Module Handbook / Modulhandbuch

Engineering, B. Sc.

Faculty of Technology and Bionics

Kleve

[29.01.2025]

Table of Contents

Module name:	**Mathematics 1**
Module Code:	3000
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr. A. Kehrein
Lecturer:	Prof. Dr. A. Kehrein, Prof. Dr. A. Struck
Language:	English
Part of focus field:	Core
Timetabled hours:	Lecture: 4 HPW Exercise: 2 HPW
Workload:	90 h attendance 90 h preparation and review
Credits:	6
Recommended prerequisites:	Highschool Mathematics: Algebra, Exponential function and Logarithm, Trigonometry
Required prerequisites:	-
Module objectives:	Students are able to gain knowledge in various ways and learn to organize their work. Students understand basic mathematical concepts and know how to apply standard mathematical methods. They are able to visualize mathematical objects and to interpret mathematical symbols and formulas. They have learned to think, to work and to express themselves with precision. Also they have acquired a feeling for handling numbers. They possess the skills to solve problems on their own and to verify the solutions. They are able to apply numerical as well as graphical solution methods to various tasks. The students will possess general problem-solving skills beyond the simple application of standard procedures.
Content:	• Numbers: irrational numbers and the difficulties associated with their representation on a pocket calculator or computer, complex numbers and the Fundamental Theorem of Algebra • Systems of linear equations: Gaussian elimination • Vector algebra and analytic geometry: linear combinations, scalar and vector products, lines and planes • Limits: concept and computation, continuity, bisection method • Differential calculus: definition of derivative, rules of differentiation, tangent, Newton’s method, monotonicity and concavity • Integral calculus: inversion of differentiation – indefinite integral, area calculation – definite integral, • Fundamental Theorem of Calculus
Assessment:	Lecture: Written examination Exercise: Attestation
Literature, Resources:	1. James Stewart (2011). *Calculus. Metric International Version.* 7th edition. Brooks/Cole

	2. James Stewart, Lothar Redlin, Saleem Watson (2012). Algebra and Trigonometry. 3rd international edition. Brooks/Cole [to catch up on high school mathematics] 3. Rhine-Waal Moodle Course “Preparatory Course: Mathematics”

Module name:	**Mathematics 2**
Module Code:	3001
Degree:	Engineering, B. Sc., B. Sc. Biomaterials
Module coordinator:	Prof. Dr. A. Kehrein
Lecturer:	Prof. Dr. A. Kehrein, Prof. Dr. A. Struck
Language:	English
Part of focus field:	Core
Timetabled hours:	Lecture: 4 HPW Practical Training: 2 HPW
Workload:	90 h attendance 90 h preparation and review
Credits:	6
Recommended prerequisites:	3000 Mathematics 1
Required prerequisites:	
Module objectives:	Students are introduced to mathematical concepts and methods beyond high-school level, in particular, matrices, infinite series, multivariate functions, and ordinary differential equations. By participating actively in the exercises students practice to communicate in precise mathematical terms and their problem-solving skills.
Content:	• Integral calculus: substitution rule, integration by parts, partial fraction decomposition, improper integrals • Linear algebra: matrices, determinants, inverse matrix, eigenvalue problems • Series: approximations using partial sums, convergence and divergence tests, power series, Taylor series • Differential calculus of several variables: partial derivatives, gradient, extrema • Ordinary differential equations: direction field, separating variables, linear differential equations of first and second order
Assessment:	Lecture: Written examination Exercise: Attestation
Literature, Resources:	• James Stewart (2016): *Calculus*. Metric International Version. 8th edition. Brooks/Cole • [Video Lectures] Mattuck, Arthur, Haynes Miller, Jeremy Orloff, and John Lewis. *18.03SC Differential Equations, Fall 2011*. (Massachusetts Institute of Technology: MIT OpenCourseWare), http://ocw.mit.edu (Accessed 08 May, 2013). License: Creative Commons BY-NC-SA • [Video Lectures] Strang, Gilbert. *18.06SC Linear Algebra, Fall 2011*. (Massachusetts Institute of Technology: MIT

	OpenCourseWare), http://ocw.mit.edu (Accessed 08 May, 2013). License: Creative Commons BY-NC-SA

Module name:	**Project Management**
Module Code	3002
Degree:	Engineering, B. Sc.
Module coordinator:	Dirk Untiedt
Lecturer:	Dirk Untiedt
Language:	English
Part of focus field:	Core
Timetabled hours:	Lecture: 1 HPW Practical Training: 1 HPW
Workload:	30 h attendance 60h preparation and review
Credits:	3
Recommended prerequisites:	-
Required prerequisites:	-
Module objectives:	After successful completion of this module: • Students know the essential terms, methods and tools of project management. • After finishing this module, students will appreciate the need for project planning and are able to distinguish between project objectives and functional goals. They are able to define and document the objectives of a project. Depending on the type of project, they are able to design a suitable project structure and plan of execution. They are able to estimate project risks using a set of tools to analyse the project execution based on time and content and to communicate and document results by creating informative target group oriented presentations.
Content:	• Projects as a modern form of working • Comparison of Project and Line Management • Challenges of Project Management • Differentiation and contents of projects • Project phases • Developing project objectives (SMART) • Documentation: brief description of the project, project proposal • Project organisation • Embedding projects in existing organisations • Typical project organisation form • Role descriptions of project committees • Stakeholder Management • Analysis of influence and demand • Developing a strategy and action plan for targeted con-tact • Project Planning • Milestones and activities

	• Project structure plan • Network Techniques • Critical Path Method (CPM) • Programme Evaluation and Review Technique (PERT) • Risk Management • Strategies for handling risks • Continuous risk assessment • Change Management within the project • Project Documentation and Reports • Reports for different recipients • Planning of project meetings • Handling expectations
Assessment:	Lecture: Attestation Practical Training: -
Forms of media/ Software	Moodle, MS Project
Literature:	• Pinto, Jeffrey K.: Project Management – Achieving competitive Advantage, 5th Edition, Pearson, 2019

Module name:	**Personal and Social Competence**
Module Code	3003
Degree:	Engineering, B. Sc.
Module coordinator:	Anja Viermann
Lecturer:	A. Viermann D. Ziegler (external lecturer for part creativity & innovation)
Language:	English
Part of focus field:	All focus fields
Timetabled hours:	Seminar: 6 HPW
Workload:	75 h attendance 105 h preparation and review 180h total
Credits:	6
Recommended prerequisites:	none
Required prerequisites:	none
Module objectives:	The aim of this module is to support students in developing and expanding a framework of personal and social competences and to sensitise them to the need for continuous, lifelong personal development in this area. Core competencies that form an important basis for employability and success in any future professional context as an individual or as a member of a team or organisation.
Content:	For this purpose, students are given access to the necessary knowledge, methods and skills in various learning units and "experience spaces" in direct interaction with other students. An appropriate framework for individual and collective learning, application, experience and reflection is provided both within and outside the courses (e.g. supplementary online lectures and assignments, independent work in various teams on specified semester tasks). The learning, experience and competence-building processes are supported by the lecturer, including moderated feedback loops in various phases of the semester. Content contributing to the core competencies addressed: <u>Social Competence:</u> Communication Competence: • “The First impression” • Filters forming perception, thinking, reactions and behaviour • Active listening and levels of communication • Basic insights into negotiation, dealing with conflicts, presentation techniques Cooperation Competence: • Teamwork: team roles & team process • First insights into methods of “Facilitation” Diversity and Intercultural competence: • Human nature dealing with differences • Impact and potential of diversity; incl. bias effects

	• Diversity in organizational and business context • Term and nature of ‘CULTURE’; culture building processes • Impact of culture on any form of human group forming process as common base of collective values & beliefs, thinking, perception and (re)action patterns and rules (Group, Organizational and National Culture) <u>Personal Competence:</u> Self-Competence • Mindfulness • Self-awareness - Self- reflection; incl. dealing with feedback • Dealing with stress Flexibility & Adaptability Competence • Change: human mechanisms & coping strategies • Adaptation to different roles, responsibilities, and context and change priorities and direction, if needed • Ambiguity tolerance Creativity & Innovation Competence • Term and importance of creativity & innovation • Repertoire of methods and strategies that support creative processes and know-how and to build a supportive work environment and innovative climate to make best use of creative potentials. Analytical & Critical Thinking • Exploring, application and critical reflection on scientific models, concepts and approaches (e.g. Hofstede: Cultural Dimensions, Oberg: Cultural Shock Model). • Adopt systemic thinking by exploring and integrating different perspectives and interdependencies Integrity and Work Ethics • Appreciate transparency, honesty and work ethic and apply them in relationships and in their own work • Admit faults and seek guidance if needed • open-minded and accountable for own actions • Be reliable and trustworthy • motivation and commitment to task
Assessment:	Attestation: • Active participation in learning & "experiential spaces" in classroom in presence (attendance) 50% • Working in diverse team on semester assignments (partly outside of class): preparation, submission written assignment (term paper); presentation in class (50%)
Literature:	De Bono, Edward: Serious Creativity, (2015, Vermilion // Trade Paperback) Gardenswartz, Lee et al.: Diverse Teams at Work: Capitalizing on the Power of Diversity (2002, Society for Human Resource Management) Hofstede, Geert et al.: Cultures and Organizations; Software of the Mind (2010, Mcgraw-Hill) Keeley, Larry Ten Types Of Innovation, (2013, Wiley) Lewis, Richard: When cultures collide – Leading across cultures (2006, Brealey Publishing) Michalko, Michael: Thinkertoys, (2006,Ten Speed Press)

	Trompenaars, Fons: Riding the Waves of Culture, (2012, Brealey Publishing) Van Aerssen, B. et al: The Innovator's Dictionary, (2018, Vahlen) V9. on Oech, Roger: A Kick In The Seat Of The Pants, (1986, Warner Books) Wolff, Jurgen: CREATIVITY NOW, (2012, Pearson Interna tional) Supplemental readings, e.g. additional literature, exercises, cases and other learning materials will be provided during class.

Module name:	**Group Project**
Module Code	3004
Degree:	Engineering, B. Sc.
Module coordinator:	Dirk Untiedt
Lecturer:	div.
Language:	English
Part of focus field:	Core
Timetabled hours:	Lecture: 0 HPW Project: 6 HPW
Workload:	90 h attendance 150 h preparation and review
Credits:	8
Recommended prerequisites:	-
Required prerequisites:	Project Management AND ALL Core Moduls from semester 1 and 2.
Module objectives:	Students work on solutions for a given task in teams (in exceptional cases individually). For this, students create a functional specifications document and calculate project costs and necessary capacities. They present their self-de-signed concepts to their clients and are able to defend these concepts. Students react constructively to suggestions and criticism and further develop their approaches into a marketable product. They determine implementation and product costs and are able to estimate market potentials. Students decide on purchase of material and components. Apart from content-related processing, students also master documenting and presenting the results and thereby interact with potential customers.
Content:	Group work supported by lecturers in presence
Assessment:	Lecture: Attestation Practical Training: -
Forms of media/ Software	Moodle
Literature:	• None

Module name:	**Electrical Engineering 1**
Module Code	3005
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. G. Gehnen
Lecturer:	Prof. Dr.-Ing. G. Gehnen
Language:	English
Part of focus field:	Electronics, ICT
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Practical Training: 1 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	School knowledge in Physics and Mathematics
Required prerequisites:	-
Module objectives:	Students are able to apply the fundamental laws of Electrical Engineering. They are able to analyse networks of passive linear components as well as to calculate currents and potentials in these networks. They are able to calculate transient processes in capacitors and inductances by means of ordinary differential equations. Additionally, they have knowledge of Alternating Currents insofar as they are able to perform simple calculations of currents, potentials and impedances with complex numbers. They are able to understand poly-phase systems. In doing so they are able to label and to estimate frequency-dependent behaviour of a circuit. They know the dangers originating from electric current. The learned abilities are trained in the exercise and attested in accompanying tutorials and in the laboratory.
Content:	• General introduction to Electrical Engineering, historical backgrounds • Electrostatics: atoms, electrons and charge • Coulomb‘s law • Current as charge movement • Electric potential and voltage • Resistors, Ohm’s law • Electric safety • Series and parallel circuit of resistors • Kirchhoff’s laws • Electric power and energy • Superposition principle • Thevenin’s theorem, alternative sources • Fundamentals of capacitors

	• Transient processes at capacitors • Induction law • Inductivities and their relation to capacitors • Transient processes at inductivities • Fundamentals of alternating currents engineering • Calculating with complex numbers in alternating currents engineering, basics of phasor diagrams • Root mean squares and peak values • Calculation of impedance and admittance • Networks in complex notation, application of phasor diagrams • Energy and power in alternating current networks • Polyphase systems • Frequency-dependent behaviour
Assessment:	Lecture / Exercise: Written examination Practical Training: Attestation
Literature, Resources:	• R.L. Boylestad: Introductory Circuit Analysis, 12th Edition, Pearson, 2010 • T.L. Floyd D.M. Buchla, Electronics Fundamentals, 8th Edition, Person, 2010 • G. Hagmann: Grundlagen der Elektrotechnik, 15. Auflage, AULA Verlag, 2011 • G. Hagmann: Aufgabensammlung zu den Grundlagen der Elektrotechnik, 14. Auflage, AULA Verlag, 2010 • Course materials from the lecturer • Laboratory documents and Exercises from the lecturer

Module name:	**Electrical Engineering 2**
Module Code	3006
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. G. Gehnen
Lecturer:	Prof. Dr.-Ing. G. Gehnen
Language:	English
Part of focus field:	Electronics, ICT
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Practical Training: 1 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3005 Electrical Engineering 1
Required prerequisites:	-
Module objectives:	Students are able to analyse networks of passive linear components as well as to calculate currents and potential differences in these networks using advanced methods. They can analyse a static electric field as a vector field, and can calculate the electrical potential as a property of the vector field. They are able to analyse simple electric flow fields and to calculate resistances from first principles. From the underlying principle of magnetism they are able to deduct some properties of inductors. Students are able to apply and validate the learned methods using simulations. Students have knowledge of alternating current circuits and can calculate currents, potential differences and impedances with complex numbers and using phasors. In doing so they are able to calculate the frequency-dependent behaviour of a circuit. They know the response of a circuit to non-Sinusoidal signals. Also they are familiar with three-phase circuits and star-delta transformations. They are able to distinguish between a feed-forward and a feedback control systems and they are able to identify problems where feedback controls are needed The students are familiar with basic types of the feedback control strategy The learnt abilities are trained and tested in an accompanying exercise and in the lab
Content:	• Temperature dependent properties of different materials

	• Node Potential and Mesh Current Analysis • Stationary electrical flow fields • Magnetism • Advanced Application of Capacitors and Inductors in DC Circuits • Circuit simulation with SPICE • AC circuit engineering • Calculating with complex numbers in AC circuit engineering, pointer indication • Networks in complex notation, phasor • Energy and power in AC networks • Frequency-dependent behaviour • Locus curves • Non Sinusoidal Signals • Transformers • Three phase networks • Triangle and star circuits • Transformation of three phase systems • Single dynamic system • Feed-forward control vs. Feedback control • Fundamentals types of feedback loops
Assessment:	Lecture / Exercise: Written examination Practical Training: Attestation
Literature, Resources:	1. R.L. Boylestad: Introductory Circuit Analysis, 12th edition, Pearson, 2010 2. G. Hagmann: Fundamentals der Elektrotechnik (Fundamentals of Electrical Engineering), 15th edition, AULA Verlag, 2011 3. Nise, Norman S.: Control Systems Engineering. 2011, John Wiley & Sons. ISBN 978-0-470-64612-0 Further Readings: 4. Allan R. Hambley, Electrical engineering: principles and applications, 6. ed., internat. ed., Pearson, 2014 5. G. Hagmann: Aufgabensammlung zu den Grundlagen der Elektrotechnik (Set of exercises regarding Fundamentals of Electrical Engineering), 14th edition, AULA Verlag, 2010 6. Course materials from the lecturer 7. Laboratory documents and exercises from the lecturer

Module name:	**Digital Electronics**
Module Code	3007
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr. R. Hartanto
Lecturer:	Prof. Dr. R. Hartanto Prof. Dr.-Ing. I. Volosyak
Language:	English
Part of focus field:	Electronics, ICT
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Practical Training: 1 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3005 Electrical Engineering 1
Required prerequisites:	-
Module objectives:	After successful completion of this module, students able to • perform binary arithmetic • create circuits to add and subtract binary numbers using logic gates and the theorems of Boolean algebra • aided by Karnaugh maps, they can create logic functions according to requirements and assemble them in specific links • simplify or represent digital circuits using equivalent logic gates • create typical combinational circuits and storage circuits for technical applications • analyse VHDL program • create and design digital circuits using FPGA with VHDL • recognize the typical characteristics of digital circuits which use TTL and CMOS circuit techniques
Content:	• The numeric system in binary representation • Digital addition and subtraction • Logic gates and switching algebra • Karnaugh maps • Technical realisation of digital circuits • TTL and CMOS • Combinational circuits • Asynchronous and synchronous circuit engineering • Storage circuits • FPGA programming using VHDL
Assessment:	Lecture / Exercise: Written examination Practical Training: Attestation

Literature, Resources:	T. Floyd: Digital Fundamentals, a systems approach, Pearson, 2012 Further Readings: Klaus Fricke: Digitaltechnik (Digital Technology), Vieweg+ Teubner, 2009 Jan M. Rabaey, Digital Integrated Circuits, Prentice Hall, 2002 Ronald J. Tocci: Digital Systems: Principles and Applications, Prentice Hall, 2010 John F. Wakerly: Digital Design: Principles and Practices, Addison Wesley, 2006

Module name:	**Analog Electronics**
Module Code	3008
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. G. Gehnen
Lecturer:	Prof. Dr.-Ing. G. Gehnen
Language:	English
Part of focus field:	Electronics, ICT
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Practical Training: 1 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3006 Electrical Engineering 2
Required prerequisites:	3005 Electrical Engineering 1
Module objectives:	Students know the fundamental conduction mechanisms in semiconductors and the effects that occur by connecting different types of semiconductors. Based on this, they can describe the functional principle of diodes and transistors. They master the basic circuits of diodes and transistors and are able to calculate the proportions of current and voltage using curves and empirical formulae. They are able to design and to analyse circuits containing operational amplifiers. They know the frequency behaviour of semiconductor components and operational amplifiers and are therefore able to make corresponding assessments for practical application. Based on this knowledge, students are able to estimate the frequency behaviour of circuits as well as to apply the related effects specifically for the operation of oscillating circuits.
Content:	• Semiconductors: Structure and conduction mechanisms • Doping of semiconductors • p-n junction and diodes • Applications of diodes • Special forms of diodes: Z-diodes, Schottky-diodes, LEDs • Bipolar transistors, fundamentals and characteristics • Basic transistor circuits • Field effect transistors • Fundamentals of operational amplifiers • Op amp circuits • Frequency-dependent behaviour: Oscillators, timers, and filters • Voltage conversion with linear control systems and clocked circuits

Assessment:	Lecture / Exercise: Written examination Practical Training: Attestation
Literature, Resources:	1. R. L. Boylestad, L. Nashelsky: Electronic Devices and Circuit Theory, 10th edition, Pearson, 2009 2. Horowitz, Hill: The Art of Electronics 3rd edition, Cam-bridge University Press; 2015 Further Readings: 3. M. Rashid: Microelectronic Circuits, 2nd edition, Cengage Learning, 2011 4. Tietze, Schenk: Halbleiterschaltungstechnik (Semi-conductor circuit Technology), Springer Verlag, 2010 5. Course materials from the lecturers 6. Laboratory documents and exercises from the lecturers

Module name:	**Microcontrollers**
Module Code	3009
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. I. Volosyak
Lecturer:	Prof. Dr.-Ing. I. Volosyak
Language:	English
Part of focus field:	Electronics, ICT
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3005 Electrical Engineering 1 3007 Digital Electronics
Required prerequisites:	3033 Programming
Module objectives:	Based on data types bit and byte, students master the typical data representation in microcontrollers. They can label the elements of a microcontroller according to Harvard architecture and show the procedural structures for command processing. They are able to write microcontroller instructions using addressing schemes and the set of commands. They can control data input and output and they know the essential development tools for creating programs for microcontrollers (C programming language).
Content:	• Data representation in bits and bytes • Princeton and Harvard architecture • CPU components • Instruction coding and addressing • Data storage • Input and output systems • Development tools
Assessment:	Lecture: Written examination Practical Training: Attestation
Literature, Resources:	1. Ivan Volosyak: Microchip AVR Programming using ATmega Microcontrollers: with Answers, 2021. 00/TXU102 2. E. Williams: Make: AVR Programming, O'Reilly and Associates, 2014. 00/TWG33

Module name:	**Signal Processing**
Module Code	3010
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. C. Budelmann
Lecturer:	Prof. Dr.-Ing. C. Budelmann Prof. Dr.-Ing. Ivan Volosyak
Language:	English
Part of focus field:	ICT - Information and Communication Technology
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Practical Training: 1 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3001 Mathematics 2 3006 Electrical Engineering 2 3017 Physics for ICT
Required prerequisites:	3000 Mathematics 1 3005 Electrical Engineering 1
Module objectives:	A signal conveys information: Any quantity that can vary over time or space can be used as a signal to share messages between observers. Signal processing focusses on describing, analyzing, modyfying and synthesizing signals. With the techniques teached in this module, students are able to detect components of interest in a measured signal, optimize transmissions, improve digital storage efficiency,and correct distorted transmissions.
Content:	• Fundamentals of signals o Analog and digital signals o Sampling o Quantization o Continuous- and discrete time signals • Linear time invariant systems • Transformations and system analysis o Fourier series and Fourier transformation o Laplace transformation o Z-transformation o Discrete and Fast Fourier Transform • Digital filters o Finite Impulse Response (FIR) filters o Infinite Impulse Response (IIR) filters • Modulation o Analogue modulation methods o Digital modulation methods o Pulse modulation methods
Assessment:	Lecture / Exercise: Written examination

	Practical Training: Attestation
Literature, Resources:	A. V. Oppenheim, A. S. Willsky, S. H. Nawab: Signals and Systems: Pearson New International Edition. Pearson Education Limited, 2013. W. Y. Yang, et al.: Signals and Systems with MATLAB. Springer-Verlag, 2009. R. M. Gray: Entropy and Information Theory. Second Edition. Springer, 2011. T. Frey, M. Bossert: Signal- und Systemtheorie. 2. Auflage. Vieweg+Teubner, 2008. W. Preuß: Funktionaltransformationen. Fourier-, Laplace- und Z-Transformationen. Carl HanserVerlag, 2009.

Module name:	**Metrology and Sensors**
Module Code	3011
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. C. Budelmann
Lecturer:	Prof. Dr.-Ing. C. Budelmann
Language:	English
Part of focus field:	Electronics
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3008 Analog Electronics
Required prerequisites:	3005 Electrical Engineering 1 3015 Physics
Module objectives:	Measurement is a cornerstone of science, trade and technology. But the ability to measure alone is insufficient: standardisation is crucial for measurements to be meaningful. In this module, students get to know metrology, the science of measurement, the principles of testing and various sensor principles. Students are enabled to define, perform, analyse and document measurements and tests. They know the advantages and disadvantages of different sensors and are capable to select the right sensor based on a specific application and can design the whole measurement chain, including sampling and quantization of electrical sensor outputs.

Content:	• Metrology
	  ○ Definition and realisation of units
	  ○ Standards
	  ○ Traceability and calibration
	  ○ Uncertainty
	• Testing
	  ○ Definition and methodology of testing
	  ○ Selected destructive and non-destructive testing principles
	• Sensors
	  ○ Principles of sensors and selection criteria
	  ○ Resistive sensors and strain gauges
	  ○ Capacitive sensors
	  ○ Inductive sensors
	  ○ Thermocouples
	  ○ Piezoelectric sensors
	  ○ Hall effect sensors
	  ○ Optical sensors

	○ Sampling and quantization of electrical sensor outputs ○ Sensor electronics
Assessment:	Lecture: Written examination Practical Training: Attestation
Literature, Resources:	H. Czichos: Measurement, Testing and Sensor Technology. Fundamentals and Application to Materials and Technical Systems. Springer International Publishing, 2018. C. W. de Silva: Sensors and Actuators. Engineering System Instrumentation. Second Edition. CRC Press, 2016.

Module name:	**Embedded Systems**
Module Code	3012
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr. A. Stamm
Lecturer:	Prof. Dr. A. Stamm
Language:	English
Part of focus field:	ICT - Information and Communication Technology
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3009 Microcontrollers
Required prerequisites:	3033 Programming
Module objectives:	Students have a broad knowledge of embedded systems for which the boundary conditions of limited resources and hardware dependencies are valid. In particular, they know the processes of modern embedded systems development. They are able to differentiate embedded systems from cyber-physical systems. Students should be able to name different motivations and the importance of embedded systems in nowadays technology and life of humans. They are able to conceptual understand the hardware development process of embedded. They are able to apply a typical design flow during embedded system development. This will include model definitions, requirements for a model, models of computation, models of communications, and combined models. Students understand concepts for testing embedded software. They are able to write software for embedded systems including the practical implementation and testing of that software on an embedded system. This includes cros/compiling of C Programs. Students are able to specify suitable embedded systems for a given task, to create a suitable software concept for this and to select necessary tools and test environments. They act in a methodical and structured manner in this regard, and use professional tools. Students who have finished this module successfully understand how embedded systems are integrated in an overall system.
Content:	• Characteristics of Embedded Systems • Architecture of Embedded Systems • Challenges during the design phase of Embedded Systems • Real time behaviour, soft and hard real time

	• Design flow • Specifications & Modeling (CFSM, StateCharts, Petri nets) • Event based languages • Von-Neumann model • Comparison of different models • Modeling levels • Embedded Systems Hardware • Embedded Systems Software • Evaluation and Validation • Program implementation: booting, cross-compiling, linking, loading, remote debugging • Hardware abstraction • Failure safety
Assessment:	Lecture: Written examination Practical Training: Attestation
Literature, Resources:	P. Marwedel: Embedded System Design, Springer, 2011 Qing Li, Caroline Yao: Real-Time Concepts for Embedded Systems. CMP Books, 2003. Further Readings: A. Forrai: Embedded Control System Design [A model driven approach], Springer, 2013 Frank Vahid and Tony Givargis: Embedded System Design: A Unified Hardware/Software Introduction. John Wiley & Sons, 2002 Arnold S. Berger: Embedded Systems Design. CMP Books, 2001.

Module name:	**Design and Manufacturing of Electronics**
Module Code	3013
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. C. Budelmann
Lecturer:	Prof. Dr.-Ing. C. Budelmann
Language:	English
Part of focus field:	Electronics
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3007 Digital Electronics 3008 Analog Electronics
Required prerequisites:	3005 Electrical Engineering 1
Module objectives:	Design for manufacturing of electronics is the process to account for manufacturing constraints of electronic devices. The design considers the assembly and testing in order to make the overall manufacturing process more efficient, improve the quality and reduce the risk for production failures. Students get insights into all steps of the design and production processes of electronics as well as computer-aided design tools. They learn how to optimize their design to meet the manufacturing, testing, assembly and procurement requirements (Design for excellence (DfX)).

Content:	• Goals and concept of the design for excellence (manufacturing, testing, assembly, procurement)
	• Sustainable design and manufacturing of electronics
	• Electronic design automation
	  ○ Computer-aided design
	  ○ Computer-aided manufacturing
	• Manufacturing of electronics
	  ○ Printed circuit board production
	  ○ SMT, THT and THR component assembly
	  ○ Soldering
	  ○ Inspection, programming and testing
	  ○ Handling of components and boards
	  ○ Cable assembly
	  ○ Encapsulation and coating
	• Sourcing and obsolescence management of electronic components

Assessment:	Lecture: Written examination Practical Training: Attestation

Literature, Resources:	T. Williams: The Circuit Designer‘s Companion. Fourth Edition. Elsevier Ltd., 2017. IPC-A-610 – Revision H – Standard Only: Acceptability of Electronic Assemblies. IPC, 2020.

Module name:	**Practical Electronics**
Module Code	3014
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr. A. Stamm
Lecturer:	Prof. Dr. A. Stamm
Language:	English
Part of focus field:	Electronics
Timetabled hours:	Lecture: 2 HPW Project: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3013 Design and Manufacturing of Electronics
Required prerequisites:	3008 Analog Electronics 3009 Microcontrollers
Module objectives:	Students will be able to design electronic circuits and implement these as printed circuit boards. It involves PCB design, system and component specification, and design principles including noise reduction, transducers, ergonomics, power supplies, and design for testability. Students are required to complete a practical PCB design and a paper system design as part of their assessment.
Content:	Lecture: • Introduction to circuit design principles • Op-amps • Rectifiers • Resistors, capacitors, inductors • Transformers • PCB design and fabrication • Sensors and transducers • Identifying noise sources and reduction Project: • Students will be meeting their group members outside of lectures and labs to discuss and decide on a project • Each group of students will be required to propose their project and their circuit to the whole class with oral feedback given by the teaching team (10 minutes) • Students have to prepare a presentation and a written report which will be part of the assessment • Students will present the outcomes in class (15 minutes) Labs: • Students will be required to attend the labs and design the desired circuit using a PCB Design software

	• Software training will be provided in class • Implementation of the developed PCB • Assembly of electronic components on the PCB • Development of software for project related tasks (if necessary) • Presentation of a working prototype
Assessment:	Lecture: Written examination Project: Attestation
Literature, Resources:	Notes supplied during lecture and labs Peter Wilson and Tim Williams, *The circuit designer's companion*, Elsevier, 2004

Module name:	**Physics**
Module Code	3015
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr. G. Bastian
Lecturer:	Prof. Dr. G. Bastian
Language:	English
Part of focus field:	Electronics
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Practical Training: 1 HPW
Workload:	60 h attendance 90 h preparation and review 30 h lab report writing
Credits:	6
Recommended prerequisites:	none
Required prerequisites:	none
Module objectives:	Students will be able to explain and understand technological and scientific phenomena using the knowledge learnt. Processes, effects and phenomena can be approached quantitatively and the necessary physical equations for this can be adapted and applied. The ability to set up, execute, analyse and assess physical experiments. Students will be able to present their own results in laboratory reports using appropriate technical terms in English and in digital form. The students are able to work safely in the laboratory using basic laboratory techniques and write lab reports.
Content:	Physical units and measurement errors Mechanics, force, energy, momentum and kinematics Oscillations and waves
Assessment:	Lecture / Exercise: Written examination Practical Training: Attestation
Literature, Resources:	Tipler: Physics for Scientists and Engineers

Module name:	**Drives and Power Electronics**
Module Code	3016
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. Dipl.-Wirt. Ing. R. Schmetz
Lecturer:	Prof. Dr.-Ing. Dipl.-Wirt. Ing. R. Schmetz Dr.-Ing. M. Hellwig
Language:	English
Part of focus field:	Electronics
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Practical Training: 1 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3001 Mathematics 2 3006 Electrical Engineering 2 3015 Physics for Electronics
Required prerequisites:	3000 Mathematics 1 3005 Electrical Engineering 1 3032 Mechanics
Module objectives:	After completion of the module students are able to • perform basic analyses of drivetrains and reduce them to a single equivalent mass inertia • understand the working principles of the most common electric motors and their properties • perform simple calculations and dimensioning tasks regarding electric motors • match the properties of electric motors with the given requirements of drivetrains • describe the most common power semiconductors and their properties and application ranges • perform simple calculations regarding the losses of power semiconductors at operation • understand the fundamentals of electrical energy conversion and inversion and describe the most common energy conversion and inversion circuits • perform simple calculations on power factor correction, rectifiers and buck-, boost- and buck-boost-converters • describe different modulation methods for the actuation of semiconductors in converters and inverters • understand the principle of speed and torque control of electric motors fed by converters and inverters
Content:	• Basics and importance of drive technology and power electronics

	• Methods for analysis (physical basics, motion analysis, mass moment of inertia, reduction of drivetrains to a single equivalent mass inertia, adaption of speed and torque, torque matching, dimensioning of drives) • Electric motors (history, importance, standards, fundamentals, separate, shunt and series wound -excited DC-motors, AC-asynchronous motors, Clarke-Park-transformation, AC-synchronous motors) • Semiconductor devices (basics, types, power modules) • Switch-mode operation of semiconductors (design of currents by pulses, pulse width modulation) • Calculation of losses (ideal versus real semiconductors) • Energy conversion circuits (circuit analysis, power analysis of sinusoidal and non-sinusoidal currents, power factors and their correction, distortions, AC-DC-converters, DC-DC-converters, self-commutated circuits) • Motion control
Assessment:	Lecture / Exercise: Written examination Practical Training: Attestation
Literature, Resources:	De Doncker, R. Lecture Notes Power Electronics - Fundamentals, Topologies, Analysis, 4th edition Institut für Stromrichtertechnik und Elektrische Antriebe (ISEA), Aachen, 2013 ISBN 978-3-943496-00-0 Mohan, N., Undeland, T., Robbins, W. Power Electronics 3rd edition, John Wiley, 2003, ISBN 978-0-471-22693-2 ***Further Readings:*** Automotive Handbook, published by Robert Bosch GmbH, 8th Edition, John Wiley & Sons Ltd., Chichester, 2011 ISBN 978-1-119-97556-4 Hughes, A., Drury, B. Electric motors and drives 4th edition, Elsevier, 2013 ISBN 978-0-08-099368-3

Module name:	**Communication Technology**
Module Code	3018
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr. A. Stamm
Lecturer:	Prof. Dr. A. Stamm Prof. Dr.-Ing. C. Budelmann
Language:	English
Part of focus field:	ICT - Information and Communication Technology
Timetabled hours:	Lecture: 2 HPW Exercise: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3005 Electrical Engineering 1 3006 Electrical Engineering 2 3017 Physics for ICT
Required prerequisites:	-
Module objectives:	Information and communication technology covers information processing and storage as well as the transmission of information over wire, radio, optical, or other electromagnetic systems. In this module, students learn the basic theories, principles and analysis methods of information and communication systems. After successfully passing the module, they are able to design transmission systems and networks, optimize transmissions, improve digital storage efficiency, and correct distorted transmissions. In addition, they know different conceptual communication models and understand the advantages of a structured data flow and hierarchical encapsulation and layering. With the knowledge about the abstractional design of modern communication systems, students are enabled to understand and use also other communication standards than these which are presented in this module.

Content:	• Information theory
	  ○ Information content
	  ○ Entropy and redundancy
	  ○ Source coding
	  ○ Channel coding
	  ○ Cryptographic coding
	  ○ Line coding
	• Fundamentals of networks
	  ○ Data transmission (serial and parallel, synchronous and asynchronous)
	  ○ Topologies in networks
	  ○ Bit rate and baud rate
	  ○ Bandwidth and latency

	○ Media access control and collision handling • Protocols and reference models ○ TCP/IP reference model ○ Hybrid reference model ○ OSI reference model • Physical layer ○ Networking technologies (Ethernet, WIFI, Bluetooth) ○ Transmission media (coaxial cables, twisted pair cables, fibre-optical cables) and devices ○ Encoding • Data link layer ○ Devices and addressing in the data link layer ○ Framing ○ Error-detection and correction codes ○ Media access control methods ○ Flow control • Network layer ○ Devices and addressing in the network layer ○ Forwarding and path determination ○ Routing ○ Internet Protocol (IP) • Transport layer ○ Devices and addressing in the transport layer ○ User Datagram Protocol (UDP) ○ Transmission Control Protocol (TCP) • Application layer ○ Domain Name System (DNS) ○ Dynamic Host Configuration Protocol (DHCP) ○ Selected other application layer protocols • Network virtualisation ○ Virtual Private Network (VPN) ○ Virtual Local Area Networks (VLAN)
Assessment:	Lecture / Exercise: Written examination
Literature, Resources:	C. Baun: Computer Networks / Computernetze. Bilingual Edition: English - German / Zweisprachige Ausgabe: Englisch - Deutsch. Springer Vieweg, 2019. „Computer Networks“, 5th Edition, Andrew S. Tanenbaum, Prentice Hall PTR, 2010 „Computer Networking“, 4th Edition, James F. Kurose und Keith W. Ross, Addison Wesley, 2007 TCP/IP“, W. Richard Stevens, Hüthik, 2004

Module name:	**Networks and Security**
Module Code	3019
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr. R. Hartanto
Lecturer:	Prof. Dr. R. Hartanto, T. Grunenberg
Language:	English
Part of focus field:	ICT - Information and Communication Technology
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Practical Training: 1 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3012 Embedded Systems 3018 Communication Technology
Required prerequisites:	3009 Microcontrollers
Module objectives:	After successful completion of this module, students able to • analyse network structure and its configuration • configure network setting in various forms, subnetting, VLAN, firewall, etc • perform cryptographic tasks, i.e., encryption / decryption, communicate in secure channel • analyse security aspect in a network configuration • recognise typical secure networking configuration
Content:	• Computer Networks • Network Technology • Network Protocols • Network Standardisation • Wireless Network • Network Layer • Basic Cryptography • (Message Integrity) • (Basic key Exchange) • (Public key Encryption) • (Digital Signature) • Secure Channel • (Virtual Private Network) • Typical Network Attacks • Firewall • Networking Tools
Assessment:	Lecture / Exercise: Written examination Practical Training: Attestation

Literature, Resources:	Tannenbaum, N. Feamster, D. Wetherall: Computer Networks, global edition, 6th edition, Pearson, 2021 W. Stallings: Cryptography and Network Security: Principles and Practice (6th edition), Pearson, 2013

Module name:	**Fundamentals of Business and Management**
Module Code	3020
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr. Dirk Berndsen
Lecturer:	Prof. Dr. Dirk Berndsen
Language:	English
Part of focus field(s):	-
Timetabled hours:	Lecture: 3 HPW Class Exercises: 1 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	-
Required prerequisites:	-
Module objectives:	Upon successful completion of this module, students will: • know and understand fundamental economic concepts and relationships in local, national and global market environments • be able to identify key economic actors, understand their interests, and their means of influencing market outcomes, with a focus on business • have a basic understanding of macroeconomic models and economic policy proposals based on them, as well as non-economic societal goals • understand the makeup of different business models and can recognize the strategic rationales for various types of observable business behaviour • acquire a good initial overview and insight into the environment and inner workings of a business organization, focused on manufacturing firms • understand the financing needs of different types of business, and know the most common ways to address them • understand how the performance of an enterprise can be measured and reported • know the basic structure and contents of standard financial reports (Balance Sheets, Income and Cash Flow Statements) as well as non-financial stakeholder reporting • can identify the key functions of a business and understand their regular interactions based on the value chain, with particular emphasis on value creation in a manufacturing firm • can make basic evaluations of a business' performance and sustainability based on information gathered from various reports
Content:	• Markets –participants, structures, market typology and market influences • Decision making in markets, market outcomes and externalities

	• Economic policy – goals, select types of state interventions and their evaluation • Definition and roles of a business • Business models (with special emphasis on manufacturing firms) and value creation • Business objectives, strategy, sustainability and stakeholder impact • Legal environment and legal setups • Financing the business – key concepts, basics of corporate performance management • Financial statements - balance sheet, income statement, statement of cash flow • Non-financial reporting (i.e. CSR,EIA), codes of conduct and compliance • Overview business organization, functions and processes • Marketing and Sales – brief introduction • Purchasing / Procurement – brief introduction • Logistics – brief introduction • Production / Operations – brief introduction • R&D – brief introduction, the role of data-driven innovation • Human Resources – brief introduction • End-to-end business performance assessment (sustainability) and improvements management
Assessment:	Lecture: Written examination, presence only (2h) Exercises: -
Literature:	GRAYSON, David / COULTER, Chris / LEE, Mark (2022): The Sustainable Business Handbook: A Guide to Becoming More Innovative, Resilient and Successful. ISBN 978-1398604049, Kogan Page NICKELS, William G. / McHUGH, James / McHUGH, Susan (2021): Understanding Business. 13th edition, ISBN 978-9814670371, McGraw-Hill PRIDE, William M. / HUGHES, Robert / KAPOOR, Jack R. (2022): Foundations of Business, 7th edition. ISBN 978-0357717943, Cengage Learning OSTERWALDER, Alexander et al. (2015): Value Pro-position Design: How to Create Products and Services Customers Want (Strategyzer). ISBN 978-1118968055, Wiley RIES, Eric (2011): The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. ISBN 978-0670921607, Portfolio Penguin

Module name:	**Accounting**
Module Code	3021
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr. Dirk Berndsen
Lecturer:	Prof. Dr. Dirk Berndsen
Language:	English
Part of focus field(s):	Management, Business Operations
Timetabled hours:	Lecture: 2 HPW Exercises: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	-
Required prerequisites:	-
Module objectives:	Upon successful completion of this module, students will be able to: • Understand and apply the fundamental principles of accounting. • Recognize and navigate basic financial statements including the income statement, balance sheet, and cash flow statement. • Analyze financial statements using various financial accounting ratios • Understand the basic concepts of cost accounting • Analyze and interpret cost accounting data • Use cost accounting information to make better business decisions • Apply cost accounting techniques to real-world scenarios – in particular business decisions, process optimization and project management • Understand the role of accounting and financial vs. non-financial information in business decision-making processes • Make basic assessments of the wider impact and sustainability of business models, decisions and practices
Content:	• Introduction to Accounting Principles and Standards • Recording Business Transactions • Introductions to Financial Statements • Financial Statement Analysis • Basic Cost Accounting • Cost-Volume-Profit Analysis

	• Job Costing and Process Costing • Activity-Based Costing (ABC) • Standard Costing and Variance Analysis • Project Costing • Accounting for Corporate Social Responsibility (CSR), Environment Impact Assessment (EIA), and Strategic Environmental Assessment (SEA) • Fundamentals of Managerial Accounting • Applying Non-Financial Business Performance Indicators • Applying Accounting for Business Sustainability
Assessment:	Lecture: Written examination, presence only (2h) Exercises: -
Literature:	• KNIGHT, John (2019): Accounting: Accounting made simple, basic accounting principles, and how to do your own bookkeeping. ISBN 978-1542385527, CreateSpace • WEYGANDT, Jerry J. / KIMMEL, Paul D. (2022): Financial Accounting with IFRS, 5th edition, ISBN 978-1119787051, Wiley • WEYGANDT, Jerry J. / KIMMEL, Paul D. / MITCHELL, Jill E. (2020): Managerial Accounting: Tools for Business Decision Making, 9th edition, ISBN 978-1119709589, Wiley • RIMMEL, Gunnar (2020): Accounting for Sustainability. ISBN 978-0367478957, Routledge

Module Name:	**B2B Marketing and Sales**
Module Code	3022
Degree	Engineering, B. Sc.
Module coordinator:	Prof. Dr. Dirk Berndsen
Lecturer:	Prof. Dr. Dirk Berndsen
Language:	English
Part of Focus Field(s):	Management
Timetabled hours:	<u>Element 1 - Fundamentals of B2B Marketing</u> Lecture + Exercises: 2 HPW <u>Element 2 - B2B Sales</u> Lecture + Exercises: 2 HPW
Workload:	60 h attendance 45 h preparation and review (3 h per week) 45 h exam preparation =150 h in total
Credits:	6
Required prerequisites:	3020
Recomm. prerequisites:	3021
Module objectives:	Upon successful completion of this module, students will be able to: • understand, apply and analyse the processes and structures necessary for a business to successfully and sustainably sell a product or service to other businesses • know the fundamental concepts of sustainable Marketing as the expression of a market-going strategy aimed at increasing sales by creating customer benefit. • understand the data foundation of Marketing measures in assessing customer preferences and requirements. • apply basic methods of market-oriented research, in particular for b2b markets • contribute meaningfully in the formulation of business propositions in b2b markets • adequately apply the arsenal of marketing measures as collected by the standard 4+P approach. • create their own basic applied Marketing Strategies for new product introductions. • identify the expectations on a b2bSalesperson, their various roles and typical organizational setups for the sales function. • apply data-driven techniques for preparing and analyzing sales interactions • assess Sales Performance and connect it to the overall goals of the business • create and evaluate a basic set of rules and guardrails for Customer Relationship Management.
Content:	<u>Fundamentals of B2B Marketing</u> • Marketing origins and goals • Data foundations – Customer preferences, competitive landscape, market specific constraints • Marketing in the digital environment • Collecting and interpreting market data • Marketing Management – overview

	• Product. Product and Service innovation, customer-oriented design, and lifecycle management • Price. Individual customer pricing, Trade Terms • Promotion. Brand, Marketing Communications, Influencers and Customer Relationships in b2b markets. • Place. Channel options, channel strategy and Sales function roles • Process & People – Extensions of the 4p approach, leading into B2B Sales <u>B2B Sales</u> • Sales function role specified • Sales process • Sales objectives, organizing, managing and motivating Salespeople • Lead Management • Lead requirements and benefits analysis • B2B customer relationships as sustainable joint value creation • Key Account Management • Team Selling and Services integration • End-to-end Sales performance indicators • Sustaining and evolving long term customer relationships for mutual and wider benefit
Assessment:	4-6 individual assignments (continuous assessment)
Literature:	CARVILL, Michelle / BUTLER, Gemma / EVANS, Geraint (2021): Sustainable Marketing: How to Drive Profits with Purpose. ISBN 978-1472979131, Bloomsbury Business HALL, Simon (2022): Innovative B2B Marketing: New Models, Processes and Theory. 2nd edition, ISBN 978-1398604766, Kogan Page JOHNSTON, Mark W. / MARSHALL, Grew W. (2020): Sales Force Management: Leadership, Innovation, Technology. 13th edition ISBN 978-0415534628, Routledge KING, Kim Ann (2015): Complete Guide to B2B Marketing: New Tactics, Tools, and Techniques to Compete in the Digital Economy. ISBN 978-0134084527, Pearson KOTLER, Philip et al. (2023): Principles of Marketing. 19th edition, ISBN 978-1292092621, Prentice-Hall

Module Name:	**Business Performance Management**
Module Code	3024
Degree	Engineering, B. Sc.
Module coordinator:	Prof. Dr. Dirk Berndsen
Lecturer:	Prof. Dr. Dirk Berndsen
Language:	English
Part of Focus Field(s):	Management
Timetabled hours:	Lecture: 2 HPW Exercises: 2 HPW
Workload:	60 h attendance 45 h preparation and review (3 h per week) 45 h exam preparation =150 h in total
Credits:	6
Required prerequisites:	3021 Accounting
Recommended prerequisites:	
Module objectives:	Upon completion of this course, students will be able to: • Understand the role of performance management in achieving business objectives • apply various performance measurement tools and techniques • analyze performance data and identify areas for improvement. • assess the performance of several business units/functions in practical terms using case study data • understand the applications of business intelligence software (including AI variants) to enrich their assessments • connect their assessments to the overall goals of the business as described in the case studies • formulate fact- and business goal-based improvement measures • develop and implement performance improvement / management plans for the areas analyzed earlier
Content:	The course covers the following topics: • Introduction to Business Performance Management • Finance-driven Ratio Analysis vs. multi perspective indicator systems • Key Performance Indicators (KPIs). Examples and Definitions • Balanced Scorecard • BSC Alternatives • Software Solutions for Business Performance Management • Business Intelligence Applications • Benchmarking • Best Practice Identification • Performance Analysis • Performance Improvement Strategies • Stakeholder Marketing (internal focus)

	• Implementation Management for Improvement Strategies
Assessment:	3 individual assignments (continuous assessment, 60% of total grade) Final written exam (in presence, 40%)
Literature:	BLOKDYK, Gerardus (2021): Business Performance Management, 3rd edition. ISBN 978-0655173380, 5STARCooks CHAN, Leong et al. (2023): Applied Artificial Intelligence in Business. Concepts and Cases. ISBN 978-3031057427, Springer PARMENTER, David (2019): Key Performance Indicators. Developing, Implementing, and Using Winning KPIs, 4th edition, ISBN 978-1119620778, Wiley

Module name:	**General Management**
Module Code	3025
Degree:	Engineering, B. Sc.
Module coordinator:	Dirk Untiedt
Lecturer:	Dirk Untiedt
Language:	English
Part of focus field:	Management, Business Operations
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	-
Required prerequisites:	Accounting
Module objectives:	After successful completion of this module: Students know the main methods and instruments of General Management. They have the ability to use them effectively. In general three management functions for any kind of company can be distinguished with respect to General Management: • Marketing Management • Finance Management and • Operations management. Students know the main tools, methods and instruments of general management. They have the ability to use them ef-fectively. They are able to formulate strategies and imple-mentation plans on all strategy levels and in specific con-texts.
Content:	• Fundamentals of General Management • Strategy • Operations Management • Finance and Controlling • Organisation and Management • Human Resource Management • Change Management • Marketing The theoretical knowledge gained in the sector of General Management will be simulated and deepened by a business simulation game.
Assessment:	Lecture: Attestation/ Written Examination Practical Training: Business Simulation
Forms of media/ Software	Moodle, Business Simulation
Literature:	• …

Module name:	**Technology and Innovation Management**
Module Code	3026
Degree:	Engineering, B. Sc.
Module coordinator:	Dirk Untiedt
Lecturer:	Dirk Untiedt
Language:	English
Part of focus field:	Management
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	-
Required prerequisites:	Fundamentals of Business and Management
Module objectives:	After successful completion of this module: Students know the main methods and instruments of General Management. They have the ability to use them effectively. In general three management functions for any kind of company can be distinguished with respect to General Management: • Marketing Management • Finance Management and • Operations management. Students know the main tools, methods and instruments of general management. They have the ability to use them ef-fectively. They are able to formulate strategies and imple-mentation plans on all strategy levels and in specific con-texts.
Content:	• Fundamentals of General Management • Strategy • Operations Management • Finance and Controlling • Organisation and Management • Human Resource Management • Change Management • Marketing The theoretical knowledge gained in the sector of General Management will be simulated and deepened by an IT based business game.
Assessment:	Lecture: Attestation/ Graded Examination Practical Training: -
Forms of media/ Software	Moodle
Literature:	• …

Module name:	**Production and Supply Chain Management**
Module Code	3027
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. Alexander Klein
Lecturer:	Prof. Dr.-Ing. Alexander Klein
Language:	English
Part of focus field:	Business Operations
Timetabled hours:	Lecture: 3 HPW Exercise: 1 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	Manufacturing Technology and Factory Equipment
Required prerequisites:	-
Module objectives:	After successful completion of this module, students • can identify business processes of a company according to the SCOR model • know the paramount tasks of production and operations management • understand the target conflicts in factory design and operations management and know how to evaluate the performance of a factory. • understand the logistic processes in a producing company and know basic means logistics • are able to plan production sites and develop efficient factory layouts • apply basic optimization techniques for supply chain processes and supply networks • understand the processes of supplier selection and supplier relationship management • can analyze and document a firm’s supply chain requirements, in particular for an industrial firm operating in a b2b environment • know common IT systems for production planning and supply chain management • are trained in research, observation, analytical and presentation skills
Content:	• Reference frameworks such as Aachen PPC model, Porter value creation model, SCOR model (SCOR model DS) • Deduction logic from sales plan to factory layout • Capacity calculation • Lean management concept and proven methods • Factory design • Material flow simulation • IT for production (APS, MES etc.) • Production logistics fundamentals (e. g. productivity vs. WIP level) • Performance measurement • Lean game or digital factory game or MIT beer game

	• Examples and use cases (case studies)
Assessment:	Graded exam
Literature:	POUND, Edward S., Jeffrey H. BELL und Mark L. SPEARMAN, [kein Datum]. Factory Physics for managers: how leaders improve performance in a Post-Lean Six Sigma world [online]. ISBN 9780071822619.

