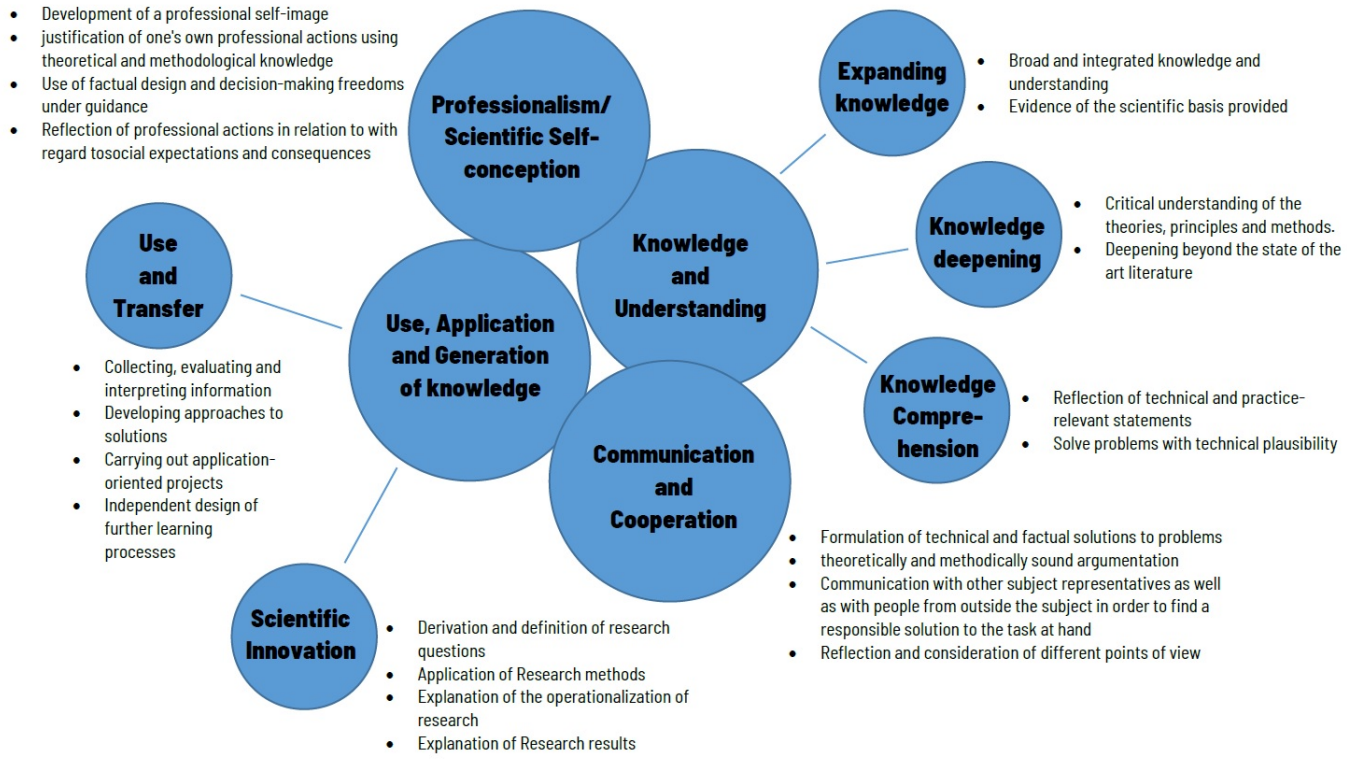
Hochschule Ravensburg-Weingarten Postfach 30 22, 88216 Weingarten

Module Manual E-Mobility and Green Energy

When designing a study program, in addition to study and examination regulations, a module handbook is created that contains a description of the content of the modules and the competencies to be acquired. Modules can be compulsory or part of the elective range. Each module is concluded with a final module examination and is assigned a certain number of credit points. Study programs and thus also modules are consistently designed from the qualification goals (learning outcomes) to be achieved. In the fields of

- Knowledge and Understanding,
- Use, application and generation of knowledge,
- Scientific self-conception/professionalism and
- Communication and Cooperation

competencies are acquired during the course of study in the respective subject-specific context. Not all competencies or their characteristics are acquired in every module; what is relevant is that at the end of the program students have acquired all competencies.
The basis for this is the Qualifications Framework for German Higher Education Qualifications (Qualifikationsrahmen für Deutsche Hochschulabschlüsse, HQR) and the model legal regulation in accordance with Article 4 Paragraphs 1 - 4 of the State Treaty on Study Accreditation of the Conference of Ministers of Education and Cultural Affairs.



Bachelor-Level

Program Objectives

The students will be able to work on projects of electromobility, renewable energies and energy management in terms of questions of efficient energy storage and a battery management system, independently and in teams. They will be able to actively shape the energy transition.

The students can participate in projects in the companies and also work on projects or sub-projects independently work on.

Students are able to consider the cost and function according to the specifications of the project.

Students will be able to apply requirements analysis methods, create specifications and implement the product.

Students know that the development of testability, and therefore the quality of the product, must accompany the entire development process.

The students learn to work independently, but also to find solutions in a team.

Content Modules

Basic studies

Messtechnik 1: Grundlagen
Electrical Engineering 1: Basics
Electrical Engineering/ Physics 2: Electrodynamics
Electrical Engineering 3: Time and Frequency Domain
Mathematics 1: Analysis 1
Mathematics 2: Linear Algebra
Mathematics 3: Analysis 2
Robotics
Programming
Electrical Engineering Practical
Digital Technology
Computer-Aided Circuit Design 1
Physics Mechanics
Materials Science
Machinery Design

Main studies

Leistungselektronik
Einführung in die Antriebstechnik
Echtzeitprogrammierung
Electronics
Digital Signal Processing
Language
Project-Seminar
Control Engineering
Microcontrollers
Elective Module
Practical semester
Automotive Electronics Controls
Intelligent Transportation Systems
Real-TimeProgramming
Elektrische Antriebsstränge
Image Processing
Solar Cells, Fuel Cells and Batteries
Green Energies and Energy Storage
Bachelor Thesis
Automotive Engineering: Basics, Practical and Computer Aided Design (CAD)

Module: Messtechnik 1: Grundlagen

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EI04
Module title:	Messtechnik 1: Grundlagen
Module responsible:	Prof. Dr.-Ing. Raphael Ruf
Typ of module:	Mandatory module
Undergraduate/Major:	Basic studies
Module Content:	In der Vorlesung: - Einheiten - Der Messvorgang, Messnormale und Kalibrierkette - Messabweichungen, Toleranzen und Fehlerfortpflanzung - Digitale Messgeräte: digitale Multimeter - Messbereichserweiterung, Messgleichrichter - Analoge und digitale Oszilloskope - Messung von Gleichspannung und Gleichstrom, Wechselspannung und Wechselstrom - Messung von Gleich- und Wechselstromwiderständen Im Praktikum: 4 Versuche, Zeitdauer jeweils ca. 3 Stunden: - Oszilloskop: Grundlagen des Umgangs mit Oszilloskopen - Berechnung und Messung von Amplituden- und Phasengang von Zweitoren --- PSPICE-Simulation derselbigen - Automatisierte Messaufbauten auf Grundlage des IEC-Buses - Leistungsmessung bei Drehstrom
Courses:	2117 Messtechnik 1 2121 Messtechnik-Labor
Teaching and learning forms:	Vorlesung, Labor (Anwesenheitspflicht, da ansonsten die Fertigkeiten nicht vermittelt werden können)
Prerequisites for participation:	Elektrotechnik 1: Grundlagen
Applicability of the module:	Elektrotechnik und Informationstechnik Elektromobilität und regenerative Energien
Prerequisites allocation ECTS:	K90, praktische Übungen
ECTS credits:	5
Grading:	benotet
Workload:	Es wird von einem Workload von 30 Stunden je ECTS ausgegangen. Somit ergibt sich ein Arbeitsaufwand von 150 h (davon 60 h für Lehrveranstaltungen, 90 h für das Selbststudium (Vor- und Nachbereitung, Prüfungsvorbereitung).
Duration of the module:	one semester
Frequency of offering:	Summer semester only
Literature:	Lerch, R.: Elektrische Messtechnik Mühl, T.: Einführung in die elektrische Messtechnik Schrüfer, E.: Elektrische Messtechnik: Messung elektrischer und nichtelektrischer Größen Morris, A.: Measurement & Instrumentation Principles
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Absolventinnen und Absolventen kennen die (Basis-)einheiten und können die Notwendigkeit einer Kalibrierkette begründen.
Absolventinnen und Absolventen wissen um die Wichtigkeit der Angabe von Abweichungen und Toleranzen bei einem Messergebnis; Ist die Messgröße von anderen Messgrößen abgeleitet, können sie die Fortpflanzung der Messabweichung berechnen.
Absolventinnen und Absolventen kennen die wichhitgsten elektrischen Messgeräte (digitales Multimeter und Oszilloskop) und können diese durch Teilnahme an den Laborterminen auch sicher bedienen.
Absolventinnen und Absolventen können einfache Filterschaltungen (RC- und RL-Filter) berechnen, simulieren und praktisch aufbauen sowie vermessen.

Focus:

Broadening of prior knowledge

Use, application and generation of knowledge/art

Absolventinnen und Absolventen wenden die gelernten Inhalte zur Überprüfung der Spezifikation elektrischer Geräte an und weisen Fehler nach. Absolventinnen und Absolventen sind in der Lage, Messergebnise zu analysieren und relevante Messpunkte von irrelevanten Messpunkten zu unterscheiden und die Qualität von Messgeräten und Messergebnissen zu beurteilen. Sie können, aus dem Umfeld eines Unternehmens, einen angepassten Labor/Prüffeldarbeitsplatz aufbauen.

Focus:

Use and transfer

Communication and cooperation

Absolventinnen und Absolventen können die gelernten Inhalte unmittelbar im Labor umsetzen und ihr Wissen in der Gruppe/Team einsetzen und diskutieren.

Scientific / artistic self-image and professionalism

Absolventinnen und Absolventen sind in der Lage nachhaltige Produkte zu entwerfen. Die Wichtigkeit einer nachhaltigen Wirtschaft wird erkannt.

Module: Leistungselektronik

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EI26
Module title:	Leistungselektronik
Module responsible:	Prof. Dr.-Ing. László Farkas
Typ of module:	Mandatory module
Undergraduate/Major:	Main studies
Module Content:	Allgemeines: -Einschalten von ohmsch-induktiven Lasten -Grundsätzliches zu Stromrichtern Leistungshalbleiter -Physik der Halbleiter -Diode -Transistoren -Thyristoren, GTO Thermischen Leitfähigkeit -Modell -Lebensdauer -Reihen- und Parallelschaltung -Verluste und Kühlung Stromrichterschaltungen: -Einpulsstromrichter -Mehrpulsige Stromrichter -Drehstromsteller, Umrichter Anwendungen: -B2x- und B6x-Schaltung (Beispiel Kfz-'Lichtmaschine') -Tiefsetzsteller -Feldorientierte Regelung (Beispiel PM-Synchronmotor)
Courses:	4651 Leistungselektronik
Teaching and learning forms:	Vorlesung, Übungen
Prerequisites for participation:	Analyse elektrischer Netzwerke, Analysis 1
Applicability of the module:	Elektromobilität und regenerative Energien Informatik & Elektrotechnik PLUS Elektrotechnik und Informationstechnik
Prerequisites allocation ECTS:	K90
ECTS credits:	5
Grading:	benotet
Workload:	Es wird von einem Workload von 30 Stunden je ECTS ausgegangen. Somit ergibt sich ein Arbeitsaufwand von 150 h (davon 60 h für Lehrveranstaltungen, 90 h für das Selbststudium (Vor- und Nachbereitung, Prüfungsvorbereitung).
Duration of the module:	one semester
Frequency of offering:	Summer semester only
Literature:	K. Heumann: Grundlagen der Leistungselektronik, Teubner 2001 N. Mohan, T.M. Undeland, W.P. Robbins: Power Electronics - Converters, Applications and Design; Wiley 2003 W. Leonhard: Control of Electrical Drives ; Springer 1997 (dt.: Regelung elektrischer Antriebe, Springer 2000)
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Absolventinnen und Absolventen können die wichtigsten Leistungshalbleiter und die damit realisierbaren Stromrichterschaltungen beschreiben. Sie sind in der Lage, die physikalische Funktionsweise der Halbleiter zu erläutern und die grundlegenden Schaltungen von Halbleiter-Stromrichtern zu beschreiben.

