Module Handbook

Electromobility, Autonomous Driving and Mobile Robotics, international

Faculty Electrical Engineering and Media Technology

Examination regulations 14.03.2024

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EMI-01 MATHEMATICS 1

Module code	EMI-01
Module coordinator	Prof. Dr. Reinhard Schlosser
Course number and name	EMI1101 Mathematics 1
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	8
ECTS	9
Workload	Contact hours: 120 hours self-study: 150 hours Total: 270 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	9/240
Language of Instruction	English

Module objective

Primary learning objective: Students should be capable of applying mathematical concepts and methods to technical tasks in both their studies and later in their professional lives.

Students will acquire the following skills: They have a working knowledge of symbolic fractions (equivalent fractions, distributive property, etc.). They are able to solve basic geometric tasks such as distance between point-line, point-plane, and line-line; and intersection angle of line-line, line-plane using vectors. They will have a good command of calculations with complex numbers; in particular, of conversion into various forms (cartesian, polar, exponential). Thus they are capable of applying the complex alternating current calculation. They are familiar with the definitions and definition areas, value areas, special function values, important calculation rules, and areas of differentiability of the basic functions (x^?, sin, cos, tan, cot, arcsin, arccos, arctan, arccot, sinh, cosh, tanh, coth, arsinh, arcosh, artanh, arcoth, exp, ln). In particular, they are able to sketch the appropriate graph. They are familiar with the definition of derivation and its physical, geometrical and analytical significance. They are familiar with the rules of differentiation and can apply them to expressions which are built up of elementary functions. They are familiar with basic integrals and are able to apply integration through substitution and partial integration to simple cases. They can apply integral calculation to geometric or physical questions. They are able to examine linear

systems of equations with the help of Gaussian elimination. They are capable of utilising matrix calculus.

The students achieve the following learning objectives

Professional skills

Students will be familiar with the kinematics and dynamics of point masses in one, two and three dimensional space. They are also familiar with the concepts of free, forced and damped linear harmonic oscillations. Students are able to work conceptually and methodically. They know the main physical models and relationships and have applied them in practical exercises. In particular, they understand the basic assumptions and theories behind the phenomena to be described. They are also able to select appropriate mathematical methods on the basis of a problem description and systematically work out the solution. They know how to interpret the results in a relevant context. In summary, students will be able to apply their acquired knowledge to practical engineering problems.

Methodological skills

Students are able to identify and successfully apply the corresponding calculation methods from a range of calculation methods depending on the task at hand. They will be able to use a scientific calculator and, if necessary, computer algebra software. Students are able to carry out independent research on the basis of extensive exercises and develop their existing knowledge independently.

Personal skills

Students are aware of their responsibility as future engineers. They are able to debate and scrutinise problems, justify their solutions and critically evaluate the results of their calculations.

Applicability in this and other degree programmes

In this programme: EM-05, EM-06, EM-07, EM-08, EM-10, EM-11, EM-12, EM-13, EM-14, EM-15, EM-16, EM-17, EM-18, EM-19, EM-20, EM-22, EM-24, EM-31, EM-32, EM-33

In other programmes:

Electrical Engineering and Information Technology, (B.Eng.): ET-02, ET-04, ET-06, ET-10, ET-11, ET-12, ET-13, ET-14, ET-15, ET-16, ET-17, ET-18, ET-19, ET-26, ET-27, ET-28, ET-29, ET-30, ET-33, ET-34, ET-35, ET-36, ET-37, ET-38, ET-39, ET-40, ET-41, ET-42, ET-43, ET-44, ET-45, ET-46

Admission and/or recommended requirements

Formally: none

In terms of content: none

Learning content

1. **Numbers and Vectors**
    - 1.1. Sets and Transformations
    - 1.2. Real Numbers
    - 1.3. Planes
    - 1.4. Vectors
    - 1.5. Products
    - 1.6. Lines and Planes
    - 1.7. Complex Numbers
2. **Functions, Tolerances, Constants**
    - 2.1. Functions (Basic Concepts)
    - 2.2. Polynomials and Rational Functions
    - 2.3. Trigonometric Functions
    - 2.4. Sequences and Limits of Sequences
    - 2.5. Calculation Rules for Limits of Sequences and Convergence Tests
    - 2.6. Limits of Functions
    - 2.7. Continuous Functions
3. **Differentiation**
    - 3.1. The Derivation of a Differentiable Function
    - 3.2. Applications of Differentiation
    - 3.3. Inverse Functions
    - 3.4. The Exponential and Logarithm Function
4. **Integration**
    - 4.1. The Definite Integral
    - 4.2. Rules of Integration
    - 4.3. Integration of Rational Functions
    - 4.4. Improper Integrals
5. **Linear Algebra**
    - 5.1. Systems of Equations and Matrices
    - 5.2. Matrix Multiplication
    - 5.3. Determinants

Teaching and learning methods

Seminar-based lessons. In class, the contents are worked out with the involvement of the students, documented with the help of a gap script, illustrated with examples and flanked and practiced with comprehension questions and 5-minute exercises. Exercises, controlled questions. hints and sample solutions help the student to rework and acquire the contents. Application-oriented examples and tasks demonstrate the usefulness of mathematical concepts and methods and build bridges to the foundation of electrical engineering, physics and electrodynamics.

Recommended reading

K. Meyberg / P. Vachenauer: Höhere Mathematik I, 6th edition. Springer Verlag, Berlin 2001.

EMI-02 BASICS OF ELECTRICAL ENGINEERING AND INFORMATION TECHNOLOGY 1

Module code	EMI-02
Module coordinator	Prof. Dr. Günter Keller
Course number and name	EMI1102 Basics of Electrical Engineering 1 EMI1103 Basics of Digital Technology
Lecturer	Prof. Dr. Günter Keller
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	7
ECTS	8
Workload	Contact hours: 105 hours self-study: 135 hours Total: 240 hours
Type of Examination	written ex. 90 min., written ex. 60 min.
Duration of Examination	150 min.
Weighting of grades	8/240
Language of Instruction	English

Module objective

The course deals with the fundamentals of studying electrical engineering and information technology, in particular with the basic terms, network analysis and complex AC calculation. The students learn the independent analysis of DC and AC networks.

The students achieve the following learning objectives in Basics of Electrical Engineering 1:

Professional Skills

The students work with the basic concepts and know the necessary units. They analyse both simple and complicated networks with universal procedures. The application of network theorems completes the analysis competence.

Students learn the application of complex AC calculation and can analyse AC networks, which include multiphase systems.

Methodological skills

The subject is strongly mathematically oriented. For this purpose, the students will get an introduction to their mathematical procedures and their application in theory and examples. The methods are each subdivided and presented in a series of process steps.

Soft Skills

Personal competence lies in the detailed application of mathematical and technical procedures.

The students achieve the following learning objectives in Principles of Digital Technology:

Primary learning objective: Students should be able to apply sequential circuits and automata to technical tasks in their studies and career.

To do this, students acquire the following skills:

- