preparation</li> </ul>
<b>Contents of teaching:</b>		
<ul style="list-style-type: none"> <li>• Introduction and overview</li> <li>• A short history of Human Computer Interaction (</li> <li>• Definition and distinction: Software Ergonomics vs Usability Engineering vs Interaction Design</li> <li>• Usability as design goal: central models and ISO norms, fundamentals of software ergonomic and cognition (a brief review of Software Ergonomics)</li> <li>• User Experience (UX) as new design goal: Models and background (i.e. pleasurable products, hedonistic and pragmatic quality, emotional design)</li> <li>• UX as aesthetic and emotional appeal</li> <li>• UX as ergonomic factor, dark patterns</li> <li>• Process models for Interaction Design: From Human-Centered Design based on the ISO-Norm to the simplified Four-Phase-Model</li> <li>• Iterative Design as mental models in action: Design Model, User Model and System Image</li> <li>• Phase 1 of Interaction Design: 'Understand' (Practical methods of design ethnography and context analysis; representation of users and tasks)</li> <li>• Phase 2 of Interaction Design: 'design' (system's paradigms: HCI as conversation, HCI as model-world, Direct Manipulation, Tangible Interaction, Proxemic Interaction, Virtual Reality; Sketching User Experiences for idea generation and solution development; design principles and guidelines as decision support, i.e. Normans' principles, gestalt laws, Human Interface Guidelines; theoretical models and techniques from research vs. design practice)</li> <li>• Phase 3 of Interaction Design 'Build' (basic principles of Prototyping; Low- vs. High-Fidelity-Prototyping; Time vs. Fidelity: Sketching, Paper Prototyping, Wireframes/Click-Through, Dynamic Prototypes, Coded Prototypes; Prototyping tools in practice)</li> <li>• Phase 4 of interaction design: 'evaluate' (analytic vs empirical methods in practice; evaluation of users experience with standardized questionnaires; formative vs. summative evaluation; usability tests, A/B studies; Continuous processes for quality control resp. UX evaluation)</li> <li>• Post WIMP interaction: Interaction Design beyond PC and Smartphone</li> </ul>		
<b>Qualification-goals/Competencies:</b>		
<ul style="list-style-type: none"> <li>• The students are able to use systematically and theoretically founded methods for the design of user interfaces of interactive systems.</li> <li>• The students are able to use their knowledge in Software Ergonomics, Media Design and Media Informatics in a realistic Interaction Design project</li> <li>• They are capable of categorizing existing systems and develop concepts for improving them.</li> <li>• They are capable of planning and designing human-computer interfaces with high user experience.</li> </ul>		
<b>Grading through:</b>		
<ul style="list-style-type: none"> <li>• portfolio exam - the concrete examination elements and their weights will be published in the course</li> <li>•</li> </ul>		
<b>Requires:</b>		
<ul style="list-style-type: none"> <li>• Software Ergonomics (CS2200-KP04, CS2200)</li> <li>• Introduction to Media Informatics (CS1600-KP04, CS1600)</li> </ul>		



**Responsible for this module:**

- [Prof. Dr. rer. nat. Hans-Christian Jetter](#)

**Teacher:**

- [Institute for Multimedia and Interactive Systems](#)
- [Prof. Dr. rer. nat. Hans-Christian Jetter](#)
- MitarbeiterInnen des Instituts

**Literature:**

- H. Sharp, J. Preece, Y. Rogers: Interaction Design: Beyond Human-Computer Interaction - Wiley, 2019
- R. Hartson, P. Pyla: The UX Book: Agile UX Design for a Quality User Experience - Morgan Kaufman, 2019
- Michael Richter, Markus Flückiger: Usability und UX kompakt - Produkte für Menschen, 2015
- Saul Greenberg, Sheelagh Carpendale, Nicolai Marquardt, Bill Buxton: Sketching User Experiences - The Workbook, 2012

**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):

- Preliminary examinations may be required and will be announced at the beginning of the semester.

Module Exam(s):

- CS2600-L1 Interaction Design and User Experience, oral exam, 50% of the module grade
- CS2600-L1 Interaction Design and User Experience, portfolio exam, 50% of the module grade during the semester

Replaces CS2600-KP08 Interaction Design

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

1 Semester

**Turnus of offer:**

each winter semester

**Credit points:**

4

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

- Bachelor 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.

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

1 Semester

**Turnus of offer:**

each winter semester

**Credit points:**

4

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam

**Requires:**

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

**Responsible for this module:**

- [Prof. Dr. Rüdiger Reischuk](#)

**Teacher:**

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

**Literature:**

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



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

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**Language:**

- offered only in German

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**Notes:**

Prerequisites for attending the module:

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

Prerequisites for the exam:

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

Module exam(s):

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

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

**Duration:**

1 Semester

**Turnus of offer:**

each winter semester

**Credit points:**

4

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam

**Responsible for this module:**

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

**Teacher:**

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

**Literature:**

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



**Language:**

- offered only in German

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**Notes:**

Prerequisites for attending the module:

- None

Prerequisites for the exam:

- Successful completion of homework assignments as stated in the beginning of the course

Exam(s):