Focus:
Broadening of prior knowledge

Use, application and generation of knowledge/art

Focus:

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Einführung in die Antriebstechnik

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EI41
Module title:	Einführung in die Antriebstechnik
Module responsible:	Prof. Dr.-Ing. László Farkas
Typ of module:	Compulsory elective module
Undergraduate/Major:	Main studies
Module Content:	Allgemeines -Wirkungsgradkette -Mechanik: Geschwindigkeiten, Beschleunigungen, Differentialgleichung der Bewegung, Vergleich Translation und Rotation Gleichstrommaschine -Aufbau, Ersatzschaltbild, Ansteuerung, Versorgung -Stabilität des Arbeitspunktes -Anwendung Drehfeldmaschinen -Prinzip, Drehfeldtheorie -3-Phasen-Maschine Asynchronmaschine -Aufbau, Ersatzschaltbild, Berechnung mit Konstantparametern -Schlupf, Wirkungsgrad, Heylandkreis -Kloss'sche Formel, Regelung -Anwendung, mechanische Besonderheit Synchronmaschine -Aufbau, Ersatzschaltbild, Vergleich mit Asynchronmaschine -Wirkungsgrad, Zeigerdiagramm, Feldorientierte Regelung, Vergleich zu DC-Maschine -Permanentmagneterregte Synchronmaschine: --Aufbau, Wicklungsschema, Drehmoment- und Stromdichte --mechanische Besonderheit, Fertigung, Materialien, Magnete, Anforderungen Rotor, Anwendung Vergleich DC- zu AC-Maschinen
Courses:	5298 Einführung in die Antriebstechnik / Elektrische Antriebe
Teaching and learning forms:	Vorlesung + praktische Übungen
Prerequisites for participation:	keine
Applicability of the module:	Elektrotechnik und Informationstechnik Elektromobilität und regenerative Energien
Prerequisites allocation ECTS:	K90
ECTS credits:	5
Grading:	benotet
Workload:	150h
Duration of the module:	one semester
Frequency of offering:	Summer semester only
Literature:	W. Leonhard: Control of Electrical Drives, Springer 1997 (dt.: Regelung elektrischer Antriebe, Springer 2000) J. Pollefliet: Electronic power control - vol.2: Electronic motor control, Academia press

Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Focus:

Use, application and generation of knowledge/art

Focus:

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Echtzeitprogrammierung

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EI42
Module title:	Echtzeitprogrammierung
Module responsible:	Prof. Dr. rer. nat. Markus Pfeil
Typ of module:	Compulsory elective module
Undergraduate/Major:	Main studies
Module Content:	Architektur moderner Automatisierungssysteme, Spezifische Anforderungen an Echtzeitsysteme, Methoden der Echtzeitverarbeitung: Zyklische Verarbeitung, zeitgesteuerte Verarbeitung, zyklische Verarbeitung mit Interrupts, Multitasking, Fixed Priority with/without Preemption FPP/FPN, Time-Slice Scheduling, Earliest Deadline First EDF Scheduling Task- und Ressourcen Synchronisation (Semaphores, Mutex), Task Kommunikation (Events, Message Queues), Grundlagen der Interruptverarbeitung, Timestamping und Synchronisation Zugriff auf gemeinsam genutzte Daten, Entwurfskriterien für Echtzeitsysteme, Vorstellung der Echtzeitbetriebssysteme VxWorks, FreeRTOS und OSEK, Realisierungsbeispiele.
Courses:	1494 Echtzeitprogrammierung 1495 Echtzeitprogrammierung Praktikum
Teaching and learning forms:	Vorlesung + praktische Übungen
Prerequisites for participation:	Grundkenntnisse der Programmiersprache C
Applicability of the module:	Elektrotechnik und Informationstechnik Elektromobilität und regenerative Energien
Prerequisites allocation ECTS:	K90 oder PF
ECTS credits:	5
Grading:	benotet
Workload:	150h
Duration of the module:	one semester
Frequency of offering:	Every semester
Literature:	- Wörn, Brinkschulte, Echtzeitsysteme, Springer 2005 - Qing Li, Carolyn Yao, Real-Time Concepts for Embedded Systems, CMP 2003
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Absolventinnen und Absolventen können die Architektur moderner Automatisierungssysteme beschreiben. Sie können die Programmierung von Echtzeitsystemen auf Basis von Echtzeitbetriebssystemen in C darstellen. Absolventinnen und Absolventen können digitale Abtastsysteme mit ihren harten Echtzeitanforderungen skizzieren, etwa bei der Realisierung des weit verbreiteten Standard PID Algorithmus der Regelungstechnik.

Focus:

Deepening of individual components of knowledge

Use, application and generation of knowledge/art

Absolventinnen und Absolventen erhalten eine Einführung in die Methoden der Echtzeitprogrammierung, in der Automatisierungstechnik bzw. im Anwendungsbereich der Embedded Systeme. Diese können sie erläutern. Es erfolgt eine Einführung in die Grundlagen der Echtzeitbetriebssysteme, deren vorrangige Aufgaben und Eigenschaften Absolventinnen und Absolventen zuordnen können. Sie sind in der Lage, wichtige Task-Scheduling Algorithmen zu nennen und diese anhand konkreter Anwendungsbeispiele zu erproben.

Focus:

Use and transfer

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Electrical Engineering 1: Basics

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE01
Module title:	Electrical Engineering 1: Basics
Module responsible:	Prof. Dr.-Ing. Andreas Siggelkow
Typ of module:	Mandatory module
Undergraduate/Major:	Basic studies
Module Content:	- Basics of electrical engineering - DC - Circuit calculation methods DC - AC - Complex numbers in AC - Circuit calculation methods AC - Basic circuits in AC - Three-phase AC - Sustainability
Courses:	Analysis of Electric Networks
Teaching and learning forms:	Lecture
Prerequisites for participation:	School mathematics, school physics
Applicability of the module:	SG Electrical Engineering and Information Technology SG E-Mobility and Green Energies Modul: Electrical Engineering/Physics 2: Electrodynamics Modul: Metrology 1: Basics Modul: Electrical Engineering 3: Time and Frequency Domains Modul: Electrical Engineering Practical Modul: Electronics
Prerequisites allocation ECTS:	K90
ECTS credits:	5
Grading:	graded
Workload:	30 h per ECTS = 150 h in total 60 h for lectures 90 h for preparations
Duration of the module:	one semester
Frequency of offering:	Every semester
Literature:	Kories, Schmidt: Electrical Engineering – A Pocket Reference, Springer Führer, Heidemann, Nerreter: Grundgebiete der Elektrotechnik, Band 1, Stationäre Vorgänge. ISBN 3-445-40668-9. Band 2, Zeitabhängige Vorgänge. ISBN 3-445-40573-9, Hanser Verlag. Altmann,S; Schlayer, D.: Lehr- und Übungsbuch Elektrotechnik. 3. Auflage, 2003.Fv Fachbuchverlag Leipzig im Hanser Verlag, ISBN 3-446-22683-4 Weißgerber, Wilfried: Elektrotechnik für Ingenieure, Band 1 Gleichstromtechnik und elektromagnetisches Feld. ISBN 3-528-44616-1, E. Band 2 Wechselstromtechnik, Ortskurven, Transformator. ISBN 3-528-44617-X , Netz, Heinrich: Formeln der Elektrotechnik und Elektronik. Herausgeber: A. Möschwitzer. ISBN-10: 3446156054, ISBN-13: 978-3446156050 Carl Hanser Verlag. Schaum's Outline of Basic Circuit Analysis
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

The students have completed their knowledge in the following fields and are able to reflect it: electrical components: resistor, capacitor, inductor; voltage, current, AC and DC.
The students are able to calculate missing voltages or currents in electrical networks. They are able to calculate in three-phase AC circuits.

Focus:

Broadening of prior knowledge

Use, application and generation of knowledge/art

The students are able to design sustainable products. The importance of an economy based on sustainable products will be understood.
The students are able to use the methods of circuit analysis and to apply them on relevant circuits.

Focus:

Use and transfer

Communication and cooperation

The students work together in groups cooperative and responsible. They are able to lead small groups with simple tasks. They present topics related to a specific field clear and precise audience oriented and can evaluate presentations from others.

Scientific / artistic self-image and professionalism

The students know their own strength and weaknesses with respect to their study achievements.
The students recognize and accept hints from others and chose appropriate solution scenarios.
The students are able to design sustainable products. The importance of an economy based on sustainable products will be understood.

Module: Electrical Engineering/ Physics 2: Electrodynamics

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE02
Module title:	Electrical Engineering/ Physics 2: Electrodynamics
Module responsible:	Prof. Dr. Thomas Doderer
Typ of module:	Mandatory module
Undergraduate/Major:	Basic studies
Module Content:	- Electric charge, charge quantisation and charge conservation - Electric field - Electrostatic potential and electric voltage - Electric current and ohmic resistance - Magnetic field - Induction - Transformer - Maxwell's displacement current - Maxwell's equations - Electromagnetic waves
Courses:	Electrodynamics
Teaching and learning forms:	Lecture, Tutorial
Prerequisites for participation:	Electrical Engineering 1: Basics, Calculus 1
Applicability of the module:	Electrical Engineering and Information Technology Electromobility and Renewable Energies As a basic subject, the knowledge and skills acquired here serve all other modules of the degree programme.
Prerequisites allocation ECTS:	K90
ECTS credits:	5
Grading:	graded
Workload:	A workload of 30 hours per ECTS is assumed. This results in a workload of 150 h (60 h for lectures, 90 h for self-study (preparation and follow-up, exam preparation).
Duration of the module:	one semester
Frequency of offering:	Every semester
Literature:	Tipler, Mosca: Physics for Scientists and Engineers Halliday, Resnick, Walker: Physics (Bachelor Edition)
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

They can solve electric and magnetic field problems using mathematical methods. They can calculate induction processes and use the component "transformer" in electrical circuits. Graduates can calculate electric motors and generators in basics (the field structure).
Graduates understand how the components capacitor and coil function at field level. They further understand how induction works in generators and makes electric motors run. They can describe Maxwell's equations. Furthermore, they understand how the transformer works from an induction point of view. They can describe and classify the different components of the entire electromagnetic spectrum.

Focus:
Broadening of prior knowledge

Use, application and generation of knowledge/art

Graduates are able to calculate electrostatic, magnetic and stationary electric flow fields. Furthermore, they can determine magnetic circuits, which form the basis for calculating chokes and transformers. Graduates recognise the components capacitor and coil from previous lectures (especially module Electrical Engineering 1) and can understand the mechanisms of action and apply them purposefully. Sustainability of the components. They can solve simple problems/tasks from electrodynamics by applying the learned general physical laws.

Focus:
Use and transfer

Communication and cooperation

Graduates work cooperatively and responsibly in groups. They can responsibly lead smaller groups with manageable tasks. In addition, they present subject-related content clearly and in a way that is appropriate for the target group and evaluate it.

Scientific / artistic self-image and professionalism

Graduates recognise their own strengths and weaknesses with regard to their course of study and develop a picture of their own development as a future graduate of the degree programme.

Graduates show willingness to take up hints from others and choose suitable approaches to solutions for themselves.

Graduates are able to design sustainable products. The importance of a sustainable economy is recognised.

Module: Electrical Engineering 3: Time and Frequency Domain

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE03
Module title:	Electrical Engineering 3: Time and Frequency Domain
Module responsible:	Prof. Dr.-Ing. Klaus Werner Kark
Typ of module:	Mandatory module
Undergraduate/Major:	Basic studies
Module Content:	- linear AC networks (LTI systems) - discrete spectra of periodic signals (real and complex form of the Fourier series, power, RMS value, distortion factor) - spectra of the Fourier transform (transition from the Fourier series, continuous spectra, transfer function of two ports) - transients in linear systems (differential equations and operator calculus, Laplace transform, correspondences, inverse transforms, switching processes) In addition to and with the content of the modules, students will learn sustainable work, design and management.
Courses:	4240 Circuit Analysis in Time and Frequency Domain
Teaching and learning forms:	Lecture with integrated exercises
Prerequisites for participation:	Mathematics 1: Analysis 1, Mathematics 3: Analysis 2, Electrical Engineering 1: Basics (Analysis of Electric Networks)
Applicability of the module:	SG Electrical Engineering and Information Technology SG E-Mobility and Green Energy can be used in advanced modules: Digital Signal Processing Communication Technology Microwaves Engineering / High Frequency Engineering Control Engineering
Prerequisites allocation ECTS:	K90
ECTS credits:	5
Grading:	graded
Workload:	The workload is approx. 150 hours (of which 50 hours for courses, 100 hours for self-study (preparation and follow-up, exam preparation).
Duration of the module:	one semester
Frequency of offering:	Summer semester only
Literature:	Führer u.a. Grundgebiete der Elektrotechnik, Carl Hanser Verlag, Band 1 - 3 Moeller/Fricke /Frohne/Vaske: Grundlagen der Elektrotechnik, Band 1. B. G. Teubner Stuttgart. Netz: Formeln der Elektrotechnik und Elektronik. Herausgeber: A. Möschwitzer. Carl Hanser Verlag. Kories, Schmidt. W.: Taschenbuch der Elektrotechnik, Verlag Harri Deutsch. Wellers: Aufgabensammlung Elektrotechnik. Girardet Verlag Scheithauer: Signale und Systeme, Teubner, Stuttgart. Weber: Laplace-Transformation, Teubner, Stuttgart. Werner: Signale und Systeme, Vieweg, Wiesbaden.
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Graduates know how to use the integral calculus and differential calculus tool. They can explain the differences in the signal description in the time domain and in the spectral domain.
Graduates understand the relationship between the spectral bandwidth and the convergence of a Fourier series.
Graduates are able to explain relationships between time functions and their spectra.
Graduates recognize the components capacitor and inductor from previous lectures (especially from the module electrical engineering 1) and can understand their effects in resonators and filters.

Focus:

Broadening of prior knowledge

Use, application and generation of knowledge/art

Graduates can calculate currents and voltages in concentrated RLC circuits with any time dependance. They can demonstrate the influence of bandwidth restrictions and envelope distortion of electrical signals. Graduates develop electrical circuits that meet bandwidth and bit rate requirements.

Focus:

Use and transfer

Communication and cooperation

Graduates can explain the benefits of high bandwidth when using modern communication systems.

Scientific / artistic self-image and professionalism

Based on measurable time functions, an alternative description of electrical signals in the spectral or operator domain is given by means of the complex calculations, which results in a completely new approach for the development of electrical circuits.

Module: Mathematics 1: Analysis 1

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE06
Module title:	Mathematics 1: Analysis 1
Module responsible:	Prof. Dr. rer. nat. Stefan Elser
Typ of module:	Mandatory module
Undergraduate/Major:	Basic studies
Module Content:	Content: 1. Fundamentals: Introduction of sets, Cartesian products, relations, and functions. 2. Numbers and the principle of induction: Introduction of natural numbers, integers, rational numbers, real numbers, and complex numbers. Proof by induction. 3. Sequences and series: Convergence criterions. Introduction of sine-, cosine-, and exponential function as a series. 4. Functions: Continuous functions, polynomials, trigonometric functions. 5. Differential calculus: Product-, quotient- and chain-rule. Extrema and their criterions. Taylor Polynomials. 6. Integral Calculus: Riemann-integral, fundamental theorem of calculus, partial fraction decomposition, numeriacal integration
Courses:	288 Analysis 1 mit Übungen
Teaching and learning forms:	Lecture with exercises
Prerequisites for participation:	Good knowledge of secondary school math
Applicability of the module:	Elektromobilität und regenerative Energien Elektrotechnik und Informationstechnik Informatik/Elektrotechnik PLUS Physical Engineering (Technik Entwicklung)
Prerequisites allocation ECTS:	K90
ECTS credits:	5
Grading:	graded
Workload:	ca. 50h for the lectures, ca. 100h at home (working over the lecture material, preparation for the final etc.)
Duration of the module:	one semester
Frequency of offering:	Summer semester only
Literature:	Omar Hijab: "Introduction to Calculus and Classical Analysis", Springer Sterling K.Berberian: "A First Course in Real Analysis", Springer Peter Hartmann: "Mathematik für Informatiker", Vieweg und Teubner Lothar Papula: "Mathematik für Ingenieure und Naturwissenschaftler Band 1", Springer

Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Students have an insight of the principle workings of the following:
Number systems, sequences, series, real-valued functions, continuity, basic differential and basic integral calculus

Focus:
Broadening of prior knowledge

Use, application and generation of knowledge/art

Students can apply the following:
Abstract decription of simple problems, basic principles to work in the topics above.

Focus:
Use and transfer

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Mathematics 2: Linear Algebra

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE07
Module title:	Mathematics 2: Linear Algebra
Module responsible:	Prof. Dr. rer. nat. Stefan Elser
Typ of module:	Mandatory module
Undergraduate/Major:	Basic studies
Module Content:	Content: 1. Fundamentals: Introduction of sets, Cartesian products, relations, and functions. 2. Vector spaces: Real value vector spaces, groups, fields, vector spaces over any field, bases, dimension, coordinate representation, inner product, and norm. 3. Systems of linear equations: Matrix representation, solutution sets, Gaussian elimination, applications. 4. Linear functions: Linear functions and matrices, Gauss-Jordan algorithm, determinants, eigenvalues, and eigenvectors, change of basis, diagonalizable matrices.
Courses:	3000 Lineare Algebra mit Übungen (Vorlesung/Übung)
Teaching and learning forms:	Lecture with exercises
Prerequisites for participation:	Good knowledge of secondary school math
Applicability of the module:	Elektromobilität und regenerative Energien Elektrotechnik und Informationstechnik Informatik/Elektrotechnik PLUS Physical Engineering (Technik Entwicklung)
Prerequisites allocation ECTS:	K90
ECTS credits:	5
Grading:	graded
Workload:	ca. 50h for the lectures, ca. 100h at home (working over the lecture material, preparation for the final etc.)
Duration of the module:	one semester
Frequency of offering:	Summer semester only
Literature:	David Poole: "Linear Algebra: A Modern Introduction", Cengage Learning Peter Hartmann: "Mathematik für Informatiker", Hartmann, Springer Vieweg Lothar Papula:"Mathematik für Ingenieure und Naturwissenschaftler", Band 1 - 2
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Students have an insight of the principle workings of the following:
Number systems,vector spaces, systems of linear equations, solutions sets, linear functions as matrices.

Focus:

Broadening of prior knowledge

Use, application and generation of knowledge/art

Students can apply the following:
Abstract decription of simple problems, basic principles to work in the topics above.

Focus:

Use and transfer

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Mathematics 3: Analysis 2

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE08
Module title:	Mathematics 3: Analysis 2
Module responsible:	Prof. Dr.-Ing. Frank Fechter
Typ of module:	Mandatory module
Undergraduate/Major:	Basic studies
Module Content:	1 Real functions of several variables 1.1 Basic definitions 1.2 Differential calculus of functions of several variables 1.3 Integration of functions of several variables 2 Vector analysis 2.1 Curves in a multidimensional vector space 2.2 Surfaces in a three dimensional vector space 2.3 Line integrals 2.4 Conservative fields and potential functions 2.5 Surface integrals 2.6 Divergence and curl of a vector field 2.7 The divergence theorem and the Stokes theorem 3 Ordinary differential equations 3.1 Introduction 3.2 First order differential equations 3.3 Higher order differential equations with constant coefficients 3.4 Systems of differential equations 3.5 Numerical methods for the solution of a differential equations
Courses:	Analysis 2
Teaching and learning forms:	lecture, exercises, tutorials, self-study
Prerequisites for participation:	Mathematics 1: Analysis 1, Mathematics 2: Algebra 1
Applicability of the module:	Metreology, High Frequency Engineering, Wireless Communications, Advanced Mathematics (Master)
Prerequisites allocation ECTS:	K 90
ECTS credits:	5
Grading:	graded
Workload:	150h
Duration of the module:	one semester

Frequency of offering:	Winter semester only
Literature:	English books Stroud, K. A.; Booth, D. J.: Engineering mathematics. Palgrave Macmillan 2007 Jeffrey, A.: Mathematics for engineers and scientists. Chapman & Hall/CRC, 2005 Croft, A.; Davison, R.; Hargreaves M.: Engineering mathematics: a foundation for electronic, electrical, communications, and systems engineers. Prentice Hall 2001 German books Papula L.: Mathematik für Ingenieure und Naturwissenschaftler Band 2. Vieweg Verlag, Braunschweig, Wiesbaden. Papula L.: Mathematik für Ingenieure und Naturwissenschaftler Band 3. Vieweg Verlag, Braunschweig, Wiesbaden. Brauch, W.; Dreyer, H.-J.; Haacke, W.: Mathematik für Ingenieure. Teubner Verlag, Stuttgart. Burg, K.; Haf, H.; Wille, F.: Höhere Mathematik für Ingenieure. Band 1 Analysis. Teubner Verlag, Stuttgart. Further Exercises can be found in: Wenzel, H.; Heinrich, G.: Übungsaufgaben zur Analysis. Teubner Verlag, Stuttgart. Papula L.: Mathematik für Ingenieure und Naturwissenschaftler Klausur- und Übungsaufgaben. Vieweg Verlag, Braunschweig, Wiesbaden. As a reference book: Bronstein, I.; Semendjajew, K.: Taschenbuch der Mathematik. Harri Deutsch Verlag, Frankfurt (Main).
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

The students are able to solve exercises from the analysis of several varaibles (extreme valus problems, Integration) and problems from vector annalysis. They are ablet to solve differend kinds of orninary differential equations.

Focus:
Broadening of prior knowledge

Use, application and generation of knowledge/art

The participants can apply mathematical methods to given problems. Besides pure mathematical problems they are also able to solve elected problems from electrical engineering and physics with mathematical methods.

Focus:

Communication and cooperation

The students work together in groups cooperative and responsible.

Scientific / artistic self-image and professionalism

The students know their own strength and weaknesses with respect to their study achievements.

Module: Robotics

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE09
Module title:	Robotics
Module responsible:	Prof. Dr.-Ing. Konrad Wöllhaf
Typ of module:	Mandatory module
Undergraduate/Major:	Basic studies
Module Content:	Introduction, objective, history, types of robots, applications, Industrial robot as exible manufacturing tool, Social impact, Kinematics, Homogeneous transformation matrices, Complements to the homogeneous Transformation matrix, The Denavit-Hartenberg parameters, Forward, backward transformation, orientation of the robot hand, compilation of the Formulas for the transformation, Inverse transformation, Hexapod robot, path planning, motivation, path planning on axis plane, path planning in Cartesian coordinates, collision avoidance, dynamics, fundamentals, principle of of virtual work, The iterative Newton-Euler algorithm, Luh-Walker-Paul, Control, Control requirements, Control of a DC motor, implementation of the control, robot control, tasks of the robot control, main components of robot control, operation modes of a of a robot controller, programming, programming languages for robots Translated with www.DeepL.com/Translator (free version)
Courses:	
Teaching and learning forms:	Lecture and Exercises
Prerequisites for participation:	Mathematik 1: Analysis 1, Mathematik 3: Analysis 2
Applicability of the module:	Elektrotechnik und Informationstechnik Informatik & Elektrotechnik PLUS Elektromobilität und regenerative Energien Technik-Entwicklung Angewandte Informatik Wirtschaftsingenieurwesen (Technik-Management)
Prerequisites allocation ECTS:	Portfolio 50 % Examination graded 50 % Praktical Work (Lab) not graded
ECTS credits:	5
Grading:	graded
Workload:	A workload of 30 hours per ECTS is assumed. Thus results in a workload of 150 h (60 h for lectures, 90 h for self-study (preparation and follow-up, exam preparation).
Duration of the module:	one semester
Frequency of offering:	Summer semester only

Literature:	Robert J. Schilling. Fundamentals of robotics: analyisis and control. Prentice-Hall, 1990. John J. Craig. Introduction to robotics: mechanics and control. Addison-Wesley, New York, 1 edition, 1989. Weber, W. Industrieroboter Hanser-Verlag, 2019 Behrens, R. Biomechanische Grenzwerte für die sichere Mensch-Roboter-Kollaboration Springer Vieweg, 2018 Hesse, S., Greifer-Praxis: Greifer in der Handhabungstechnik Vogel, 1991 DIN EN ISO 10218-2 Industrieroboter - Sicherheitsanforderungen - Teil 2: Robotersysteme und Integration (ISO 10218-2:2011) Beuth Verlag, Betlin, 2012 Hesse, S. & Malisa, V. (Eds.) Taschenbuch Robotik - Montage - Handhabung Carl Hanser Verlag GmbH & Co. KG, 2016 Buxbaum, H.-J. (Ed.) Mensch-Roboter-Kollaboration Springer-Verlag, 2020
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Graduates know how the individual axes of a robot must be controlled in order to enable the
the targeted movement of the robot hand in space. They are also able to transfer their knowledge of kinematics to other applications such as computer vision and 3D CAD.

Focus:
Broadening of prior knowledge

Use, application and generation of knowledge/art

Focus:
Use and transfer

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Programming

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE10
Module title:	Programming
Module responsible:	Prof. Dr.-Ing. Lothar Berger
Typ of module:	Mandatory module
Undergraduate/Major:	Basic studies
Module Content:	- Programming basics: computer, operating system, compiler - Elements of C programming: main program, variables, basic data types, operators, branching, looping - Procedures, functions, passing of parameters - Compound data types: arrays, structs, pointers - Dynamic memory - File input-output - Recursion - Enumerations - Preprocessor
Courses:	Programming
Teaching and learning forms:	Lecture; Lab - or - E-Learning: Lessons, Exercises; Homework: Practical work
Prerequisites for participation:	
Applicability of the module:	Microcontrollers, Real-Time Programming
Prerequisites allocation ECTS:	RPA (PF: 50% PA graded, 50% R graded): Practical work, documented by a seminar paper and presentation
ECTS credits:	5
Grading:	graded
Workload:	Presence: 48h, Self-study: 102h - or - Online: 24h, Self-study: 102h, Homework: 24h
Duration of the module:	one semester
Frequency of offering:	Summer semester only
Literature:	Script - or - lessons, exercises, and sample solutions; and complementary: - Darnell, Peter A. und Philip E. Margolis: C: A Software Engineering Approach. Springer-Verlag, New York, 1996 (ISBN: 0-387-94675-6) - Sedgewick, Robert: Algorithms in C. Addison Wesley. 1990 (ISBN: 978-0201514254)
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Attendees learned about C programming language concepts, and applying these for implementing short programs; utilizing development tools.

Focus:
Broadening of prior knowledge

Use, application and generation of knowledge/art

Attendees learned about programming and implementation of basic programs using C programming language.

Focus:
Use and transfer

Communication and cooperation

Attendees learned about applying programming skills within project teams.

Scientific / artistic self-image and professionalism

Attendees learned about applying basic knowledge of procedural programming with the C programming language; as required by the more advanced subjects Microcontrollers, Real-Time Programming, and Embedded GUI

Module: Electrical Engineering Practical

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE11
Module title:	Electrical Engineering Practical
Module responsible:	Prof. Dr.-Ing. Raphael Ruf
Typ of module:	Mandatory module
Undergraduate/Major:	Basic studies
Module Content:	- Analyzing of electrical circuits - Dimensioning of electrical circuits - Soldering course - Circuit diagram CAD - Practical handling of circuit measurements - Finding errors in electrical circuits - Choosing the right measurement device
Courses:	7092 Basic training electrical enginnering 1: fundamental circuits 7079 Basic training electrical enginnering 2: implementation and verification
Teaching and learning forms:	Laboratory work and exercises
Prerequisites for participation:	None
Applicability of the module:	- Electrical Engineering and Information Technology - Computer Science and Electrical Engineering PLUS - Electromobility and Regenerative Energies
Prerequisites allocation ECTS:	Portfolio - Grades of successfully completed parts of the course are equally weighted and comprise the final grade.
ECTS credits:	5
Grading:	graded
Workload:	30 hours per ECTS. Hence, total workload amounts to 150 hours (60 hours laboratory presence and 90 hours self study time).
Duration of the module:	one semester
Frequency of offering:	Summer semester only
Literature:	
Compulsory attendance:	yes
Reason:	Students need to conduct practical experiments which necessitates personal attendance for all schedules.

Competence dimensions

Knowledge and understanding

Graduates have broadened their existing knowledge in the following fields and can not only recite technical contents, but also explain them:
- Analyzing of electrical circuits
- Dimensioning of electrical circuits
- Soldering of simple PCBs
- Circuit diagram CAD
- Practical handling of circuit measurements
- Finding errors in electrical circuits
- Choosing the right measurement device

Focus:
Deepening of individual components of knowledge

Use, application and generation of knowledge/art

Graduates can practically apply knowledge in the following fields:
- Dimensioning of electrical circuits
- Soldering of simple PCBs
- Circuit diagram CAD
- Practical handling of circuit measurements
- Finding errors in electrical circuits
- Choosing the right measurement device

Focus:
Use and transfer

Communication and cooperation

Scientific / artistic self-image and professionalism
Graduates are able to develop sustainable products. The importance of a sustainable economy is recognized.

Module: Digital Technology

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE13
Module title:	Digital Technology
Module responsible:	Prof. Dr.-Ing. Andreas Siggelkow
Typ of module:	Mandatory module
Undergraduate/Major:	Basic studies
Module Content:	- Boolean algebra - Combinational circuits - Sequential circuits - Description of logic circuits - Minimization of logic - Digital systems - PLD, FPGA, etc - VHDL basics
Courses:	Digital Technology
Teaching and learning forms:	Lecture
Prerequisites for participation:	none
Applicability of the module:	SG Electrical Engineering and Information Technology SG E-Mobility and Green Energies Modul: Computer Technology Modul: Digital Practical Modul: Computer-Aided Circuit Design 1, 2 Modul: Digital Signal Processing Modul: Microcontroller
Prerequisites allocation ECTS:	K90
ECTS credits:	5
Grading:	graded
Workload:	30 h per ECTS = 150 h in total 60 h for lectures 90 h for preparations
Duration of the module:	one semester
Frequency of offering:	Every semester
Literature:	Roth, C. H.: Fundamentals of Logic Design, Nelson Engineering (Englisch) Fricke, K.: Digitaltechnik - Lehr- und Übungsbuch für Elektrotechniker und Informatiker, Teubner (Deutsch)
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

The students have completed their knowledge in the following fields and are able to reflect it: logic minimization, combinational circuits, sequential circuits, logic devices, hardware description languages.
The students are able to design digital logics.

Focus:

Broadening of prior knowledge

Use, application and generation of knowledge/art

The students are able to design sustainable products. The importance of an economy based on sustainable products will be understood.
The students are able to use the methods of digital circuit design and to apply them on relevant circuits.

Focus:

Use and transfer

Communication and cooperation

The students work together in groups cooperative and responsible. They are able to lead small groups with simple tasks. They present topics related to a specific field clear and precise audience oriented and can evaluate presentations from others.

Scientific / artistic self-image and professionalism

The students know their own strength and weaknesses with respect to their study achievements.
The students recognize and accept hints from others and chose appropriate solution scenarios.
The students are able to design sustainable products. The importance of an economy based on sustainable products will be understood.

Module: Electronics

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE16
Module title:	Electronics
Module responsible:	Prof. Dr. rer. nat. Markus Pfeil
Typ of module:	Mandatory module
Undergraduate/Major:	Main studies
Module Content:	Ideal and real amplifiers Inverting and non-inverting amplifier, summing and subtracting amplifiers, differentiators and integrators. Filter Diodes and Zener Diodes Bipolar Transistors Basic circuit applications with a transistor
Courses:	1815 Electronics
Teaching and learning forms:	Lecture, Exercises
Prerequisites for participation:	Electrical Engineerin 1: Basics Metrology 1: Basics
Applicability of the module:	Electrical Engineering and Information Technology E-Mobility and Green Energy
Prerequisites allocation ECTS:	K90
ECTS credits:	5
Grading:	Graded
Workload:	30h per ETCS, totalling 150h split in 60h Lectures 90h Revision and Preparation
Duration of the module:	one semester
Frequency of offering:	Every semester
Literature:	Gossner, Stefan: Grundlagen der Elektronik, 3.Auflage, Shaker-Verlag. Tietze, Schenk: Halbleiterschaltungstechnik, 11. Auflage, Springer-Verlag.
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Successful students can describe basic electronic components and circuits as well as basic analytical methods for electronic circuits. Basic components include ideal and real Operational Amplifiers , Diodes and MOS- or bipolar Transistors. Basic Circuits and filters include one active basic component.

Focus:

Broadening of prior knowledge

Use, application and generation of knowledge/art

Successful students can analyse the behaviour of typical circuits using manual calculation as well as computer tools such as MATLAB and PSPICE. The practical aspects of the lecture are supportet by the Electronics Lab.