Module name:	**Operations Research and Data Analytics**
Module Code	3028
Degree:	Engineering, B. Sc.
Module coordinator:	A. Struck
Lecturer:	A. Struck, A. Kehrein
Language:	English
Part of focus field:	Core
Timetabled hours:	Lecture: 2 HPW Exercise: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3001, 3031
Required prerequisites:	3000, 3033
Module objectives:	The objective of this module is to make students familiar with the ideas of Operations Research and Data Analytics. They will be able to analyse complex processes and procedural networks in business context and to formulate multivariate cost and gain functions. Students have an overview of optimization methods that they can employ to optimise processes and cost structures. Students will be trained to collect and organize data from various sources that can bolster the possibility to make evidence-based managerial decisions. They will adapt standard methods to clean data sets and prepare them for structural exploration, the latter including applications of statistical analysis, dimension reduction, feature engineering, clustering and model based predictions.
Content:	Operations Research: • Modelling and Decision Analysis • Optimisation • Linear programming in Operations Research • Simplex method and sensitivity analysis • Nonlinear Optimisation Data Analytics: • Data wrangling with quantitative and categorical variables • Principal component analysis • Multivariate linear regression • Logistic Regression • K nearest neighbours • Decision trees • Linear discriminant analysis
Assessment:	Lecture: Written examination Exercise: Attestation
Literature:	H.A. Eiselt C.-L. Sandblom “Operations Research. A model-based approach“, Springer 2012

	David Anderson et. al., „An Introduction to Management Science“ cengage learning 2012 Frederick Hilier, “Introduction to Operations Research”, MacGraw-Hill, 2004 Chirag Shah, “A Hands-On Introduction to Data Science”, Cambridge, 2020 Foster Provost, “Data Science for Business: What you need to know about data mining and data-analytic thinking”, O’Reilly, 2013

Module name:	**Technical Investment Planning and Purchasing**
Module Code	3030
Degree:	Engineering, B. Sc.
Module coordinator:	Dirk Untiedt
Lecturer:	Dirk Untiedt
Language:	English
Part of focus field:	Core
Timetabled hours:	Lecture: 1 HPW Project: 3 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	Production and Supply Chain Management
Required prerequisites:	Accounting Project Management
Module objectives:	After successful completion of this module: Students are able to evaluate planned technological invest-ments. They are able to systematize issues, to formulate in-vestment-planning tasks, to compile requirement and functional specifications if applicable and to select suitable methods and instruments of evaluation. They are able to evaluate results, assess them critically and to present them to a well-informed audience. Students know the methodical fundamentals of organising purchases, types of goods and acquisition strategies. They are especially able to select and apply suitable context-specific methods and tools of technical purchasing. The students know the difference between strategic and operational purchasing.
Content:	Within the framework of a project, a limited (industrial) investment project is made available to students. Students work in teams. They analyse the task, create requirement and functionality specifications when applicable, invite offers and evaluate investment alternatives according to technical and especially economical points of view. There will be a presentation of the overall results of the investment project. Purchasing: • Order processing • Terms and objectives of acquisition • Financial importance of acquisition • Single, modular, system and global sourcing • Material groups and supplier strategy • Supplier management • Organisation of acquisition • Analysis of purchasing programme (ABC, XYZ analysis) • Purchase pricing and negotiations • Statistical methods of demand forecasts and disposition methods, and optimal order volume

Assessment:	Lecture: Graded Examination Practical Training: -
Forms of media/ Software	Moodle
Literature:	• Literature and material from lecturer • Lysons, K.; Farrington, B.: Purchasing and Supply Chain Management. 7th edition, Prentice Hall, 2006

Module name:	**Statistics and Probability**
Module Code	3031
Degree:	Engineering, B. Sc.
Module coordinator:	A. Struck
Lecturer:	A. Struck, A. Kehrein
Language:	English
Part of focus field:	Core
Timetabled hours:	Lecture: 2 HPW Exercise: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3001
Required prerequisites:	3000, 3033
Module objectives:	The objective of this module is to introduce students to probability theory and statistics. They will learn how to calculate probabilities and conditional probabilities for the outcomes in a variety of applied examples within the frequentist as well as the Bayesian framework. Students will encounter the concept of random variables and their use in statistical modelling. They will employ important probability distributions and get to know important statistical tests in order to examine situational evidence for statistical relevance. Quantitative and categorical variables will be discussed in depth to formulate comprehensive models for analysis in the context of business intelligence.
Content:	Descriptive statistics: • Measures of location and dispersion: mean, median, mode, variance, skewness Fundaments of probability and statistics: • Random variables • Expected Value and Variance • Frequentist probability, Kolmogorov axioms, sum rules • Conditional Probability • Bayes Theorem:Philosophy and Applications • Prosecutor’s fallacy • Distributions, probability density and mass functions • Central limit theorem Inferential statistics: • Statistical modelling, hypothesis and test strategies • Sampling methods • Confidence intervals • Simple tests, use and ill-use of p-values, p-value hacking • Essential tests • Comparing samples: ANOVA Fundamentals of time series analysis
Assessment:	Lecture: Written examination

	Exercise: Attestation
Literature:	• James Stewart (2016): *Calculus*. Metric International Version. 8th edition. Brooks/Cole • John Devore (2008) *Probability and Statistics for Engineering and the Sciences*. 7th int. student edition. Brooks/Cole • DeVeaux, Velleman, Bock (2004) *Stats: Data and Models*. Pearson • Freedman, Pisani, Purves (2007) *Statistics*. 4th edition. Norton • Gailmard(2014): *Statistical Modelling and Inference for Social Sciences*, Cambridge University Press. • Wilcox (2017): *Understanding and applying basic statistical methods using R*. Wiley.

Module name:	**Mechanics**
Module Code	3032
Degree:	Engineering, B. Sc.
Module coordinator:	H. Schütte, N. Ostergaard
Lecturer:	H. Schütte, H. Ostergaard
Language:	English
Part of focus field:	Core
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	-
Required prerequisites:	-
Module objectives:	After successful completion of this module, students are able to • Isolate bodies to draw free body diagrams • Use the equilibrium equations to solve for unknown reaction forces – also in systems of bodies • Draw internal force diagrams for beams • Understand position, velocity and acceleration • Understand Newtons law of motion and the inertia of a body in translation and rotation • Draw kinetic diagrams for the dynamic equilibrium
Content:	1. Fundamentals 1.1 Definition of force as vector 1.2 Newtonian laws 1.3 Rigid body 1.4 Cutting principle 2. Forces with a common point of origin 2.1 Composition of forces in a plane 2.2 Dismantling of forces in a plane 2.3 Equilibria in a plane 3. Force systems and equilibrium of the rigid body 3.1 Forces in a plane 3.2 Torque vector 4. Median point 4.1 Median point and centre of mass of a body 4.2 Centroid of an area 4.3 Centroid of a line 5. Bearing reactions 5.1 Plain structures 5.2 Simple multi-piece structures

	6. Beams 6.1 Support reactions for beams 6.2 Internal forces in beams 7. Motion 7.1 rectilinear motion of particles 7.2 curvelinear motion of particles 8. Kinetics of particles 8.1 Newtons laws 8.2 Dynamic equilibrium / Kinetic Diagrams 8.3 Conservation of linear momentum 8.4 Conservation of angular momentum
Assessment:	Written examination
Literature:	• Lecture Notes • Ferdinand Beer, Jr. Johnston, Vector Mechanics for Engineers: Statics and Dynamics, 10th edition

Module name:	**Programming**
Module Code	3033
Degree:	Engineering, B. Sc.
Module coordinator:	M. Krauledat
Lecturer:	M. Krauledat, R. Hartanto, G. Bastian
Language:	English
Part of focus field:	Core
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	-
Required prerequisites:	-
Module objectives:	After successful completion of this module, students are able to • recognize limitations and complexity of computer based operations • use algorithmic concepts such as recursion • transfer technical problems to program code • implement simple algorithms • assess similarities and differences between different programming languages
Content:	Algorithmic Concepts • Input and Output • Recursion and Iteration Program structures in high-level programming languages such as Python • Syntax and Semantics • Expressions and statements • Variables, lists and tuples • Operators • Data Visualization • Basic Control flow: Conditional statements, Loops • Program structures: scripts and functions • Recursion • Objects • Getting started in other programming languages
Assessment:	Lecture: Written examination Practical Training: Attestation
Literature:	• James R. Parker (2021) “Python. An Introduction to Programming”. 2nd edition. Mercury Learning & Information. • Magnus Lie Hetland (2017) “Beginning Python: From novice to professional”. 3rd edition. New York: Apress • Mark Lutz (2011) “Programming Python”. 4th edition. O’Reilly

	• John V Guttag (2013) “Introduction to computation and programming using Python”. MIT Press

Module name:	**System Theory and Controls**
Module Code	3034
Degree:	Engineering, B. Sc.
Module coordinator:	D. Nissing
Lecturer:	D. Nissing, I. Volosyak, R. Hartanto
Language:	English
Part of focus field:	Robotics
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Practical Training: 1 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3005, 3032
Required prerequisites:	3000, 3001
Module objectives:	After finishing this module, students have fundamental knowledge and abilities for the mathematical description and regulation of technical systems and are able to present these via block wiring diagrams. Furthermore, students are able to analyse and evaluate mathematically described time-continuous single-input/single-output (SISO) control systems by means of system theory knowledge. By doing this, a controller can be designed correspondingly meeting given requirements regarding stationary and dynamic behaviour. Additionally, students gain the ability to deduce requirements for the necessary measurement technique. The control engineering methods learnt this way will be deepened by laboratory work. Here, computer based development tools will be used, particularly Matlab/Simulink, so students are also able to cope with descriptions, calculations and analyses in a practice-oriented manner. Students are able to transfer and apply the knowledge to control a robot arm.
Content:	• Mathematical modelling of technical systems by means of differential equations • System description via block diagrams • Functionality and basic structure of control circuits • Characteristics of control systems – Linear and non-linear systems – Linearization – Systems with concentrated/distributed parameters – Time-variant and time-invariant systems – Causal and non-causal systems • Description of linear continuous systems – Time domain: step response, impulse response, convolution integral – Frequency domain: Laplace transformation, transfer functions • Characteristics of systems – Proportional, integral, derivative and its combinations

	– Block diagram transformation – Closed-loop transfer function: Reference and disturbance transfer function • Frequency domain characteristics – Nyquist-Plot – Bode-diagram • Stability of linear continuous control systems – Definition of stability and stability condition – Hurwitz criterion/Routh criterion/Nyquist criterion – Gain and phase margin • Design method for linear continuous control systems
Assessment:	Lecture: Written examination
Literature:	Nise, Norman S.: Control Systems Engineering. 2011, John Wiley & Sons. ISBN 978-0-470-64612-0 Dorf, R. C., R.H. Bishop: Modern Control Systems. 2011, Pearson Education. ISBN 978-0-13-138310-4 Franklin, G. F., J.D. Powell, A. Emami-Naeini: Feedback Control of Dynamic Systems. 2010, Pearson Education. ISBN 978-0-13-500150-9 Ogata, K.: Modern Control Engineering. 2010, Pearson Education. ISBN 978-0-13-713337-6

Module name:	**Modelling and Numerical Simulation**
Module Code	3035
Degree:	Engineering, B. Sc.
Module coordinator:	T. Brandt
Lecturer:	T. Brandt, D. Nissing
Language:	English
Part of focus field:	Core
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3038
Required prerequisites:	3032, 3001
Module objectives:	After successful completion of this module, students are able to • apply engineering modelling techniques to problems arising in the fields of mechanical and electrical engineering and beyond. • to represent models of dynamic systems in their state space form. • select and apply numerical methods in the numerical simulation process of models of dynamic systems. • Implement fundamental simulation models in MATLAB/Simulink.
Content:	• Introduction to modelling of technical systems • Practical implementation of dynamic simulation models in MATLAB/Simulink • Numerical solution of differential equations: forward and backward Euler, Runge-Kutta,, stability, implicit vs. explicit schemes • State space equations (initial value problem) • Linearization of systems of ordinary differential equations • Definition of steady states • Iterative solution of non-linear systems, in particular Newton’s Method • Constraints of technical systems
Assessment:	Lecture: Written examination Practical Training: -
Literature:	Klaus Janschek: Mechatronic Systems Design: Methods, Models, Concepts, Springer 2012, SBN-13: 978-3642175305 William Press, Saul Teukolsky, William Vetterling, Brian Flannery (2007) *Numerical Recipes – The Art of Scientific Computing*. 3rd edition. Cambridge. Cambridge University Press. (online materials available from http://numerical.recipes) 00/TKX 5

	Parviz Moin (2010) *Fundamentals of Engineering Numerical Analysis*. 2nd edition. Cambridge. Cambridge University Press. 00/WAT 1 Further Readings: F.E. Cellier: Continuous System Modeling, Springer Verlag, 1991

Module name:	**Multibody Dynamics**
Module Code	3036
Degree:	Engineering, B. Sc.
Module coordinator:	T. Brandt
Lecturer:	T. Brandt, N. Ostergaard
Language:	English
Part of focus field:	Core
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	Modules: 3035
Required prerequisites:	Modules: 3033;3038
Module objectives:	After successfully finishing the module, students are • familiar with the fundamentals of multibody dynamics. • able to apply basic concepts from linear algebra such as vectors and matrices to mechanical systems. • able to model the kinematics of technical joints such as revolute joints by algebraic constraints. • able to model the dynamics of constraint multibody dynamic systems based on the method of Newton-Euler. • able to develop basic programming code in order to simulate planar multibody dynamic systems and to perform analysis of planar multibody dynamic systems.
Content:	The course focuses on the modelling and numerical simulation of dynamic multibody systems. The following content is covered: • Definitions: bodies, joints, and coordinates • Planar kinematics: rotation, translation • Kinematic constraints • Kinematic analysis on position velocity and acceleration level • Jacobian matrices of different joints • System’s Jacobian Matrix • Dynamics: Newton-Euler equations • Development of multibody dynamics simulation code • Analysis of multibody dynamic systems
Assessment:	Lecture: Written examination Practical Training: -
Literature:	P. E. Nikravesh: Planar Multibody Dynamics - Formulation, Programming, and Application, CRC press,2008 Further Readings: A.A. Shabana: Dynamics of Multibody Systems, 1998

Module name:	**Robots Kinematics**
Module Code	3037
Degree:	Engineering, B. Sc.
Module coordinator:	T. Brandt
Lecturer:	T. Brandt, R. Hartanto
Language:	English
Part of focus field:	Core
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	Modules: 3034;3035
Required prerequisites:	Modules 3038;3001;3032;3005
Module objectives:	After successful completion of this module, students are able to • identify advantages and disadvantages of different locomotion systems. • formulate kinematic equations for wheel-based locomotion systems. • classify wheel-based locomotion systems in terms of their kinematics. • describe the geometry of manipulators. • recognize kinematic structures of manipulators. • apply coordinate transformations. • formulate forward kinematics equations of manipulators on position level. • distinguish between different solution methods to inverse kinematics of manipulators on position level • formulate forward and inverse kinematics equations of manipulators on velocity level.
Content:	• Introduction to locomotion systems • Kinematic models and constraints of mobile robots • Design of manipulators • Rigid motions and homogeneous transformations • Kinematic chains and Denavit-Hartenberg convention • Forward and inverse kinematics of manipulators on position level • Velocity kinematics of manipulators
Assessment:	Lecture: Written examination Practical Training: -
Literature:	• Mark W. Spong, Seth Hutchinson, M. Vidyasagar (2006) “Robot Modelling and Control”. 1st edition. John Wiley & Sons.

