# Mechatronics

Bachelor of Engineering

# Module Manual

Study and examination regulations (PO) 01

Valid from: SoSe25

# Basic studies

Mechatronics 1: Basics
Electronics 1: Basics
Computer Science 1: Basics and Programming
Mechanics 1: CAD and Technical Drawing
Maths1: Analysis 1
Maths2: Linear Algebra
Mechatronics 2: Metrology
Electronics 2: Analog Circuits
Computer Science 2: Object Oriented Programming
Mechanics 2: Statics and Mechanics of Materials
Maths3: Analysis 2
Sciences 1: Fundamentals of Physics
Mechatronics 3: Sensors and Control
Electronics 3: Digital Circuits
Computer Science 3: Application Programming
Mechanics 3: Kinetics and Engineering Design
Maths4: Numerical Analysis
Sciences 2: Electrodynamics

# Main studies

Mechatronics 4: Electric Drives
Mechatronics 5: Modeling and Simulation
Sustainability 1: Energy
Sciences 3: Materials
Mechatronics 6: Microcontroller
Mechatronics 7: Scientific Project
Mechatronics 8: Robotics
Deutsch als Fremdsprache B2 für nicht deutschsprachige Studierende
Practical Semester
Elective 1
Elective 2
Sustainability 2
Bachelor Thesis
Production Mechatronics 1: Digital Production and Industry 4.0
Production Mechatronics 2: Introduction Production Technologies
Production Mechatronics 3: Advanced Production Technologies
Automation 1: Digital Production and Industry 4.0
Automation 2: Control Systems
Automation 3: Human-Machine-Interface Design
Smart Sensors 1: Sensors Overview
Smart Sensors 2: Data Analytics & Statistics
Smart Sensors 3: Digital Twins
Mobility 1: Automotive Engineering
Mobility 2: Mobility Laboratory
Mobility 3: High Voltage Vehicles
Energy Mechatronics 1: Energy and Process Technology
Energy Mechatronics 2: Energy technology lab course
Energy Mechatronics 3: Renewable Energy and Energy Storage
Photonics 1: Engineering Optics
Photonics 2: Machine Vision

## Program Objectives

The Bachelor of Engineering in Mechatronics is an interdisciplinary degree program that combines the fields of mechanical engineering, electrical engineering, computer science and natural sciences. The main objective is. To enable students to understand and develop complex mechatronic systems in their entirety.

The course offers individual specialization options that are oriented towards current job profiles in the various industries. These include Automotive industry, aerospace engineering, information and communication technology, medical technology, automation technology, mechanical engineering, robotics, drive technology, automation technology, energy and environmental technology. The following job profiles are to be covered by a range of elective courses in the degree program: Automation engineer, production engineer, design engineer, product developer engineer in drive technology, quality manager, technical project manager, production planner, engineer for purchasing and sales of mechatronic systems, etc.

Sustainability is an integral part of the degree program and is firmly anchored in the modules. Students are encouraged to consider sustainable aspects in their final thesis and to integrate sustainable principles into their mechatronic developments in order to minimize both environmental and social impacts. In addition, hot topics with links to sustainability are specifically integrated into courses.

Another important part of the course, especially for international students, is the practical semester, which on the one hand enables the close integration of theory and practice and on the other hand promotes the integration of future graduates into the German working world. During the practical semester, students work in a company and apply their theoretical knowledge in practice. They are accompanied and supported by a supervisor at the university and a supervisor in the company. The aim is for students to learn how to apply their theoretical knowledge to specific problems in practice.

## Connection of the modules

The modules in the foundation course focus primarily on knowledge and understanding. The focus is on teaching a broad methodological basis (including mathematics, physics, mechanical engineering, electrical engineering and computer science) for scientific engineering work. Theory is usually taught in traditional teaching formats with accompanying exercises, which are supplemented by practicals and tutorials.

In the main course, the focus shifts to the application and generation of knowledge, communication and cooperation as well as professionalism. By learning different methods from the field of engineering (e.g. simulation, control engineering, sensor technology, robotics), students learn how to apply the fundamentals in practical applications. Individual modules, especially those with a methodological focus on student interaction through project work and presentations, also promote personal development and the development of social skills. Additional elective modules and an elective project are available to students to deepen and round off their own professional and personal profile.

The content is taught by lecturers from a wide range of RWU subjects from a total of three faculties and is closely coordinated.

English is used as the language of instruction in the undergraduate and graduate courses of Mechatronics.

The above points illustrate the orientation of the Bachelor's degree program in Mechatronics with regard to teaching and research, practice, interdisciplinary cooperation and internationality. With this education, future graduates will be able to meet the increasing challenges of ever more complex mechatronic systems and open up new potential for synergies and creative solutions.

# Implementation of RWU mission statement

| SEM. | MODULE OVERVIEW | | | | | | ECTS |
|---|---|---|---|---|---|---|---|
| 1 | Maths 1: Analysis 1 5 | Maths 2: Linear Algebra 5 | Mechanics 1: CAD and Technical Drawing 5 | Computer Science 1: Basics and Programming 5 | Electronics 1: Electrical Eng. + Lab 5 | Mechatronics 1: Basics 5 | **30** |
| 2 | Maths 3: Analysis 2 5 | Science 1: Fundamental of Physics 5 | Mechanics 2: Statics and Mechanics of Materials 5 | Computer Science 2: Object Oriented Programming 5 | Electronics 2: Analog Circuits + Lab 5 | Mechatronics 2: Metrology + Lab 5 | **30** |
| 3 | Maths 4: Numerical Analysis 5 | Science 2: Electrodynamics 5 | Mechanics 3: Kinetics and Engineering Design 5 | Computer Science 3: Application Programming 5 | Electronics 3: Digital Circuits + Lab 5 | Mechatronics 3: Sensors and Control 5 | **30** |
| 4 | Specialization Module 1 5 | Specialization Module 2 5 | Science 3: Materials 5 | Sustainability 1: Energy 5 | Mechatronics 4: Electric Drives 5 | Mechatronics 5: Modeling and Simulation 5 | **30** |
| 5 | Specialization Module 3 5 | Specialization Module 4 5 | German B2 5 | Scientific Project 5 | Mechatronics 6: Microcontroller 5 | Mechatronics 7: Robotics 5 | **30** |
| 6 | Company Internship 30 | | | | | | **30** |
| 7 | Bachelor Thesis 15 | | | Elective 1 5 | Elective 2 5 | Sustainability 2 5 | **30** |

Lecture subjects  Projects and internship  Thesis

# Mechatronics 1: Basics

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 01 |
| Modul title: | Mechatronics 1: Basics |
| Module responsible: | Prof. Dr.-Ing. Andreas Haag |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Basic studies |
| Module Content: | Module contents:<br>- Structure of mechatronic systems: sensors, signals, control, actuators<br>- Development process of mechatronic systems<br>- Systems & borders: flows of material, energy, information<br>- Control & regulation with examples<br>- System modelling with examples<br>- Basic system behavior: Proportional, Integrational, Derivative, and combinations |
| Courses: | Mechatronic Basics |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | None |
| Applicability of the module: | Subsequent modules with focus on mechatronics |
| Prerequisites allocation ECTS: | K60 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | 150h; ca. 50h lectures, ca. 100 self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Summer semester only |
| Literature: | Clarence W. de Silva , "Mechatronics: A Foundation Course"<br>Godfrey C. Onwubolu , "Mechatronics: Principles and Applications" |
| Compulsory attendance: | no |

# Competence dimensions Mechatronics 1: Basics

## Knowledge and understanding: Broadening of prior knowledge

Graduates can explain the development process of mechatronic products as well as the main components. They are able to define systems and system borders and to determine the crossing flows. Graduates know the basic principles of system behaviour as well as control theory.

## Use, application and generation of knowledge/art: Use and transfer

Graduates are able to divide systems into structural components. They can prepare schedules of development actions for mechatronic components and are able to create basic models of the system's behaviour and determine appropriate control structures.

## Communication and cooperation

The students discuss justifiable solutions to problems with the lecturer in a subject-related manner. They are able to work on complex systems in groups.

## Scientific / artistic self-image and professionalism

# Electronics 1: Basics

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 02 |
| Modul title: | Electronics 1: Basics |
| Module responsible: | Prof. Dr.-Ing. Samuel Vogel |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Basic studies |
| Module Content: | Lecture:<br>1. Current, voltage, power<br>2. Ideal and real voltage and current sources<br>3. Ideal and real measuring of voltages and currents<br>4. Electric safety and grounding<br>5. (Specific) resistance and networks of resistors<br>6. Solving electric networks: superposition theorem, Kirchoff laws<br><br>Laboratory:<br>1. Resistor Networks I: Calculate and measure resistances<br>2. Resistor Networks II: Calculate and measure voltages and currents<br>3. Oscilloscope I: Introduction oscilloscope and function generator<br>4. EAGLE I: Introduction and modeling simple circuits with EAGLE<br>5. Soldering I: Introduction, soldering exercises and soldering analog Korsel |
| Courses: | Lecture with Exercise: Linear Network Analysis<br>Laboratory: BET1 |
| Teaching and learning forms: | Lectures with exercises and laboratory<br>Language: English. |
| Prerequisites for participation: | Good knowledge of school mathematics |
| Applicability of the module: | Subsequent modules with focus on mechatronics |
| Prerequisites allocation ECTS: | PF (Lecture: K60 + Lab Reports) |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures and lab, ca. 100h self-study (lecture preparation, home work exercises, laboratory report writing, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | |

| | |
|---|---|
| Literature: | P. Scherz, S. Monk: Practical Electronics for Inventors<br>P. Horowitz, W. Hill: The Art of Electronics |
| Compulsory attendance: | no |

# Competence dimensions Electronics 1: Basics

## Knowledge and understanding: Broadening of prior knowledge

Graduates understand and are able to explain the basic principles of linear electric networks. Graduates will be able to understand and explain the differences between ideal and real components and the concept of equivalent circuits.

## Use, application and generation of knowledge/art: Use and transfer

Graduates are able to dimension and solve electric resistor networks. Graduates will be able to build and measure the linear network in the laboratory scale and explain the behavior.

## Communication and cooperation

Graduates learn to build simple electronic circuits in small teams. They are able to communicate in professional language with the appropriate technical vocabulary.

## Scientific / artistic self-image and professionalism

Graduates are taught a mechatronics-based approach to electrical engineering. Applications in the professional field of mechatronics are particularly emphasized, thus clarifying the job profile of the mechatronics engineer.

# Computer Science 1: Basics and Programming

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 03 |
| Modul title: | Computer Science 1: Basics and Programming |
| Module responsible: | Prof. Dr. Jörg Eberhardt |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Basic studies |
| Module Content: | This module is divided into 2 parts. A lecture part with practical exercises with focus on Computer Science and a practical part with focus on the introduction to programming.<br><br>1. Computer Science Basics<br>- Hardware and Computer Architectures<br>- Binary numbers<br>- Operating Systems<br>- Networks<br><br>2. Basics of programming with Python<br>- Basic concepts of programming<br>- Syntactic structure of the Python language<br>- Case distinctions<br>- Iterations<br>- Strings and lists<br>- functions<br>- files<br>- 2D Plots with Python |
| Courses: | Computer Science Basics<br>Programming 1: Basics |
| Teaching and learning forms: | Lectures with exercises and practical training |
| Prerequisites for participation: | None |
| Applicability of the module: | Subsequent modules with focus on computer science and programming |
| Prerequisites allocation ECTS: | K60 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |

| | |
|---|---|
| Duration of the module: | one semester |
| Frequency of offering: | Summer semester only |
| Literature: | Connor P. Milliken: Python Projects for Beginners, A Ten-Week Bootcamp approach to Python Programming |
| Compulsory attendance: | no |

# Competence dimensions Computer Science 1: Basics and Programming

## Knowledge and understanding: Broadening of prior knowledge

Graduates will be able to describe the structure of PCs, the hardware used, operating systems and networks. Graduates are able to describe basic binary number representations and the structures and components of operating systems and networks.

## Use, application and generation of knowledge/art: Use and transfer

Graduates apply basic knowledge of the structure of IT hardware and use it, for example, to independently plan a network.

## Communication and cooperation

Graduates can, among other things, present the coarse planning of a network in a communicative way and show it in a group in an argumentative way.

## Scientific / artistic self-image and professionalism

Graduates know the importance of IT systems for their field of activity and are familiar with the development of recent years. At the same time, they are able to assess the change and importance of these systems for the future.

# Mechanics 1: CAD and Technical Drawing

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 04 |
| Modul title: | Mechanics 1: CAD and Technical Drawing |
| Module responsible: | Prof. Dr.-Ing. hab. Ralf Stetter |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Basic studies |
| Module Content: | - 3D solid modeling in a current CAD system;<br>- Drawing creation in a current CAD system;<br>- General drawing specifications:<br>- views and sections,<br>- axonometric projections,<br>- dimension entry,<br>- thread representation,<br>- Geometric Product Specification (GPS),<br>- tolerances and fits,<br>- shape and position tolerances,<br>- weld seam representation and designation,<br>- technical surfaces<br>- representation of machine elements / standard parts |
| Courses: | 10208 Technical Drawing and CAD |
| Teaching and learning forms: | Lectures with exercises and laboratory |
| Prerequisites for participation: | none |
| Applicability of the module: | Subsequent modules with focus on mechatronics and mechanics |
| Prerequisites allocation ECTS: | PF (Combination of final CAD audit, three technical drawing audits and two technical drawing questionnaires) |
| ECTS credits: | 5 |
| Grading: | not graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |

| | |
|---|---|
| Literature: | Wittel, Muhs, Jannasch, Voßiek: Roloff/Matek Maschinenelemente. Springer Vieweg.<br>Hoischen (Technisches Zeichnen: Grundlagen, Normen, Beispiele, Darstellende Geometrie, Geometrische Produktspezifikation) Verlag Cornelen.<br>Wyndorps, P.: 3D-Konstruktion mit Creo Parametric. Europa Lehrmittel |
| Compulsory attendance: | no |

# Competence dimensions Mechanics 1: CAD and Technical Drawing

## Knowledge and understanding: Broadening of prior knowledge

Graduates can explain complex technical drawings in detail.

## Use, application and generation of knowledge/art: Use and transfer

Graduates can produce sketches and create technical drawings with extensive tolerance and surface specifications. They can solve basic tasks in descriptive geometry.

## Communication and cooperation

Participants will be able to create 3D solid models and technical drawings in CAD. The participants can successfully design selected machine elements in hand drawings and CAD designs and perform and finally present production-relevant drawing derivations.

## Scientific / artistic self-image and professionalism

Graduates become aware of the importance of mathematical skills for their professional field of activity.

# Maths1: Analysis 1

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|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 05 |
| Modul title: | Maths1: Analysis 1 |
| Module responsible: | Prof. Dr. rer. nat. Stefan Elser |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Basic studies |
| Module Content: | 1. Fundamentals: Introduction of sets, Cartesian products, relations, and functions.<br>2. Numbers and the principle of induction: Introduction of natural numbers, integers, rational numbers, real numbers, and complex numbers. Proof by induction.<br>3. Sequences and series: Convergence criterions. Introduction of sine-, cosine-, and exponential function as a series.<br>4. Functions: Continuous functions, polynomials, trigonometric functions.<br>5. Differential calculus: Product-, quotient- and chain-rule. Extrema and their criterions. Taylor Polynomials.<br>6. Integral Calculus: Riemann-integral, fundamental theorem of calculus, partial fraction decomposition, numerical integration |
| Courses: | 288 Analysis 1 with exercises |
| Teaching and learning forms: | Lectures with exercises<br>Language: English |
| Prerequisites for participation: | Good knowledge of secondary school mathematics |
| Applicability of the module: | Subsequent modules with focus on mathematics and physics |
| Prerequisites allocation ECTS: | K90 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Summer semester only |
| Literature: | Omar Hijab: "Introduction to Calculus and Classical Analysis", Springer<br>Sterling K.Berberian: "A First Course in Real Analysis", Springer<br>Peter Hartmann: "Mathematik für Informatiker", Vieweg und Teubner<br>Lothar Papula: "Mathematik für Ingenieure und Naturwissenschaftler Band 1", Springer |
| Compulsory attendance: | no |

# Competence dimensions Maths1: Analysis 1

## Knowledge and understanding: Broadening of prior knowledge

Students have an insight of the principle workings of the following:

Number systems, sequences, series, real-valued functions, continuity, basic differential and basic integral calculus

## Use, application and generation of knowledge/art: Use and transfer

Students can apply the following:

Abstract description of simple problems, basic principles to work in the topics above.

## Communication and cooperation

Graduates are able to describe problem in other technical fields using correct mathematical notation. These formulas can be used to deduce own solutions and communicate these solutions or algorithms.

Graduates are able to understand mathematical solutions provided by others.

## Scientific / artistic self-image and professionalism

Graduates are aware of the necessity of proper mathematical notation to solve technical problems. Graduates use mathematics to solve purposeful technical problems.

# Maths2: Linear Algebra

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 06 |
| Modul title: | Maths2: Linear Algebra |
| Module responsible: | Prof. Dr. rer. nat. Stefan Elser |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Basic studies |
| Module Content: | 1. Fundamentals: Introduction of sets, Cartesian products, relations, and functions.<br>2. Vector spaces: Real value vector spaces, groups, fields, vector spaces over any field, bases, dimension, coordinate representation, inner<br>product, and norm.<br>3. Systems of linear equations: Matrix representation, solution sets, Gaussian elimination, applications.<br>4. Linear functions: Linear functions and matrices, Gauss-Jordan algorithm, determinants, eigenvalues, and eigenvectors, change of basis,<br>diagonalizable matrices. |
| Courses: | 3000 Linear Algebra with exercises |
| Teaching and learning forms: | Lectures with exercises<br>Language: English |
| Prerequisites for participation: | Good knowledge of secondary school mathematics |
| Applicability of the module: | Subsequent modules with focus on mathematics and mechatronics |
| Prerequisites allocation ECTS: | K90 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Summer semester only |
| Literature: | David Poole: "Linear Algebra: A Modern Introduction", Cengage Learning<br>Peter Hartmann: "Mathematik für Informatiker", Hartmann, Springer Vieweg<br>Lothar Papula: "Mathematik für Ingenieure und Naturwissenschaftler", Band 1 - 2 |
| Compulsory attendance: | no |

# Competence dimensions Maths2: Linear Algebra

## Knowledge and understanding: Broadening of prior knowledge

Students have an insight of the principle workings of the following:

Number systems, vector spaces, systems of linear equations, solutions sets, linear functions as matrices.

## Use, application and generation of knowledge/art: Use and transfer

Students can apply the following:

Abstract description of simple problems, basic principles to work in the topics above.

## Communication and cooperation

Graduates are able to describe problem in other technical fields using correct mathematical notation. These formulas can be used to deduce own solutions and communicate these solutions or algorithms.

Graduates are able to understand mathematical solutions provided by others.

## Scientific / artistic self-image and professionalism

Graduates are aware of the necessity of proper mathematical notation to solve technical problems. Graduates use mathematics to solve purposeful technical problems.

# Mechatronics 2: Metrology

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 07 |
| Modul title: | Mechatronics 2: Metrology |
| Module responsible: | Prof. Dr. rer. nat. Martin Störzer |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Basic studies |
| Module Content: | Lecture:<br>Unit Systems and SI Units<br>The measurement process and calibration chain<br>Measuring electrical quantities: Voltage, Current, Resistance<br>Volt and Amperemeters with range extension<br>Resistance Measurement: Two and Four Wire Measurements<br>Measuring AC Voltage and Current<br>First and Second Order systems<br>Rectification<br>AD Conversion<br><br>Laboratory:<br>2 Experiments, 6h duration each:<br>1.1 Oscilloscope: Basic Handling and Measurement routine<br>1.2 Function Generator: Operation and Limits<br>2.1 Measuring High-, Low- and Band Pass Filters<br>2.2 Simulation of Filters and their measurements |
| Courses: | 2117 Metrology 1<br>2121 Metrology Lab |
| Teaching and learning forms: | Lecture, Laboratory (Presence required), Online Simulation with self-assessment |
| Prerequisites for participation: | Electrical Engineering 1: Basics |
| Applicability of the module: | Subsequent modules with focus on mechatronics, electronics and sensors |
| Prerequisites allocation ECTS: | K90 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |

| | |
|---|---|
| Frequency of offering: | Every semester |
| Literature: | Lerch, R.: Elektrische Messtechnik<br>Mühl, T.: Einführung in die elektrische Messtechnik<br>Schrüfer, E.: Elektrische Messtechnik: Messung elektrischer und nichtelektrischer Größen<br>Morris, A.: Measurement & Instrumentation Principles |
| Compulsory attendance: | no |

# Competence dimensions Mechatronics 2: Metrology

## Knowledge and understanding: Broadening of prior knowledge

Graduates know the (base) units and can justify the necessity of a calibration chain.
Graduates are aware of the importance of specifying deviations and tolerances for a measurement result; if the measured variable is derived from other measured variables, they can calculate the propagation of the measurement deviation.
Graduates know the most important electrical measuring instruments (digital multimeter and oscilloscope) and can operate them safely by participating in laboratory sessions.
Graduates will be able to calculate, simulate and practically set up and measure simple filter circuits (RC and RL filters).

## Use, application and generation of knowledge/art: Use and transfer

Graduates apply the contents learned to check the specification of electrical devices and detect errors. Graduates are able to analyze measurement results and distinguish relevant measurement points from irrelevant measurement points and assess the quality of measuring devices and measurement results. They can, in the environment of a company, set up an adapted laboratory/test field workstation.

## Communication and cooperation

Graduates are able to apply the learned content directly in the laboratory and use and discuss their knowledge in the group/team.

## Scientific / artistic self-image and professionalism

Graduates are able to design sustainable metrology solutions. The importance of a sustainable economy is recognized.

# Electronics 2: Analog Circuits

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|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 08 |
| Modul title: | Electronics 2: Analog Circuits |
| Module responsible: | Prof. Dr.-Ing. Samuel Vogel |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Basic studies |
| Module Content: | Lecture:<br>1. Capacitors and inductors<br>2. Switching on and off circuits with capacitors and inductors<br>3. Solving AC circuits using complex numbers (phase, amplitude, power)<br>4. Passive filter circuits<br>5. Operational Amplifiers<br>Lab:<br>1. Operational amplifier and transistor circuits<br>2. LTspice I: Introduction to circuit simulation (high pass, low pass)<br>3. Oscilloscope II: Building and measuring high pass and low pass<br>4. EAGLE II: Advanced circuit design<br>5. Soldering II: Soldering Arduino Nano breakout and Korsel |
| Courses: | Lecture with Exercise: Analog Circuits<br>Laboratory: BET2 |
| Teaching and learning forms: | Lectures with exercises and laboratory |
| Prerequisites for participation: | Module Electronics 1: Basics |
| Applicability of the module: | Subsequent modules with focus on mechatronics and electronics |
| Prerequisites allocation ECTS: | PF (Lecture: K60 + Lab Reports) |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures and lab, ca. 100h self-study (lecture preparation, home work exercises, laboratory report writing, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | P. Scherz, S. Monk: Practical Electronics for Inventors<br>P. Horowitz, W. Hill: The Art of Electronics |

| | |
|---|---|
| Compulsory attendance: | no |

# Competence dimensions Electronics 2: Analog Circuits

## Knowledge and understanding: Broadening of prior knowledge

Graduates understand and are able to explain the function of inductors and capacitors in AC and DC circuits. Graduates are able to explain the behavior of inductors and transistors when switched on/off and under AC conditions.

## Use, application and generation of knowledge/art: Use and transfer

Graduates are able to dimension solve linear electric networks consisting of resistors, inductors and capacitors. Graduates are able to build and measure linear networks including capacitors and inductors in the laboratory scale and explain the behavior.

## Communication and cooperation

Graduates learn to build simple electronic circuits with linear components (resistors, capacitors, inductors) in small teams. They are able to communicate in professional language with the appropriate technical vocabulary.

## Scientific / artistic self-image and professionalism

Graduates are taught a mechatronics-based approach to electrical engineering. Applications in the professional field of mechatronics are particularly emphasized, thus clarifying the job profile of the mechatronics engineer.

# Computer Science 2: Object Oriented Programming

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 09 |
| Modul title: | Computer Science 2: Object Oriented Programming |
| Module responsible: | Prof. Dr.-Ing. Markus Till |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Basic studies |
| Module Content: | This module introduces the basic concepts of object-oriented programming. Lecture and practical exercises merge seamlessly.<br>The concepts are explained using examples and best practices.<br>Contents:<br>1. Basic concepts of OOP: classes, objects, inheritance, data encapsulation.<br>2. Creation and use of classes and objects and their visualization (e.g. using the UML notation).<br>3. Understanding and applying class inheritance.<br>4. Error and exception handling<br>5. Data encapsulation<br>6. Examples and best practices |
| Courses: | Object Oriented Programming |
| Teaching and learning forms: | Lectures and practical exercises |
| Prerequisites for participation: | Computer Science 1 |
| Applicability of the module: | Subsequent modules with focus on computer science, programming and mechatronics |
| Prerequisites allocation ECTS: | RPA |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Winter semester only |
| Literature: | Python Crash Course, 2nd Edition: A Hands-On, Project-Based Introduction to Programming, Eric Matthes (Author)<br>Python 3 Object Oriented Programming (English Edition), Dusty Phillips (Author) |
| Compulsory attendance: | no |

# Competence dimensions Computer Science 2: Object Oriented Programming

## Knowledge and understanding: Broadening of prior knowledge

Graduates have an insight of object-oriented programming with Python, including topics like class definition, inheritance, and more. Graduates will gain a comprehensive understanding of OOP principles enabling them to design and build OOP-based software.

## Use, application and generation of knowledge/art: Use and transfer

Graduates gain practical skills in applying OOP concepts to design and implement Python programs, including creating reusable classes, utilizing inheritance and demonstrating proficiency in error handling for building robust software solutions. The focus is on real-world problem-solving and developing maintainable code using OOP principles in Python.

## Communication and cooperation

Graduates can, among other things, present graphical representations of class diagrams in a group and explain the underlying concepts.

## Scientific / artistic self-image and professionalism

Graduates understand the importance of object-oriented programming and are familiar with the development of recent years.

# Mechanics 2: Statics and Mechanics of Materials

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 10 |
| Modul title: | Mechanics 2: Statics and Mechanics of Materials |
| Module responsible: | Prof. Dr. Michael Winkler |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Basic studies |
| Module Content: | Statics: - Introduction; Basic concepts; Systems of forces; Systems of rigid bodies; Center of forces and centroids; Stress resultants<br><br>Mechanics of Materials: - Fundamentals of Mechanics of Materials; Tension and compression; Bending; Transverse shear; Torsion; Stress state, combination of loadings and strain state; Buckling |
| Courses: | 10524 Statics and Mechanics of Materials |
| Teaching and learning forms: | V+Ü (with several supporting e-learning-materials) |
| Prerequisites for participation: | Mathematik 1 und 2 (EUT); Analysis 1 (IPE); Maths 1 and Maths 2 (Mechatronics) |
| Applicability of the module: | Subsequent modules with focus on mechatronics and science |
| Prerequisites allocation ECTS: | Portfolio (PF) with 10% online tests and 90% exam (90 minutes) |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | 45h presence, 105h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Winter semester only |
| Literature: | - Gross, D.; Hauger, W.; Schröder, J.; Wall, W.A.; Rajapakse, N.: Engineering Mechanics 1 Statics; Springer; 2013.<br>- Gross, D.; Hauger, W.; Schröder, J.; Wall, W.A.; Bonet, J.: Engineering Mechanics 2 Mechanics of Materials; Springer; 2018.<br>- Gross, D.; Ehlers, W.; Wriggers, P.; Schröder, J.; Müller, R.: Statics Formulas and Problems. Springer; 2017.<br>- Gross, D.; Ehlers, W.; Wriggers, P.; Schröder, J.; Müller, R.: Mechanics of Materials Formulas and Problems. Springer; 2017.<br>- Mittelstedt, C.: Engineering Mechanics 2; Strength of Materials - An introduction with many examples; Springer Vieweg; 2023. |
| Compulsory attendance: | no |

# Competence dimensions Mechanics 2: Statics and Mechanics of Materials

## Knowledge and understanding: Broadening of prior knowledge

The graduates can describe the basic principles of statics and the basic equations of mechanics of materials (kinematical relations, Hooke's law, equilibrium).
The graduates can explain the different types of loading and the according theoretical approaches.

## Use, application and generation of knowledge/art: Use and transfer

Graduates can draw free-body diagrams and use these in order to calculate support reactions and calculate centroids and stress resultants (internal forces and moments).
Graduates can use the theoretical approaches for the different types of loading in order to calculate stresses and deformations.
They can determine the load-bearing capacity of a structure and dimension parts.

## Communication and cooperation

Graduates can solve mechanical problems in the fields of statics and mechanics of materials on their own. Especially, they can adequately justify the procedure for the solution. The acquirement of the communication competence is supported by solving problems.

## Scientific / artistic self-image and professionalism

Graduates acquire a high degree of professional working by conducting analytical calculations. Especially, the conscientious and correct execution is of high importance.
Such precise working is also important in an industrial environment. They acquire the capability to manage the learning process on their own (time planning, self-study).
This is an important competence for the job.

# Maths3: Analysis 2

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 11 |
| Modul title: | Maths3: Analysis 2 |
| Module responsible: | Prof. Dr. rer. nat. Martin Smaga |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Basic studies |
| Module Content: | -Multivariable Functions<br>-Differential Calculus with Multivariable Functions<br>-Integral Calculus with Multivariable Functions<br>-Ordinary Differential Equations |
| Courses: | 10243 Analysis 2 |
| Teaching and learning forms: | Lectures with exercises<br>Language: Englisch. |
| Prerequisites for participation: | Analysis 1 and Linear Algebra |
| Applicability of the module: | Subsequent modules with focus on mathematics, sensors and mechatronics |
| Prerequisites allocation ECTS: | K90 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | Apostol, T.: Calculus Vol. 2, John Wiley & Sons (1969)<br>Meyberg, K., Vachenauer, P.: Höhere Mathematik 1, Springer (2001)<br>Meyberg, K., Vachenauer, P.: Höhere Mathematik 2, Springer (2001)<br>Strang, G.: Calculus, Wellesley-Cambridge Press (2017) |
| Compulsory attendance: | no |

# Competence dimensions Maths3: Analysis 2

## Knowledge and understanding: Broadening of prior knowledge

Graduates will be able to reproduce the basic mathematical principles that belong to the topics mentioned in the contents.