Focus:

Use and transfer

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Computer-Aided Circuit Design 1

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE17
Module title:	Computer-Aided Circuit Design 1
Module responsible:	Prof. Dr.-Ing. Andreas Siggelkow
Typ of module:	Mandatory module
Undergraduate/Major:	Basic studies
Module Content:	- Understanding a design problem - Simulation of digital circuits - Synthesis of digital circuits - Verification and test of digital circuits - Set-up of the Arduino IDE - Writing a program for the Arduino - Programming an Arduino - Usage of the Arduino I/Os
Courses:	- Basic Practical Electrical Engineering: Programming of uC - Circuit Design Practical
Teaching and learning forms:	Practical
Prerequisites for participation:	- Electrical Engineering Practical - Digital Technology - Computer Technology
Applicability of the module:	SG Electrical Engineering and Information Technology SG E-Mobility and Green Energies Modul: Computer-Aided Circuit Design 2 Modul: Digital Signal Processing Modul: Microcontroller
Prerequisites allocation ECTS:	- 50% prog. VHDL - 50% prog. uC - Both, practical with written documentation
ECTS credits:	5
Grading:	graded
Workload:	30 h per ECTS = 150 h in total 60 h for lectures 90 h for preparations
Duration of the module:	one semester
Frequency of offering:	Winter semester only
Literature:	Gunther Lehmann, Bernhard Wunder, Manfred Selz, Schaltungsdesign mit VHDL1998, Franzis Verlag GmbH Douglas Perry; VHDL: Programming by Example
Compulsory attendance:	yes
Reason:	It is a practical.

Competence dimensions

Knowledge and understanding

The students know and understand the components from digital electronics.
The students know and understand the difference of „Concurrent Design“ und „Sequential Design" and can demonstrate it by means of VHDL.
The students know and understand the difference of „Behavioral Design Style“ und „Structural Design Style" and can demonstrate it by means of VHDL.
The students know possible interactions between FPGA and microcontroller (UART).

Focus:

Deepening of individual components of knowledge

Use, application and generation of knowledge/art

The students apply the learned principles by means of simple examples.
The students will be able to judge the quality of VHDL code: testability, synchronous.
The students will be able to plan and develop an own ASIC project (working together with an uC).

Focus:

Use and transfer

Communication and cooperation

The ASIC project will be given by the lecturers the students will be able to understand and ask questions to generate the requirements and to write the specification.

The students work together in groups cooperative and responsible. They are able to lead small groups with simple tasks. They present topics related to a specific field clear and precise audience oriented and can evaluate presentations from others.

Scientific / artistic self-image and professionalism

The students know their own strength and weaknesses with respect to their study achievements.
The students recognize and accept hints from others and chose appropriate solution scenarios.
The students are able to design sustainable products. The importance of an economy based on sustainable products will be understood.

Module: Physics Mechanics

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE18
Module title:	Physics Mechanics
Module responsible:	Prof. Dr. rer. nat. habil. Thomas Doderer
Typ of module:	Mandatory module
Undergraduate/Major:	Basic studies
Module Content:	Introduction to experimental physics, to physical procedures, reduction of real facts to the essential influencing variables, definition of physical variables through measurement processes, derivation of laws from axioms and from experimental results, illustration of physics laws through experiments, acquiring the ability to convert a problem into a mathematical formula and to present it in graphic form, solving equations, deriving, integrating, being able to use the most important mathematical functions. 1. kinematics of the mass point 2. dynamics of the mass point, force, force impact, momentum 3. energy, law of conservation of energy, friction 4. law of conservation of momentum, impact processes 5. law of gravity, motion of a body around a centre of gravity 6. kinematics and dynamics of rigid bodies, angular momentum, torque 7. law of conservation of angular momentum, application to rolling and gyroscopic motion 8. free and forced oscillations, damping
Courses:	Physics 1: Mechanics
Teaching and learning forms:	Lecture, Tutorial
Prerequisites for participation:	none
Applicability of the module:	Electrical Engineering and Information Technology Physical Engineering (Technology Development) As a foundation subject, the knowledge and skills acquired here serve all other modules of the degree programme.
Prerequisites allocation ECTS:	K90
ECTS credits:	5
Grading:	graded
Workload:	A workload of 30 hours per ECTS is assumed. This results in a workload of 150 h (60 h for lectures, 90 h for self-study (preparation and follow-up, exam preparation).
Duration of the module:	one semester
Frequency of offering:	Every semester
Literature:	Tipler, Mosca: Physics for Scientists and Engineers Halliday, Resnick, Walker: Physics (Bachelor Edition)
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Graduates are able to reduce a real situation to the essential influencing variables and to define physical variables through measurement processes.

Focus:

Broadening of prior knowledge

Use, application and generation of knowledge/art

Graduates can derive laws from axioms and from experimental results and illustrate physics laws through experiments. Furthermore, they can convert a problem into a mathematical formula and present it in graphical form. They can solve equations, derive, integrate and use the most important mathematical functions. They can solve simple problems/tasks from mechanics by applying the general physical laws they have learned.

Focus:

Use and transfer

Communication and cooperation

Graduates work cooperatively and responsibly in groups. They can responsibly lead smaller groups with manageable tasks. In addition, they present subject-related content clearly and in a way that is appropriate for the target group and evaluate it.

Scientific / artistic self-image and professionalism

Graduates recognise their own strengths and weaknesses with regard to their course of study and develop a picture of their own development as a future graduate of the degree programme.

Graduates show willingness to take up hints from others and choose suitable approaches to solutions for themselves.

Graduates are able to design sustainable products. The importance of a sustainable economy is recognised.

Module: Digital Signal Processing

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE19
Module title:	Digital Signal Processing
Module responsible:	Vivien Glönkler, M.Sc.
Typ of module:	Mandatory module
Undergraduate/Major:	Main studies
Module Content:	Introduction to MATLAB, analog and discrete signals, sampling theorem and aliasing, ideal and practical sampling, properties of the LTI-system. Analysis in the time domain: discrete convolution, difference equations, FIR- and IIR-systems. Analysis in frequency domain: DFT and FFT, basics of the Cooley-Tukey algorithm, implementations in MATLAB. Definition and properties of the Z-transform, Z-transfer function, stability of discrete systems. Design of digital filters: properties of IIR- and FIR- filters, design methods of FIR-filters using window functions. IIR-filter design method: bilinear transformation, impulse invariance method. Design examples with implementation in MATLAB.
Courses:	Digital Signal Processing
Teaching and learning forms:	Lecture and Lab
Prerequisites for participation:	Electrical Engineering 3: time and frequency domain Digital Technology
Applicability of the module:	Course of studies: Electrical Engineering and Information Technology Course of studies: E-mobility and green energy Module: Regelungstechnik (MATLAB)
Prerequisites allocation ECTS:	Portfolio: written examination K60 (exam of 60mins) 70%, 4 exercises (approx. monthly) 30%
ECTS credits:	5
Grading:	graded
Workload:	A workload of 30 hours per ECTS is assumed. This results in a workload of 150 hours (60 hours of which are for courses, 90 hours for self-study (preparation and follow-up, exam preparation).
Duration of the module:	one semester
Frequency of offering:	Every semester
Literature:	- Discrete-time signal processing, Alan V. Oppenheim; Ronald W. Schafer, Pearson Education, 3. ed., internat. ed., 2010 - The scientist and engineer's guide to digital signal processing, Steven W. Smith, California Technical Publishing, 1997 - Signals and Systems, Alan V. Oppenheim, Alan S. Willsky, Pearson New International Edition, 2013
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Building on the knowledge about analog signal processing from various previous lectures, graduates first learn about the properties of sampled discrete signals.

The students can reproduce the properties of sampled discrete signals and apply them in digital filters. Students can design simple digital filters.

Focus:
Deepening of individual components of knowledge

Use, application and generation of knowledge/art

Graduates can visualize the design of digital filters. They can calculate a variety of exercises. After a short repetition of the Laplace and Fourier transformations, graduates are able to use both the discrete Fourier transformations DTFT and DFT as well as the Z-transform and are able to examine the relationships in numerous MATLAB exercises accompanying the lecture.

Focus:
Use and transfer

Communication and cooperation

Graduates work cooperatively and responsibly in groups. They can responsibly lead smaller groups with manageable tasks. In addition, they present subject-related content clearly and in a way that is appropriate for the target group and assess it.

Scientific / artistic self-image and professionalism

Graduates recognize their own strengths and weaknesses about their course of study and develop a picture of their own development as a future graduate of the course.

Graduates show willingness to take up advice from others and choose suitable solutions for themselves.

Graduates can design sustainable products. The importance of a sustainable economy is recognized. They can determine the design methods for digital filters using practical circuits and calculations.

Module: Language

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE21
Module title:	Language
Module responsible:	Dipl.-Soz. Wiss. Fabienne Ronssin
Typ of module:	Mandatory module
Undergraduate/Major:	Main studies
Module Content:	
Courses:	
Teaching and learning forms:	
Prerequisites for participation:	
Applicability of the module:	
Prerequisites allocation ECTS:	
ECTS credits:	
Grading:	
Workload:	
Duration of the module:	
Frequency of offering:	
Literature:	
Compulsory attendance:	yes
Reason:	

Competence dimensions

Knowledge and understanding

Focus:

Use, application and generation of knowledge/art

Focus:

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Project-Seminar

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE24
Module title:	Project-Seminar
Module responsible:	Prof. Dr.-Ing. Andreas Siggelkow
Typ of module:	Mandatory module
Undergraduate/Major:	Main studies
Module Content:	Besides the topic and content of this module, the students learn sustainable and economic product design. The knowledges of the basic studies will be deepened and lifted to a level that enables them to start with a bachelor thesis. Consideration of the gender studies: - know famous female engineers - critical discussion of stereotypes and structures in electrical engineering
Courses:	scientific work
Teaching and learning forms:	seminar and practical
Prerequisites for participation:	-
Applicability of the module:	Bachelor Thesis
Prerequisites allocation ECTS:	oral examination
ECTS credits:	5
Grading:	graded
Workload:	150 hours
Duration of the module:	one semester
Frequency of offering:	Every semester
Literature:	as needed
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

The students are able to plan a project.

Focus:
Deepening of individual components of knowledge

Use, application and generation of knowledge/art

The students are able to plan and work on a project based on their learned theoretical and practical skills.

Focus:
Use and transfer

Communication and cooperation

The students are able to plan and work on a project based on their learned theoretical and practical skills.

Scientific / artistic self-image and professionalism

The students are able to design sustainable products and they understand the economic importance.

Module: Control Engineering

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE27
Module title:	Control Engineering
Module responsible:	Prof. Dr.-Ing. Lothar Berger
Typ of module:	Mandatory module
Undergraduate/Major:	Main studies
Module Content:	Mathematical modeling of controlled systems in time and frequency domain; through linear transfer elements. Linear control loop: constituent parts, requirements, stability, stationary and transient behaviour. Control design, control loop synthesis; through Bode plot, pole-zero plot, frequency response based methods. Frequency response measurement and establishment of transfer function. Control design through root locus. Within the lab, application on practical set-ups: industrial process, motor control. Implementation of basic analog and digital controllers. Control design and simulation of control loop utilizing MATLAB/Simulink, and through C programming of a microcontroller.
Courses:	Control Engineering with Exercises Control Engineering Lab
Teaching and learning forms:	Lecture; Lab - or - E-Learning: Lessons, Exercises; Homework: Practical work
Prerequisites for participation:	Analysis 1, Analysis 2, Linear Algebra, Digital Signal Processing, Microcontrollers
Applicability of the module:	Bachelor Thesis
Prerequisites allocation ECTS:	K90: Written examination; 90 minutes
ECTS credits:	6
Grading:	graded
Workload:	Presence: 72h, Self-study: 108h - or - Online: 48h, Self-study: 108h, Homework: 24h
Duration of the module:	one semester
Frequency of offering:	Every semester
Literature:	Script - or - lessons, exercises, and sample solutions; and complementary: Macia, N. F., Thaler, G. J.: Modeling and Control of Dynamic Systems, Cengage Learning Press, W. H., Teukolsky, S. A., Numerical Recipes in C, Cambridge
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Attendees learned about properly modeling industrial processes for applying basic control methods; and about designing basic control methods – like PID control.