	• John J. Craig “Introduction to Robotics - Mechanics and Control”. 3rd edition. London: Pearson Education International • Roland Siegwart and Illah R. Nourbakhsh (2004) “Introduction to Autonomous Mobile Robots”. 1th edition. Cambridge: The MIT Press

Module name:	**Dynamics**
Module Code	3038
Degree:	Engineering, B. Sc.
Module coordinator:	N. Ostergaard
Lecturer:	N. Ostergaard, H. Schütte
Language:	English
Part of focus field:	Core
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	Modules: 3001
Required prerequisites:	Modules: 3000;3032
Module objectives:	After successful completion of this module, students are able to • understand the basic kinematics and kinetics for plane motions of particles, systems of particles and rigid bodies required for development and engineering analysis of mechanical systems. • describe mechanical based on Newtonian mechanics with focus on the link between kinematic properties and force. • independently formulate equations of motion and are familiar with the solution procedures.
Content:	• Particle kinematics • Cartesian coordinates (recti- and curvilinear motions, rotating motion, ballistics) • Polar coordinates and curvilinear frames • The concepts of relative motion and kinematic constrains • Particle dynamics, Newton’s 2nd law in Cartesian coordinates • Free-body diagrams and kinetic diagrams • mass-wire-pulley problems • Coulomb friction • The linear and angular momentums and their properties • Motion under a central force (for example satellites) • Application to a system of particles • The rocket equation (Tsiolkovsky) • Free and forced vibrations of damped and undamped single degree of freedom systems • Mass-spring-damper systems • Kinematics of rigid bodies • Dynamics of rigid bodies • Euler’s law of motion and moment equilibriums around arbitrary points in the plane • Rolling and slipping • Gears and sliding bar problems • Reciprocating mechanisms • Conceptual introduction to 3D dynamics

	• The Newton-Euler equations and gyro moments
Assessment:	Written examination
Literature:	Beer, Johnston, Cornwell: Vector Mechanics for Engineers: Dynamics (Global Ed.), McGraw-Hill Recommended secondary literature: Meriam and Kraige: Dynamics (SI Ed.), Wiley Publishing

Module name:	**Statistical Learning**
Module Code	3039
Degree:	Engineering, B. Sc.
Module coordinator:	M. Krauledat
Lecturer:	M. Krauledat, R. Hartanto
Language:	English
Part of focus field:	Core
Timetabled hours:	Lecture: 2 HPW Exercise: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3001
Required prerequisites:	3000, 3033
Module objectives:	The objective of this module is to introduce students to the fundamentals of machine learning, encompassing both its theoretical principles and algorithmic concepts. Within this module, various essential algorithmic learning approaches and the associated machine learning models commonly applied in real-world scenarios will be explored. Special attention will be dedicated to the mathematical and statistical theories that form the basis of these concepts. After completion of the course the students have a general overview of the Statistical Machine Learning field. They know about implementations of various classification and regression methods and understand the mathematical background of the corresponding algorithms. Students are able to select suitable methods to given problems, apply algorithms (based on the respective application fields) and evaluate their performance according to different cost functions.
Content:	Mathematical basics: • Random variables • Expected Value and Variance • Multivariate Normal Distribution • Eigenvectors • Eigenvalues • Orthogonality • Matrix operations Machine Learning concepts: • Supervised Learning (Classification, Regression) • Unsupervised Learning • Bayesian Decision Theory (Losses, Risks, Discriminant Functions) • Multivariate Methods • Dimensionality Reduction (PCA, Multidimensional Scaling, LDA) • Design and Analysis of Machine Learning Experiments (Cross Validation, Measuring Classifier Performance, Guidelines for ML experiments)

Assessment:	Lecture: Written examination Exercise: Attestation
Literature:	• DeVeaux, Velleman: Intro Stats, Pearson, 2004 • Devore: Probability and Statistics for engineering and the sciences, Cengage Learning, 2017 • Strang: Linear Algebra, Wellesley-Cambridge Press, 2009 • Alpaydin: Introduction to Machine Learning, 2nd edition, The MIT Press, 2010 • Duda, Hart, Stork: Pattern Classification, 2nd edition, Wiley 2001

Module name:	**Machine Learning**
Module Code	3040
Degree:	Engineering, B. Sc.
Module coordinator:	R. Hartanto
Lecturer:	R. Hartanto, M. Krauledat
Language:	English
Part of focus field:	Robotics
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3039
Required prerequisites:	3033, 3001
Module objectives:	In this module, students will develop a comprehensive understanding of key machine learning algorithms, including reinforcement learning, clustering, neural networks, and deep learning techniques. They will explore advanced concepts like large language models (LLMs), as well as kernel-based approaches such as support vector machines and the kernel trick. Through these topics, students will gain the ability to design, train, and evaluate machine learning models tailored to diverse challenges. The course equips students with practical competencies in applying machine learning to application areas like computer vision and speech recognition, emphasizing hands-on experience with programming frameworks. Students will learn essential implementation considerations, including data preparation, augmentation, and quality assessment, while also addressing hardware-related constraints and requirements. By the end of the module, students will be prepared to build scalable and efficient machine learning solutions, bridging theoretical knowledge and practical expertise.
Content:	Algorithms • Reinforcement Learning • Clustering • Multilayer Perceptrons / Neural Networks • Deep Learning (Autoencoder, Generative Models) • Large Language Models (LLM, Transformer) • Kernel Machines (Optimal Hyperplanes, SVM, Kernel Trick) Application Areas • Computer Vision (Object Recognition, Object Tracking, Video Streams) • Speech Recognition

	Implementation Considerations • Data Preparation (Data Quality Assessment, Data Augmentation) • Machine Learning Frameworks (TensorFlow, Keras, PyTorch) • Hardware Aspects (RAM, Acceleration, CPU usage)
Assessment:	Lecture: Written examination Exercise: Attestation
Literature:	• Alpaydin: Introduction to Machine Learning, 2nd edition, The MIT Press, 2010 • Bishop: Pattern Recognition and Machine Learning, Springer, 2007 • Schölkopf, Smola: Learning with kernels, The MIT press, 2002 • Mitchell: Machine Learning, McGraw-Hill Education, 1997 • Szeliski: Computer Vision and Applications, Springer, 2011

Module name:	**Robot Intelligence**
Module Code	3041
Degree:	Engineering, B. Sc.
Module coordinator:	R. Hartanto
Lecturer:	R. Hartanto, M. Krauledat
Language:	English
Part of focus field:	Robotics
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3035, 3040
Required prerequisites:	3034, 3039
Module objectives:	After successful completion of this module, students are able to • use a few intelligence algorithms for controlling autonomous robots • select or develop necessary algorithms for autonomous robots • determine appropriate sensors of autonomous robots • describe the underlying principles of intelligence algorithms • assess similarities and differences between concurrent algorithms, i.e., using state of the art measurement metrics • use Robot Operating System (ROS)
Content:	Intelligent Robot’s Sensors • Localization sensors • Perception sensors Algorithms • Obstacle Avoidance • Kalman Filters • Particle Filters • Localization algorithms • Simultaneous Localization and Mapping (SLAM) • Path Planning algorithms • Object recognition algorithms (SIFT, SURF) • Task / Action Planning algorithms ROS • Basic Concept of ROS – Middleware • ROS Framework and Its Library
Assessment:	Lecture: Written examination Exercise: Attestation
Literature:	• Sebastian Thrun, Wolfram Burgard, and Dieter Fox. 2005. Probabilistic Robotics (Intelligent Robotics and Autonomous Agents). The MIT Press.

	• Ghallab, M., Nau, D., & Traverso, P. (2016). Automated Planning and Acting. Cambridge: Cambridge University Press. • LaValle, S. (2006). Planning Algorithms. Cambridge: Cambridge University Press. • Bruno Siciliano and Oussama Khatib. 2007. Springer Handbook of Robotics. Springer-Verlag, Berlin, Heidelberg. • *Robot Operating System (ROS): The Complete Reference (Volume 1)*. Edited by Anis Koubaa. Vol. 625. Cham: Springer, 2016. • Anis Koubaa. 2017. Robot Operating System (ROS): The Complete Reference (Volume 2) (1st. ed.). Springer Publishing Company, Incorporated. • Robot Operating System (ROS): The Complete Reference (Volume 3). Edited by Anis Koubaa. Vol. 778. Cham: Springer, 2018.

Module name:	**Sustainable Electronics**
Module Code	3042
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr. A. Stamm
Lecturer:	Prof. Dr. A. Stamm
Language:	English
Part of focus field:	Elective
Timetabled hours:	Lecture: 2 HPW Practical Training: 1 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3006 Electrical Engineering 2
Required prerequisites:	3005 Electrical Engineering 1
Module objectives:	Students know the life cycle of electronic devices and are able to name the requirements resulting from rules such as IEC 62430. They are able to classify and optimise the design process by means of the energy consumption aspects in the company, the necessary resources for production and disposal. Students understand the production processes of many different components used in electronic products and are able to understand the complexity of new electronic products. They are familiar with proper recycling methods used to recycle end-of-life electronic products and how to design product in the way of optimal recycling later on.
Content:	• Life cycle of electronic devices • Standards and regulations for the design: IEC 62430 • Raw materials and their production • Production of electronic components • Operational energy consumption • Recycling and environmentally sound waste disposal
Assessment:	Lecture: Written examination Practical Training: Attestation
Literature, Resources:	Sammy G. Shina, Green Electronics, 2008 (Library: 00/XVU 2) Wolfgang Wimmer et al.: ECODESIGN -- The Competitive Advantage, Springer, 2010 (Library: 00/PWP 30)

Module name:	**Low Power Design**
Module Code	3043
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. G. Gehnen
Lecturer:	Prof. Dr.-Ing. G. Gehnen
Language:	English
Part of focus field:	Elective
Timetabled hours:	Lecture: 2 HPW Project: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3008 Analog Electronics
Required prerequisites:	3005 Electrical Engineering 1
Module objectives:	Based on the fundamentals of electronic circuit engineering, students are able to name the cause of power consumption and choose measures to minimise power consumption de-pending on circuit type and area of application. They master design methods to avoid power consumption early on during the design process. They are familiar with the susceptibility to interference of power-optimised circuits. Students are able to select suitable methods from common energy harvesting methods, and apply them, with due consideration of load profiles and production potentials.
Content:	• Causes of power consumption of electronic circuits • Performance optimisation of Analogue circuits • Reduction of power consumption of digital circuits • Processor based systems and their software • Sensitivity towards disturbances • Energy Harvesting • Case Studies
Assessment:	Written or oral examination
Literature, Resources:	1. John Rabaey, Low Power Design Essentials, Springer, 2009 2. Nihal Kularatna: Power Electronics Design Handbook: Low-Power Components and Applications: Low-power Components and Applications, Newnes, 1998 Further Readings: 3. Nianxiong Nick Tan, Zhihua Wang, Dongmei Li: Ultra-Low Power Integrated Circuit Design: Circuits, Systems, and Applications, Springer, 2011 4. Laurie Kelly, Piguet Piguet, Christian Piguet: Low-Power Electronics Design, Crc Pr. 2005

Module name:	**Hardware Programming**
Module Code	3044
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr. R. Hartanto
Lecturer:	Prof. Dr. R. Hartanto
Language:	English
Part of focus field:	Elective
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3012 Embedded Systems
Required prerequisites:	3009 Microcontrollers
Module objectives:	After successful completion of this module, students able to • write advance program for FPGA • implement code to be run on a specific hardware, GPU or TPU • perform hardware / software optimization • run application on containerized environment • program code for other CPU platform, cross compiling • write real time program to be run on RTOS • run a program on multiple CPU-cores / computers
Content:	• Shell Programming • FPGA Programming • GPU Programming • Tensor Acceleration on TPU • Container and Virtualization • Real Time OS • Real Time Programming • Cross Compiling (e.g., x86 to ARM) • Multicore Programming • Hardware/Software Codesign
Assessment:	Lecture: Written examination Practical Training: Attestation
Literature, Resources:	• P. Chu: FPGA Prototyping by VHDL Examples, Wiley, 2008 • C. Kormanyos: Real-Time C++: Efficient Object-Oriented and Template Microcontroller Programming, Springer, 2018 • M. Barr, A. Massa: Programming Embedded Systems, 2nd edition, O’Reilly, 2006 • D. Storti, M. Yurtoglu: CUDA for Engineers: An Introduction to High-Performance Parallel Computing

	• H. Maarseveen: Google Tensor Processing Unit (TPU): Unraveling the Legacy the Powerhouse, 2023 • P. Schaumont: A Practical Introduction to Hardware/Software Codesign, 2nd edition, Springer, 2013

Module name:	**Advanced Communication Technologies**
Module Code	3045
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. C. Budelmann
Lecturer:	Prof. Dr.-Ing. C. Budelmann Prof. Dr. A. Stamm
Language:	English
Part of focus field:	Elective
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3018 Communication Technology
Required prerequisites:	3005 Electrical Engineering 1 3006 Electrical Engineering 2
Module objectives:	In this course, students gain a deeper knowledge and understanding of selected embedded and industrial networks based on the information and communication technology fundamentals already taught in "Communication Technology". In the laboratory exercises, the theoretical knowledge is applied to enable the students to set up networks and to find faults in various networks using different measurement and analysis methods. Based on selected service oriented architectures, students learn not only how data is transported, but how data is processed across different platforms and described semantically in a machine-readable way.

Content:	• Network requirements for actual and future applications
	• Selected actual network standards, e. g.
	  ○ Controller Area Network (CAN)
	  ○ Single Pair Ethernet (SPE)
	  ○ 5G cellular
	• Cross-platform standards for data exchange and service oriented architectures, e. g.
	  ○ OPC Unified Architecture (OPC UA)
	As the state of the art in communication technology is constantly changing, the named network standards are only examples and can be updated or changed, if necessary.

Assessment:	Lecture: Written examination Practical Training: Attestation
Literature, Resources:	State of the art literature recommendations will be provided in the lecture.

Module name:	**Renewable Energy and Storages**
Module Code	3046
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr. A. Stamm
Lecturer:	Prof. Dr. A. Stamm Prof. Dr. G. Bastian
Language:	English
Part of focus field:	Elective
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Practical Training: 1 HPW
Workload:	60 h attendance 90 h preparation and review 30 h lab report writing
Credits:	6
Recommended prerequisites:	Analog electronics
Required prerequisites:	Physics 3005 Electrical Engineering 1
Module objectives:	Students will learn to evaluate and distinguish different existing technologies for renewable energies. They understand the key parameters, the theoretical operation principle and practical constraints. During practical lab sessions students will learn basic operation of different energy conversion systems.
Content:	Different forms of energy and power Power requirements, distribution and conversion Energy storage systems Wind power systems Solar power systems Heat conversion techniques Synthetic fuels and fuel cells
Assessment:	Lecture / Exercise: Written examination Practical Training: Attestation
Literature, Resources:	

Module name:	**Optoelectronics**
Module Code	3047
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr. G. Bastian
Lecturer:	Prof. Dr. G. Bastian
Language:	English
Part of focus field:	Elective
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Practical Training: 1 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	
Required prerequisites:	Analog electronics
Module objectives:	Students have a general view of the conversion of light into electronic signals and vice versa. They are able to classify and evaluate optoelectronic components with regard to occurring effects, functions, specifications and areas of application. Students therefore have the skill to dimension and use optoelectronic components in complete systems.
Content:	The lecture starts with the fundamentals of optics and semi-conductor physics. The application-related main part is structured in optical signal generation (LED, laser, displays) on the one hand and optical receivers (photodiodes, detector types, solar cells) on the other hand.
Assessment:	Lecture / Exercise: Written examination Practical Training: Attestation
Literature, Resources:	Physics of photonic devices, Shun LienChuang, Wiley (2012)

Module name:	**Biomedical Electronics**
Module Code	3048
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. I. Volosyak
Lecturer:	Prof. Dr.-Ing. I. Volosyak
Language:	English
Part of focus field:	Elective (Electronics)
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Practical Training: 1 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3007 Analog Electronics 3009 Microcontrollers 3043 Low Power Design
Required prerequisites:	3010 Signal Processing
Module objectives:	Students know the fundamentals of electric potential within the human body that can be measured by ECG or EEG for example. They know a selection of sensors supporting different diagnostic processes, by which they are able to select and specify sensor systems for these areas of application. They master basic methods of image processing as used in tomography, for example. The students understand the fundamentals of electrical potentials in the human brain which can be detected with non-invasive and invasive methods. They can derive, from first principles, real architectures for modern Brain-Computer Interfaces. They are aware of the legal and other requirements for medical products and based on this, they are able to estimate which constructive measures are necessary. A brief introduction to implantology allows students to recognise the limits and possibilities of implanting electronic components for supporting sensory and actuatory functions.
Content:	• The body as an electric system • EKG, EEG • Brain-Computer Interfaces • Sensor systems for medical applications • Introduction to image-processing systems • Requirements for medical products • Implantable electronics
Assessment:	Written examination (CA, continuous assessment)
Literature, Resources:	1. L. Street: Introduction to Biomedical Engineering Technology, 2nd edition, CRC Press, 2011 00/VUT9

	2. W. Saltzmann: Biomedical Engineering, Cambridge University Press, 2009 00/WBK33 3. M. Culjat: Medical Devices, Wiley, 2013 00/VUT13

Module name:	**Audio and Speech Processing**
Module Code	3049
Degree:	Engineering, B. Sc.
Module coordinator:	M. Krauledat
Lecturer:	M. Krauledat, G. Gehnen
Language:	English
Part of focus field:	Elective
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	
Required prerequisites:	3000, 3033
Module objectives:	Students understand the characteristics of audio signals and their representation in digital systems. They are able to de-sign suitable methods for input, processing and output of audio signals with available resources, within given quality parameters. Students recognize the acoustic characteristics of human language. They categorize audio compression systems according to their working principles.
Content:	• Basic characteristics of audio signals • Representation of audio signals in digital systems • Recording and playback • Characteristics of speech signals • The human ear and its characteristics • Audio analysis • Audio synthesis • Speech processing • Compression of speech and audio
Assessment:	Written examination
Literature:	1. Ian McLoughlin, Applied Speech And Audio Processing: With Matlab Examples, Cambridge University Press, 2009 2. Proakis, Digital Signal Processing, Prentice Hall, 2008 3. U. Zölzer, Digital Audio Signal Processing, John Wiley & Sons, 2008 Further Readings: 4. Peter Vary, Rainer Martin, Digital Speech Transmission, John Wiley & Sons, 2006 5. Course materials from the lecturer

Module name:	**Electrical Testing and Compliance**
Module Code	3050
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. C. Budelmann
Lecturer:	Prof. Dr.-Ing. C. Budelmann
Language:	English
Part of focus field:	Elective
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	
Required prerequisites:	3005 Electrical Engineering 1
Module objectives:	Commercial products have to comply with various environmental, safety and health protection standards. In this module, students get to know the most important standards for electrical and electronic devices. Using a real product example, students learn and go through all the steps of compliance testing of a product: identification of the relevant standards and implementation of a risk analysis, execution of the different test methods and documentation of the test results in accordance with the standards.