- CS3010-L1 Mensch-Computer-Interaktion, Klausur, 90min, 100% der Modulnote

**CS3051-KP04, CS3051 - Parallel Computing (ParallelVa)**
**Duration:**

1 Semester

**Turnus of offer:**

normally each year in the summer semester

**Credit points:**

4

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- Viva Voce or test

**Requires:**

- Theoretical Computer Science (CS2000-KP08, CS2000)

**Responsible for this module:**

- [Prof. Dr. rer. nat. Till Tantau](#)

**Teacher:**

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

**Literature:**

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





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

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**Language:**

- offered only in German

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**Notes:**

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

**CS3201-KP04, CS3201 - Usability Engineering (UsabUXEng)**

**Duration:**

1 Semester

**Turnus of offer:**

each winter semester

**Credit points:**

4

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

- Introduction and motivation
- Cognitive Systems Engineering
- Software and Usability Engineering
- Ability-Based and Inclusive Design
- Interdisciplinary teams and social processes
- cost-benefit analysis
- Task analysis
- User analysis
- Organizational and contextual analysis
- Modeling and design of interactive systems
- Criteria for interactive systems
- Evaluation of interactive systems
- Summary

**Qualification-goals/Competencies:**

- Students are able to explain the basic user-centered development processes for interactive multimedia systems.
- They are able to apply and adapt basic processes for specific projects and needs.
- They are able to explain that these processes are influenced by formal und informal requirements as well as social structures and behaviors.

**Grading through:**

- written exam

**Requires:**

- Software Ergonomics (CS2200-KP04, CS2200)

**Responsible for this module:**

- [Prof. Dr. phil. André Calero Valdez](#)

**Teacher:**

- [Institute for Multimedia and Interactive Systems](#)
- [Prof. Dr. phil. André Calero Valdez](#)

**Literature:**

- Deborah J. Mayhew: The Usability Engineering Lifecycle - Morgan Kaufmann Publ., 1999
- Mary B. Rosson, John M. Carroll: Usability Engineering: Scenario-Based Development of Human-Computer Interaction - Morgan Kaufmann Publ., 2002
- Karen Holtzblatt, Hugh Beyer: Contextual Design. Defining Customer-Centered Systems - Morgan Kaufmann Publ., 1997

**Language:**

- offered only in German

**Notes:**

Replaces CS3201-KP04 Usability-Engineering.

Prerequisites for attending the module:

- None

Prerequisites for the exam:

- Successful completion of homework assignments as stated at the beginning of the course

Exam(s):

- CS3201-L1 Usability- und UX-Engineering, Klausur, 90min, 100% der Modulnote

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

1 Semester

**Turnus of offer:**

each summer semester

**Credit points:**

4

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam

**Requires:**

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

**Responsible for this module:**



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

**Teacher:**

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

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**Literature:**

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

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**Language:**

- offered only in German

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**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

**CS3420-KP04, CS3420 - Cryptology (Krypto14)**
**Duration:**

1 Semester

**Turnus of offer:**

each winter semester

**Credit points:**

4

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam

**Responsible for this module:**

- [Prof. Dr. Rüdiger Reischuk](#)

**Teacher:**

- [Institute for Theoretical Computer Science](#)
- [Prof. Dr. Rüdiger Reischuk](#)
- [Prof. Dr. Maciej Liskiewicz](#)

**Literature:**

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



**Language:**

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

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**Notes:**

Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s):

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

Module exam(s):