Focus:

Broadening of prior knowledge

Use, application and generation of knowledge/art

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

Focus:

Scientific innovation

Communication and cooperation

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

Scientific / artistic self-image and professionalism

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

Module: Microcontrollers

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE28
Module title:	Microcontrollers
Module responsible:	Prof. Dr.-Ing. Lothar Berger
Typ of module:	Mandatory module
Undergraduate/Major:	Main studies
Module Content:	Presentation of distinctions of computers versus embedded systems; and microprocessors versus microcontrollers. Introduction to industry standard microcontrollers families 8-bit 8051 and 32-bit ARM. Presentation of specific properties and functions: program and data memory, clock generation, timers, interrupts, internal buses - I2C, SPI - and external buses - UART, USB; and usage of ADC and DAC for basic monitoring and automation. Programming and implementation of algorithms in C and assembler. Linking microcontrollers to graphical user interfaces. Within the lab, application and programming of microcontrollers for selected use cases, demonstrated by 8051 simulation, breadboard set-up, development board with peripherals; and ARM Cortex A with realtime operating system; Cortex M0 breadboard set-up, and Cortex M3 development board with peripherals.
Courses:	Microcontrollers with Exercises Microcontrollers Lab
Teaching and learning forms:	Lecture; Lab - or - E-Learning: Lessons, Exercises; Homework: Practical work
Prerequisites for participation:	Programming, Digital Technology, Computer Technology
Applicability of the module:	Control Engineering, Automation, Real-Time Programming, Project-Seminar, Bachelor Thesis
Prerequisites allocation ECTS:	RPA (PF: 50% PA graded, 50% R graded): Practical work, documented by a seminar paper and presentation
ECTS credits:	5
Grading:	graded
Workload:	Presence: 48h, Self-study: 102h - or - Online: 24h, Self-study: 102h, Homework: 24h
Duration of the module:	one semester
Frequency of offering:	Every semester
Literature:	Script - or - lessons, exercises, and sample solutions
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Attendees learned about realizing distinctions of computers versus embedded systems; and microprocessors versus microcontrollers; and about describing specific properties and functions of industry standard microcontrollers families 8-bit 8051 and 32-bit ARM: program and data memory, clock generation, timers, interrupts, internal buses - I2C, SPI - and external buses - UART, USB

Focus:

Broadening of prior knowledge

Use, application and generation of knowledge/art

Attendees learned about programming and implementation of basic microcontrollers monitoring and automation tasks, utilizing algorithms in C and assembler, and usage of ADC and DAC; and linking microcontrollers to graphical user interfaces.

Focus:

Use and transfer

Communication and cooperation

Attendees learned about presenting and applying basic microcontrollers monitoring and automation tasks; aimed at interdisciplinary projects; operated within a team of scientists, engineers, designers, and economists.

Scientific / artistic self-image and professionalism

Attendees learned about economical and ecological considerations for implementing basic microcontrollers monitoring and automation tasks; different to implementing monitoring and automation tasks using computers, PLC, or FPGA

Module: Elective Module

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE32
Module title:	Elective Module
Module responsible:	Prof. Dr.-Ing. Andreas Siggelkow
Typ of module:	Mandatory module
Undergraduate/Major:	Main studies
Module Content:	See electives
Courses:	See electives
Teaching and learning forms:	See electives
Prerequisites for participation:	See electives
Applicability of the module:	See electives
Prerequisites allocation ECTS:	See electives
ECTS credits:	See electives
Grading:	See electives
Workload:	See electives
Duration of the module:	one semester
Frequency of offering:	Every semester
Literature:	See electives
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Focus:

Use, application and generation of knowledge/art

Focus:

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Practical semester

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE34
Module title:	Practical semester
Module responsible:	Prof. Dr.-Ing. Andreas Siggelkow
Typ of module:	Mandatory module
Undergraduate/Major:	Main studies
Module Content:	Engineering work in electrical engineering relevant companies. Get to know the requirements of an industrial working environment.
Courses:	Practical semester
Teaching and learning forms:	Practical semester
Prerequisites for participation:	The lectures of the first and second semester must be completed (60 ECTS).
Applicability of the module:	SG Electrical Engineering and Information Technology SG E-Mobility and Green Energies
Prerequisites allocation ECTS:	Practical work
ECTS credits:	30
Grading:	not graded
Workload:	20 weeks for students having a pre-practical 26 weeks for students not having a pre-practical
Duration of the module:	one semester
Frequency of offering:	Every semester
Literature:	as needed
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

The students are able to plan and work on engineering projects in a company.

Focus:

Deepening of individual components of knowledge

Use, application and generation of knowledge/art

The students are able to plan and work on engineering projects in a company.

Focus:

Use and transfer

Communication and cooperation

The students can apply their so far achieved theoretical and practical skills in a company and present the results to an auditorium.

Scientific / artistic self-image and professionalism

The students are able to design sustainable products and understand the importance of a sustainable economics.

Module: Automotive Electronics Controls

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE38
Module title:	Automotive Electronics Controls
Module responsible:	Prof. Dr.-Ing. Andreas Siggelkow
Typ of module:	Compulsory elective module
Undergraduate/Major:	Main studies
Module Content:	1 Introduction 1.1 Control System Structure 1.2 Process Controlling System 1.3 Process Interfaces 1.4 Representation of Information 2 Binary Signal Treatment 2.1 Binary Signal Sources 2.2 Binary Interfaces of PLC 2.3 Debouncing of Metallic Contacts 2.4 Binary Interface Components 2.5 Ohmic-inductive Load 2.6 Modes of Operation 3 Analogue Signal Treatment 3.1 Wiring Analogue Signals 3.2 Analogue Interface Connection 3.3 Signal Adaptation 3.4 Analogue Input 3.5 Analogue Output 3.6 Superimposed Noise 4 Sensor / Actuator Characteristics 4.1 Measurement Principles 4.2 Actuating Principles 4.3 DC Drive 4.4 Linearization
Courses:	Automotive Electronic Controls
Teaching and learning forms:	Lecture + practicals
Prerequisites for participation:	Mathematics Digital Technology
Applicability of the module:	SG: Electrical Engineering and Information Technology SG: E-Mobility and Green Energies
Prerequisites allocation ECTS:	K90
ECTS credits:	5
Grading:	graded
Workload:	30 h per ECTS = 150 h in total 60 h for lectures 90 h for preparations
Duration of the module:	one semester
Frequency of offering:	Winter semester only
Literature:	- Deutsches Vorlesungsskript - English Lecture Notes [1] Andrew S. Tanenbaum, Computernetzwerke, Prentice Hall [2] K. Etschberger, Controller-Area-Network, Hanser Verlag [3] Bosch, Kreftfahrzeugtechnisches Handbuch, Vieweg [4] K. Reif, Automobilelektronik, Vieweg
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

The students can explain the electrical components in a car.

Focus:
Deepening of individual components of knowledge

Use, application and generation of knowledge/art

The students can explain the electrical components in a car.

Focus:

Communication and cooperation

The students work together in groups cooperative and responsible. They are able to lead small groups with simple tasks. They present topics related to a specific field clear and precise audience oriented and can evaluate presentations from others.

Scientific / artistic self-image and professionalism

The students know their own strength and weaknesses with respect to their study achievements.

The students recognize and accept hints from others and chose appropriate solution scenarios.

The students are able to design sustainable products. The importance of an economy based on sustainable products will be understood.

Module: Intelligent Transportation Systems

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE39
Module title:	Intelligent Transportation Systems
Module responsible:	Prof. Dr.-Ing. Frank Fechter
Typ of module:	Mandatory module
Undergraduate/Major:	Main studies
Module Content:	1. Introduction 2. Navigation and positioning 3. Inducement of traffic 4. Toll collection systems 5. Basics of digital data transmission 6. Broadcast based traffic information systems 7. Car-to-X Ad-Hoc-Networks 8. Mobile communication based traffic information systems 9. Security and privacy 10. Economical, political and legal aspects
Courses:	Intelligent Transportation Systems
Teaching and learning forms:	Lecture, Self-study
Prerequisites for participation:	
Applicability of the module:	
Prerequisites allocation ECTS:	M
ECTS credits:	5
Grading:	graded
Workload:	150h
Duration of the module:	one semester
Frequency of offering:	Every semester

Literature:	World Health Organization: GLOBAL STATUS REPORT ON ROAD SAFETY, https://www.who.int/violence_injury_prevention/road_safety_status/2018/en/ 2018 World Health Organization: Saving millions of lives. https://www.who.int/violence_injury_prevention/publications/road_traffic/saving_millions_lives_en.pdf 2011 World Health Organization: Health for the world's adolescents. 2014 Eberspächer, J.; Arnold, H.; Hertwich,R.: Das vernetzte Automobil. Hüthig Verlag 2009 Krosch, T. et al.: Automotive Internetworking. Verlag John Wiley & Sons 2012 Schnieder, E.: Verkehrsleittechnik. Springer 2007 Marsch, P.; Bulakci Ö.; Queseth, O.; Boldi, M: 5G System Design. Verlag John Wiley & Sons 2018 Mansfeld W.: Satellitenortung und Navigation. Vieweg 2004 White C. E. et al: Some map matching algorithms for personal navigation assistants. Transportation Research Part C 8 (2000) 91-108 Quddus M. A. et al: Current map-matching algorithms for transport applications: State-of-the art and future research directions.Transportation Research Part C 15 (2007) 312-328 Sommer C.; Dressler F.: Vehicular Networking. Cambridge University Press 2014 3GGP TR 22.885: Study on LTE support for Vehicle to Everything (V2X) services. www.3gpp.org, 2015. Winner, H. et al.: Handbuch Fahrerassistenzsysteme Springer-Verlag 2015 Riegelhuth, G.; Sandrock,M.: Verkehrsmanagementzentralen für Autobahnen. Springer Vieweg Wiesbaden, 2018
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

The participants are able to explain important systems of intelligent transportation with his own words, e.g. navigation, car-to-car communication, traffic information systems etc. They know the development targets of new and established systems, can explain the functional principles and assess the performance.

Focus:
Broadening of prior knowledge

Use, application and generation of knowledge/art

The students are in a position to solve elected problems with appropriate calculation methods and algorithms. They are able to compare alternative systems and to elaborate their strengths and weaknesses.

Focus:
Use and transfer

Communication and cooperation

The students work together in groups cooperative and responsible.

Scientific / artistic self-image and professionalism

The students know their own strength and weaknesses with respect to their study achievements. The importance of a sustainable mobility will be understood. The can explain methods of intelligent transportation systems that contribute to a sustainable mobility.