## Use, application and generation of knowledge/art: Use and transfer

Graduates are able to apply the methods of analysis they have learned. They can solve problems from differential and integral calculus of several variables, as well as vector analysis. They can calculate solution functions of the treated classes of differential equations.

## Communication and cooperation

Graduates learn to present their own problem-solving processes in small groups. They learn to argue and convey knowledge to other participants.

## Scientific / artistic self-image and professionalism

Graduates become aware of the importance of mathematical skills for their professional field.

# Sciences 1: Fundamentals of Physics

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 12 |
| Modul title: | Sciences 1: Fundamentals of Physics |
| Module responsible: | Prof. Dr. rer. nat. Jan Schlemmer |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Basic studies |
| Module Content: | 1. Introduction: Tasks of (natural) science, division into subfields, physical quantities<br>2.Coordinate systems, kinematics of point mass, reference frames<br>3.Dynamics of point mass, force and momentum<br>4.Energy, energy conservation, friction<br>5.Momentum conservation and collision processes<br>6.Oscillations (free and forced)<br>7.Temperature and heat, heat capacity, first law of thermodynamics<br>8.Heat engines, thermodynamic cycles, second law of thermodynamics<br>9.Carnot cycle and efficiency<br>10. Non-reversibility and generation of entropy |
| Courses: | Fundamental of Physics |
| Teaching and learning forms: | Lectures (including experiments) with exercises. |
| Prerequisites for participation: | Good knowledge of school mathematics |
| Applicability of the module: | Subsequent modules with focus on mechatronics and physics |
| Prerequisites allocation ECTS: | K90 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | Demtröder: „Mechanics and Thermodynamics"<br>Tipler/Mosca: „Physics for scientists and engineers : with modern physics"<br>Halliday/Resnick: Fundamentals of Physics |
| Compulsory attendance: | no |

# Competence dimensions Sciences 1: Fundamentals of Physics

## Knowledge and understanding: Broadening of prior knowledge

Graduates have expanded their knowledge in the following areas and are able to reproduce this knowledge: Description of the kinematics of mass points, basic equations of dynamics, conservation variables, concept of temperature and heat, main laws of thermodynamics, Carnot cycle and efficiency.

## Use, application and generation of knowledge/art: Use and transfer

Graduates will be able to apply conservation laws in example processes such as impacts, they will be able to use the concept of thermodynamic efficiency in the evaluation of various machines and technologies.

## Communication and cooperation

Graduates learn to present physical relationships. They learn to argue and convey knowledge to other participants.

## Scientific / artistic self-image and professionalism

Graduates become aware of the importance of physical mechanisms in technical processes and thus the benefit of a basic understanding of physics in a technical profession.

# Mechatronics 3: Sensors and Control

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 13 |
| Modul title: | Mechatronics 3: Sensors and Control |
| Module responsible: | Prof. Dr. rer. nat. Jan Schlemmer |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Basic studies |
| Module Content: | 1. Fundamentals of measurement: Physical quantities, units, uncertainties<br>2.Electronics in measurements: Conversion to voltages and amplification, digitization<br>3.Characteristics of (analog) signals, bandwidth, high-pass, low-pass<br>4.Basic concepts in control, open loop vs feedback control<br>5.PID controllers, simple tuning strategies<br>6.Limits of simple controllers, strategies beyond these (outlook) |
| Courses: | Sensors and Control |
| Teaching and learning forms: | Lectures with exercises, experiments in small groups (using simulations as well as simple circuits) |
| Prerequisites for participation: | Electronics1, Maths 1 & 2 |
| Applicability of the module: | Subsequent modules with focus on mechatronics and sensors |
| Prerequisites allocation ECTS: | Succesful completion of experiments (PF) |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | Alan S. Morris, Reza Langari: "Measurement & Instrumentation"<br>Karl J. Äström and Richard M. Murray: „Feedback Systems"<br>Ogata: „Modern control engineering" |
| Compulsory attendance: | no |

# Competence dimensions Mechatronics 3: Sensors and Control

## Knowledge and understanding: Broadening of prior knowledge

Graduates have expanded their knowledge in the following areas and are able to reproduce this knowledge: Concept of measurement errors and their estimation, typical electronics at the beginning of a measurement chain, digitization, bandwidth of signals, phase shift, open-loop and closed-loop control, PID controllers and their limitations.

## Use, application and generation of knowledge/art: Use and transfer

Graduates can apply the concept of error propagation to measurement chains with several links; they can identify typical elements occurring in measurement technology circuits; they can classify the behavior as control or regulation for technical devices in their environment.

## Communication and cooperation

Graduates learn to present physical relationships. They learn to argue and convey knowledge to other participants.

## Scientific / artistic self-image and professionalism

Graduates learn to present physical relationships. They learn to argue and convey knowledge to other participants.

# Electronics 3: Digital Circuits

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 14 |
| Modul title: | Electronics 3: Digital Circuits |
| Module responsible: | Prof. Dr.-Ing. Samuel Vogel |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Basic studies |
| Module Content: | Lecture:<br>1. Diodes and transistors<br>2. Basic transistor (amplifier) circuits<br>3. Transistor logics (binary logic, logical gates)<br>4. Flip-flop circuits<br>5. Power stages (buck converters [PWM], frequency inverter, H-bridge)<br>Lab:<br>1. Timer IC NE555: Basic circuits<br>2. Ltspice II: Advanced circuit simulation<br>3. Oscilloscope III: Multifunctional exercises, measuring microcontroller signals<br>4. Power electronics: flywheel diode, H-bridge, PWM |
| Courses: | Lecture with Exercise: Digital Circuits<br>Laboratory: BET3 |
| Teaching and learning forms: | Lectures with exercises and laboratory |
| Prerequisites for participation: | Module Electronics 2: Analog |
| Applicability of the module: | Subsequent modules with focus on electronics and mechatronics |
| Prerequisites allocation ECTS: | PF (Lecture: K60 + Lab Reports) |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures and lab, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | P. Scherz, S. Monk: Practical Electronics for Inventors<br>P. Horowitz, W. Hill: The Art of Electronics |
| Compulsory attendance: | no |

# Competence dimensions Electronics 3: Digital Circuits

## Knowledge and understanding: Broadening of prior knowledge

Graduates understand and are able to explain the function of diodes and transistors. Graduates are able to explain typical usages of diodes and transistors in mechatronic applications.

## Use, application and generation of knowledge/art: Use and transfer

Graduates are able to dimension and solve electric resistor networks. Graduates will be able to build and measure non-linear networks including transistors and diodes in the laboratory scale and explain the behavior.

## Communication and cooperation

Graduates learn to build electronic circuits including digital and analog components in small teams. They are able to communicate in professional language with the appropriate technical vocabulary.

## Scientific / artistic self-image and professionalism

Graduates are taught a mechatronics-based approach to digital electronics. Typical mechatronics applications as power conversion and electric drives are particularly emphasized, thus clarifying the later job profile of the mechatronics engineer.

# Computer Science 3: Application Programming

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 15 |
| Modul title: | Computer Science 3: Application Programming |
| Module responsible: | Prof. Dr.-Ing. Markus Till |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Basic studies |
| Module Content: | The focus of this module is the creation of software applications for real-world problems. The problem accompanies the students over a semester, e.g. recording and evaluating measurement data from a vehicle test bench.<br>Contents:<br>- Interface design (API, frameworks, etc.)<br>- Graphical User Interfaces and/or web frameworks<br>- Testing (unit tests, etc.)<br>- Debugging<br>- Versioning with Git or comparable services. |
| Courses: | |
| Teaching and learning forms: | Lectures with practical exercises |
| Prerequisites for participation: | Computer Science 1 and Computer Science 2 |
| Applicability of the module: | Subsequent modules with focus on computer science and programming |
| Prerequisites allocation ECTS: | RPA |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Summer semester only |
| Literature: | David Beazley and Brian K. Jones, "Python Cookbook"<br>Brett Slatkin, "Effective Python: 90 Specific Ways to Write Better Python" |
| Compulsory attendance: | no |

# Competence dimensions Computer Science 3: Application Programming

## Knowledge and understanding: Broadening of prior knowledge

Graduates have an insight of Python programming concepts, enabling them to design, implement, and debug Python applications effectively.

## Use, application and generation of knowledge/art: Use and transfer

Graduates can apply their practical Python knowledge to create real-world applications for data analysis, automation, and more.

## Communication and cooperation

Graduates learn to present and discuss their application designs in small groups. They learn to argue and convey knowledge to other participants.

## Scientific / artistic self-image and professionalism

# Mechanics 3: Kinetics and Engineering Design

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 16 |
| Modul title: | Mechanics 3: Kinetics and Engineering Design |
| Module responsible: | Prof. Dr.-Ing. hab. Ralf Stetter |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Basic studies |
| Module Content: | Module contents:<br>- kinematics of a point<br>- kinematics of solid bodies<br>- kinetics: axioms of kinetics, accelerations, mass moment of inertia, linear and angular momentum, energy, power, free vibrations, damped vibrations<br>design methodology in mechatronic product development<br>selected machine elements<br>joining technologies<br>- life cycle assessment of mechatronic products |
| Courses: | Kinetics and Engineering Design |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | none |
| Applicability of the module: | Subsequent modules with focus on mechatronics and mechanics |
| Prerequisites allocation ECTS: | K60 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Summer semester only |
| Literature: | Dankert&Dankert: Technische Mechanik: Statik, Festigkeitslehre, Kinematik/Kinetik. Vieweg Teubner Verlag; 2013.<br>Hibbeler: Statics&Dynamics. MACMILLAN.<br>Wittel, Muhs, Jannasch, Voßiek: Roloff/Matek Maschinenelemente. Springer Vieweg. |
| Compulsory attendance: | no |

# Competence dimensions Mechanics 3: Kinetics and Engineering Design

## Knowledge and understanding: Broadening of prior knowledge

Graduates can explain the basics of engineering mechanics (kinematics, kinetics, and dynamics). Graduates deepen the systematic approach of mechatronic product development. Graduates can dimension selected machine elements and apply them in mechatronics.

## Use, application and generation of knowledge/art: Use and transfer

The graduates can solve problems in the context of kinematics and kinetics. The graduates are able to calculate and design the mechanical parts of a mechatronic product.

## Communication and cooperation

The students discuss justifiable solutions to problems with the lecturer in a subject-related manner. They are able to analyze mechanisms dynamically.

## Scientific / artistic self-image and professionalism

# Maths4: Numerical Analysis

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 17 |
| Modul title: | Maths4: Numerical Analysis |
| Module responsible: | Prof. Dr. rer. nat. Martin Smaga |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Basic studies |
| Module Content: | -Basic Principles of Numerical Analysis<br>-Numerical Methods for Systems of Linear Equations<br>-Numerical Methods for Systems of Non-Linear Equations<br>-Numerical Methods for Differential Equations<br>-Fourier Analysis and Integral Transforms |
| Courses: | 2111 Numerical Analysis |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | Analysis 1, Linear Algebra and Analysis 2 |
| Applicability of the module: | Subsequent modules with focus on mathematics and mechatronics |
| Prerequisites allocation ECTS: | K90 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | Dahmen, Reusken: Numerik für Ingenieure und Naturwissenschaftler, Springer (2008)<br>Hamming: Numerical Methods for Scientists and Engineers, Dover Publications (1987)<br>Meyberg, K., Vachenauer, P.: Höhere Mathematik 2, Springer (2001) |
| Compulsory attendance: | no |

# Competence dimensions Maths4: Numerical Analysis

## Knowledge and understanding: Broadening of prior knowledge

Graduates will be able to reproduce the basic mathematical principles that belong to the topics mentioned in the contents.

## Use, application and generation of knowledge/art: Use and transfer

Graduates master numerical methods for solving equations, they can apply the methods to technical and scientific problems and interpret the results.

## Communication and cooperation

Graduates learn to present their own problem-solving processes in small groups. They learn to argue and convey knowledge to other participants.

## Scientific / artistic self-image and professionalism

Graduates become aware of the importance of mathematical skills for their professional field.

# Sciences 2: Electrodynamics

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 18 |
| Modul title: | Sciences 2: Electrodynamics |
| Module responsible: | Prof. Dr. Daniel Kolacyak |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Basic studies |
| Module Content: | Electrostatics: relationship between static charge distributions and electric fields, work in the electric field, potential, voltage<br>Dielectrics: polarization of matter and influence on the fields of charge distributions, types of dielectrics,<br>Electrodynamics: magnetic fields of current distributions,<br>influence of matter on magnetic polarization, types of magnetic materials,<br>Electromagnetic induction,<br>Derivation of the wave equation from the Maxwell equations, wave types, wave properties,<br>phase and group speed<br>For more see lecture |
| Courses: | Electrodynamics |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | Physics 1 |
| Applicability of the module: | Subsequent modules with focus on mechatronics, electronics and photonics |
| Prerequisites allocation ECTS: | K60 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Summer semester only |
| Literature: | Tipler, Mosca: Physik für Wissenschaftler und Ingenieure<br>Griffiths: Elektrodynamik<br>Reineker, Schulz: Elektrodynamik<br>Bartelmann, Feuerbacher, Krüger, Lüst, Rebhan, Wipf: Elektrodynamik<br>Fließbach: Elektrodynamnik<br>Wolschin: Elektrodynamik |
| Compulsory attendance: | no |

# Competence dimensions Sciences 2: Electrodynamics

## Knowledge and understanding: Broadening of prior knowledge

The students are able to enumerate formulas from the field of electrostatics and electrodynamics. They are able to reproduce, sketch and explain relationships in electrostatics and in electrodynamics.

## Use, application and generation of knowledge/art: Use and transfer

The module is designed for applications in the mobility industry from a fundamental scientific perspective.

## Communication and cooperation

Students reflect on the specific interfaces in the (natural) scientific field and in engineering applications.

## Scientific / artistic self-image and professionalism

The students know the importance of simple physical conditions and their importance for their professional field.