Content:	• Introduction to testing and compliance
	• Different processes for conformity assessment
	• Risk analysis
	• Selected standards and directives, e. g.:
	  ○ Electromagnetic compatibility
	  ○ Low voltage directive
	  ○ Radio equipment directive
	  ○ Restriction of hazardous substances in electrical and electronic equipment
	• Compiling of technical documentation

Assessment:	Lecture: Written examination Practical Training: Attestation
Literature, Resources:	S. Loznen, C. Bolintineanu, J. Swart: Electrical product compliance and safety engineering. Artech House, 2017. Excerpts of relevant standards are handed out in the lecture, as the underlying directives are regularly adapted and modified.

Module name:	**Brain-Computer Interfaces**
Module Code	3051
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. I. Volosyak
Lecturer:	Prof. Dr.-Ing. I. Volosyak
Language:	English
Part of focus field:	Elective (ICT)
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Practical Training: 1 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3007 Analog Electronics 3008 Digital Electronics
Required prerequisites:	3010 Signal Processing
Module objectives:	The students understand the fundamentals of electrical potentials in the human brain that can be detected with non-invasive and invasive methods. They can derive, from first principles, real architectures for modern Brain-Computer Interfaces. They are able to design and build, using specialized communications structures and sensors, systems for, among other things, the support of physically handicapped individuals. They appreciate the safety and social aspects of modern Brain-Computer Interfaces and can name the relevant risks.
Content:	• Human body as electrical system • The concept of a Brain-Computer Interface • Data collection with non-invasive methods, in particular Electroencephalograms (EEG) • Fundamentals of EEG • Applications of BCIs for communication with and control of external machines • SSVEP, P300 and ERD/ERS based BCI
Assessment:	Written examination (CA, continuous assessment)
Literature, Resources:	1. Jonathan R. Wolpaw, Elizabeth W. Wolpaw, Brain-Computer Interfaces – Principles and Practice, Oxford University Press, 2012, 00/TVU33 2. Rajesh P. N. Rao, Brain-Computer Interfacing, Cam-bridge University Press, 2013, 00/WBK78 3. Ivan Volosyak, Recent advances in VEP-based BCI systems, Shaker, 2019, 00/WBK 115

Module name:	**Metallic Materials and Testing**
Module Code	3052
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. R. Sicking
Lecturer:	Prof. Dr.-Ing. R. Sicking
Language:	English
Part of focus field:	Sustainable Product Creation
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	Chemistry of Materials
Required prerequisites:	none
Module objectives:	*Students will be able to:* • Define and draw crystal structures and different classes of metals. • Explain crystal defects and their role for plastic deformation of metals • Report with basic knowledge concerning alloy systems, phase transformations, strength increasing mechanisms as well as mechanical and technological properties. • Understand suitable thermal treatments in different areas of the metal industry. • Perform different testing and analysis methods for materials characterization. • Know different classifications of steel • Consider the main corrosion phenomenons
Content:	• Introduction into atomic structure and built-up of single and polycrystals, lattice structures, lattice defects • Strength increase mechanisms (cold forming/plastic deformation, Hall-Petch, solid solution, dispersion, precipitates, texture, phase transformation) • Thermal Effects (diffusion, recovery, recrystallization, grain coarsening, phase transitions, nucleation) • Mechanical load, stress-strain diagram, fracture, metal groups as well as a first introduction into corrosion • Equilibrium: component / phase / microstructure, 2-component system / equilibrium diagrams, phase diagrams, phase rule, lever rule. • Introduction of important testing methods (micro and macro hardness, impact test, tensile test) • Microscope techniques and its basics including metallographic preparation • Jominiy test and displacive transformation (martensite formation) in steels • Classification of steels In addition specific application examples are presented.

Assessment:	Lecture: Written examination Practical Training: Lab reports
Literature:	1. M. F. Ashby, D. R. H. Jones: Engineering Materials 2 – An Introduction to Microstructures and Processing, 4th ed., 2013, ISBN-13 978-0-08-096668-7 2. D. R. Askeland, W. J. Wright: The Science and Engineering of Materials, enhanced 7th edition, 2022, ISBN 978-0-357-44786-4 3. G. Gottstein: Physical Foundations of Materials Science, 1st Edition, 2004, ISBN 978-3-642-07271-0 4. Bunge, H.J., Pöhlandt, K., Tekkaya, A.E., Banabic, D.; Pöhlandt, Klaus (Eds.): Formability of Metallic Materials, Plastic Anisotropy, Formability Testing, Forming Limits, XV, 2000, ISBN 978-3-540-67906-6 5. Y. Leng, Materials Charakterization – Introduction to Microscopic and Spectroscopic Methods, 2nd ed., 2013, ISBN 978-3-527-33463-6 6. V. John, Testing of Materials, 1st ed., 1992, ISBN 978-0-333-56814-9

Module name	**Non-metallic Materials**
Module code	3053
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr. C. Heß
Lecturer:	Prof. Dr. C. Heß
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 2 HPW Practical training: 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	6
Recommended prerequisites:	2006 Organic Chemistry or 2007 Chemistry of Materials
Module objectives:	Students are able to - specify basic chemical structures of polymers, ceramics and glasses. - conclude on characteristic properties of polymers, ceramics and glasses from the respective structure. - select suitable materials for a given application task. - modify specific properties of a material by adjustment of its formulation or processing parameters. - understand and explain the most important processing technologies for non-metallic materials. - select appropriate processing technologies for a given product application. - consider process-induced changes of material properties and evaluate process limitations. - assess processing methods in regard of product quality and economic efficiency.
Content:	- Thermoplastic and thermosetting polymers - Physical properties of ceramics and glasses: Hardness, strength, thermal properties - Fundamentals of polymer processing: Material flow, processing equipment, products, recycling, disposal - Fundamentals of polymer compounding: Twin screw extrusion, blending, additives, fillers - Processing technologies for polymers: Profile extrusion, injection molding, blown film extrusion, sheet film extrusion, blow molding, thermoforming, compression molding, resin infusion, resin transfer molding - Ceramic process, sintering of materials - Processing of glass and glass-ceramics - Rapid prototyping - Process-induced changes of material: Orientation, degradation, shrinking, anisotropic properties - Fundamentals of rheology: Newtonian and non-Newtonian fluids, viscoelasticity, dynamic mechanical analysis (DMA), storage and loss modulus
Assessment:	Lecture: Written examination Practical training: Reports
Media:	Whiteboard, Beamer, Laboratories

Literature:	1. Rosen S. L.: *Fundamental Principles of Polymeric Materials* 2. Halary J. L., Laupretre F., Monnerie L.: *Polymer Materials: Macroscopic Properties and Molecular Interpretations* 3. Callister W. D.: *Materials Science and Engineering: An Introduction* 4. Gedde U. W., Hedenqvist M. S., Hakkarainen M., Nilsson F., Das O.: *Applied Polymer Science* 5. Ehrenstein G., Pongratz S.: *Resistance and Stability of Polymers, Vols. 1 and 2* 6. Munz D., Fett T.: *Ceramics – Mechanical Properties, Failure Behaviour, Materials Selection* 7. Carter C.B., Norton M. G.: *Ceramic Materials - Science and Engineering*

Module name:	**Materials Technology**
Module Code	3054
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. R. Sicking
Lecturer:	Prof. Dr.-Ing. R. Sicking
Language:	English
Part of focus field:	Sustainable Product Creation
Timetabled hours:	Lecture: 4 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	2107 Non-metallic Materials 2110 Materials Analysis
Required prerequisites:	Physics and Error Statistics or Mechanics 1 2106 Metallic Materials and Testing
Module objectives:	*Students will be able to:* • To give an overview of the value creation chain from raw material to the final product for aluminium and steel • Know the most important manufacturing processes for semi-finished metals like casting, rolling and extrusion • Show the link between process, microstructure and macroscopic properties and can select a process accordingly. • Explain the primary forming by powder metallurgy and sintering of ceramics • Understand special demands to materials for mobility applications including light weight constructions • Analyse some special cases in which various materials are used together to attain the properties required • Distinguish between different important light weight construction materials. In addition, appropriate joining technologies can be selected. • Answer basic questions concerning material selection • Refer to prominent examples for the important role of specific materials in important applications Optional there will be an excursion to see materials production or manufacturing in industrials practice.
Content:	• Smelting of aluminium and steel • Casting, rolling and extrusion of metals • Microstructure development during the production process, • Influence on microstructure and properties by primary forming and semi-finished forming processes • Sintering of ceramics and powder metals • Heat Treatment of steels • Steels for transport applications, high strength steels, TRIP steels • Aluminum alloys for light weight constructions

	• Reinforced materials for strength, stiffness and fire resistance • Carbon fibres: Production, properties and applications • Rubber tires and their manufacturing • Joining techniques for mobile applications
Assessment:	Lecture: Written or oral examination
Literature:	1. M. F. Ashby, D. R. H. Jones: Engineering Materials 2 – An Introduction to Microstructures and Processing, 4th ed., 2013, ISBN-13 978-0-08-096668-7, Elsevier 2. B. Ilschner, R. F. Singer: Werkstoffwissenschaften und Fertigungstechnik – Eigenschaften, Vorgänge, Technologien; 5. Ed., 2010, ISBN 978-3-642-01733-9, Springer-Verlag 3. A. C. Reardon (Editor): Metallurgy for the Non-Metallurgist, 2nd edition, 2011, ISBN-13 978-1-61503-821-3, ASM International 4. D. Altenpohl: Aluminium von Innen, 5. Ed., 1994, ISBN 3-87017-235-5, Aluminium Verlag 5. G. W. Ehrenstein: Faserverbund-Kunststsoffe – Werkstoffe – Verarbeitung – Eigenschaften; 2nd Ed., 2006, ISBN 978-3-446-22716-3, Hanser 6. C. B. Carter, M. G. Norton: Ceramic Materials - Science and Engineering, 2nd Ed., 2013, ISBN 978-1-4614-3522-8, Springer-Verlag 7. F. Henning, E. Moeller (Hrsg.): Handbuch Leichtbau - Methoden, Werkstoffe, Fertigung; 1st Ed., 2011, ISBN 978-3-446-42267-4, Carl Hanser Verlag 8. Z. L. Wang and Z. C. Kang, Functional and Smart Materials: Structural Evolution and Structure Analysis; 1998, ISBN 978-0-306-45651-0

Module name:	**Corrosion and Colloids**
Module Code	3055
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr. N. Shirtcliffe
Lecturer:	Prof. Dr. N. Shirtcliffe
Language:	English
Part of focus field:	Product creation
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	
Required prerequisites:	
Module objectives:	
Content:	
Assessment:	Lecture: Written examination Exercise: Attestation
Literature:	

Module name:	**3D Product Specification**
Module Code	3056
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. Stéphane Danjou
Lecturer:	Prof. Dr.-Ing. Stéphane Danjou
Language:	English
Part of focus field:	Product creation
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	none
Required prerequisites:	none
Module objectives:	Upon successful completion of this module, students will: - 3D CAD: Acquire proficiency in the industry-standard 3D CAD software SolidWorks, and demonstrate the ability to create, modify, and analyse 3D models. - Design Fundamentals: Understand and apply the core principles of mechanical design, including part modelling and assembly design, and define product specification. - Collaboration and Documentation: Develop skills in creating professional 3D product documentation, including 2D drawings, bills of materials (BOMs), and reports. - Parametric Modelling: Understand and apply the concept of parametric modelling, enabling the creation of designs that can be easily modified and adapted for various design scenarios. - 3D Scanning: Understand the principles and methodologies behind 3D scanning technologies and gain hands-on experience with a range of 3D scanning equipment, mastering their operation, calibration, and data capture. - Reverse Engineering: Develop expertise in reverse engineering by converting scanned data into parametric CAD models, understanding how to extract design intent from physical objects. - Design Integration: Understand how reverse-engineered components can be integrated into existing design projects and systems, and adapt to real-world engineering applications. - Project Management: Gain experience in managing design projects, including setting project goals, timelines, and deliverables, and working effectively within a team environment.
Content:	This module serves as a fundamental introduction to 3D Computer-Aided Design (CAD) and 3D scanning within the context of an Engineering degree programme. It equips students with the knowledge and skills necessary to effectively use CAD software tools and 3D

	scanners for design, analysis, visualization and reverse engineering. This module lays the foundation for students to become proficient in the use of the CAD software SolidWorks and to apply these skills in the broader context of 3D product specification. It prepares students to approach complex design challenges with the ability to recreate and optimize existing physical objects, fostering innovation and problem-solving in the field of mechanical engineering. Covered topics: − 2D sketching and constraints − 3D solid modelling − Parametric modelling − Assemblies and relationships − Modelling techniques − Deriving engineering drawings from 3D CAD models − Types of 3D scanning technologies − 3D scanning equipment and data capture − 3D mesh data and mesh processing − Fundamentals of reverse engineering − Design collaboration and data management
Assessment:	Graded digital examination
Literature:	Paul J. Schilling, Randy H. Shih: Parametric Modeling with SOLIDWORKS 2023. SDC Publications, 2023. ISBN: 978-1-63057-549-6 David C. Planchard: Engineering Design with SOLIDWORKS 2023. SDC Publications, 2023. ISBN: 978-1-63057-550-2 Gary Confalone, John Smits, Thomas Kinnare: 3D Scanning for Advanced Manufacturing, Design, and Construction. Wiley, 2023. ISBN: 9781119758518

Module name:	**Additive Manufacturing**
Module Code	3057
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. Stéphane Danjou
Lecturer:	Prof. Dr.-Ing. Stéphane Danjou
Language:	English
Part of focus field:	Product creation
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 75 h preparation and review 15 h exam preparation 30 h report preparation
Credits:	6
Recommended prerequisites:	none
Required prerequisites:	none
Module objectives:	Upon successful completion of this module, students will: - AM Fundamentals: Gain a deep understanding of the principles, processes, and classifications of additive manufacturing technologies. - Materials and Processes: Learn about the range of materials used in AM and the processes associated with each, including Fused Deposition Modeling (FDM), Stereolithography (SLA), and Selective Laser Sintering (SLS). - Design for AM: Be able to design components specifically for AM, taking advantage of its capabilities and addressing its limitations. This includes considerations for support structures, overhangs, and geometrical complexity. - Hands-On Printing: Gain practical experience in operating desktop 3D printers. - Quality Control: Understand the importance of quality control in AM, including post-processing, surface finish, and dimensional accuracy. Students will know how to assess the quality of AM parts and identify common defects and resolutions. - AM Applications: Explore a range of applications for AM in engineering, from rapid prototyping to custom tooling, aerospace components, and medical implants. - Material Selection: Evaluate and choose materials based on mechanical, thermal, and chemical properties for specific engineering applications. - Sustainability and Environmental Impact: Investigate the environmental impact of AM processes and identify sustainable practices.