Module: Real-TimeProgramming

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EIE42
Module title:	Real-TimeProgramming
Module responsible:	Prof. Dr. rer. nat. Markus Pfeil
Typ of module:	Compulsory elective module
Undergraduate/Major:	Main studies
Module Content:	Architecture of modern Automatisation Systems. Specific requirements for realtime systems. Methods of Realtime Programming: Loops, time controlled programs, loops with interrupt mechnism, multitasking, fixed priority scheduling with and without preemption, time slice scheduling, earliest deadline andrate monotonic scheduling, Task and Ressource Synchronisation (Semaphores, Mutex), Intertask Communication (Queues, Events, Sockets), Interrupt Handling (deferred and direct). Timestamping and Synchronisation. Shared access for data and memory. Design criteria for realtime systems, Discussion of FreeRTOS as a realtime operating system. Design and exercises on given example applications.
Courses:	1494 Echtzeitprogrammierung 1495 Echtzeitprogrammierung Praktikum
Teaching and learning forms:	Lecture and practical work, online simulations
Prerequisites for participation:	Basic programming skills in C
Applicability of the module:	E-Mobility and Green Energy Electrical Engineering and Information Technology
Prerequisites allocation ECTS:	K90
ECTS credits:	5
Grading:	Graded
Workload:	30h per credit, split into 60h Lecture 60h Preparation and Revision 30h Exercises
Duration of the module:	one semester
Frequency of offering:	Every semester
Literature:	- Wörn, Brinkschulte, Echtzeitsysteme, Springer 2005 - Qing Li, Carolyn Yao, Real-Time Concepts for Embedded Systems, CMP 2003
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Successful sudents are able to describe the architecture of modern automation systems. They can describe the programming of realtime systems on the basis of realtime operating systems in C. Successful students can sketch digital data acquisition systems with hard realtime requirements, such as control loops and sampling systems.

Focus:

Deepening of individual components of knowledge

Use, application and generation of knowledge/art

Successful students are able to apply methods of realtime programming in applications of automatisation and embedded systems. They can discuss possible solutions and problems. Successful students can work with the discussed realtime operating systems and can describe their features and basic structure. They can describe and apply important task scheduling algorithms in a number of applications.

Focus:

Use and transfer

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Elektrische Antriebsstränge

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EM29
Module title:	Elektrische Antriebsstränge
Module responsible:	Prof. Dr.-Ing. László Farkas
Typ of module:	Mandatory module
Undergraduate/Major:	Main studies
Module Content:	-Motivation, Notwendigkeit und Umfeld für moderne Hybrid-/Fahrantriebe -Definitionen: Micro-, Mild-, Fullhybrid, (E-Antrieb) -Bisheriger Entwicklungstand Hybrid-Antriebe -Konzeptvergleich verschiedener Hersteller -Ausblick Energiebereitstellung für (elektrische) Hybrid-Antriebe (Batteriesysteme, ...) -Ausblick: Hybrid als Vorstufe zum voll elektrischen (Alternativen) Antrieb -Auswahlkriterien der (Antriebs)elektromaschine in Verbindung mit der Leistungselektronik und dem zur Verfügung stehenden Bauraum (Packaging) -Vergleich: Permanenterregte Synchronmaschine zu Asynchronmaschine als Antrieb -Ausblick: Anforderung für Serienentwickungsprozess, Stückzahl, Kosten, FMEA -Künftiges Entwicklungspotential unter Ressourcenberücksichtigung
Courses:	4913 Grundlagen der Hybride im KFZ
Teaching and learning forms:	Vorlesung, Übungen
Prerequisites for participation:	Elektrotechnik 1 und 2, Analysis 1 und 2
Applicability of the module:	
Prerequisites allocation ECTS:	K90
ECTS credits:	5
Grading:	benotet
Workload:	Es wird von einem Workload von 30 Stunden je ECTS ausgegangen. Somit ergibt sich ein Arbeitsaufwand von 150 h (davon 60 h für Lehrveranstaltungen, 90 h für das Selbststudium (Vor- und Nachbereitung, Prüfungsvorbereitung).
Duration of the module:	one semester
Frequency of offering:	Every semester
Literature:	
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Absolventinnen und Absolventen können, ausgehend von einigen Grundlagen zu elektrischen Antrieben (Maschine, LE, Batterie,...) das wissenschaftliche, wirtschaftliche und ökologische Verständnis von modernen Hybridantrieben als Vorstufe zu den elektrischen Fahrantrieben, hier besonders in zukünftigen Kraftfahrzeugen, darstellen. Absolventinnen und Absolventen sind in der Lage insbesondere die verschiedenen Konzeptmöglichkeiten und Zukunftsentwicklungen zu erläutern vor allem unter Berücksichtigung von Kosten, Ressourcen und technischer Darstellbarkeit.

Focus:
Deepening of individual components of knowledge

Use, application and generation of knowledge/art

Focus:

Communication and cooperation

Absolventinnen und Absolventen können sich sprachlich effektiv austauschen. Sie haben durch die Belegung des Moduls ihre Kommunikationsfähigkeiten in folgenden Bereichen (fachlich/allgemein/Fremdsprache) verbessert:
- Energiewende
- Nachhaltiges Wirtschaften
- Einsatz regenerativer Energien
- Einsatz intelligenter, selbstfahrender Fahrzeuge und die Gefahren.

Sie können in der Diskussion ihre Meinung begründet darlegen und abweichende Meinungen akzeptieren.

Scientific / artistic self-image and professionalism

Module: Image Processing

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EME04
Module title:	Image Processing
Module responsible:	Prof. Dr. rer. nat. Stefan Elser
Typ of module:	Mandatory module
Undergraduate/Major:	Main studies
Module Content:	The lecture will be in German. Content: 1. Image aquisition 2. Changing the color space, brightness, and contrast 3. Filters and convolutions 4. Projections 5. Camera Calibration 6. Feature Detection and matching 7. Segmentation and outlook on possible applications in Computer Vision using artificial neural networks We will use libraries like OpenCV to apply and evaluate image processing algorithms.
Courses:	7662 Grundlagen der Bildverarbeitung
Teaching and learning forms:	Lecture with exercises
Prerequisites for participation:	Good knowledge in math. Knowledge in Python, MATLAB, or C++
Applicability of the module:	Elektromobilität und regenerative Energien E-Mobility and Green Energy (EN)
Prerequisites allocation ECTS:	regular: PF (50% PA and 50% K60) SoSe 2021 (Corona): PA benotet
ECTS credits:	5
Grading:	graded
Workload:	ca. 50h for the lectures, ca. 100h at home (working over the lecture material, prepartion for the final etc.)
Duration of the module:	one semester
Frequency of offering:	Summer semester only
Literature:	OpenCV tutorials (C++, Python) https://docs.opencv.org/trunk/ B. Jähne: "Digitale Bildverarbeitung", Springer-Verlag R. Szeliski: "Computer Vision: Algorithms and Applications", Springer Science & Business Media http://szeliski.org/Book/
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Students have an insight of the principle workings of the following:
The basic principles of image processing including filters, convolutions, projections, camera calibration, feature detection, and feature matsching.

Focus:
Deepening of individual components of knowledge

Use, application and generation of knowledge/art

Students can apply the following:
Implementation and evaluation of image processing alogrithms.

Focus:
Use and transfer

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Solar Cells, Fuel Cells and Batteries

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EME05
Module title:	Solar Cells, Fuel Cells and Batteries
Module responsible:	Prof. Ziegler
Typ of module:	Mandatory module
Undergraduate/Major:	Main studies
Module Content:	Basic understanding of photovoltaics (PV), assessment of the characteristics of solar cells and modules 1. introduction 2. solar radiation - characteristic quantities 3. solid-state physical basics of photovoltaics (PV) 4. different types of PV cells 5. the future of PV - Solid State Batteries - Lithium-Ion Batteries - Solid Oxide Fuel Cells - Alkaline Fuel Cells - Molten Carbonate Fuel Cells - Polymer Electrolyte Fuel Cells
Courses:	- Photovoltaics - 6752 Batteries and Fuel Cells
Teaching and learning forms:	Lectures
Prerequisites for participation:	Physics
Applicability of the module:	Electrical Engineering and Information Technology Computer Science & Electrical Engineering PLUS Electromobility and Renewable Energies
Prerequisites allocation ECTS:	K90
ECTS credits:	5
Grading:	graded
Workload:	A workload of 30 hours per ECTS is assumed. This results in a workload of 150 hours.
Duration of the module:	one semester
Frequency of offering:	Every semester
Literature:	- H.-G. Wagemann, H. Eschrich: Photovoltaik : Solarstrahlung und Halbleitereigenschaften, Solarzellenkonzepte und Aufgaben, Vieweg + Teubner - A. Wagner: Photovoltaik Engineering : Handbuch für Planung, Entwicklung und Anwendung, Springer - Fuel Cell Systems Explained James Larminie, Andrew Dicks - Moderne Akkumulatoren richtig einsetzen Wolfgang Weydanz, Andreas Jossen - Elektrochemische Speicher Peter Kurzweil, Otto Dietlmeier - Energiespeicher Michael Sterner, Ingo Stadler
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Graduates have expanded their knowledge in the following area and can also reproduce this knowledge:
Understand photovoltaics, batteries und fuel cells in terms of their physical principles and their technical implementation
They are able to familiarise themselves with more detailed questions concerning PV, batteries und fuel cells on the given basis.

Focus:
Broadening of prior knowledge

Use, application and generation of knowledge/art

By taking the module, graduates have improved their ability and increased their willingness to absorb information and take it into account when solving problems in the areas of PV, batteries und fuel cells.

Focus:
Scientific innovation

Communication and cooperation

By taking the module, they have improved their communication skills in the following
areas (technical/general/foreign language):
- understand PV, batteries and fuel cells in terms of their physical principles and their technical implementation
- discuss the importance of PV, batteries und fuel cells in a future energy mix

Graduates are able to present their opinions in a well-founded manner in discussions on the above-mentioned topics and to accept dissenting opinions.

Scientific / artistic self-image and professionalism

Module: Green Energies and Energy Storage

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EME06
Module title:	Green Energies and Energy Storage
Module responsible:	Prof. Ziegler
Typ of module:	Mandatory module
Undergraduate/Major:	Main studies
Module Content:	The course contains - Climate Change and energy system - Solar Energy - Wind Energy - Biomass - Geothermal power - Basics of LIBs and PEMFC
Courses:	96 Alternative Energies to be replaced by (Summer Term 2022 onwards): 10063 Alternative Energies 10064 Energy storage 6140 Practical Training
Teaching and learning forms:	Lecture and exercises
Prerequisites for participation:	Physics
Applicability of the module:	EME
Prerequisites allocation ECTS:	K90+PA
ECTS credits:	7
Grading:	marked
Workload:	210 h
Duration of the module:	one semester
Frequency of offering:	Every semester
Literature:	Quaschning, V., Regenerative Energiesysteme: Technologie, Berechnung, Simulation, Hanser Verlag 2007 - Kaltschmitt, M, Streicher, W., Wiese, A., Erneuerbare Energien, Systemtechnik, Wirtschaftlichkeit, Umweltaspekte, 4. Aufl., Springer 2006 - Holger Watter, Regenerative Energiesysteme. Grundlagen, Systemtechnik und Anwendungsbeispiele aus der Praxis. 2011. Springer Vieweg, Wiesbaden - Michael Sterner, Ingo Stadler, Energiespeicher. Bedarf, Technologien, Integration. Springer Vieweg
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

- Understand alternative energy sources with regard to their physical bases and their technical implementation.
- To discuss the importance of alternative energies in a future energy mix.
- To know the cost structure of renewable energy.
- Various issues relating to alternative energy.

Focus:

Deepening of individual components of knowledge

Use, application and generation of knowledge/art

Understanding and application of the design principles regarding green energies.