# Mechatronics 4: Electric Drives

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|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 19 |
| Modul title: | Mechatronics 4: Electric Drives |
| Module responsible: | Prof. Dr.-Ing. Andreas Haag |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Main studies |
| Module Content: | Technology-independent characteristics and definitions such as IP code, IC code, materials and materials of electrical engineering; important relationships and designations, sizes of the equivalent circuit, complex calculus, basic equations, thermal analogy; DC machines and brushed motors; the general rotating field machine, what is a rotating field, origin, characteristics, terminology of the three-phase system; Asynchronous machine, construction, types, mode of operation, power balance, operating characteristics, control, starting and braking methods, special characteristics; standard machines, mechanical interfaces, growth laws, IM code, bearing concepts, nominal voltages, star-delta starting, soft starters, driven machines, run-up characteristics, selection from manufacturer lists, run-up time, power loss balance, run-up heat, operating mode, coupling to driven machine, explosion-proof machines; Synchronous machine, structure, type, mode of operation, power balance, operating characteristics, control, special characteristics; traction drives, comparison of internal combustion engine/electric drive, vehicle model, traction resistance, tractive force diagram of electric drive, standard driving profiles, real driving profile; power electronics and inverter hardware, introduction, converter types, sensors, control methods; inverter software and control technology, introduction (controller, controller setting), control of DC drives (basics, control loop), control of three-phase drives (fundamentals and principle of field orientation, structure of a controlled three-phase drive system, control of PM-excited synchronous machines, control of asynchronous machines), control methods; ripple frequency control, carrier method, rotary pointer modulation), sensors (voltage measurement, current measurement, speed measurement, angular position measurement, temperature measurement). |
| Courses: | Electric drives |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | Maths 1 & 2 |
| Applicability of the module: | Subsequent modules with focus on mechatronics and electric drives |
| Prerequisites allocation ECTS: | K90 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |

| | |
|---|---|
| Literature: | Bechtloff: Regelungstechnik, Vogel<br>Weidauer: Elektrische Antriebstechnik, Siemens<br>Hagl: Elektrische Antriebstechnik, Hanser<br>Brosch: Moderne Stromrechterantriebe, Vogel<br>Bederke-Vaske: Elektrische Antriebe und Steuerungen, Teubner<br>Stölting: Handbuch Elektrische Kleinantriebe, Hanser<br>Fischer: Elektrische Maschinen, Hanser<br>Schröder: Elektrische Antriebe Grundlagen, Springer<br>Müller: Grundlagen elektrischer Maschinen, Wiley-VCH<br>Binder: Elektrische Antriebe, Springer<br>Heumann: Grundlagen der Leistungselektronik, Teubner<br>Jenni: Steuerverfahren für selbstgeführte Stromrichter, vdf/Teubner<br>Leonhard: Control of Electrical Drives, Springer<br>Quang: Praxis der feldorientierten Drehstromantriebsregelungen, Expert |
| Compulsory attendance: | no |

# Competence dimensions Mechatronics 4: Electric Drives

## Knowledge and understanding: Broadening of prior knowledge

Graduates can explain the operation of common electrical machines and are able to specify an electrical drive.

## Use, application and generation of knowledge/art: Use and transfer

Graduates can select from a manufacturer's list, compare list data, and provide necessary design details. Graduates can identify and respond to interface problems where useful use of common software Excel, Matlab/Octave, etc. reveals itself.

## Communication and cooperation

Graduates can effectively collaborate with multidisciplinary teams to analyze, design, and implement advanced Electric Drives solutions

## Scientific / artistic self-image and professionalism

Graduates demonstrate a strong work ethic in this field and continuously advance their knowledge and expertise in Electric Drives

# Mechatronics 5: Modeling and Simulation

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|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 20 |
| Modul title: | Mechatronics 5: Modeling and Simulation |
| Module responsible: | Prof. Dr.-Ing. Konrad Wöllhaf |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Main studies |
| Module Content: | - Simulation as a project<br>- Model forms<br>- Simulations algorithms<br>- Models for different applications<br>- Hardware in the Loop<br>Half of the class are exercise with Matlab and Simulink |
| Courses: | |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | Mathematics, Programming and Physics from semester 1-3 |
| Applicability of the module: | Subsequent modules with focus on mechatronics and simulation |
| Prerequisites allocation ECTS: | K90 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Winter semester only |
| Literature: | Angermann, A.; Beuschel, M.; Rau, M. & Wohlfarth, U. (2002), Matlab-Simulink-Stateflow, Ol-denbourg. Atkinson, L.V. & Harley,<br>P.J. (1983), An Introduction to Numerical Methods with Pascal, Addison-Wesley. Cellier, F.E. (1992), Continuous system modeling,<br>Springer. Karnopp, D.C.; Margolis, D.L. & Rosenbert, R.C. (2000), System Dynamics, John Wiley & Sons, New York. Lyshevski, S.E.<br>(1999), Electromechanical Systems, Electric Machines, and Applied Mechatron-ics, CRC Press. Mathews, J.H. (1992), Numerical<br>Methods, Prentice-Hall. Tiller, M. (2001), Introduction to Physical Modeling with Modelica, Kluwer Academic Publishers Group |
| Compulsory attendance: | no |

# Competence dimensions Mechatronics 5: Modeling and Simulation

## Knowledge and understanding: Broadening of prior knowledge

The students know different model forms. They know the simulation algorithms for ordinary differential equations and nonlinear equations and know how to implement and apply them. They can develop models for mechatronic systems and can implement them in Matlab and Simulink. They are able to do simulation studies by their own.

## Use, application and generation of knowledge/art: Use and transfer

Graduates will be able to apply the knowledge from the following topics: Formal description of technical systems, implementation in a simulation model, systematic execution of simulation experiments.

## Communication and cooperation

Graduates learn to present their own problem-solving processes in small groups. They learn to argue and convey knowledge to other participants.

## Scientific / artistic self-image and professionalism

Graduates become aware of the importance of mathematical skills for their professional field.

# Sustainability 1: Energy

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 21 |
| Modul title: | Sustainability 1: Energy |
| Module responsible: | Prof. Dr.-Ing. Samuel Vogel |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Main studies |
| Module Content: | Part 1: Sustainability<br>1. Climate Change<br>2. Sustainability: Introduction and Definition<br>3. Evaluation of Sustainability<br>Part 2: Integrated Energy System<br>4. Sector Coupling<br>5. Physical Domains and Networks<br>6. Energy Network<br>7. Energy Conversion and Storage |
| Courses: | Integrated Sustainable Energy System |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | Science 1-2, Maths 1- 4 |
| Applicability of the module: | Subsequent modules with focus on mechatronics, energy and sustainability |
| Prerequisites allocation ECTS: | K90 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation, home work exercises, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Winter semester only |
| Literature: | H. Lund: Renewable Energy Systems A Smart Energy System Approach to the Choice and Modeling of 100% Renewable Solutions, Academic Press Elsevier.<br>P. Komarnicki, M. Kranhold, Z. Styczynski: Sector Coupling- Energy-Sustainable Economy of the Future.<br>M. Tiller: Introduction to Physical Modeling with Modelica; Springer.<br>F. Cellier: Continuous System Modeling; Springer. |
| Compulsory attendance: | no |

# Competence dimensions Sustainability 1: Energy

## Knowledge and understanding: Broadening of prior knowledge

Graduates are able to explain the basics principles of sustainability and integrated energy systems. Graduates can explain the need for integrated sustainable energy systems and understand the mathematical and structural commonalities of different physical domains.

## Use, application and generation of knowledge/art: Use and transfer

Graduates are able to dimension and solve physical network on the energy level. The top-down solution approach taught can be transferred to other systems.

## Communication and cooperation

Graduates are able to exchange about topics of sustainability. They learn the professional language with the appropriate technical vocabulary in the field of energy networks.

## Scientific / artistic self-image and professionalism

Graduates will be able to reflect the essential ideas and approaches of sustainable action in the technical field. These can then be incorporated as cross-sectional ideas into the various applications within the job profile of the mechatronics engineer.

# Sciences 3: Materials

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 24 |
| Modul title: | Sciences 3: Materials |
| Module responsible: | Prof. Dr. Daniel Kolacyak |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Main studies |
| Module Content: | Overview of the most important materials, properties, manufacturing processes and areas of application:<br>- manifestations of matter; - atomic models; Hydrogen, metallic and carbon-based systems, elements of power generation; energetics and kinetics of reactions; chemical corrosion, equilibrium considerations, - phase diagrams; - Crystallographic structures; - iron-carbon system; - - metals and alloys; ceramics, glasses and superconductors; - plastics;- composite materials, - properties of materials; For more see Moodle |
| Courses: | Materials 1 |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | Good knowledge of school mathematics |
| Applicability of the module: | Subsequent modules with focus on physics and mechanics |
| Prerequisites allocation ECTS: | K60 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Winter semester only |
| Literature: | James F. Shackelford: Introduction to Materials Science for Engineers<br>W. D. Callister, Jr.: Materials Science and Engineering |
| Compulsory attendance: | no |

# Competence dimensions Sciences 3: Materials

## Knowledge and understanding: Broadening of prior knowledge

The students are able to indicate the relationships between the structural composition of the materials and the corresponding material properties.
They can describe the most important material testing methods and know typical parameters for material properties.
The students know traditional materials from the field of metals, but also modern material developments in the field of high-performance ceramics, polymers, (nano)composites and semiconductors

## Use, application and generation of knowledge/art: Use and transfer

Students name possible applications in the field of high-performance ceramics, polymers, (nano)composites, semiconductors, among others.

## Communication and cooperation

Students reflect on the specific interfaces in the (natural) scientific field and in engineering applications.

## Scientific / artistic self-image and professionalism

Students are aware of the specific interfaces between fundamental natural sciences and engineering applications with special consideration of sustainability aspects.

# Mechatronics 6: Microcontroller

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 25 (FT30) |
| Modul title: | Mechatronics 6: Microcontroller |
| Module responsible: | Prof. Dr.-Ing. Tim Nosper |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Main studies |
| Module Content: | - Microcontroller basics (terms and definitions, history, manufacturing)<br>- Micromedia Development Board<br>- Development environment DIE<br>- Schematic and layout editor<br>- Electrostatic Discharge<br>- Programming of first examples<br>- Basics ARM processor STM 32 F407VGT6<br>- Exercise examples and debugger<br>- Further exercises on analog/digital converter, timer, PWM signals, H-bridge<br>- Control of a display<br>- Design of an own circuit<br>- Design and programming of your own circuit |
| Courses: | Advanced Microcontroller Programming |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | none |
| Applicability of the module: | Subsequent modules with focus on mechatronics and programming |
| Prerequisites allocation ECTS: | RPA |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | 150h; ca. 15h lectures, 45 practical training, ca. 90 self-study (lecture and training preparation and follow-up) |
| Duration of the module: | one semester |
| Frequency of offering: | Summer semester only |
| Literature: | Heimo Gaicher: AVR Mikrocontroller - Programmierung in C: Eigene Projekte selbst entwickeln und verstehen<br>Sven Löbmann,Toralf Riedel, Alexander Huwaldt:mySTM32 Lehrbuch |
| Compulsory attendance: | no |

# Competence dimensions Mechatronics 6: Microcontroller

## Knowledge and understanding: Broadening of prior knowledge

Graduates have basic knowledge of the structure, function and programming of microcontrollers. They are able to program simple tasks and are able to independently design simple electronic circuits as a circuit board, to assemble the circuit board by hand and then to test and program it.

## Use, application and generation of knowledge/art: Use and transfer

Graduates perform programming tasks independently, can eliminate errors and are proficient in common development environments.
The students can independently design their own simple circuits and create a PCB layout.
Graduates have experience in procuring and assembling their own circuit boards and are able to program them.

## Communication and cooperation

Graduates are able to exchange about topics of microcontrollers. They learn the professional language with the appropriate technical vocabulary in the field of microcontroller.

## Scientific / artistic self-image and professionalism

# Mechatronics 7: Scientific Project

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 26 |
| Modul title: | Mechatronics 7: Scientific Project |
| Module responsible: | Dean of studies |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Main studies |
| Module Content: | The students work in groups on assigned projects. At the end of the semester, there is a presentation for each project. The knowledge and methods acquired in the course of study are to be applied to the project work. The scientific project serves as preparation for the Bachelor thesis. |
| Courses: | Scientific project seminar |
| Teaching and learning forms: | Project seminar |
| Prerequisites for participation: | Computer Science 1-2, Mechatronics 1, Math 1-2, Electronics 1 |
| Applicability of the module: | Subsequent modules with focus on mechatronics and Bachelor Thesis |
| Prerequisites allocation ECTS: | Presentation of project results and a written report. |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | A workload of 30 hours per ECTS is assumed. |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | Mechatronics Project Management: Techniques and Tools for Success by John C. Jackowsk<br>Managing Mechatronics Projects by Lech Gulbinowicz and Damian Kuczynski |
| Compulsory attendance: | no |

# Competence dimensions Mechatronics 7: Scientific Project

## Knowledge and understanding: Deepening of individual components of knowledge

Graduates deepen their specialist knowledge in project-related tasks.

## Use, application and generation of knowledge/art: Use and transfer

Graduates develop solutions for project-related tasks. They are able to plan the project according to milestones and define work packages for the individual project steps

## Communication and cooperation

Graduates can present project goals and their planned activities in small groups in a communicative manner. They discuss proposed solutions and negotiate action steps.

## Scientific / artistic self-image and professionalism

Graduates understand their role in project management and can act in a subject-specific and solution-oriented manner. They can present their work steps to other professional groups.

# Mechatronics 8: Robotics

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 27 |
| Modul title: | Mechatronics 8: Robotics |
| Module responsible: | Prof. Dr.-Ing. Konrad Wöllhaf |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Main studies |
| Module Content: | Lecture:<br>-Introduction, Robotics and Automation, Social Aspects<br>-Kinematics<br>-Trajectory Generation<br>-Dynamics<br>-Control<br>-Programming<br>-Security<br>-MRC<br>Lab:<br>-Robot-Movement, Teaching of tool and base, Formula based programming<br>-Programming with robot-simulation-program, solution of an automation task with robots<br>-Test of a simulated robot program on a real robot |
| Courses: | Robotics (5761) and Robotics Lab (5768) |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | Mathematics from semester 1-3 |
| Applicability of the module: | Subsequent modules with focus on mechatronics and robotics |
| Prerequisites allocation ECTS: | K60 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Winter semester only |

| | |
|---|---|
| Literature: | Robert J. Schilling. Fundamentals of robotics: analyisis and control. Prentice-Hall, 1990.<br>John J. Craig. Introduction to robotics: mechanics and control. Addison-Wesley, New York, 1 edition, 1989<br>WEBER, Wolfgang. Industrieroboter. Hanser-Verlag, 2019.<br>ISO 13849-1, DIN EN. Sicherheit von Maschinen - Sicherheitsbezogene Teile von Steuerungen - Teil 1: Allgemeine Gestaltungsleitsätze. Beuth Verlag, Berlin, 2016.<br>Mensch-Roboter-Kollaboration. Buxbaum, Hans-Jürgen. Springer-Verlag, 2020. |
| Compulsory attendance: | no |

# Competence dimensions Mechatronics 8: Robotics

## Knowledge and understanding: Deepening of individual components of knowledge

Graduates know the characteristics and possible applications of industrial robots. They can solve automation tasks taking into account the special properties of industrial robots, which the students understand mathematically.

## Use, application and generation of knowledge/art: Use and transfer

Graduates know the range of application of industrial robots and can solve automation tasks with robots

## Communication and cooperation

Graduates learn to present their own problem-solving processes in small groups. They learn to argue and to teach knowledge to others.

## Scientific / artistic self-image and professionalism

Graduates become aware of the importance of mathematical skills for their professional field of activity.