- CS3420-L1: Cryptology, written exam, 90 minutes, 100% of module grade

<b>CS4172-KP04, CS4172 - Dependability of Computing Systems (ZuvelRSys)</b>		
<b>Duration:</b>	<b>Turnus of offer:</b>	<b>Credit points:</b>
1 Semester	each summer semester	4
<b>Course of study, specific field and term:</b>		
<ul style="list-style-type: none"> <li>• Bachelor Computer Science 2019 (optional subject), major subject informatics, Arbitrary semester</li> <li>• Bachelor Robotics and Autonomous Systems 2020 (optional subject), computer science, 5th or 6th semester</li> <li>• Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester</li> <li>• Bachelor Robotics and Autonomous Systems 2016 (optional subject), computer science, 5th or 6th semester</li> <li>• Bachelor IT-Security 2016 (compulsory), IT-Security, 6th semester</li> <li>• Bachelor Computer Science 2014 (optional subject), central topics of computer science, 6th semester</li> <li>• Bachelor Computer Science 2014 (compulsory), specialization field IT security and safety, 6th semester</li> <li>• Bachelor Computer Science 2012 (compulsory), specialization field IT security and safety, 6th semester</li> <li>• Master Computer Science 2012 (optional subject), advanced curriculum security, 2nd or 3rd semester</li> <li>• Master Computer Science 2012 (optional subject), specialization field software systems engineering, 3rd semester</li> <li>• Master Computer Science 2012 (optional subject), advanced curriculum parallel and distributed system architectures, 2nd or 3rd semester</li> <li>• Master Computer Science 2012 (optional subject), specialization field robotics and automation, 3rd semester</li> </ul>		
<b>Classes and lectures:</b>		<b>Workload:</b>
<ul style="list-style-type: none"> <li>• Dependability of Computing Systems (lecture, 2 SWS)</li> <li>• Dependability of Computing Systems (exercise, 1 SWS)</li> </ul>		<ul style="list-style-type: none"> <li>• 55 Hours private studies</li> <li>• 45 Hours in-classroom work</li> <li>• 20 Hours exam preparation</li> </ul>
<b>Contents of teaching:</b>		
<ul style="list-style-type: none"> <li>• Basic terms</li> <li>• General redundancy techniques</li> <li>• Fault diagnosis</li> <li>• Reconfiguration and recovery</li> <li>• Fault masking</li> <li>• Examples for fault-tolerant systems</li> </ul>		
<b>Qualification-goals/Competencies:</b>		
<ul style="list-style-type: none"> <li>• The students are able to present the most important fault types in hardware and software and their abstraction to fault models.</li> <li>• They are able to elucidate the basic redundancy techniques (static and dynamic redundancy, hybrid forms etc.).</li> <li>• They are able to explain various methods for fault diagnosis, reconfiguration, recovery and fault masking.</li> <li>• They are able to describe typical application examples and sample fault-tolerant computers.</li> <li>• They are able to analyze fault tolerance techniques quantitatively by mathematical reliability models.</li> <li>• They are able to evaluate and compare suitable fault tolerance techniques and to select them for a given application area.</li> </ul>		
<b>Grading through:</b>		
<ul style="list-style-type: none"> <li>• Written or oral exam as announced by the examiner</li> </ul>		
<b>Responsible for this module:</b>		
<ul style="list-style-type: none"> <li>• <a href="#">Prof. Dr.-Ing. Mladen Berekovic</a></li> </ul>		
<b>Teacher:</b>		
<ul style="list-style-type: none"> <li>• <a href="#">Institute of Computer Engineering</a></li> <li>• <a href="#">Prof. Dr.-Ing. Mladen Berekovic</a></li> </ul>		
<b>Literature:</b>		
<ul style="list-style-type: none"> <li>• E. Dubrova: Fault-Tolerant Design - Springer 2013</li> <li>• K. Ehtle: Fehlertoleranzverfahren - Springer 1990</li> <li>• I. Koren, C. M. Krishna: Fault Tolerant Systems - Morgan-Kaufman 2007</li> <li>• K. Trivedi: Probability and Statistics with Reliability, Queuing, and Computer Science Applications - Wiley 2001</li> </ul>		
<b>Language:</b>		
<ul style="list-style-type: none"> <li>• offered only in German</li> </ul>		





**Notes:**

Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s):

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

Module Exam(s):

- CS4172-L1: Dependability of Computing Systems, written exam, 90min, 100% of the module grade

**MA3110-KP04, MA3110 - Numerics 1 (Num1KP04)**
**Duration:**

1 Semester

**Turnus of offer:**

each winter semester

**Credit points:**

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

**Language:**

- 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:**

1 Semester

**Turnus of offer:**

each winter semester

**Credit points:**

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 ordinary differential 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 be analysed qualitatively.
- Students are able to present important models of the natural sciences which can be 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

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**Language:**

- offered only in German

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**Notes:**

Prerequisites for the module:

- nothing

Prerequisites for admission to the written examination:

- Successful completion of homework assignments during the semester

Module exam:

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

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

1 Semester

**Turnus of offer:**

every second year

**Credit points:**

4

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- Oral examination

**Requires:**

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

**Responsible for this module:**

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

**Teacher:**

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

**Literature:**

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



**Language:**

- offered only in German

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**Notes:**

Admission requirements for taking the module:

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

Admission requirements for taking module examination(s):

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

Module Exam(s):

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

**ME2151-KP04, ME2151 - Introduction to Medical Engineering (EMedTecMI)**
**Duration:**

1 Semester

**Turnus of offer:**

each winter semester

**Credit points:**

4

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

- Bachelor Robotics and Autonomous Systems 2020 (optional subject), Robotics and Autonomous Systems, 5th or 6th semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory), Robotics and Autonomous Systems, 5th semester
- Bachelor Medical Informatics 2014 (compulsory), medical computer science, 3rd semester

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- portfolio exam

**Responsible for this module:**

- [Prof. Dr.-Ing. Matthias Gräser](#)