	− Economic Considerations: Examine the economic viability of AM, including cost-benefit analysis and comparisons to traditional manufacturing methods.
Content:	This module delves into the fascinating and transformative field of Additive Manufacturing (AM), also known as 3D printing, within the context of an Engineering degree programme. Students will explore the principles, technologies, and applications of AM and gain hands-on experience in designing, building, and testing additive manufactured parts. They will plan and execute the whole process chain, starting with model preparation and finishing with real, ready-to-use parts. Covered topics: − AM processes and materials − 3D printing technologies such as o Vat photopolymerization (SLA, DLP, CDLP) o Material jetting o Powder bed fusion (SLS, SLM) o Material extrusion (FDM) − Quality control and post-processing of 3D printed parts − AM in industry − Materials selection and mechanical properties − Design principles for AM − Standardization in AM − Economic considerations and cost analysis − Sustainability and environmental impact − Emerging trends in additive manufacturing
Assessment:	Graded digital examination
Literature:	Gebhardt, A.; Kessler, J. et al. (2018): 3D Printing: Understanding Additive Manufacturing (Second edition). Munich: Carl Hanser Fachbuchverlag. Gibson, I., Rosen, D., & Stucker, B. (2020). Additive Manufacturing Technologies (Third Edition). Springer. Anderhofstadt, R.; Disselkamp, M. (2023): Disruptive 3D Printing. Munich: Carl Hanser Fachbuchverlag. ISO 17296-2, 15.01.2015: Additive manufacturing - General principles - Part 2: Overview of process categories and feedstock. ISO/ASTM 52900, 15.12.2015: Additive manufacturing - General principles - Terminology.

Module name:	**Product Development**
Module Code	3058
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. Stéphane Danjou
Lecturer:	Prof. Dr.-Ing. Stéphane Danjou
Language:	English
Part of focus field:	Product creation
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Project: 1 HPW
Workload:	60 h attendance 90 h preparation and review 30 h exam preparation
Credits:	6
Recommended prerequisites:	3D Product Specification
Required prerequisites:	none
Module objectives:	Upon successful completion of this module, students will: - Concept to Prototype: Understand the entire product development process from conceptualization to prototyping. - Product Lifecycle: Gain insight into the various stages of a product's lifecycle, including concept development, design, manufacturing, and testing. - Design Thinking: Be able to apply design thinking principles to develop user-centred products. - Team Collaboration: Develop skills in effective teamwork, communication, and collaboration among multidisciplinary teams. Students will demonstrate the ability to collaborate with diverse teams, incorporating mechatronic or electronic concepts into the broader design process. - Market Analysis: Understand the importance of market research and analysis in defining a product's requirements and specifications. - Prototyping and Testing: Explore rapid prototyping techniques and be able to create functional prototypes and iterate based on testing and user feedback. - Regulatory and Ethical Considerations: Understand the regulatory and ethical aspects of product development, including safety, environment, intellectual property, and compliance.
Content:	This module serves as a foundational exploration of product development within the context of mechanical engineering, aiming to provide students with essential knowledge and skills necessary to understand and engage in the multifaceted process of bringing a product from concept to realization. It introduces key concepts, principles, and methodologies in product development that are vital for engineering students.

	Covered topics: − The product development process − Stages of the product lifecycle − Design methodology − Working within cross-functional teams − Requirements: customer needs, market gaps and regulations − The EU machinery directive − Concept development and ideation techniques − Rapid prototyping methods and tools − Intellectual property and regulatory considerations − Sustainability
Assessment:	Project-based graded assessment
Literature:	Shetty, D. (2015): Product Design for Engineers, International Edition. Cengage Learning Emea Mattson, C. A.; Sorensen, C. D. (2020): Product Development: Principles and Tools for Creating Desirable and Transferable Designs. Springer. Has, M. (2022). Sustainable Products: Life Cycle Assessment, Risk Management, Supply Chains, Eco-Design. De Gruyter.

Module name:	**Manufacturing Technology and Factory Equipment**
Module Code	3059
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. Alexander Klein
Lecturer:	Prof. Dr.-Ing. Alexander Klein
Language:	English
Part of focus field:	Business Operations
Timetabled hours:	Lecture: 3 HPW Exercise: 1 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	-
Required prerequisites:	-
Module objectives:	After successful completion of this module, students • know common manufacturing technologies and their basic advantages and disadvantages, mainly for cutting, deforming and selected shaping technologies • know the most important process parameters of selected manufacturing technologies and have an understanding of the challenge to find good process parameters to achieve a good total utility of the process with oftentimes conflicting goals • have a good basic knowledge about the types of machines used for the manufacturing technologies. • understand the quality requirements of machine tools and other related pieces of production equipment and metrology equipment needed for quality assurance • know the basic functions of CAM tools (computer aided manufacturing) and its role in industrial manufacturing (and the CAD/CAM chain) as well as other software tools in manufacturing • can select suitable manufacturing processes and machines for specific manufacturing tasks considering production volume and product quality • can define a suitable automation concept and select the necessary automation equipment • know common intra logistic means and storage systems and can plan the internal material storage and transport in a factory
Content:	• Manufacturing technologies overview according to DIN 8580 • Core equipment: Machine tools including tooling and devices (fixtures) and machining centres • Secondary value creation equipment (e.g. tool reconditioning, tool and die making) • Intra logistics hardware (AGVs, conveyors, cranes, miscellaneous vehicles) • Storage systems • Production related building infrastructure

	• Automation solutions and robots • Quality assurance equipment (soft- and hardware) • Linked systems and flexible manufacturing systems • Software and IT structures for production (CAM, APS, MES, material flow simulation, vehicle routing etc.) • Examples and use cases (case studies)
Assessment:	Graded exam
Literature:	DIN 8580 BARTENSCHLAGER, Jörg, Josef DILLINGER, Walter ESCHERICH, Werner GÜNTER, Eckhard IGNATOWITZ, Stefan OESTERLE, Ludwig REISSLER, Andreas STEPHAN, Reinhard VETTER und Falko WIENEKE, 2016. Metal engineering textbook. 1st English edition. Haan-Gruiten: Verlag Europa-Lehrmittel. ISBN 3808512431 KALPAKJIAN, Serope, Steven R. SCHMID und K. S. Vijay SEKAR, 2014. Manufacturing engineering and technology. 7. ed. in SI units. Singapore [u.a.]: Pearson. ISBN 9789810694067 BRECHER, Christian und Manfred WECK, 2023. Machine Tools Production Systems 1: Machine Types and Application Fields. 1st ed. 2024. Berlin, Heidelberg: Springer Berlin Heidelberg, Imprint: Springer. ISBN 9783662681190. BRECHER, Christian und Manfred WECK, 2021. Machine Tools Production Systems 2: Design, Calculation and Metrological Assessment. 1st ed. 2021. Berlin, Heidelberg: Springer Berlin Heidelberg, Imprint: Springer. ISBN 9783662608630. BRECHER, Christian und Manfred WECK, 2022. Machine Tools Production Systems 3: Mechatronic Systems, Control and Automation. 1st ed. 2022. Wiesbaden: Springer Fachmedien Wiesbaden, Imprint: Springer. ISBN 9783658346225. COLLIER, David A. und James R. EVANS, [2017]. OM6: Operations + supply chain management. [6th edition]. Boston, MA: 4LTR Press ; Cengage Learning. ISBN 9781305664791

Module name:	**Sustainability, Quality and Business Process Management**
Module Code	3060
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. Alexander Klein
Lecturer:	Prof. Dr.-Ing. Alexander Klein
Language:	English
Part of focus field:	Business Operations
Timetabled hours:	Lecture: 3 HPW Exercise: 1 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	-
Required prerequisites:	-
Module objectives:	After successful completion of this module, students • know the theoretical models, concepts and methods of sustainable development and sustainable management • can address the targets and conflicts of sustainability in a business environment • know industry standards for quality and sustainability management • can apply quality management and quality assurance methods in the context of product development and production planning • are able to select and evaluate quality management systems • understand the principles and structures of business processes and business process management • are able to develop and optimize business processes • know software solutions for sustainability, quality management and assurance and business process management
Content:	• Examples and use cases (case studies) • Sustainability definition • ESG reporting • Fair and green supply chains, labels • Means to improve sustainability • Circular economy • Quality definitions • Perceived quality • Continuous improvement • Auditing • Benchmarking • APQP, quality assurance, inspection planning including Design FMEA and Process FMEA • Quality function deployment • Metrology basics • Statistical process control • Six sigma basics

	• Important standards for QM, Safety management, health management, Environment, such as DIN EN ISO 9001, 14001, 45001, 50001 • Business process definition and business process modelling notation • Tools and proven approaches for business process improvements • Digital workflows
Assessment:	Graded exam
Literature:	BELL, Simon, 2018. Routledge Handbook of Sustainability Indicators. Routledge. ISBN 9781315561103 DIN EN ISO 9001 DIN EN ISO 14001 DIN ISO 45001 DIN EN ISO 50001 AIAG & VDA, 2022. FMEA Handbook. GOLDRATT, Eliyahu M. und Jeff COX, 2014. The goal: a process of ongoing improvement. 4., rev. ed., 30. anniversary ed. Great Barrington, Mass.: North River Press. ISBN 9780884271956

Module name:	**Applied Manufacturing Technology**
Module Code	3061
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. Alexander Klein
Lecturer:	Prof. Dr.-Ing. Alexander Klein
Language:	English
Part of focus field:	Elective
Timetabled hours:	Lecture: 1 HPW Project: 3 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	Manufacturing Technology and Factory Equipment
Required prerequisites:	-
Module objectives:	After successful completion of this module, students • understand the parameters and needs of a specific manufacturing task (workpiece value addition) • are able to evaluate the feasibility of workpiece features • can derive conclusions about potentially suitable manufacturing technologies and generate manufacturing option hypotheses (possible value chain candidates) • can narrow down options and clarify suitability of these candidates, assess them depending on different boundary conditions (e.g. milling vs. forming for small and large quantities) • can configure and determine detailed process parameters and settings for different options
Content:	• Overview over miscellaneous manufacturing technologies from all 6 families according to DIN 8580 • Definition of technical requirements for a specific, individual workpiece for the selection of suitable manufacturing technologies under consideration of the required production volume • Cost and capacity calculation for core process and for support process such as tool making and reconditioning • Technology selection and detailed parameter definition with respect to currently available manufacturing technologies • Potential product optimization for simplification of manufacturing processes • Supervision or execution of manufacturing processes • If necessary: o Optimization of manufacturing processes in factory environments o Design of Experiments (basics) • Examples and use cases (case studies)
Assessment:	Graded project

Literature:	DIN 8580 BARTENSCHLAGER, Jörg, Josef DILLINGER, Walter ESCHERICH, Werner GÜNTER, Eckhard IGNATOWITZ, Stefan OESTERLE, Ludwig REISSLER, Andreas STEPHAN, Reinhard VETTER und Falko WIENEKE, 2016. Metal engineering textbook. 1st English edition. Haan-Gruiten: Verlag Europa-Lehrmittel. ISBN 3808512431 GOMERINGER, Roland, Max HEINZLER, Roland KILGUS, Volker MENGES, Stefan OESTERLE, Thomas RAPP, Claudius SCHOLER, Andreas STENZEL, Andreas STEPHAN und Falko WIENEKE, 2021. Mechanical and metal trades handbook. 4th edition 2018, corrected reprint 2021. Haan-Gruiten, Germany: Verlag Europa-Lehrmittel Nourney, Vollmer GmbH & Co. KG. ISBN 9783808519158 KALPAKJIAN, Serope, Steven R. SCHMID und K. S. Vijay SEKAR, 2014. Manufacturing engineering and technology. 7. ed. in SI units. Singapore [u.a.]: Pearson. ISBN 9789810694067 BRECHER, Christian und Manfred WECK, 2023. Machine Tools Production Systems 1: Machine Types and Application Fields. 1st ed. 2024. Berlin, Heidelberg: Springer Berlin Heidelberg, Imprint: Springer. ISBN 9783662681190. BRECHER, Christian und Manfred WECK, 2021. Machine Tools Production Systems 2: Design, Calculation and Metrological Assessment. 1st ed. 2021. Berlin, Heidelberg: Springer Berlin Heidelberg, Imprint: Springer. ISBN 9783662608630. BRECHER, Christian und Manfred WECK, 2022. Machine Tools Production Systems 3: Mechatronic Systems, Control and Automation. 1st ed. 2022. Wiesbaden: Springer Fachmedien Wiesbaden, Imprint: Springer. ISBN 9783658346225.

Module name:	**Leadership**
Module code	3062
Degree:	Bachelor of Sciences in Engineering
Module coordinator:	Anja Viermann
Lecturer:	Anja Viermann or external lecturer
Language:	English
Part of focus field:	All focus fields
Place in curriculum:	Elective
Timetabled hours:	Seminar: 4 HPW
Workload:	60 h attendance 120 h preparation, review and working on the assignment
Credits:	6
Recommended prerequisites:	Project Management
Required prerequisites:	Social and Personal Competence
Module objectives:	The students will • gain profound conciseness, experience, and knowledge of key-theories, -concepts and -methods of leadership-research and -practice. • acquire the ability to make use of this knowledge facing concrete practical challenges. • acquire social and methodical competencies which enable them to take on leadership responsibilities. • improve their intercultural collaboration and communication skills as well as presentation abilities.

Content:	• Definition, Context and Significance of Leadership
	• Introduction to Success Factors of Modern Leadership
	• The Principal of Leadership Success Factor Modeling
	• A practical Leadership Flow Landscape
	• Success Factors of Leadership in Detail
	  • Key Target Areas (e.g. Change, People, Values)
	  • Key Activities (e.g. Coaching, Empowering, Facilitation)
	  • Key Functional Qualities (e.g. Decision making, Project Management, Crisis Management and Prevention)
	  • Key Social Leadership Qualities (e.g. Building Mindset, building Resilience, building Trust)
	• Practical Modelling and Embodyment of Success Factors in different Group Assignments

Assessment:	Examination: • Individual assignments: preparation, submission and oral presentation of a written assignment (50%) • Oral assessment or written examination (50%)
Forms of media:	Video-Input (Offline), Work-Sessions and Joint Reviews (Webex), Whiteboard, PowerPoint, Projector, Flip-Chart, Moderation Kit, Films, Case Analysis, Role Plays

Literature:	• Afsaneh Nahavandi (2015): Art and Science of Leadership, 7th Edition, Pearsons Education • Edgar H. Schein (2017): Organizational Culture and Leadership, 5th Edition, John Wiley & Sons • Fredmund Malik (2015) – second Edition: Managing Performing Living - Effective Management for a New World, Campus • Robert B. Dilts (2016): Next Generation Entrepreneurs – Success Factor Modeling Volume I Supplemental readings, e.g. additional literature sources, exercises, cases and other learning materials will be provided during class.

Module name:	**Entrepreneurship**
Module Code	3063
Degree:	Engineering, B. Sc.
Module coordinator:	D. Untiedt
Lecturer:	D. Untiedt
Language:	English
Part of focus field:	Elective
Timetabled hours:	Lecture: 1 HPW Practical Training: 3 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	Accounting
Required prerequisites:	-
Module objectives:	Entrepreneurial thinking and acting of the students will be trained specifically with regard to the main responsibilities of business establishment. After finishing the module, students are able to analyse and evaluate markets, market develop-ments, customer values and competitive advantages. They show fundamental knowledge of generating business plans in which the business concept always remains the focal point.
Content:	• Theoretical basics • Legal forms • Business plan creation
Assessment:	Lecture: Graded Examination Practical Training: -
Forms of media/ Software	Moodle, Business Simulation Game
Literature:	• Barringer, B. R.; Ireland, D.: Entrepreneurship – Successfully Launching New Ventures, 4th edition, Prentice Hall, 2012.