# Deutsch als Fremdsprache B2 für nicht deutschsprachige Studierende

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 28 |
| Modul title: | Deutsch als Fremdsprache B2 für nicht deutschsprachige Studierende |
| Module responsible: | Natalia De Pascale Speck |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Main studies |
| Module Content: | 1) Breites Spektrum an authentischen Textsorten zu aktuellen und relevanten Themen aus Alltag, Beruf und Wissenschaft. 2) Training aller Fertigkeiten (lesen, schreiben, hören und sprechen), die in realistische Situationen und Anlässe eingebettet werden. 3) Interkulturelle Sensibilisierung für die Unterschiede zwischen verschiedenen Kulturen und dem Leben und Arbeiten in Deutschland. |
| Courses: | 4631 Deutsch als Fremdsprache B2<br><br>Deutsch B2 wird jedes Semester angeboten, ebenso Deutsch A1+, A2+ und B1+, die zum Erreichen des Niveaus B2 dienen. Die Studierenden besuchen nach einem Einstufungstest die Kurse Deutsch A1+, A2+, B1+, die ebenfalls jedes Semester stattfinden.<br>Pro Stufe ist mindestens 1 Semester vorgesehen. Credits werden ab B2 vergeben. ( LSF A1 /4382 – A2/ 4634 – B1/4630) |
| Teaching and learning forms: | Seminar + Übung: Bei der Auswahl der Unterrichtsmaterialien und -aktivitäten stehen die Lernerautonomie, das soziale Lernen sowie die Handlungsorientierung im Vordergrund. Eine aktive Beteiligung an Diskussionen und abwechslungsreichen Unterrichtsaktivitäten vonseiten der Studierenden ist Voraussetzung für eine erfolgreiche Teilnahme. |
| Prerequisites for participation: | Solide Vorkenntnisse mind. auf dem Niveau B1 gemäß dem Gemeinsamen Europäischen Referenzrahmen für Sprachen. Vorkenntnisse durch einen Einstufungstest oder durch das Bestehen des B1+ Kurses an der RWU bescheinigt. |
| Applicability of the module: | Als Pfichtfach:<br>• Electrical Engineering and Information Technology (Bachelor) Elektrotechnik und Informationstechnik (Bachelor EN)<br>• E-Mobility and Green Energy (Bachelor) Elektromobilität und regenerative Energien (EN)<br>• Maschinenbau / International Project Engineering Physical Engineering ( EN)<br>• Physical Engineering (Phisikalische Technik) EN<br>• Mechatronics (Bachelor) EN<br><br>Als Wahlfach:<br>Electrical Engineering and Enbedded Systems ( Master) EN<br>Mechatronics ( Master) EN<br>International Business Management and Sustainability MBA (Master) EN |

| | |
|---|---|
| Prerequisites allocation ECTS: | Das Portfolio besteht aus mehreren Leistungen in verschiedenen relevanten Fertigkeiten: Präsentation, Diskussion, schriftliche Tests, Essay zur Interkulturellen Kompetenz /Abschlussreflexion.<br>1. Präsentation/ Monologisches Sprechen – 25 Punkte – 25 %<br>2. Abschlusstest (Leseverstehen, Hörverstehen, Grammatik) – 25 Punkte – 25 %<br>3. Diskussion/ Dialogisches Sprechen – 25 Punkte – 25 %<br>4. Schriftlicher Ausdruck – 25 Punkte – 25 % |
| ECTS credits: | 5 |
| Grading: | benotet |
| Workload: | 150h |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | Lehrwerke für Deutsch als Fremdsprache B2 |
| Compulsory attendance: | yes |
| Reason: | Studierende können sich den komplexen Wissensstoff grundsätzlich nicht im Selbststudium aneignen. Außerdem lebt der Sprachkurs von der Debatte und dem Diskurs. Daher ist eine Anwesenheitspflicht für den Studienerfolg erforderlich. Pro Semester wird die unentschuldigte Abwesenheit an maximal 1 Termin toleriert. Weitere Abwesenheiten aus nicht zu vertretenden Gründen erfordern eine Entschuldigung inklusive Nachweis. |

# Competence dimensions Deutsch als Fremdsprache B2 für nicht deutschsprachige Studierende

## Knowledge and understanding: Broadening of prior knowledge

Studierende kennen die benötigten Vokabeln sowie die ensprechende Grammatik der deutschen Sprache.

## Use, application and generation of knowledge/art: Use and transfer

Absolventinnen und Absolventen können dem Niveau B2 entsprechend - sich spontan und fließend mit Muttersprachlern verständigen, - ohne größere Anstrengung für beide Seiten, - einen konstruktiven Beitrag leisten: auf Ergebnisse hinarbeiten (Aufgabenstellungen verstehen und angemessen lösen), einen Standpunkt erklären, auf andere Meinung eingehen und ggf. Kompromisse formulieren und Fehler bzw. Vor- und Nachteile benennen, - interkulturelle Unterschiede erkennen, wenn nötig ansprechen und Lösungsvorschläge anbieten, Diagramme analysieren und die Inhalte zusammenfassen und vergleichen.

## Communication and cooperation

Absolventinnen und Absolventen können dem Niveau B2 entsprechend - in verschiedenen sozialen und interkulturellen Kontexten adäquat kommunizieren: unterschiedliche Sprach- und Kommunikationsstile akzeptieren und sich ansatzweise anpassen, - die Hauptinhalte komplexer Texte zu konkreten und abstrakten Themen und im eigenen Spezialgebiet auch Fachdiskussionen verstehen, - sich zu einem breiten Themenspektrum klar und detailliert ausdrücken, einen Standpunkt zu einer aktuellen Frage erläutern und die Vor- und Nachteile verschiedener Möglichkeiten angeben.

## Scientific / artistic self-image and professionalism

Absolventinnen und Absolventen können, - die Struktur der Zielsprache bewerten und sich selbst einstufen, - beurteilen, welche Kriterien für Wortschatz, Grammatik, Aussprache und verschiedene Textformen (jeweils dem Niveau B2 entsprechend) sowie kulturelle Unterschiede relevant sind, - mindestens zwei Sprachen und ausgewählte Kulturen würdigen, vergleichen, unterschiedliche Werte abwägen und einordnen.

# Practical Semester

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 31 |
| Modul title: | Practical Semester |
| Module responsible: | Dean of studies |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Main studies |
| Module Content: | The mandatory practical study semester includes a practical activity in a company, the contents of which must be designed in accordance with the job profile of the study program. The competencies acquired during the course of study are to be applied and deepened by working on suitable projects in the company. The students should become acquainted with the technical requirements, the working methods and the operational environment in practice and, as far as possible, work on applied projects independently as well as co-responsibly, considering the operational conditions. |
| Courses: | Practical semester seminar |
| Teaching and learning forms: | Practical semester and seminar |
| Prerequisites for participation: | The practical semester can only be started if the intermediate examination according to § 7 (2) has been passed. |
| Applicability of the module: | Mechatronics modules and Bachelor Thesis |
| Prerequisites allocation ECTS: | written elaboration and presentation |
| ECTS credits: | 30 |
| Grading: | not graded |
| Workload: | Project work with a workload of 30 hours per ECTS is assumed |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | |
| Compulsory attendance: | no |

# Competence dimensions Practical Semester

## Knowledge and understanding: Deepening of individual components of knowledge

Graduates expand their acquired knowledge in a company context.

## Use, application and generation of knowledge/art: Use and transfer

Graduates apply their specialist knowledge from theory in a practical environment and learn about and apply industry-related elements of action.

## Communication and cooperation

Graduates communicate with colleagues and other professional groups about operational tasks.

## Scientific / artistic self-image and professionalism

Graduates learn the technical requirements, the working methods and the operational environment in practice and are able to work on projects as independently as possible as well as co-responsibly, considering the operational circumstances; in doing so, they are aware of their professional role and know the interfaces to other professional groups.

# Elective 1

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 32 |
| Modul title: | Elective 1 |
| Module responsible: | Dean of studies |
| Language of lecture: | english |
| Typ of module: | Elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | |
| Courses: | |
| Teaching and learning forms: | |
| Prerequisites for participation: | |
| Applicability of the module: | |
| Prerequisites allocation ECTS: | |
| ECTS credits: | |
| Grading: | |
| Workload: | |
| Duration of the module: | |
| Frequency of offering: | |
| Literature: | |
| Compulsory attendance: | no |

## Competence dimensions Elective 1

**Knowledge and understanding: Broadening of prior knowledge**

**Use, application and generation of knowledge/art: Use and transfer**

**Communication and cooperation**

**Scientific / artistic self-image and professionalism**

# Elective 2

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 33 |
| Modul title: | Elective 2 |
| Module responsible: | Dean of studies |
| Language of lecture: | english |
| Typ of module: | Elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | |
| Courses: | |
| Teaching and learning forms: | |
| Prerequisites for participation: | |
| Applicability of the module: | |
| Prerequisites allocation ECTS: | |
| ECTS credits: | |
| Grading: | |
| Workload: | |
| Duration of the module: | |
| Frequency of offering: | |
| Literature: | |
| Compulsory attendance: | no |

## Competence dimensions Elective 2

**Knowledge and understanding: Broadening of prior knowledge**

**Use, application and generation of knowledge/art: Use and transfer**

**Communication and cooperation**

**Scientific / artistic self-image and professionalism**

# Sustainability 2

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 34 |
| Modul title: | Sustainability 2 |
| Module responsible: | Dean of studies |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Main studies |
| Module Content: | Students critically analyze ethical and sustainable dimensions of their Thesis topic. Typical topics covered are:<br>- Introduction to Ethics and Sustainability<br>- Ethical Considerations in Academics and Research<br>- Potential conflicts of interest and research integrity.<br>- Role of research in addressing sustainability challenges<br>- Tools and Methods for Ethical Decision-Making<br>- Sustainability Metrics and Measurement |
| Courses: | Sustainability 2 |
| Teaching and learning forms: | Seminar |
| Prerequisites for participation: | This module runs in parallel with the Bachelor Thesis |
| Applicability of the module: | Bachelor Thesis and Sustainability |
| Prerequisites allocation ECTS: | written elaboration included in the Bachelor Thesis |
| ECTS credits: | 30 |
| Grading: | not graded |
| Workload: | ca. 150h self-study and reflection (30h per ECTS) |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | Sustainable Manufacturing: Challenges, Solutions and Implementation Perspectives by Günther Seliger and Jérémy Bonvoisin<br>Artificial Intelligence: A Modern Approach by Stuart Russell and Peter Norvig<br>Robot Ethics: The Ethical and Social Implications of Robotics by Patrick Lin, Keith Abney, and Ryan Jenkins |
| Compulsory attendance: | no |

# Competence dimensions Sustainability 2

## Knowledge and understanding: Deepening of individual components of knowledge

Graduates enhance their understanding of sustainability challenges, ethical contemplations, and the interrelations among environmental, social, and economic factors

## Use, application and generation of knowledge/art: Use and transfer

Graduates learn to adapt sustainability concepts and ethical considerations to real-life scenarios, projects, and decision-making processes. Graduates integrate knowledge from various disciplines to formulate holistic solutions that balance environmental, social, and economic aspects.

## Communication and cooperation

Graduates learn to facilitate informed dialogue on ethical and environmental matters

## Scientific / artistic self-image and professionalism

Graduates demonstrate a commitment to ethical conduct, integrity, and responsible behavior within their academic and professional pursuits.

# Bachelor Thesis

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 35 |
| Modul title: | Bachelor Thesis |
| Module responsible: | Dean of studies |
| Language of lecture: | english |
| Typ of module: | Mandatory module |
| Undergraduate/Major: | Main studies |
| Module Content: | The module includes the preparation and writing of the bachelor thesis according to §5 of the SPO of the Mechatronics B.Eng. study course. |
| Courses: | Bachelor Seminar |
| Teaching and learning forms: | Bachelor's thesis with accompanying bachelor's seminar |
| Prerequisites for participation: | The bachelor's thesis can only be started if all study achievements of the first four semesters and the practical semester have been successfully completed. |
| Applicability of the module: | Mechatronics |
| Prerequisites allocation ECTS: | The work must be officially submitted no later than 6 months after the issue date. |
| ECTS credits: | 12 + 3 |
| Grading: | graded |
| Workload: | The topic and scope of the bachelor thesis are to be limited by the Thesis supervisor in such a way that the work can be completed in approx. 360 working hours, corresponding to 12 ECTS. |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | Lawrence A. Machi and Brenda T. McEvoy , "The Literature Review: Six Steps to Success"<br>David Evans and Paul Gruba, "How to Write a Better Thesis |
| Compulsory attendance: | no |

# Competence dimensions Bachelor Thesis

## Knowledge and understanding: Knowledge Comprehension

Graduates show a sound understanding of problems related to the field of Mechatronics.

## Use, application and generation of knowledge/art: Scientific innovation

Graduates work on a problem in the area of Mechatronics using the required methods in the specified period of time.

## Communication and cooperation

Graduates can make use of the relevant technical language when writing their Bachelor Thesis.

## Scientific / artistic self-image and professionalism

Graduates have a sound and reflected understanding of the connections in the field of Mechatronics; in doing so, they are aware of their professional role and know the interfaces to other professional groups.

# Production Mechatronics 1: Digital Production and Industry 4.0

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 36 |
| Modul title: | Production Mechatronics 1: Digital Production and Industry 4.0 |
| Module responsible: | Prof. Dr. Markus Straub |
| Language of lecture: | english |
| Typ of module: | Compulsory elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | 1. Introduction<br>2. Digtal Production<br>3. Automated communication methods<br>4. Industry 4.0 |
| Courses: | Digital Production and Industry 4.0 |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | none |
| Applicability of the module: | Subsequent modules with focus on production |
| Prerequisites allocation ECTS: | RPA |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | 150h; ca. 60h lectures, ca. 90 self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Summer semester only |
| Literature: | A. Keyvani.Modular Fixture Design for BIW Lines Using Process Simulate: Improving Concurrent Engineering By Using Virtual Manufacturing Tools. Lampert. (2012) |
| Compulsory attendance: | no |

# Competence dimensions Production Mechatronics 1: Digital Production and Industry 4.0

## Knowledge and understanding: Broadening of prior knowledge

Graduates will be able to describe the main programming tasks encountered in industrial companies.

## Use, application and generation of knowledge/art: Use and transfer

Graduates will be able to program industrial controls. They can classify a programming task in industrial operations as well as analyze exemplary possible solutions.

## Communication and cooperation

Graduates formulate professional and factual solutions to problems in their work and are able to justify them in discourse with representatives of the subject area and with people from outside the subject area using theoretically and methodologically sound argumentation. They communicate and cooperate with other representatives of the subject area and with people from outside the subject area in order to solve a task responsibly and reflect on and take into account the different points of view and interests of other parties involved.

## Scientific / artistic self-image and professionalism

Graduates develop a professional self-image that is oriented towards goals and standards of professional action in predominantly non-scientific professional fields. They justify their own professional actions with theoretical and methodological knowledge and are able to assess their own abilities, autonomously reflect on factual design and decision-making freedoms and use these under guidance. They recognize situationally appropriate framework conditions for professional action and justify their decisions in terms of responsible ethics and critically reflect on their professional actions in relation to social expectations and consequences.

# Production Mechatronics 2: Introduction Production Technologies

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|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 37 |
| Modul title: | Production Mechatronics 2: Introduction Production Technologies |
| Module responsible: | Prof. Dr. Markus Straub |
| Language of lecture: | english |
| Typ of module: | Compulsory elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | Overview of production engineering and manufacturing technology, classification and structuring of manufacturing processes,<br>process examples for the economic use of manufacturing processes.<br>- Classification and division of the manufacturing processes according to DIN 8580 into main groups,<br>- Requirements of manufacturing technology for materials and manufacturing properties of materials,<br>- Main groups of manufacturing processes, classification features, division into process groups and subgroups,<br>- master molds: Fundamentals of casting, casting materials, principles for the design of castings, classification of casting processes with process examples, fundamentals of sintering technology and plastics processing,<br>- Forming: Fundamentals of forming technology, pressure forming, tension forming, tensile forming, roll forming, die forming,<br>extrusion, deep drawing, spinning, stretch forming and hollow stamping.<br>- Cutting: Cutting, machining processes, material removal, shear cutting, fundamentals of machining, turning, drilling, milling<br>and broaching, high speed machining, grinding, honing and lapping, thermal, chemical and electrochemical removal,<br>- Joining: Fundamentals of joining, welding, brazing and bonding,<br>- Coating: Functional applications of coatings, painting, powder coating and electroplating,<br>- Modifying material properties: Modification of material properties by conversion, introduction or elimination of material particles, thermal heat treatment processes of steel materials, annealing, hardening and tempering, quenching and tempering,<br>carburizing and nitriding, heat treatment of nonferrous metals,<br>- economic feasibility studies and economic comparison in the selection of manufacturing processes.<br>- Manufacturing feasibility studies (feasibility) / manufacturing concept / work plan |
| Courses: | Introduction Production Technologies |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | none |
| Applicability of the module: | Subsequent modules with focus on production |
| Prerequisites allocation ECTS: | K60 |
| ECTS credits: | 5 |

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|---|---|
| Grading: | graded |
| Workload: | 150h; ca. 60h lectures, ca. 90 self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Summer semester only |
| Literature: | Warnecke, H. J. ; Westkämper, E.: Einführung in die Fertigungstechnik, Teubner Verlag, Stuttgart Awiszus, B. ; Bast, J. ; Dürr, H. ;<br>Matthes, K.-J.: Grundlagen der Fertigungstechnik, Fachbuchverlag Leipzig im Carl Hanser Verlag |
| Compulsory attendance: | no |

# Competence dimensions Production Mechatronics 2: Introduction Production Technologies

## Knowledge and understanding: Deepening of individual components of knowledge

Graduates will be able to assess production engineering processes and use them sensibly. Alternative technologies can be compared and evaluated (technically and economically).

## Use, application and generation of knowledge/art: Use and transfer

Graduates will be able to name and evaluate manufacturing processes and assess the effect of the manufacturing processes used on the design. Workpieces can be assessed by the students with regard to their manufacturability. One application is to create manufacturing concepts/work plans based on the bill of materials. Based on the
knowledge imparted, technical formulas can be used (applied) and interpreted (cutting forces, etc.).

## Communication and cooperation

Graduates formulate professional and factual solutions to problems in their work and are able to justify them in discourse with representatives of the subject area and with people from outside the subject area using theoretically and methodologically sound argumentation. They communicate and cooperate with other representatives of the subject area and with people from outside the subject area in order to solve a task responsibly and reflect on and take into account the different points of view and interests of other parties involved.

## Scientific / artistic self-image and professionalism

Graduates develop a professional self-image that is oriented towards goals and standards of professional action within and outside of science and justify their own professional action with theoretical and methodological knowledge.

# Production Mechatronics 3: Advanced Production Technologies

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|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 38 |
| Modul title: | Production Mechatronics 3: Advanced Production Technologies |
| Module responsible: | Prof. Dr.-Ing. Theresa Breckle, MBA |
| Language of lecture: | english |
| Typ of module: | Compulsory elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | Based on the module "Introduction Production Technologies", modern and highly developed production processes are covered.<br>The state of the art is (constantly) being developed further.<br>• New production strategies (e.g. from mass production to customized mass production or production of personalized products)<br>• Additive manufacturing<br>• Introduction to new technologies (lasers, bonding, processing of sustainable/recycled/new materials)<br>• Technological trends in pharmaceutical production engineering and food productin<br>• Technology for future emission-free production<br>• Lean Manufacturing<br>• Challenges to production technology for smart manufacturing ("Industry 4.0")<br>- Factory and production system planning and its processes<br>- Organization<br>- Infrastructure<br>- Supply Chain |
| Courses: | Advanced Production Technologies |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | none |
| Applicability of the module: | Subsequent modules with focus on production |
| Prerequisites allocation ECTS: | K60 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |

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|---|---|
| Literature: | The International Academy for Production Engineering, Luc Laperrière, Gunther Reinhart: CIRP Encyclopedia of Production Engineering, Springer Verlag, 2014<br>Sanjay Kumar: Additive Manufacturing Processes, Springer Verlag, 2020<br>Ian Gibson David, Rosen Brent, Stucker Mahyar Khorasani: Additive Manufacturing Technologies, Springer Verlag, 2021<br>Anca Draghici, Larisa Ivascu: Sustainability and Innovation in Manufacturing Enterprises, Springer Verlag, 2022<br>Kaiser, Wolfgang: Ultrashort Laser Pulses - Generation and Applications, Springer Verlag, 2017.<br>Eichler, Jürgen, Eichler, Hans Joachim: Laser - Bauformen, Strahlführung, Anwendungen, Springer Verlag, 2018.<br>Andreas Gebhardt, Julia Kessler, Laura Thurn: 3D Printing - Additive Manufacturing (AM), Carl Hanser Verlag, 2. Auflage. 2018.<br>Shia-Chung Chen, Lih-Sheng Turng: Advanced Injection Molding Technologies, Carl Hanser Verlag, 2019<br>Obermaier, Robert.: Handbuch Industrie 4.0 und Digitale Transformation, Springer Verlag, 2019<br>Bracht, Uwe, Geckler Dieter, Wenzel Sigrid: Digitale Fabrik, Springer Verlag, 2018 |
| Compulsory attendance: | no |

# Competence dimensions Production Mechatronics 3: Advanced Production Technologies

## Knowledge and understanding: Deepening of individual components of knowledge

Graduates have expanded their knowledge in the following areas and are able to reflect this knowledge: New production strategies, additive manufacturing, new technologies (lasers, bonding, processing of sustainable/recycled/new materials), technology trends in pharmaceutical production engineering and food production, technology for future zero-emission production, lean manufacturing, production engineering challenges for smart manufacturing.

## Use, application and generation of knowledge/art: Use and transfer

Graduates will be able to practically apply knowledge from the following topics:: Understanding of manufacturing processes especially in advanced production technologies, understanding and applying the process chain for additive manufacturing.

## Communication and cooperation

Graduates learn to present their own problem-solving processes in small groups. They learn to argue and convey knowledge to other participants.

## Scientific / artistic self-image and professionalism

Graduates become aware of the importance of production engineering skills for their professional field of activity.

# Automation 1: Digital Production and Industry 4.0

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|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 40 |
| Modul title: | Automation 1: Digital Production and Industry 4.0 |
| Module responsible: | Prof. Dr. Markus Straub |
| Language of lecture: | english |
| Typ of module: | Compulsory elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | 1. Introduction<br>2. Digtal Production<br>3. Automated communication methods<br>4. Industry 4.0 |
| Courses: | Digital Production and Industry 4.0 |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | none |
| Applicability of the module: | Subsequent modules with focus on production |
| Prerequisites allocation ECTS: | RPA |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | 150h; ca. 60h lectures, ca. 90 self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Summer semester only |
| Literature: | A. Keyvani.Modular Fixture Design for BIW Lines Using Process Simulate: Improving Concurrent Engineering By Using Virtual Manufacturing Tools. Lampert. (2012) |
| Compulsory attendance: | no |

# Competence dimensions Automation 1: Digital Production and Industry 4.0

## Knowledge and understanding: Broadening of prior knowledge

Graduates will be able to describe the main programming tasks encountered in industrial companies.

## Use, application and generation of knowledge/art: Use and transfer

Graduates will be able to program industrial controls. They can classify a programming task in industrial operations as well as analyze exemplary possible solutions.

## Communication and cooperation

Graduates formulate professional and factual solutions to problems in their work and are able to justify them in discourse with representatives of the subject area and with people from outside the subject area using theoretically and methodologically sound argumentation. They communicate and cooperate with other representatives of the subject area and with people from outside the subject area in order to solve a task responsibly and reflect on and take into account the different points of view and interests of other parties involved.

## Scientific / artistic self-image and professionalism

Graduates develop a professional self-image that is oriented towards goals and standards of professional action in predominantly non-scientific professional fields. They justify their own professional actions with theoretical and methodological knowledge and are able to assess their own abilities, autonomously reflect on factual design and decision-making freedoms and use these under guidance. They recognize situationally appropriate framework conditions for professional action and justify their decisions in terms of responsible ethics and critically reflect on their professional actions in relation to social expectations and consequences.

# Automation 2: Control Systems

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 41 |
| Modul title: | Automation 2: Control Systems |
| Module responsible: | Prof. Dr.-Ing. Lothar Berger |
| Language of lecture: | english |
| Typ of module: | Compulsory elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | Mathematical modeling of linear and nonlinear processes in time domain (state space) and frequency domain (transfer function). Linear control loop: constituent parts, requirements, stability, stationary and transient behaviour. Frequency response measurement and establishment of transfer function. Control design, control loop synthesis through frequency domain methods: Bode plot, Root locus. Demonstration and simulation of industrial processes, motor control. Implementation of basic analog (PID) and digital (FIR) controllers. Control design and simulation of control loop utilizing MATLAB/Simulink. Outlook: Control design through time domain methods: State feedback control, Optimal control, Feedforward control, Machine Learning based control. |
| Courses: | Digital Production and Industry 4.0 |
| Teaching and learning forms: | Lecture and Exercises<br>- or -<br>E-Learning: Lessons, Exercises; Homework |
| Prerequisites for participation: | Maths 1+2, Computer Science 1, Sciences 1 |
| Applicability of the module: | Subsequent modules with focus on automation |
| Prerequisites allocation ECTS: | K90 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | Presence: 48h, Self-study: 102h<br>- or -<br>Online: 24h, Self-study: 102h, Homework: 24h |
| Duration of the module: | one semester |
| Frequency of offering: | Winter semester only |
| Literature: | Script - or - lessons, exercises, and sample solutions; and complementary:<br>Macia, N. F., Thaler, G. J.: Modeling and Control of Dynamic Systems, Cengage Learning |
| Compulsory attendance: | no |

# Competence dimensions Automation 2: Control Systems

## Knowledge and understanding: Broadening of prior knowledge

Graduates learned about properly modelling industrial processes for applying basic control methods; and about designing basic control methods like PID control.

## Use, application and generation of knowledge/art: Use and transfer

Graduates learned about theory of basic control methods design, and applying that to realistic use-cases, by implementing basic analog and digital controllers.
Graduates learned about properly modelling industrial processes, based on measurements or on theory, and then based on such a model, design the controller, using basic methods.
Attendees learned to investigate the closed control loop stationary and dynamic behaviour, especially considering stability. Attendees learned about control design and simulation of control loop utilizing MATLAB/Simulink.

## Communication and cooperation

Graduates learned about presenting and applying basic control methods as a systems science; aimed at interdisciplinary projects; operated within a team of scientists, engineers, designers, and economists.

## Scientific / artistic self-image and professionalism

Attendees learned about economic and ecological considerations in choosing and implementing basic control methods for industrial processes.

# Automation 3: Human-Machine-Interface Design

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 42 |
| Modul title: | Automation 3: Human-Machine-Interface Design |
| Module responsible: | Prof. Dr.-Ing. Lothar Berger |
| Language of lecture: | english |
| Typ of module: | Compulsory elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | Introduction of Human Machine Interface (HMI) for allowing users to control and interact with machines. HMI design for particular machine vs. HMI design for overall production plant: SCADA (Supervisory Control and Data Acquisition).<br>Realization of HMI by e.g. touchscreen panel: Data visualization, control levels. Consideration of HMI safety requirements and usability, depending on industry and application: Reliable machine startup, User Experience (UX), productivity, efficiency, process optimization. HMI vs.<br>Safety Instrumented System (SIS). Long-term availability of HMI hardware, software design tools, software libraries. Legal considerations: Machinery Directive, risk assessment for machine safety. Presentation of commercial tools for PC-based HMI design (from PLC vendors); commercial graphical-user-interface (GUI) toolkits; opensource GUI toolkits. PC-based graphical GUI<br>programming using e.g. WinCC; GUI programming using C/C++, C#, Python. Microcontroller (MCU) based Embedded HMI design:<br>commercial vs. opensource. Tablet and smartphone based HMI design. Web based HMI design. Outlook: HMI via facial expressions, gestures, and speech vs. Keep it simple (KISS)<br>Within the lab, HMI realization for simulated production plant by opensource crossplatform (Windows, Linux) tools and GUI library, using C/C++ and event-based, asynchronous programming. |
| Courses: | Human-Machine-Interface Design with Lab |
| Teaching and learning forms: | Lecture; Lab<br>- or -<br>E-Learning: Lessons, Exercises; Homework: Practical work |
| Prerequisites for participation: | Computer Science 1-3 |
| Applicability of the module: | Subsequent modules with focus on automation and HMI design |
| Prerequisites allocation ECTS: | RPA: Practical work, documented by a seminar paper and presentation;<br>module grade = practical work grade + ( seminar paper grade + presentation grade ) / 2 ) / 2 |
| ECTS credits: | 5 |
| Grading: | graded |

| | |
|---|---|
| Workload: | 48h, Self-study: 102h<br>- or -<br>Online: 24h, Self-study: 102h, Homework: 24h |
| Duration of the module: | one semester |
| Frequency of offering: | Summer semester only |
| Literature: | |
| Compulsory attendance: | no |

# Competence dimensions Automation 3: Human-Machine-Interface Design

## Knowledge and understanding: Broadening of prior knowledge

Graduates learned about Human Machine Interface (HMI) for allowing users to control and interact with machines, HMI design for particular machine, HMI design for overall
production plant, realization of HMI data visualization, control levels. Attendees were made aware of HMI safety requirements and usability, depending on industry and application. Attendees were introduced to commercial tools for HMI design; commercial graphical-user-interface (GUI) toolkits; opensource GUI toolkits.

## Use, application and generation of knowledge/art: Use and transfer

Graduates learned about programming and implementation of Human Machine Interface (HMI) by opensource crossplatform tools and GUI library, using C/C++ and eventbased, asynchronous programming.

## Communication and cooperation

Graduates learned about presenting and applying Human Machine Interface (HMI) design; aimed at interdisciplinary projects; operated within a team of scientists, engineers, designers, and economists.

## Scientific / artistic self-image and professionalism

Graduates learned about economic and ecological considerations for implementing Human Machine Interface (HMI) to control and interact with machines; including risk assessment and long-term availability considerations.

# Smart Sensors 1: Sensors Overview

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|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 44 |
| Modul title: | Smart Sensors 1: Sensors Overview |
| Module responsible: | Prof. Dr. rer. nat. Jan Schlemmer |
| Language of lecture: | english |
| Typ of module: | Compulsory elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | 1. Terminology: Embedded systems, sensor networks, cyber physical systems<br>2.Sensors: Properties and data generated by important class of sensors<br>3.Algorithms for sensor-data processing: Tracking, fusion, localization<br>4.Sensor interconnects: From onboard data-transfer to field buses and IP based networks<br>5.Processing platforms<br>6.Challenges and design-concepts for deeply embedded software |
| Courses: | |
| Teaching and learning forms: | Lectures with exercises. |
| Prerequisites for participation: | Electronics 1, Maths 1 & 2 |
| Applicability of the module: | Subsequent modules with focus on sensors and data analysis |
| Prerequisites allocation ECTS: | K90 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | E.A. Lee, S.A. Seshia: „Introduction to Embedded Systeme - A Cyber-Physical Systems Approach"<br>Peter Marwedel: „Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems, and the Internet of Things" |
| Compulsory attendance: | no |

# Competence dimensions Smart Sensors 1: Sensors Overview

## Knowledge and understanding: Broadening of prior knowledge

Graduates have expanded their knowledge in the following areas and are able to reproduce this knowledge: Important classes of (modern) sensors and the (digital) data they generate, operating principles of tracking, fusion and localization algorithms, ways of connecting sensors to each other and to data processing units, data processing platforms and the challenges of developing software running on them.