**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:  
- None





<b>ME3400-KP04, ME3400 - Medical Electrical Engineering Lab Course (METechPrak)</b>		
<b>Duration:</b> 1 Semester	<b>Turnus of offer:</b> each winter semester	<b>Credit points:</b> 4 (Typ B)
<b>Course of study, specific field and term:</b>		
<ul style="list-style-type: none"> <li>• Bachelor MES 2020 (compulsory), electrical engineering, 5th semester</li> <li>• Bachelor Robotics and Autonomous Systems 2016 (optional subject), electrical engineering, 5th or 6th semester</li> <li>• Bachelor MES 2014 (compulsory), electrical engineering, 5th semester</li> <li>• Bachelor Robotics and Autonomous Systems 2020 (optional subject), Additionally recognized elective module, 5th or 6th semester</li> </ul>		
<b>Classes and lectures:</b>		<b>Workload:</b>
<ul style="list-style-type: none"> <li>• Medical Electrical Engineering Lab Course (practical course, 3 SWS)</li> </ul>		<ul style="list-style-type: none"> <li>• 65 Hours work on project</li> <li>• 45 Hours in-classroom work</li> <li>• 10 Hours oral presentation and discussion (including preparation)</li> </ul>
<b>Contents of teaching:</b>		
<ul style="list-style-type: none"> <li>• Basics of electrical safety with focus on medical devices.</li> <li>• Safety in the lab.</li> <li>• Development, planning, creation and testing of an electrical circuit in the context of medical devices.</li> <li>• Independent realization of a concrete project in a small team.</li> </ul>		
<b>Qualification-goals/Competencies:</b>		
<ul style="list-style-type: none"> <li>• Students can plan, design, specify and realize an electrical circuit.</li> <li>• Students gain experience in the area of project management.</li> <li>• Students know how to deliver and present results in a timely manner.</li> </ul>		
<b>Grading through:</b>		
<ul style="list-style-type: none"> <li>• presentation</li> </ul>		
<b>Requires:</b>		
<ul style="list-style-type: none"> <li>• Fundamentals of Electrical Engineering 2 (ME2700-KP08, ME2700)</li> <li>• Fundamentals of Electrical Engineering 1 (ME2400-KP08, ME2400)</li> </ul>		
<b>Responsible for this module:</b>		
<ul style="list-style-type: none"> <li>• <a href="#">Prof. Dr. Philipp Rostalski</a></li> </ul>		
<b>Teacher:</b>		
<ul style="list-style-type: none"> <li>• <a href="#">Institute for Electrical Engineering in Medicine</a></li> <li>• <a href="#">Prof. Dr. Philipp Rostalski</a></li> </ul>		
<b>Literature:</b>		
<ul style="list-style-type: none"> <li>• U. Tietze, C. Schenk, E. Gamm: Halbleiter-Schaltungstechnik - ISBN 978-3-642-31025-6</li> </ul>		
<b>Language:</b>		
<ul style="list-style-type: none"> <li>• offered only in German</li> </ul>		
<b>Notes:</b>		
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.		

<b>RO5300-KP06 - Humanoid Robotics (HumRob)</b>		
<b>Duration:</b> 1 Semester	<b>Turnus of offer:</b> Currently not available	<b>Credit points:</b> 6
<b>Course of study, specific field and term:</b> <ul style="list-style-type: none"> <li>• Master Biophysics 2019 (optional subject), Elective, 1st or 2nd semester</li> <li>• Bachelor Media Informatics 2020 (optional subject), Robotics and Autonomous Systems, 5th or 6th semester</li> <li>• Bachelor Robotics and Autonomous Systems 2020 (optional subject), Robotics and Autonomous Systems, 5th or 6th semester</li> <li>• Bachelor Medical Informatics 2019 (optional subject), medical computer science, 4th to 6th semester</li> <li>• Bachelor Medical Informatics 2014 (optional subject), Robotics and Autonomous Systems, 5th or 6th semester</li> <li>• Bachelor Media Informatics 2014 (optional subject), Robotics and Autonomous Systems, 5th or 6th semester</li> <li>• Bachelor IT-Security 2016 (optional subject), Robotics and Autonomous Systems, Arbitrary semester</li> <li>• Bachelor Robotics and Autonomous Systems 2016 (optional subject), Robotics and Autonomous Systems, 5th or 6th semester</li> </ul>		
<b>Classes and lectures:</b> <ul style="list-style-type: none"> <li>• Humanoid Robotics (lecture, 2 SWS)</li> <li>• Humanoid Robotics (exercise, 2 SWS)</li> </ul>	<b>Workload:</b> <ul style="list-style-type: none"> <li>• 100 Hours private studies</li> <li>• 60 Hours in-classroom work</li> <li>• 20 Hours exam preparation</li> </ul>	
<b>Contents of teaching:</b> <ul style="list-style-type: none"> <li>• Walking and locomotion</li> <li>• Soft Robotics</li> <li>• Action planning</li> <li>• Processing heterogeneous and uncertain knowledge</li> <li>• Image processing and sensor technology for humanoid robots</li> <li>• Integration of planning and sensor systems</li> <li>• Learning for humanoid robots</li> <li>• Interaction between humans and humanoid robots</li> </ul>		
<b>Qualification-goals/Competencies:</b> <ul style="list-style-type: none"> <li>• The students acquire the ability to solve application-oriented exercises from robotics, with a focus on running (humanoid) robots with a mathematical background, independently and on time in a group.</li> <li>• You have a basic understanding of the kinematic properties of humanoid robots</li> <li>• You understand the complexity and necessity of knowledge processing and sensor data analysis for robotics applications</li> <li>• You have gained insight into learning procedures for planning action sequences of humanoid robots, including dynamic processes</li> <li>• You understand the hazards and risks involved in the interaction of humans and humanoid robots</li> </ul>		
<b>Grading through:</b> <ul style="list-style-type: none"> <li>• Written or oral exam as announced by the examiner</li> </ul>		
<b>Responsible for this module:</b> <ul style="list-style-type: none"> <li>• <a href="#">Prof. Dr.-Ing. Achim Schweikard</a></li> </ul>		
<b>Teacher:</b> <ul style="list-style-type: none"> <li>• <a href="#">Institute for Robotics and Cognitive Systems</a></li> <li>• MitarbeiterInnen des Instituts</li> </ul>		
<b>Literature:</b> <ul style="list-style-type: none"> <li>• Murray, Li and Sastry: A mathematical introduction to robotic manipulation - CRC Press 1994</li> <li>• B. Siciliano, L. Sciavicco: Robotics: Modelling, Planning and Control - Springer 2009</li> <li>• Kevin M. Lynch and Frank C. Park: MODERN ROBOTICS, MECHANICS, PLANNING, AND CONTROL - Cambridge University Press 2017</li> <li>• Bishop: Pattern Recognition and Machine Learning - Springer 2006</li> <li>• Barber: Bayesian Reasoning and Machine Learning - Cambridge University Press 2007</li> </ul>		
<b>Language:</b> <ul style="list-style-type: none"> <li>• offered only in English</li> </ul>		