Module name:	**Information Competence and Scientific Working**
Module Code	3064
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. A. Struck
Lecturer:	NN
Language:	English
Part of focus field:	Elective
Timetabled hours:	Lecture: 2 HPW Exercise: 2 HPW
Workload:	180
Credits:	6 CP
Recommended prerequisites:	
Required prerequisites:	
Module objectives:	Upon completion of this module, students will be able to: • Understand the philosophical underpinnings of how scientists generate reproducible and reliable knowledge, and how to assess differences in the quality of scientific studies in terms of study design • Assess challenges to the quality of scientific information (such as the reproducibility problems, confirmation and publication bias, poor experimental design, p-hacking, and predatory journals) • Understand how science is communicated to fellow scientists and to the public and how academic communication differs from non-academic science communication Understand challenges to accurate science communication among scientists and from scientists to the public and learn strategies how to overcome them
Content:	At its core, scientists and science communicators have the same goal: They want to know the truth about the world and accurately communicate it to others. This module teaches how to keep the research reliable and how to communicate these findings without getting things wrong.
Assessment:	Attestation: Continuous Assessment
Forms of media/ Software	
Literature:	• Hume, D. (1748): An enquiry concerning human understanding • Russell, B. (1946/2004): History of Western Philosophy • Popper, K. (1959): The Logic of Scientific Discovery • Snow, CP (1959): The Two Cultures and the Scientific Revolution • Kuhn, T.S. (1962): The Structure of Scientific Revolutions • von Bubnoff, A. (2007): Numbers Can Lie (LA Times) • Nuzzo, R. (2014): Scientific Method: Statistical errors. • von Bubnoff, A. (2016): Experimental Quality

	• Giuseppe Biondi-Zoccai, ed. (2016): Umbrella Reviews: Evidence Synthesis with Overviews of Reviews and Meta-Epidemiologic Studies • Harris, R. (2017): Rigor Mortis: How Sloppy Science Creates Worthless Cures, Crushes Hope, and Wastes Billions • Montgomery, S.L. (2017): The Chicago Guide to Communicating Science • Pinker, S. (2021): Rationality.

Module name:	**Numerical Mathematics**
Module Code	3065
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr. A. Kehrein
Lecturer:	Prof. Dr. A. Kehrein, Prof. Dr. A. Struck
Language:	English
Part of focus field:	Elective
Timetabled hours:	Lecture: 2 HPW Exercise: 2 HPW
Workload:	60 h attendance 90 h preparation and review
Credits:	6
Recommended prerequisites:	
Required prerequisites:	3000 Mathematics 1, 3001 Mathematics 2
Module objectives:	The students learn that use of a computer introduces new mathematical difficulties: not all numbers are representable; there are roundoff errors and propagation errors. Mathematically equivalent formulas may produce different results on a computer. The students learn how to do computations effectively within the machine limitations. The students learn some standard methods of numerical mathematics but, more importantly, how to adapt or even develop numerical methods to fit the problem at hand. The students become active learners and look for applications of the new methods on their own. They become independent in checking the correctness of their results.
Content:	• Presentation of numbers in a computer: INT and FLOAT; roundoff errors • Loss of significant digits, error propagation • Interpolation: Lagrange polynomials and splines • Numerical differentiation: use of Taylor approximations, order of a numerical method, truncation error • Numerical integration: midpoint rule, trapezoid rule, Romberg scheme • Fixed-point iteration • Iterative solution of non-linear systems, in particular Newton’s Method • Numerical solution of differential equations: forward and backward Euler, stability, implicit vs. explicit schemes
Assessment:	Lecture: Written examination Exercise: Attestation
Literature, Resources:	1. Forman S. Acton (2005) *Real Computing Made Real – Preventing Errors in Scientific and Engineering Calculations*. Mineola. Dover Publications. 00/TKX 19´

	2. Cleve Moler (2004) *Numerical Computation with Matlab*, Society for Industrial and Applied Mathematics (pdf available from https://de.mmathworks.com/moler/chapters.html) 3. Gilbert Strang (2007) *Computational Science and Engineering*. Wellesley. Wellesley-Cambridge Press. 00/TKX 3 4. Richard Burden and Douglas Faires (2011) *Numerical Analysis*. 9th international edition. Brooks/Cole. 00/TKX 17 5. Parviz Moin (2010) *Fundamentals of Engineering Numerical Analysis*. 2nd edition. Cambridge. Cambridge University Press. 00/WAT 1 6. William Press, Saul Teukolsky, William Vetterling, Brian Flannery (2007) *Numerical Recipes – The Art of Scientific Computing*. 3rd edition. Cambridge. Cambridge University Press. (online materials available from http://numerical.recipes) 00/TKX 5

Module name:	**Inner Engineering**
Module Code	3067
Degree:	Engineering, B. Sc.
Module coordinator:	Anja Viermann
Lecturer:	A. Viermann
Language:	English
Part of focus field:	All focus fields / Elective (Attestation)
Timetabled hours:	Seminar: 4 HPW
Workload:	60h attendance 120h preparation and review 180h total
Credits:	6
Recommended prerequisites:	Module: Personal and Social Competences
Required prerequisites:	A personalised pre-program, preliminary meeting and interview with your lecturer. (This course is not suitable for participants with deeper mental health problems and psychiatric diagnosis of major depressive disorder or bipolar, psychotic or post-traumatic stress disorder and substance abuse or dependence).
Module objectives:	This module is very much geared towards experience-based learning. It requires a high level of intrinsic motivation from the students - the willingness to actively engage with themselves and the other participants and a strong desire to develop further. The aim of this module is to support students: • Building up knowledge coming from neurosciences about the functionality of the brain and the interplay of conscious and subconscious processes and their impact on perception, thinking, creativity and decision-making, reaction, behavior. • Understanding the interplay between mind and body – seeing to which extent, of what goes on in our head has an effect on our body. The intertwining, the interconnection of our physiology and the behaviour - with the underlying emotions, thoughts and memories - and the capacity of each to deeply influence the other. • Based on this background, getting to know and apply different approaches and methods (e.g. coming from psychology, mindfulness research and hypno-systemic approaches used in areas of mental training and coaching) that make helpful use of this intertwine knowledge, to come into a better “cooperation” with these processes running and positively influence them. • By developing and expanding a framework of knowledge and methods, step by step students can build up skills and start to recognise the possibility of becoming an "Inner Engineer" - finding effective and better individual ways of dealing with areas such as stress, emotions, focus/attention span, learning behavior, creativity or challenges and change. • This course approaches at the level of personal and social skills development, supporting students to increase their individually perceived self-efficacy and resilience. Helping them to improve a

	more self-reflective and mindful approach to oneself, one's fellow human beings and one's environment. Going with all this, making a positive contribution to their individual level of well-being and their perceived quality of life as well as improve the communication behavior and relationship qualities.
Content:	1. Introduction to the intertwine of body, mind and thinking, feeling and (re)acting etc. • How our brain works; About our filters and how conscious and subconscious processes influence us in the way we perceive, think, make decisions. • How body and mind is connected: e.g. embodiment, placebo-effects, epigenetics, etc. • Positive Psychology: better understanding of what factors contribute to the level of well-being • How mental training and mindfulness-based approaches and meditation can affect us. 2. Learning and practising a scientifically well-researched program, based on mindfulness (MBSR - Mindfulness Based Stress Reduction – the official 8-week program, is included in the lecture). In particular for this program, positive effects on the following factors have been investigated to date: • attention • emotion regulation • stress reduction • connectedness & compassion, with wider effects on health and the working environment Different forms of meditation (including sitting meditation, walking meditation, body scan) form one important base of this program and for its efficiency, should be regularly and independently be practiced by the students as well outside of the course. 3. In addition, applying and practising individually, in pairs or groups different methods (e.g. coming from psychology including hypno-systemic approaches; used in areas of mental training and coaching), supporting students to increase self-efficacy and improve the way of how they individually learn to better deal with topics like • stress & emotions • challenges and change • goal setting and goal achievement • decision making
Assessment:	Attestation: • Active and regular participation in learning & "experiential spaces" in classroom in presence (attendance) 80% • Willingness to practice meditation on a daily basis • Active participation in the exercises during and after the sessions (incl. peer partner exchange) • Reflection of the practical experience in a learning diary (20 %)
Literature:	Auhagen, Ann Elisabeth: Positive Psychologie: Anleitung zum "besseren" Leben, Nikol (2 Sept. 2019) Dijksterhuis, Ap: Het slimme onbewuste: denken met gevoel; Prometheus, Uitgeverij; 39. edition (20 Jan. 2015) Kahnemann, Daniel: Thinking, Fast and Slow, Penguin; 1st edition (10 May 2012)

	Roth, Gerhard: Persönlichkeit, Entscheidung und Verhalten: Warum es so schwierig ist, sich und andere zu ändern; Klett-Cotta; 13., vollständig überarbeitete Neuauflage 2019 (13 Feb. 2015) Seligmann, Martin E.P.: Flourish: A Visionary New Understanding of Happiness and Well-being; Atria; Reprint edition (7 Feb. 2012) Sapolsky, Robert M. Behave: The Biology of Humans at Our Best and Worst; Penguin Press; Illustrated edition (2 May 2017) Tschacher, Wolfgang and Storch, Maja et al.: Embodiment: Die Wechselwirkung von Körper und Psyche verstehen und nutzen; Hogrefe AG; 4. überarb. Auflage 2023 (7 Nov. 2022) Various publications on the current state of research on mindfulness and the MBSR program: e.g. American Mindfulness Research Association: https://goamra.org/ Deutscher MBSR Verband https://www.mbsr-verband.de/achtsamkeit/forschung Achtsame Hochschule https://achtsamehochschulen.de/hubs/ Supplemental readings, e.g. additional literature, exercises, cases and other learning materials will be provided during class.

Module name	**Mentoring**
Module code	3100
Degree:	Engineering, B. Sc.
Module coordinator:	A. Struck
Lecturer:	NN
Language:	English
Part of focus field:	All focus fields
Place in curriculum:	1st and 2nd semester
Timetabled hours:	2 SWS
Workload:	30 h attendance
Credits:	1
Recommended prerequisites:	none
Required prerequisites:	none
Module objectives:	Students understand the essential content of their degree program with its various specializations. Through the mentoring program, students are supported in developing an individually tailored and feasible study plan for themselves according to their inclinations, abilities and goals. so that they are able to plan their individual study path by choosing the appropriate subject combinations at the end of the standard entry semester (1st semester) in the second semester. In the process, the development of the following skills is supported and further strengthened for the future: • Reflection competence: The student develops a high level of self-awareness (especially in the context given in regards to their personal professional interests and strength) and the ability to self-reflect as base to identify own development needs, considering own perception but as well including perceptions of others (external perception). • Self-competence: The student can master his professional development largely independent of external influences. Meaning, there is very few needs for external support, such as mentoring, to find and go own path in the future. • Decision-making competence: The student gains clarity about their own goals, interests and potentials - and is able to make conscious decisions on that base. • Integrity Competence: The student appreciates transparency, honesty and work ethic and applies them in relationships and in their own work. Admitting faults and seek guidance, if needed. The student comes in touch with the importance of applying accountability. • Initiative and performance competence: The student has the ability to self-motivate and organize the

	own work and development in order to achieve results. Showing resilience, overcoming setbacks and not being discouraged by challenges.
Content:	• Participation at the Onboarding-Week of the Faculty • Regular participation in the group mentoring and study guidance • Participation in two one-on-one mentoring appointments, including preparation and follow-up
Assessment:	• 70% participation in all in-person-sessions • Participation in 2 mentoring appointments, first at the end of the 1st semester, second during the 2nd semester.
Requirements:	Successfully finished mentoring and achieved Creditpoint is required for all 4th semester modules.

Module name	**Microelectronic Control Systems**
Module code	3069
Degree:	Engineering, B. Sc.
Module coordinator:	Prof. Dr.-Ing. I. Volosyak
Lecturer:	Prof. Dr.-Ing. I. Volosyak
Language:	English
Part of focus field:	Information and Communication Technology
Place in curriculum:	
Timetabled hours:	Lectures: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 120 h preparation and review
Credits:	6
Recommended prerequisites:	3009 Microcontrollers 3034 System Theory and Controls
Required prerequisites:	
Module objectives:	After completing this module, students are able to design the architecture of microelectronic controls. They are able to select corresponding components and to evaluate them for application. They master the essential aspects of microcontroller-based control systems in hardware and software and are able to interpret them corresponding to relevant principles. Students are familiar with key technologies for realising modern control systems such as networks, real time systems and modern interactive interfaces. They are able to create analyses of the expected requirements and to select corresponding systems.
Content:	• Architecture of control systems • Components of microelectronic controls • Security aspects in designing control systems • Safety-oriented programming • Safety-oriented hardware • Object-oriented programming in Automation engineering • Distributed controls • The concept of real time • Graphical user interface
Assessment:	Attestation within the scope of laboratory (T)
Requirements:	
Media:	Webex/Moodle, Laboratory experiments on campus
Literature:	1. Ivan Volosyak: Microchip AVR Programming using ATmega Microcontrollers: with Answers, 2021. 00/TXU102

	2. E. Williams: Make: AVR Programming, O'Reilly and Associates, 2014. Also available as online resource: http://www.digibib.net/permalink/1383/FHBRHW-x/HBZ:HT019887239 3. S. Barret: Embedded Systems Design with the Atmel AVR Microcontroller, Morgan & Claypool Publishers, 2009 4. Nobuyasu Kanekawa, Eishi H. Ibe, Takashi Suga, Yutaka Uematsu: Dependability in Electronic Systems: 4. Mitigation of Hardware Failures, Soft Errors, and Electro-Magnetic Disturbances, Springer, 2010 5. Course materials from the lecturer

Module name:	**Bachelor Thesis**
Module Code	2017
Degree:	Engineering, B. Sc.
Module coordinator:	Heads of the degree programme
Lecturer:	Supervisor of the bachelor thesis
Language:	English
Part of focus field:	
Timetabled hours:	
Workload:	360 h
Credits:	12 CP
Recommended prerequisites:	
Required prerequisites:	183 CP in the respective courses
Module objectives:	The students • demonstrate their capability to work independently on a subject in alignment with their course of studies, meeting all topical and scientific requirements in a limited period of time • are able to organize their workflow in order to meet the demands of the problems formulated in their theses, as well as to monitor progress and make necessary amendments are able to document their approach and their results to meet the requirements of a scientific publication
Content:	Thesis content depends on the chosen topic and is agreed upon with the supervisor. Documentation is granted by an adequately sized description of the topic/problem, the chosen approach, used methods and results.
Assessment:	Written and graded thesis in the range of 15000 to 20000 words (50–70 DIN A4 pages)

Module name:	**Colloquium**
Module Code	2018
Degree:	Engineering, B. Sc.
Module coordinator:	Heads of the degree programme
Lecturer:	Supervisor of the bachelor thesis
Language:	English
Part of focus field:	
Timetabled hours:	
Workload:	90 h
Credits:	3 CP
Recommended prerequisites:	
Required prerequisites:	207 CP in the respective courses
Module objectives:	The students • are able to defend the results of the Bachelor Thesis • place their work in a suitable context and present their results in a proper form for the audience. They are able to explain their approach and to critically analyse their own results. are able to analyze questions concerning their thesis and results and answer them suitably.
Content:	Content is aligned with the content of the Bachelor Thesis, with an operative focus on discussion of their results, methods and alternatives.
Assessment:	Oral examination, graded
Literature:	1. M. Powell: Presenting in English – how to give successful presentations, Heinle Cengage Learning, 2011 2. S. Krantman: The Resume Writer’s Workbook, fourth edition, South-Western Cengage Learning, 2013

Module name:	**Internship / Semester Abroad**
Module Code	2016
Degree:	Engineering, B. Sc.
Module coordinator:	Heads of the degree programme
Lecturer:	Professors
Language:	English
Part of focus field:	
Timetabled hours:	
Workload:	900 h
Credits:	30 CP
Recommended prerequisites:	
Required prerequisites:	90 CP in the respective courses
Module objectives:	Internship Semester: Student's work in one or more functional units of an enterprise. They will apply their gained knowledge and methods in technical, analytical, and social matters. The students will have to use their theoretical gained knowledge in their respective practical discipline and reflect it afterwards. Students have to use the following key skills: • Interdisciplinary project work • Intercultural skills • Transfer theoretical knowledge into the practical knowledge • Organization and self-management skills • Set priorities and organize work according to priorities • Team oriented work and communication skills • English as international language • Ability to handle changes during task • Work under pressure of time The internship can be completed abroad. Semester abroad: Students can decide to substitute the internship semester with a study abroad semester. Selecting a study abroad semester offers the student to being immersed into a different educational system and helps therefore understanding other tertiary systems. Study abroad is further defined as a semester at a university in a country other than their nationality or country of origin. The study abroad semester tailors a strengthening of the following key skills:

	• Deepen and broaden their knowledge of certain subjects (e.g. additional courses) • Gain knowledge of other political, economic, and cultural systems • Widen the cultural background • Increase language capabilities • Widen their social competencies • Interdisciplinary project work • Intercultural skills • Organization and self-management skills • Interdisciplinary team oriented work and communication skills • English as international language • Planning and set-up skills Students will increase their intercultural competencies and get an insight into a different culture as well as organization including many administrative tasks.
Content:	Internship Semester: The contents of the internship are based on the business activities and the business environment of the company. They are closely coordinated between the company and the university, so that a consistent professional tie is guaranteed to the study. Semester Abroad: The contents of the Semester abroad are based on the university programs selected by the student. They are closely coordinated between the sending university and the receiving university, so that a consistent professional tie is guaranteed to the study.
Assessment:	Attestation