## Use, application and generation of knowledge/art: Use and transfer

Graduates can transfer the general concepts of trackers and fusion systems to concrete combinations of sensors (e.g. lidar tracking, radar tracking, fusion of the resulting positions). They can identify the data transmission systems and processing platforms used in concrete sensor networks or cyber-physical systems.

## Communication and cooperation

Graduates learn to present technical correlations. They learn to argue and convey knowledge to other participants.

## Scientific / artistic self-image and professionalism

Graduates learn about the close relationship between sensors, data processing units and software/algorithmics. This knowledge enables them to evaluate and specify sensors in consideration of the possible data evaluation when solving tasks in the professional environment.

# Smart Sensors 2: Data Analytics & Statistics

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|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 45 |
| Modul title: | Smart Sensors 2: Data Analytics & Statistics |
| Module responsible: | Prof. Dr. rer. nat. Martin Smaga |
| Language of lecture: | english |
| Typ of module: | Compulsory elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | -Data Analysis with Python<br>-Statistical Methods for Engineers<br>-Basics of Statistical Learning<br>-Regression Models, Tree based models and Ensemble Models |
| Courses: | Data Analytics and Statistics |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | Analysis 1, Linear Algebra and Analysis 2 |
| Applicability of the module: | Subsequent modules with focus on sensors and data analysis |
| Prerequisites allocation ECTS: | K90 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | Johnson: Miller & Freund's Probability and Statistics for Engineers, Pearson<br>James, Witten, Hastie, Tibshirani (2023): An Introduction to Statistical Learning, Springer<br>Abu-Mostafa, Magdon-Ismail, Lin (2012): Learning from Data, AMLBook<br>Bruce, Gedeck (2020): Practical Statistics for Data Scientists, O'Reilly |
| Compulsory attendance: | no |

# Competence dimensions Smart Sensors 2: Data Analytics & Statistics

## Knowledge and understanding: Deepening of individual components of knowledge

Graduates will be able to explain the basics and the most important principles of statistical methods for engineers. They can explain the methods covered and their properties.

## Use, application and generation of knowledge/art: Use and transfer

Graduates will be able to apply the discussed methods and implement and execute them in Python. They can evaluate, interpret and assess the results obtained.

## Communication and cooperation

Graduates are able to communicate problems and approaches to solutions in teams and adopt multidisciplinary perspectives.

## Scientific / artistic self-image and professionalism

Graduates are able to assess the impact of their solutions in advance and recognize interfaces with other professional groups.

# Smart Sensors 3: Digital Twins

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|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 46 |
| Modul title: | Smart Sensors 3: Digital Twins |
| Module responsible: | Prof. Dr.-Ing. Samuel Vogel |
| Language of lecture: | english |
| Typ of module: | Compulsory elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | 1. Introduction and Definition of Digital Twins<br>2. Industrial Use Cases and Examples of Digital Twins<br>3. Modeling the time domain of physical systems<br>4. Implementation of an exemplary Digital Twin<br>5. Applications of the Digital Twin (Diagnosis, Predictive Maintenance, Model-based control, ...) |
| Courses: | Digital Twins |
| Teaching and learning forms: | Lectures with exercises and programming lab |
| Prerequisites for participation: | Science 1-2, Computer Science 1-3, Maths 1-4, |
| Applicability of the module: | Subsequent modules with focus on sensors and data analysis |
| Prerequisites allocation ECTS: | K90 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation, home work exercises, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | M. Asch: A Toolbox for Digital Twins: From Model-Based to Data-Driven, SIAM.<br>S. V. Nath, P. v. Schalkwyk: Building Industrial Digital Twins: Design, develop, and deploy digital twin solutions for real-world industries using Azure Digital Twins, Packt Publishing.<br>V. Raghunathan, S. D. Barma: Digital Twin: A Complete Guide For The Complete Beginner, Amazon Kindle. |
| Compulsory attendance: | no |

# Competence dimensions Smart Sensors 3: Digital Twins

## Knowledge and understanding: Deepening of individual components of knowledge

Graduates are able to explain and understand the basics principles digital twins. Graduates understand are able to explain the advantages and possible applications of digital twins in industrial use cases.

## Use, application and generation of knowledge/art: Use and transfer

Graduates are able to implement simple digital twins. The concept behind the usage of digital twins can be transferred to different industrial applications.

## Communication and cooperation

Graduates are able to exchange in professional language about the topics of setting up digital twins. The digital twins themselves are understood as a representation possibility of a mechatronic system, with the help of which interdisciplinary teams can collaborate, develop and improve mechatronic systems themselves.

## Scientific / artistic self-image and professionalism

Graduates will be able to reflect the essential ideas and approaches of digital twins in the technical field. These concepts can then be incorporated as crosssectional solution principled into the various applications within the job profile of the mechatronics engineer to enhance mechatronic systems and products.

# Mobility 1: Automotive Engineering

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|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 48 |
| Modul title: | Mobility 1: Automotive Engineering |
| Module responsible: | Prof. Dr.-Ing. Benedikt Reick |
| Language of lecture: | english |
| Typ of module: | Compulsory elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | - Introduction to automotive engineering<br>- Longitudinal Dynamics<br>- Transverse Dynamics<br>- Vertical Dynamics |
| Courses: | 7087 Automotive Engineering |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | none |
| Applicability of the module: | Subsequent modules with focus on automotive mechatronics |
| Prerequisites allocation ECTS: | PF (50% practical exercises in Moodle, 50% K90 written) |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation, home work exercises, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | - Mitschke, Wallentowitz: Dynamik der Kraftfahrzeuge (VDI-Buch)<br>- Lechner, Naunheimer: Fahrzeuggetriebe, Grundlagen, Auswahl, Auslegung und Konstruktion<br>- Heißing, Ersoy, Gies: Fahrwerkhandbuch: Grundlagen . Fahrdynamik . Komponenten . Systeme . Mechatronik . Perspektiven (ATZ/MTZ-Fachbuch) (Deutsch und Englisch verfügbar)<br>- Crolla et. al.: Automotive Engineering: Powertrain, Chassis System and Vehicle Body (English Edition) 1. Edition<br>- Stone, Ball: Automotive Engineering Fundamentals |
| Compulsory attendance: | no |

# Competence dimensions Mobility 1: Automotive Engineering

## Knowledge and understanding: Broadening of prior knowledge

Graduates have broadened their knowledge in the field of vehicle technology, in particular driving resistances and their influencing variables, and can also reproduce this knowledge.
Graduates are able to derive and present the significance, functionality and design of driving safety systems for lateral and longitudinal dynamics from the theoretical principles of vehicle technology

## Use, application and generation of knowledge/art: Use and transfer

Graduates are able to apply the knowledge from the fundamentals of automotive engineering (e.g. driving resistances) in laboratory tests and in computational tasks.

## Communication and cooperation

Graduates will be able to communicate effectively using language. They have improved their communication skills in the field of automotive engineering by taking the module.

## Scientific / artistic self-image and professionalism

Graduates recognize their own strengths and weaknesses with regard to their course of study and develop a picture of their own development as a future graduate of the electromobility and regenerative energies program. Graduates are able to develop sustainable products. The importance of sustainable mobility concepts can be assessed. For this purpose, the differences of different drive systems (vehicle with combustion engine as energy converter, vehicle with electric motor as energy converter) can be estimated and evaluated.

# Mobility 2: Mobility Laboratory

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|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 49 |
| Modul title: | Mobility 2: Mobility Laboratory |
| Module responsible: | Prof. Dr. André Kaufmann |
| Language of lecture: | english |
| Typ of module: | Compulsory elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | •Driving performance on the roller dynamometer<br>•Changing the wheel position when compressing and rebounding<br>•Troubleshooting using a diagnostic device<br>•12V System of vehicles (Generator, Battery etc.)<br>•Determination of braking force distribution<br>•Drag forces of a vehicle model in the wind tunnel<br>•Characteristics of an electric vehicle<br>•Regenerative braking control systems<br>•Control engineering: Application of a control circuit for an electronic throttle control<br>•Bus systems: Exercises and example using a CAN and Most bus system on a test bench with vehicle CANalyzer |
| Courses: | Motor Vehicles, Practical Training / Practical Automotive Engineering (7034) |
| Teaching and learning forms: | Practical laboratory work |
| Prerequisites for participation: | Good knowledge of school mathematics |
| Applicability of the module: | Subsequent modules with focus on automotive mechatronics |
| Prerequisites allocation ECTS: | RPA |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 60h preparation (self-study), ca. 40h laboratory work, ca. 50h preparation of portfolio |
| Duration of the module: | one semester |
| Frequency of offering: | Winter semester only |

| | |
|---|---|
| Literature: | Merker, G. P.; Teichmann, R.: Grundlagen Verbrennungsmotoren, Springer Vieweg 2018.<br>- Konrad Reif: Sensoren im Kraftfahrzeug, Bussysteme, Automobilelektronik, Fahrstabilisierungssysteme und Fahrerassistenzsysteme.<br>- Hermann Winner, Stephan Hakuli, Felix Lotz, Christina Singer: Handbuch Fahrerassistenzsysteme.<br>- Langeheinecke, K.; Thermodynamik für Ingenieure, 10., Springer Vieweg 2017.<br>- Braess, H.-H: Vieweg Handbuch Kraftfahrzeugtechnik, Springer Vieweg 2013.<br>- Bell, M et al.: Tabellenbuch Fahrzeugtechnik, Handwerk und Technik 2017 |
| Compulsory attendance: | yes |
| Reason: | Practical work is not possible without attendance. |

# Competence dimensions Mobility 2: Mobility Laboratory

## Knowledge and understanding: Deepening of individual components of knowledge

Course participants link the theoretical knowledge of vehicle components and functions with the practical applications in a vehicle. Participants can name different components in passenger vehicles and explain the working principle. Those include the 12V system, vehicle dynamics, electric propulsion system components, breaking systems and vehicle communication systems.

## Use, application and generation of knowledge/art: Use and transfer

Course participants can apply the acquired knowledge on vehicles. They can identify the components in vehicles of different manufacturers and perform a rudimentary error analysis.

## Communication and cooperation

Course participants work in small teams (2-3 persons) and perform the Lab work as a team. In the team they perform measurements and analyse, and interpret the results. As a team, they are required to present and explain the results to the other students.

## Scientific / artistic self-image and professionalism

Course participants realize the importance of skills acquired in related courses to perform engineering work in the field of mobility.

# Mobility 3: High Voltage Vehicles

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 50 |
| Modul title: | Mobility 3: High Voltage Vehicles |
| Module responsible: | Prof. Dr.-Ing. Benedikt Reick |
| Language of lecture: | english |
| Typ of module: | Compulsory elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | eLearnings:<br>- Electrical hazards and first aid<br>- Protective measures against electrical body currents and arc flashes<br>- Organization of safety and health in electrical work<br>- Technical and leadership responsibility<br>- Employee qualification in the field of electrical engineering<br>- Use of high-voltage systems<br>- Structure and function of high-voltage components<br>Practical training:<br>- Electrical measurement techniques in the field of electromobility<br>- Interpretation of measurement values<br>- Certified isolation of a high-voltage system<br>- Performing work in a de-energized state<br>- Acceptance of work on the de-energized high-voltage system<br>- Commissioning of the high-voltage system according to checklist and operating instructions<br>- Instruction and training of employees on high-voltage vehicles<br>- Selection, safe and professional use of tools<br>- Installation of high-voltage cables<br>- Charging infrastructure and charging of high-voltage vehicles |
| Courses: | 10278 High Voltage Vehicles |
| Teaching and learning forms: | - e-Learnings in Moodle<br>- Lecture<br>- Student presentation on selected topics in the field of high-voltage vehicles<br>- practical training |

| | |
|---|---|
| Prerequisites for participation: | The lecture is only offered in the German language because the certificate obtained from it is only applicable in the German job market and is based on an informational brochure from the German accident insurance. Good German language skills are required.<br>Electrical engineering background knowledge is mandatory: Basics of electrical engineering:<br>- Current, voltage<br>- Resistors<br>- Capacitors and inductors<br>- Direct and alternating current<br>- Electric machines |
| Applicability of the module: | Subsequent modules with focus on automotive mechatronics |
| Prerequisites allocation ECTS: | PF<br>- 1/3 grading based on group presentation<br>- 1/3 grading based on written examination (K60 during the semester) before conducting the practical examination<br>- 1/3 grading based on the practical examination (oral appointments organized by the examiner) at the end of the semester |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam + practical training preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | - DGUV Information 209-093<br>- Reick, Benedikt: Script Hochvoltfahrzeuge / High Voltage Vehicles |
| Compulsory attendance: | yes |
| Reason: | Practical work is not possible without attendance. |

# Competence dimensions Mobility 3: High Voltage Vehicles

## Knowledge and understanding: Broadening of prior knowledge

Graduates have broadened their knowledge in the following areas and are able to demonstrate this knowledge:

- Electrical hazards and first aid for high-voltage systems
- Protective measures and equipment against electrical body currents and arc flashes
- Organization of safety and health in electrical work
- Use of high-voltage systems
- Structure and function of high-voltage components

## Use, application and generation of knowledge/art: Use and transfer

Graduates can apply their knowledge practically in the following areas:

- Application of electrical measurement techniques in the field of electromobility
- Interpretation of measurement values
- Certified isolation of a high-voltage system
- Performing work in a de-energized state
- Acceptance of work on the de-energized high-voltage system
- Commissioning of the high-voltage system according to checklist and operating instructions
- Selection, safe and professional use of tools
- Installation of high-voltage cables
- Charging infrastructure and charging of high-voltage vehicles

## Communication and cooperation

Graduates are able to communicate effectively. By completing the module, they have improved their communication skills in the following areas (technical/general/foreign

language):
- Communication of the functioning and structure of high-voltage vehicles
- Independent instruction and training of employees on high-voltage vehicles as competent persons for high-voltage (FuP)

## Scientific / artistic self-image and professionalism

Graduates are capable of developing sustainable products in the field of high-voltage vehicles. They can assess the importance of sustainable mobility concepts.

# Energy Mechatronics 1: Energy and Process Technology

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 52 |
| Modul title: | Energy Mechatronics 1: Energy and Process Technology |
| Module responsible: | N.N. |
| Language of lecture: | english |
| Typ of module: | Compulsory elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | Energy industry and energy demand;<br>Overall structure of energy technology systems and power plants such as thermal power plants, hydroelectric power plants, Gas turbine power plants, combined gas and steam power plants.<br>Thermodynamics of the power plant process, exergy and anergy<br>Environmental issues, carbon emissions, waste heat, waste and exhaust gases |
| Courses: | Energy and Process Technology |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | Mechatronics 1, Science 1, Maths 1 |
| Applicability of the module: | Subsequent modules with focus on energy mechatronics |
| Prerequisites allocation ECTS: | K90 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Winter semester only |
| Literature: | Francis Vanek, Louis D. Albright, and Largus T. Angenent, "Energy Systems Engineering: Evaluation and Implementation"<br>Clive Beggs , "Energy: Management, Supply, and Conservation"<br>Lecture script |
| Compulsory attendance: | no |

# Competence dimensions Energy Mechatronics 1: Energy and Process Technology

## Knowledge and understanding: Broadening of prior knowledge

Graduates understand the structure and operation of energy systems, in particular specify and use thermal systems for generating electricity and heat.