**Notes:**

Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s):

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

Module Exam(s):

- RO5300-L1: Humanoid Robotics, Form of examination is specified at the beginning of the semester, 100% of the module grade

RO5401 - Seminar Robotics and Navigation (SemRobNav)		
<b>Duration:</b> 1 Semester	<b>Turnus of offer:</b> each semester	<b>Credit points:</b> 4 (Typ B)
<b>Course of study, specific field and term:</b> <ul style="list-style-type: none"> <li>• Bachelor Robotics and Autonomous Systems 2020 (optional subject), Robotics and Autonomous Systems, 5th or 6th semester</li> <li>• Bachelor Robotics and Autonomous Systems 2016 (optional subject), Robotics and Autonomous Systems, 5th or 6th semester</li> </ul>		
<b>Classes and lectures:</b> <ul style="list-style-type: none"> <li>• Seminar Robotics and Navigation (seminar, 2 SWS)</li> </ul>	<b>Workload:</b> <ul style="list-style-type: none"> <li>• 90 Hours work on an individual topic with written and oral presentation</li> <li>• 30 Hours in-classroom work</li> </ul>	
<b>Contents of teaching:</b> <ul style="list-style-type: none"> <li>•</li> <li>•</li> <li>•</li> <li>•</li> </ul>		
<b>Qualification-goals/Competencies:</b> <ul style="list-style-type: none"> <li>•</li> <li>•</li> <li>•</li> <li>•</li> <li>•</li> <li>•</li> </ul>		
<b>Grading through:</b> <ul style="list-style-type: none"> <li>• presentation</li> </ul>		
<b>Responsible for this module:</b> <ul style="list-style-type: none"> <li>• <a href="#">Prof. Dr.-Ing. Achim Schweikard</a></li> </ul> <b>Teacher:</b> <ul style="list-style-type: none"> <li>• <a href="#">Institute for Electrical Engineering in Medicine</a></li> <li>• <a href="#">Institute for Robotics and Cognitive Systems</a></li> <li>• <a href="#">Institute of Computer Engineering</a></li> <li>• <a href="#">Prof. Dr.-Ing. Mladen Berekovic</a></li> <li>• <a href="#">Prof. Dr.-Ing. Achim Schweikard</a></li> <li>• <a href="#">Prof. Dr. Philipp Rostalski</a></li> </ul>		
<b>Language:</b> <ul style="list-style-type: none"> <li>• German and English skills required</li> </ul>		
<b>Notes:</b> <p>Admission requirements for taking the module: - None</p> <p>Admission requirements for participation in module examination(s): - None</p> <p>Module Exam(s): - RO5401-L1: Seminar Robotics and Navigation, Seminar, 100% of module grade.</p>		

**CS3100-KP08, CS3100SJ14 - Signal Processing (SignalV14)**
**Duration:**

1 Semester

**Turnus of offer:**

each winter semester

**Credit points:**

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

<b>CS3501-KP04, CS3501 - Lab Course Robotics and Automation (PraktRob)</b>		
<b>Duration:</b> 1 Semester	<b>Turnus of offer:</b> each winter semester	<b>Credit points:</b> 4 (Typ B)
<b>Course of study, specific field and term:</b> <ul style="list-style-type: none"> <li>• Bachelor Robotics and Autonomous Systems 2020 (compulsory), Robotics and Autonomous Systems, 5th semester</li> <li>• Bachelor Robotics and Autonomous Systems 2016 (compulsory), Robotics and Autonomous Systems, 5th semester</li> <li>• Bachelor Computer Science 2014 (compulsory), specialization field robotics and automation, 5th semester</li> <li>• Bachelor Computer Science 2012 (compulsory), specialization field robotics and automation, 5th semester</li> </ul>		
<b>Classes and lectures:</b> <ul style="list-style-type: none"> <li>• Lab Class Robotics and Automation (practical course, 3 SWS)</li> </ul>	<b>Workload:</b> <ul style="list-style-type: none"> <li>• 45 Hours in-classroom work</li> <li>• 45 Hours group work</li> <li>• 30 Hours private studies</li> </ul>	
<b>Contents of teaching:</b> <ul style="list-style-type: none"> <li>• Combination of robotics and navigation</li> <li>• Introduction to project management</li> <li>• Realization of different robotic tasks in virtual and real environment</li> <li>• Kinematics (direct and inverse)</li> <li>• Implementation in the environments using sensor technology</li> <li>• Human-Robot-Interaction</li> </ul>		
<b>Qualification-goals/Competencies:</b> <ul style="list-style-type: none"> <li>• The students can realize different concepts of robot and navigation system control and of mobile robots in real life systems.</li> <li>• They are able to implement the combination of robotics and navigation for simple tasks.</li> <li>• The students are in a position to do the project planning and realize it in teamwork according to predefined milestones.</li> </ul>		
<b>Grading through:</b> <ul style="list-style-type: none"> <li>• programming project</li> </ul>		
<b>Requires:</b> <ul style="list-style-type: none"> <li>• Robotics (CS2500-KP04, CS2500)</li> </ul>		
<b>Responsible for this module:</b> <ul style="list-style-type: none"> <li>• <a href="#">Prof. Dr.-Ing. Achim Schweikard</a></li> </ul>		
<b>Teacher:</b> <ul style="list-style-type: none"> <li>• <a href="#">Institute for Electrical Engineering in Medicine</a></li> <li>• <a href="#">Institute of Computer Engineering</a></li> <li>• <a href="#">Institute for Robotics and Cognitive Systems</a></li> <li>• <a href="#">Prof. Dr.-Ing. Achim Schweikard</a></li> <li>• <a href="#">Prof. Dr.-Ing. Mladen Berekovic</a></li> <li>• <a href="#">Prof. Dr. Philipp Rostalski</a></li> <li>• <a href="#">Dr.-Ing. Kristian Ehlers</a></li> </ul>		
<b>Literature:</b> <ul style="list-style-type: none"> <li>• Jazar: Theory of applied Robotics: Kinematics, Dynamics and Control</li> <li>• Hertzberg et.al.: Mobile Roboter - Springer 2012</li> <li>• Siegert: Robotik: Programmierung intelligenter Roboter</li> <li>• Siegwart et.al.: Autonomous Mobile Robots - MIT Press, 2011</li> </ul>		
<b>Language:</b> <ul style="list-style-type: none"> <li>• offered only in German</li> </ul>		
<b>Notes:</b>		





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

**ME3100-KP04, ME3100SJ14 - Medical Imaging (MBG14)**
**Duration:**

1 Semester

**Turnus of offer:**

each winter semester

**Credit points:**

4

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

- Bachelor Robotics and Autonomous Systems 2020 (optional subject), Additionally recognized elective module, 5th semester
- Master Auditory Technology 2022 (optional subject), Auditory Technology, 1st semester
- Master Auditory Technology 2017 (optional subject), Auditory Technology, 1st semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), medical image processing, 5th or 6th semester
- Bachelor Medical Informatics 2019 (optional subject), medical computer science, 4th to 6th semester
- Bachelor Medical Informatics 2014 (optional subject), medical computer science, 5th or 6th semester

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam

**Responsible for this module:**

- [Prof. Dr. rer. nat. Martin Koch](#)

**Teacher:**



- [Institute of Medical Engineering](#)
- [Prof. Dr. rer. nat. Martin Koch](#)

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**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

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**Language:**

- German and English skills required

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**Notes:**

Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s):

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

Module Exam(s):

- ME3100-L1: Medical Imaging, written exam, 60min, 100% of the module grade.