Focus:

Use and transfer

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Bachelor Thesis

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EME08
Module title:	Bachelor Thesis
Module responsible:	Prof. Dr.-Ing. Andreas Siggelkow
Typ of module:	Mandatory module
Undergraduate/Major:	Main studies
Module Content:	The students should proof their theoretical and practical knowledges achieved so far by means of a relevant electrical engineering project. Besides the topic of the project, sustainability, economics and planning are relevant. The knowledges achieved by the studies should be proven in within scientific environment.
Courses:	Bachelor Thesis
Teaching and learning forms:	Engineering work
Prerequisites for participation:	- Practical semester - All lectures of the first four semesters
Applicability of the module:	SG: Electrical Engineering and Information Technology SG: Electromobility and Green Energy
Prerequisites allocation ECTS:	Bachelor Thesis and Colloquium
ECTS credits:	12
Grading:	graded
Workload:	Topic and project must be limited in a way, that it can be solved within 360 hours (12 ECTS).
Duration of the module:	one semester
Frequency of offering:	Every semester
Literature:	as needed
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

The students can define, work on, judge and explain scientific topics.

Focus:

Knowledge Comprehension

Use, application and generation of knowledge/art

The students can define, work on, judge and explain scientific topics.

Focus:

Scientific innovation

Communication and cooperation

The students can prove their knowledges achieved during their studies theoretically, practically and will be able to defend it.

The students have to discuss throughout the duration of the thesis their work with others.

Scientific / artistic self-image and professionalism

The students see their own strength and weakness with respect to their studies and work on a scenario for their future as an engineer.

The students are open to accept hints and ideas from colleagues.

The students are able to design sustainable products.

Module: Materials Science

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EME14
Module title:	Materials Science
Module responsible:	Prof. Dr.-Ing. Benedikt Reick
Typ of module:	Mandatory module
Undergraduate/Major:	Basic studies
Module Content:	Basics - Atomic bonds - Material Structures - Diffusion - Mechanical behavior - Thermal behavior - Failure analysis - Phase diagrams - Materials (metals, ceramics, composites and polymers) and their application - Materials for electrical applications and their properties
Courses:	1421 Materials Science
Teaching and learning forms:	Lecture, Exercises
Prerequisites for participation:	keine
Applicability of the module:	Study course: E-mobility and green energies - Module: Physics Mechanics - Module: Introduction to Power Train Engineering - Module: Electric Power Trains - Module: Machinery Design - Module: Automotive Engineering: Basics, Practical and Computer Aided Design (CAD)
Prerequisites allocation ECTS:	K90
ECTS credits:	5
Grading:	benotet
Workload:	A workload of 30 hours per ECTS is assumed. This results in a workload of 150 h (60 h for lectures, 90 h for self-study (preparation and follow-up, Moodle online tests, exam preparation).
Duration of the module:	one semester
Frequency of offering:	Winter semester only
Literature:	Deutsch und Englisch / German and English [1] Bargel/Schulze, Werkstoffkunde (VDI) [2] Roos, Maile, Werkstoffkunde für Ingenieure (Springer) English / englisch [3] James F. Shackelford, Introduction to Materials Science for Engineers (Pearson) [4] William D. Callister, Jr., Materials Science and Engineering - An Introduction
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Students will be able to describe the essential principles of materials science and formulate their significance. They are able to discuss facts and correlations and derive the significance for their field of expertise from the theoretical principles of materials science and transfer them to other disciplines. The students are able to explain areas of application for material groups and to name suitable materials on the basis of the requirement profile of a component.

Focus:

Use, application and generation of knowledge/art

Students are able to apply the knowledge they have acquired with regard to the relationships between the chemical-physical structure and the resulting material properties. They can reproduce the methods of materials testing and, using suitable formulas, process and solve simple tasks to determine electrical, thermal or mechanical properties.
Students will be able to analyze, interpret and contrast research results on current materials science issues.

Focus:

Communication and cooperation

Students are able to communicate using the basic technical vocabulary of materials science, critically evaluate results from materials tests and present subject-related content clearly and in a manner appropriate to the target group. They are able to participate in scientific discussions and represent their point of view with coherent arguments and reasons.

Scientific / artistic self-image and professionalism

Students realistically assess their own strengths and weaknesses with regard to their studies and develop a picture of their own further development as a future graduate in the electromobility and regenerative energies degree program. They pick up on the professional and personal advice of others, examine it critically and are able to select suitable solutions for themselves.

Module: Machinery Design

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EME15
Module title:	Machinery Design
Module responsible:	Prof. Dr.-Ing. Benedikt Reick
Typ of module:	Mandatory module
Undergraduate/Major:	Basic studies
Module Content:	Introduction to machine design - Technical drawings - Fits and tolerances - Technical surfaces - Basics of dimensioning - Technical systems - Basic rules of construction Machine elements - Shafts - springs - Bearings - Gear wheels
Courses:	7086 Maschinery Design
Teaching and learning forms:	Lecture, Exercises
Prerequisites for participation:	none
Applicability of the module:	Study course: E-mobility and green energies - Module: Physics Mechanics - Module: Introduction to Power Train Engineering - Module: Electric Power Trains - Module: Materials Science - Module: Automotive Engineering: Basics, Practical and Computer Aided Design (CAD)
Prerequisites allocation ECTS:	PF: K90 (50%) and Moodle-Online-Tasks during the semester (50%)
ECTS credits:	5
Grading:	graded
Workload:	A workload of 30 hours per ECTS is assumed. This results in a workload of 150 h (60 h for lectures, 90 h for self-study (preparation and follow-up, Moodle online tests, exam preparation).
Duration of the module:	one semester
Frequency of offering:	Winter semester only
Literature:	Deutsch und Englisch / German and English [1] Grote, Bender, Göhlich, Dubbel – Taschenbuch für den Maschinenbau [2] Avallone, Baumeister, Sadegh, Marks' Standard Handbook for Mechanical Engineers [3] Steinhilper, Sauer, Konstruktionselemente des Maschinenbaus 1 und 2 [4] Roloff, Matek, Maschinenelemente [5] Budynas, Nisbett, Shigley's Mechanical Engineering Design [6] Pahl, Beitz, Konstruktionslehre [7] Pahl, Beitz, Engineering Design (english version of [6])
Compulsory attendance:	no

Competence dimensions

Knowledge and understanding

Graduates have broadened their knowledge in the field of machine design and can also reproduce this knowledge. Students can name the essential principles for designing machine elements, for example shafts, springs or bearings, and state the basic equations.

Focus:

Use, application and generation of knowledge/art

Graduates can practically apply analyses to technical systems.
Graduates can reproduce the methods of strength calculation and can apply them to shafts, springs or bearings. They can solve strength calculation tasks by selecting the appropriate solution method.

Focus:

Communication and cooperation

Graduates work cooperatively and responsibly in groups on set online tasks. They present subject-related content clearly and assess the results of their online assignments in collaboration with the teacher.

Scientific / artistic self-image and professionalism

Graduates are able to test their own ideas on technical systems. The importance of sustainable economic and safe construction can be assessed.

Module: Automotive Engineering: Basics, Practical and Computer Aided Design (CAD)

Course of study:	E-Mobility and Green Energy
Degree:	Bachelor of Engineering (B.Eng.)
Module number:	EME16
Module title:	Automotive Engineering: Basics, Practical and Computer Aided Design (CAD)
Module responsible:	Prof. Dr.-Ing. Benedikt Reick
Typ of module:	Mandatory module
Undergraduate/Major:	Main studies
Module Content:	Basic lecture automotive engineering - Introduction to - Longitudinal Dynamics - Transverse Dynamics - Vertical Dynamics Motor vehicles practical course - Driving performance on the chassis dynamometer - Chassis technology (toe and camber changes during wheel movements) - Troubleshooting using diagnostic equipment - Determination of brake force distribution - Vehicle model in the wind tunnel - Characteristic values of a gasoline engine - Characteristic values of a diesel engine - High-voltage systems - electrically instructed person Machine design: CAD: - Basic knowledge of SolidWorks - Basic knowledge of technical drawing - 3D modeling in SolidWorks of milled parts - 3D modeling in SolidWorks of turned parts - Modeling of assemblies consisting of milled and turned parts - Creation of drawings in SolidWorks (according to standards, according to production)
Courses:	7087 Automotive engineering 7034 Automotive engineering practical 7295 CAD
Teaching and learning forms:	Lecture, practical and exercises
Prerequisites for participation:	none
Applicability of the module:	Study course: E-mobility and green energies - Module: Physics Mechanics - Module: Introduction to Power Train Engineering - Module: Electric Power Trains - Module: Machinery Design - Module: Materials Science

Prerequisites allocation ECTS:	Portfolio, each course is weighted according to its SWS. 7087 Automotive engineering: 50 % (4 SWS) 7034 Automotive engineering practical: 25 % (2 SWS) 7295 CAD: 25 % (2 SWS) The grade within the course is calculated as follows: 7087 Automotive engineering: 50% practical exercises in Moodle, 50% K90 written. 7034 Automotive engineering practical: 33.3 % Multiple-choice preparation questions in Moodle, 66.6 % Submitted pre- and post-work in Moodle. 7295 CAD: 50 % practical exercises in Moodle during the semester, 50 % Moodle submission of the project assignment at the end of the semester
ECTS credits:	10
Grading:	graded
Workload:	A workload of 30 hours per ECTS is assumed. This results in a total workload of 300 hours. These are divided into lecture / practical / self-study on the events: - Automotive engineering: 60 h / 0 h / 90 h - Automotive engieneering practical: 10 h / 15 h / 50 h - CAD: 30 h / 0 h / 45 h
Duration of the module:	one semester
Frequency of offering:	Summer semester only
Literature:	- Hoischen: Technisches Zeichnen, Fritz/Hoischen (Cornelsen) - Konstruieren mit SolidWorks, Vogel (Hanser) - SolidWorks - kurz und bündig, Vajna (Springer) - Mitschke, Wallentowitz: Dynamik der Kraftfahrzeuge (VDI-Buch) - Lechner, Naunheimer: Fahrzeuggetriebe, Grundlagen, Auswahl, Auslegung und Konstruktion - Heißing, Ersoy, Gies: Fahrwerkhandbuch: Grundlagen · Fahrdynamik · Komponenten · Systeme · Mechatronik · Perspektiven (ATZ/MTZ-Fachbuch) (Deutsch und Englisch verfügbar) - Crolla et. al.: Automotive Engineering: Powertrain, Chassis System and Vehicle Body (English Edition) 1. Edition - Stone, Ball: Automotive Engineering Fundamentals
Compulsory attendance:	yes
Reason:	It is a practical.

Competence dimensions

Knowledge and understanding

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

Focus:

Use, application and generation of knowledge/art

Graduates are able to apply the knowledge from the fundamentals of automotive engineering (e.g. driving resistances) in laboratory tests and in computational tasks.
Graduates can reproduce the methods used for computer-aided modeling in automotive engineering and can apply the modeling with the help of technical descriptions. They can create technical drawings of any components with concrete tasks.

Focus:

Communication and cooperation

Graduates will be able to communicate effectively using language. They have improved their communication skills in the field of automotive engineering by taking the module.
Graduates work cooperatively and responsibly in groups in the context of a laboratory and when creating technical drawings. They also present subject-related content (e.g. experimental work or technical drawings) clearly and evaluate it.

Scientific / artistic self-image and professionalism

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

Valid from: SoSe21 (Deadline 15.02.2021)

SPO: 03.12.2020

Print date: 02.03.2021