## Use, application and generation of knowledge/art: Use and transfer

Graduates can apply their knowledge practically in the area of energy and process technology.

## Communication and cooperation

Graduates can, among other things, present the concept of energy and process technology in a communicative way and show it in a group in an argumentative way.

## Scientific / artistic self-image and professionalism

Graduates know the importance of energy and process technology for their field of activity and are familiar with the development of recent years. At the same time, they are able to assess the change and importance of these technologies for the future.

# Energy Mechatronics 2: Energy technology lab course

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 53 |
| Modul title: | Energy Mechatronics 2: Energy technology lab course |
| Module responsible: | Prof. Dr. Christoph Ziegler |
| Language of lecture: | english |
| Typ of module: | Compulsory elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | Measurement technologies on energy systems:<br>Electrochemical and solar energy<br>- Lithium ion batteries<br>- Fuel cells and flow cells<br>- Supercapacitors<br>- Solar cells and panels<br>Turbo machines<br>- Airfoils in the wind tunnel<br>- Model fan of axial design<br>- Centrifugal compressor<br>- Model of a bulb turbine (Kaplan principle)<br>- Small gas turbine |
| Courses: | Energy Technology Lab Course |
| Teaching and learning forms: | Practical Lab Course |
| Prerequisites for participation: | Mechatronics 1, Science 1, Maths 1 |
| Applicability of the module: | Subsequent modules with focus on energy mechatronics |
| Prerequisites allocation ECTS: | RPA |
| ECTS credits: | 5 |
| Grading: | ungraded |
| Workload: | 150h (30h per ECTS for lab course preparation, execution and follow-up) |
| Duration of the module: | two semester |
| Frequency of offering: | Every semester |
| Literature: | Experiment descriptions;<br>Schwister, K., Leven, V., Process Engineering for Engineers, Hanser<br>Bockhardt, H.-D., Güntzschel, P., Poetchukat, A., Fundamentals of Process Engineering for Engineers, 4th ed., Wiley-VCH, 1997, |

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| Compulsory attendance: | no |

# Competence dimensions Energy Mechatronics 2: Energy technology lab course

## Knowledge and understanding: Deepening of individual components of knowledge

Graduates can understand the theoretical relationships in energy systems and comprehend and understand operating behavior in experimental test stands.

## Use, application and generation of knowledge/art: Use and transfer

Graduates can investigate thermodynamic relationships in experiments, operate some basic energy engineering operations in practice. They know the practice of measurement process engineering relationships, can apply theoretical concepts from the lecture in practice and present the implementation and results of the tests in protocols. Graduates can apply the contents of the entire course to a given practical task.

## Communication and cooperation

The lab course is organized in small teams. Graduates can co-operate and communicate to complete technically relevant experimental tasks.

## Scientific / artistic self-image and professionalism

# Energy Mechatronics 3: Renewable Energy and Energy Storage

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 54 |
| Modul title: | Energy Mechatronics 3: Renewable Energy and Energy Storage |
| Module responsible: | Prof. Dr. Christoph Ziegler |
| Language of lecture: | english |
| Typ of module: | Compulsory elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | Renewable Energy Systems:<br>- Solar thermal energy<br>- Photovoltaics<br>- Wind energy<br>- Biomass<br>- Geothermal energy<br>- Fundamentals of Energy Storage<br>- Thermal energy storage<br>- Biogas<br>- Electrochemical energy Storage |
| Courses: | Renewable Energy, Energy Storage |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | Mechatronics 1, Science 1, Maths 1 |
| Applicability of the module: | Subsequent modules with focus on energy mechatronics, renewable energy and energy storage |
| Prerequisites allocation ECTS: | K90 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Winter semester only |
| Literature: | Godfrey Boyle , "Renewable Energy: Power for a Sustainable Future"<br>Alexander V. Dimitrov, "Introduction to Energy Technologies for Efficient Power Generation"<br>Lecture script |
| Compulsory attendance: | no |

# Competence dimensions Energy Mechatronics 3: Renewable Energy and Energy Storage

## Knowledge and understanding: Broadening of prior knowledge

The students can understand the basics of the most common current and future forms of renewable energy and energy storage. They build up their understanding in the areas of renewable energy technologies with increasing share and the current and future options for energy storage.

## Use, application and generation of knowledge/art: Use and transfer

Graduates can apply their knowledge practically the area of renewable energy and ergy storage

## Communication and cooperation

Graduates can present and discuss the concepts of renewable energy and energy storage in a communicative way.

## Scientific / artistic self-image and professionalism

# Photonics 1: Engineering Optics

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 56 |
| Modul title: | Photonics 1: Engineering Optics |
| Module responsible: | Prof. Dr. sc. techn. Michael Pfeffer |
| Language of lecture: | english |
| Typ of module: | Compulsory elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | Optical quantities and their formula symbols<br>1. Light, light propagation and optical imaging<br>- Properties of light<br>- Wave optics (characteristics of waves, propagation of waves, the principle of Huygens, interference, diffraction, refraction, reflection, transmission of radiation through matter, coherence, polarization)<br>- Quantum optics<br>- Optical imaging (requirements for images, types of images, gaussian optics, paraxial domain, characteristics of optical systems, imaging with optical systems)<br>2. Imaging components<br>- Materials<br>- Plane surfaces, plane plates, reflection prisms and beam splitters<br>- Prisms with beam deflection by refraction<br>- Spherical surfaces, lenses, multilevel systems in the Gaussian domain<br>- Single lenses and systems in air<br>- Thin lenses<br>- Aberrations<br>- Special lens shapes<br>- Beam path in the non-paraxial region<br>- Reflex reduction<br>3. Bundle limitation<br>4. Specification of optical elements according to ISO 1010 |
| Courses: | Photonics 1 with exercises |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | Science 1-2 |
| Applicability of the module: | Subsequent modules with focus on photonics |
| Prerequisites allocation ECTS: | M |
| ECTS credits: | 5 |
| Grading: | graded |

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|---|---|
| Workload: | |
| Duration of the module: | one semester |
| Frequency of offering: | Summer semester only |
| Literature: | Eugene Hecht: "Optics - Global edition", Pearson Education; 5. Edition (5th December 2016);<br>Bahaa E. A. Saleh, Malvin Carl,Teich: "Fundamentals of Photonics: 2 Volume Set" (Wiley Series in Pure and Applied Optics), John Wiley & Sons Inc; 3. Edition (19th January 2019);<br>Wiley-VCH; 1. Edition (12th July 2016);<br>Herbert Groß; "Handbook of Optical Systems, 5 Volume Set" Wiley-VCH; 1. Edition (12th July 2016);<br>Max Born, Emil Wolf: "Principles of Optics: 60th Anniversary Edition" Cambridge University Press; 7.Edition (19th December 2019); |
| Compulsory attendance: | no |

# Competence dimensions Photonics 1: Engineering Optics

## Knowledge and understanding: Broadening of prior knowledge

Graduates can explain the basics of engineering optics and are able to specify an optical element.

## Use, application and generation of knowledge/art: Use and transfer

Graduates are able to design, calculate and represent an optical element graphically.

## Communication and cooperation

Graduates can explain the basics of engineering optics and corresponding problems and discuss them in groups in a solution-oriented manner.

## Scientific / artistic self-image and professionalism

Graduates know the importance of optics for their future field of action. They can identify new areas of application and development opportunities.

# Photonics 2: Machine Vision

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 57 |
| Modul title: | Photonics 2: Machine Vision |
| Module responsible: | Prof. Dr. Jörg Eberhardt |
| Language of lecture: | english |
| Typ of module: | Compulsory elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | Machine Vision is a field that seamlessly combines computer science, optics, and image processing to enable machines to interpret and understand visual information. This module covers the following key topics:<br>1. Introduction to Machine Vision<br>- Definition and importance of machine vision in various industries.<br>- Comparison with human vision and its limitations.<br>2. Image Formation and Acquisition:<br>- Basics of optics and light interaction with objects.<br>- Sensors and cameras: types, resolution, and image formation process.<br>3. Image Representation and Processing:<br>- Pixel representation and color models<br>- Image filtering<br>- Edge detection<br>- Object detection<br>4. 3D Vision and Depth Perception:<br>- Depth sensing techniques: stereo vision, structured light, and time-of-flight.<br>- Applications in robotics, quality control, and augmented reality.<br>5. Challenges and Future Trends:<br>- Handling variations in lighting, viewpoint, and environmental conditions.<br>- Role of neural networks in image classification and segmentation |
| Courses: | Machine Vision |
| Teaching and learning forms: | Lectures with exercises and programming lab |
| Prerequisites for participation: | Science 1-2, Computer Science 1-3, Maths 1-3 |
| Applicability of the module: | Subsequent modules with focus on machine vision and photonics |
| Prerequisites allocation ECTS: | PF (K60 and practical work) |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |

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|---|---|
| Duration of the module: | one semester |
| Frequency of offering: | Winter semester only |
| Literature: | Computer Vision: Algorithms and Applications by Richard Szeliski<br>Digital Image Processing by Rafael C. Gonzalez and Richard E. Woods<br>Machine Vision by David Vernon<br>Computer Vision: Models, Learning, and Inference by Simon J.D. Prince |
| Compulsory attendance: | no |

# Competence dimensions Photonics 2: Machine Vision

## Knowledge and understanding: Broadening of prior knowledge

Graduates have knowledge of 2D and 3D cameras, as well as lighting and imaging techniques. Graduates can name the components of the cameras and describe how they work.

## Use, application and generation of knowledge/art: Use and transfer

Graduates are capable of utilizing the techniques and procedures acquired in this module to analyze images captured by cameras.

## Communication and cooperation

Graduates have the ability to present the methodologies and steps acquired in this module. They can engage in discussions about aspects of machine vision and their associated limitations.

## Scientific / artistic self-image and professionalism

Graduates can reflect the importance of machine vision for their professional field of activity.

# Photonics 3: Optoelectronics

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 58 |
| Modul title: | Photonics 3: Optoelectronics |
| Module responsible: | Prof. Dr. sc. techn. Michael Pfeffer |
| Language of lecture: | english |
| Typ of module: | Compulsory elective module |
| Undergraduate/Major: | Main studies |

| | |
|---|---|
| Module Content: | 1. Introduction/classification of optoelectronics<br>2. Semiconductor physical aspects (band model, technological aspects, new materials)<br>3. Optoelectronic light sources<br>•Electroluminescence, LEDs<br>o Principle<br>o Power density spectrum<br>o Output power<br>o Modulation<br>•Semiconductor lasers<br>•Optoelectronic displays<br>4. Fibre optic amplifiers<br>•Introduction<br>•Erbium fibres<br>5. Optoelectronic receivers<br>•Simplest receiver<br>o Transimpedance stage<br>•PN photodiode<br>o Basic structure photodiode, PN junction<br>o Photocurrent Iph<br>o Characteristic curve of a photodiode<br>•PIN photodiode<br>o Dynamic behaviour of PIN photodiodes<br>o PIN diodes as heterostructure photodiodes<br>•Avalanche photodiodes (APD)<br>•Optocouplers<br>•Light barrier<br>6. Noise in photodiodes<br>•Power spectral density<br>•Definition of power density<br>•Sum of individual events<br>•Generalisation<br>•Shot noise of the photocurrent<br>o Photocurrent due to absorption of single particles<br>o Interpretation<br>•Thermal noise of resistors<br>•Additional noise in avalanche photodiodes<br>•Lumped model of photodetectors with noise sources<br>7. Wave propagation in optical fibres<br>•Step index fibre<br>o Wave equation<br>o LP mode fields for step index fibre<br>o fundamental mode<br>o guided modes, radiation modes and leakage waves |

| | |
|---|---|
| | 8. Properties of fused silica fibres<br>•Attenuation mechanisms<br>o Absorption in SiO2<br>o Scattering<br>o Attenuation by impurities<br>•Curvature losses<br>9. Non-linearities in optical fibres<br>•Introduction<br>•Pulse propagation in the presence of the Kerr effect<br>10. Fibre optic transmission systems<br>•Binary intensity modulation and bit error rate<br>•power balance and rise time balance<br>•Attenuation and dispersion limited transmission systems<br>•WDM systems |
| Courses: | Photonics 3 with exercises |
| Teaching and learning forms: | Lectures with exercises |
| Prerequisites for participation: | Photonics 1 and Photonics 2 |
| Applicability of the module: | Subsequent modules with focus on photonics |
| Prerequisites allocation ECTS: | K90 |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | ca. 50h lectures, ca. 100h self-study (lecture preparation and follow-up, exam preparation) |
| Duration of the module: | one semester |
| Frequency of offering: | Summer semester only |
| Literature: | Safa Kasap:"Optoelectronics & Photonics: Principles & Practices: International Edition", Pearson; 2. Edition (13th February 2013),<br>Emmanuel Rosencher: "Optoelectronics", Cambridge University Press; Illustrated Edition (30th May 2002),<br>Xun Li : Optoelectronic Devices: Design, Modeling, and Simulation Cambridge University Press; 1. Edition (11th June 2009) |
| Compulsory attendance: | no |

# Competence dimensions Photonics 3: Optoelectronics

## Knowledge and understanding: Deepening of individual components of knowledge

Graduates have expanded their knowledge in the following areas and can also reproduce this knowledge:
Fundamentals of semiconductor physics (band model, optoelectronic materials), optoelectronic light sources, optoelectronic receivers, light propagation in waveguides, optical fibre types (step index fibres, single-mode, multi-mode, GRIN), attenuation and noise effects in optoelectronic components.

## Use, application and generation of knowledge/art: Use and transfer

Based on the optoelectronic components mentioned above, graduates are able to analyse, engineer and dimension a simple optoelectronic.

## Communication and cooperation

Graduates can explain the basics of optoelectronics and corresponding problems and discuss them in groups in a solution-oriented manner

## Scientific / artistic self-image and professionalism

Graduates know the importance of optoelectronics for their future field of action. They can identify new areas of application and development opportunities.

# Diversification Module

| | |
|---|---|
| Course of study: | Mechatronics |
| Degree: | Bachelor of Engineering (B.Eng.) |
| Modul number: | 59 |
| Modul title: | Diversification Module |
| Module responsible: | Dean of studies |
| Language of lecture: | english |
| Typ of module: | Compulsory elective module |
| Undergraduate/Major: | Main studies |
| Module Content: | The study course Mechatronics offers individual profile specializations that reflect modern job profiles. The students have to choose one with the re-immatriculation for the 4th semester. The number of offered specializations can depend on the number on enrolled students and availability of resources. The currently offered specializations will be decided in the faculty council and will be announced in due time. Each profile specialization offers one diversification module. This allows students to choose one module from the list of the other profile specializations to gain knowledge and skills in areas beyond their specialization choice.<br>§ 52 Bachelor Study Program Mechatronics (3) |
| Courses: | |
| Teaching and learning forms: | |
| Prerequisites for participation: | |
| Applicability of the module: | |
| Prerequisites allocation ECTS: | |
| ECTS credits: | 5 |
| Grading: | |
| Workload: | |
| Duration of the module: | |
| Frequency of offering: | |
| Literature: | |
| Compulsory attendance: | no |

# Competence dimensions Diversification Module

## Knowledge and understanding: Broadening of prior knowledge

## Use, application and generation of knowledge/art: Use and transfer

## Communication and cooperation

## Scientific / artistic self-image and professionalism

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