<b>RO3100-KP07 - Bachelor Project Robotics and Autonomous Systems (BacProjRAS)</b>		
<b>Duration:</b> 1 Semester	<b>Turnus of offer:</b> each winter semester	<b>Credit points:</b> 7 (Typ B)
<b>Course of study, specific field and term:</b> <ul style="list-style-type: none"> <li>• Bachelor Robotics and Autonomous Systems 2020 (compulsory), Robotics and Autonomous Systems, 5th semester</li> <li>• Bachelor Robotics and Autonomous Systems 2016 (compulsory), Robotics and Autonomous Systems, 5th semester</li> </ul>		
<b>Classes and lectures:</b> <ul style="list-style-type: none"> <li>• Bachelor Project Robotics and Autonomous Systems (practical course, 5 SWS)</li> </ul>	<b>Workload:</b> <ul style="list-style-type: none"> <li>• 120 Hours group work</li> <li>• 45 Hours in-classroom work</li> <li>• 15 Hours written report</li> <li>• 10 Hours oral presentation (including preparation)</li> </ul>	
<b>Contents of teaching:</b> <ul style="list-style-type: none"> <li>• Team-based planning and realization of a complete development project in the domain of robotics and autonomous systems ranging from requirement engineering to installation while observing standards and deadlines.</li> </ul>		
<b>Qualification-goals/Competencies:</b> <ul style="list-style-type: none"> <li>• In discussions with users, the students can gather the requirements for a system solution.</li> <li>• They can analyse complex tasks, structure them into subtasks, and implement them in team work</li> <li>• They can estimate the costs, plan the activities, and allocate the resources meeting the goals of the project</li> <li>• They can integrate components into an overall application while ensuring software quality</li> <li>• They can manage created artefacts, document implementations and present results</li> </ul>		
<b>Grading through:</b> <ul style="list-style-type: none"> <li>• successful addressing of the project goals</li> </ul>		
<b>Responsible for this module:</b> <ul style="list-style-type: none"> <li>• <a href="#">Prof. Dr. Philipp Rostalski</a></li> </ul>		
<b>Teacher:</b> <ul style="list-style-type: none"> <li>• <a href="#">Institute of Computer Engineering</a></li> <li>• <a href="#">Institute for Robotics and Cognitive Systems</a></li> <li>• <a href="#">Institute for Electrical Engineering in Medicine</a></li> <li>• Alle prüfungsberechtigten Dozentinnen/Dozenten des Studienganges</li> </ul>		
<b>Literature:</b> <ul style="list-style-type: none"> <li>• Udo Lindemann: Methodische Entwicklung technischer Produkte: Methoden flexibel und situationsgerecht anwenden (VDI-Buch) - Springer, 2009</li> </ul>		
<b>Language:</b> <ul style="list-style-type: none"> <li>• offered only in German</li> </ul>		
<b>Notes:</b> <p>Admission requirements for taking the module:</p> <ul style="list-style-type: none"> <li>- None</li> </ul> <p>Admission requirements for participation in module examination(s):</p> <ul style="list-style-type: none"> <li>- Successful completion of the internship assignment</li> <li>- Documentation and (possibly interim) presentation as specified when the internship is issued.</li> </ul> <p>Module examination(s):</p> <ul style="list-style-type: none"> <li>- RO3100-L1: Bachelor Project Robotics and Autonomous Systems, internship performance and documentation and presentation, 100% of module grade.</li> </ul>		

**CS3050-KP04, CS3050 - Coding and Security (CodeSich)**
**Duration:**

1 Semester

**Turnus of offer:**

each summer semester

**Credit points:**

4

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- written exam

**Requires:**

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

**Responsible for this module:**

- [Prof. Dr. Rüdiger Reischuk](#)

**Teacher:**

- [Institute for Theoretical Computer Science](#)
- [Prof. Dr. Rüdiger Reischuk](#)
- [Prof. Dr. Maciej Liskiewicz](#)

**Literature:**

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



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

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**Language:**

- German and English skills required

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**Notes:**

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

**CS3140-KP04 - Cloud and Web Technologies (WebTech)**

**Duration:**

1 Semester

**Turnus of offer:**

each summer semester

**Credit points:**

4

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

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

**Grading through:**

- Written or oral exam as announced by the examiner

**Responsible for this module:**

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

**Teacher:**

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

**Literature:**

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

**Language:**

- German and English skills required

**Notes:**



Prerequisites for attending the module:

- None

Prerequisites for the exam:

- Successful completion of homework and project assignments during the semester



**CS3204-KP04, CS3204 - Artificial Intelligence 1 (KI1)**
**Duration:**

1 Semester

**Turnus of offer:**

each summer semester

**Credit points:**

4

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

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

**Classes and lectures:**

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

**Workload:**

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

**Contents of teaching:**

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

**Qualification-goals/Competencies:**

- 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, Portfolio examination, 100% of the module grade

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

**ME3300-KP04, ME3300 - Measurement Technology (MTech)**
**Duration:**

1 Semester

**Turnus of offer:**

each summer semester

**Credit points:**

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

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**Language:**

- German and English skills required

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**Notes:**

currently suspended

<b>RO3990-KP15 - Bachelor Thesis Robotics and Autonomous Systems (BScRAS)</b>		
<b>Duration:</b> 1 Semester	<b>Turnus of offer:</b> each semester	<b>Credit points:</b> 15
<b>Course of study, specific field and term:</b> <ul style="list-style-type: none"> <li>• Bachelor Robotics and Autonomous Systems 2020 (compulsory), Robotics and Autonomous Systems, 6th semester</li> <li>• Bachelor Robotics and Autonomous Systems 2016 (compulsory), Robotics and Autonomous Systems, 6th semester</li> </ul>		
<b>Classes and lectures:</b> <ul style="list-style-type: none"> <li>• Bachelor Thesis Robotics and Autonomous Systems (supervised self studies, 1 SWS)</li> <li>• Colloquium (presentation (incl. preparation), 1 SWS)</li> </ul>		<b>Workload:</b> <ul style="list-style-type: none"> <li>• 360 Hours research for and write up of a thesis</li> <li>• 90 Hours oral presentation and discussion (including preparation)</li> </ul>
<b>Contents of teaching:</b> <ul style="list-style-type: none"> <li>• investigating a given problem in robotics and autonomous systems or application areas and developing a good solution</li> <li>• colloquium to represent the results including a discussion with the referees</li> </ul>		
<b>Qualification-goals/Competencies:</b> <ul style="list-style-type: none"> <li>• Students are able to solve a limited task of a scientific problem with the means of their discipline.</li> <li>• They have the expertise to plan, organize and carry out a project work.</li> <li>• They can present complex information in written and oral form.</li> <li>• They are experts for a clearly defined topic.</li> </ul>		
<b>Grading through:</b> <ul style="list-style-type: none"> <li>• Written report</li> </ul>		
<b>Responsible for this module:</b> <ul style="list-style-type: none"> <li>• Studiengangsleitung Robotik und Autonome Systeme</li> </ul>		
<b>Teacher:</b> <ul style="list-style-type: none"> <li>• <a href="#">Institutes of the Department of Computer Science/ Engineering</a></li> <li>• Alle prüfungsberechtigten Dozentinnen/Dozenten des Studienganges</li> </ul>		
<b>Literature:</b> <ul style="list-style-type: none"> <li>• depends on subject:</li> </ul>		
<b>Language:</b> <ul style="list-style-type: none"> <li>• thesis can be written in German or English</li> </ul>		
<b>Notes:</b> <p>Admission requirements for taking the module: - See study program regulations (e.g. certain minimum CP achieved).</p> <p>Admission requirements for participation in module examination(s): - see study program regulations</p> <p>Module Exam(s): - RO3990-L1: Bachelor Thesis Robotics and Autonomous Systems, final paper, 100% of module grade.</p>		

<b>RO4400-KP08 - Control Systems (RegelSys)</b>		
<b>Duration:</b> 1 Semester	<b>Turnus of offer:</b> every summer semester	<b>Credit points:</b> 8
<b>Course of study, specific field and term:</b>		
<ul style="list-style-type: none"> <li>• Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester</li> <li>• Bachelor Robotics and Autonomous Systems 2020 (compulsory), Robotics and Autonomous Systems, 6th semester</li> <li>• Bachelor Robotics and Autonomous Systems 2016 (compulsory), Robotics and Autonomous Systems, 6th semester</li> </ul>		
<b>Classes and lectures:</b>		<b>Workload:</b>
<ul style="list-style-type: none"> <li>• Control Systems (lecture, 2 SWS)</li> <li>• Advanced Methods in Control (lecture, 2 SWS)</li> <li>• Control Systems (exercise, 1 SWS)</li> <li>• Advanced Methods in Control (exercise, 1 SWS)</li> </ul>		<ul style="list-style-type: none"> <li>• 110 Hours private studies</li> <li>• 90 Hours in-classroom work</li> <li>• 40 Hours exam preparation</li> </ul>
<b>Contents of teaching:</b>		
<ul style="list-style-type: none"> <li>• Modeling of dynamic systems</li> <li>• Dynamic behavior of systems</li> <li>• Feedback concepts</li> <li>• Controller design in time domain</li> <li>• System representation in frequency domain</li> <li>• Stability</li> <li>• Controller design in frequency domain</li> <li>• State space models, canonical representations and properties</li> <li>• Design of state feedback controllers and state observers</li> <li>• Optimal control and state estimation</li> <li>• Linear parameter-varying systems</li> <li>• Model predictive control</li> </ul>		
<b>Qualification-goals/Competencies:</b>		
<ul style="list-style-type: none"> <li>• Students can model physical systems mathematically as well as describe and analyze their dynamic behavior.</li> <li>• Students know the fundamental tools and can formulate requirements with respect to systems in the time and frequency domain. Students are able to design control loops using time and frequency domain-based tools.</li> <li>• Students are able to analyze stability of feedback systems and can evaluate the resulting dynamic properties with respect to control performance and robustness.</li> <li>• Students know how to describe and analyze state space models.</li> <li>• Students know how to synthesize and design state feedback controllers.</li> <li>• Students know how to design observers and observer-based controllers.</li> <li>• Students know the basics about optimal control and how to utilize it.</li> <li>• Students know the class of linear, parameter-varying systems and the basic principles of controller synthesis for this class of systems.</li> <li>• Students understand the concept of model-predictive control and know how to implement such a control strategy.</li> </ul>		
<b>Grading through:</b>		
<ul style="list-style-type: none"> <li>• written exam</li> </ul>		
<b>Responsible for this module:</b>		
<ul style="list-style-type: none"> <li>• <a href="#">Prof. Dr. Philipp Rostalski</a></li> </ul>		
<b>Teacher:</b>		
<ul style="list-style-type: none"> <li>• <a href="#">Institute for Electrical Engineering in Medicine</a></li> <li>• <a href="#">Prof. Dr. Philipp Rostalski</a></li> <li>• <a href="#">Prof. Dr.-Ing. Christian Herzog</a></li> </ul>		
<b>Literature:</b>		
<ul style="list-style-type: none"> <li>• as described for the module parts:</li> </ul>		
<b>Language:</b>		



- German and English skills required

**Notes:**

This module replaces ME2450-KP08

Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s):

- None

Module Exam(s):

- RO4400-L1: Control Systems, written exam, 90min, 100% of module grade.

**CS2101-KP04, CS2101 - Embedded Systems (ES)**
**Duration:**

1 Semester

**Turnus of offer:**

each summer semester

**Credit points:**

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.)
- Conceptual 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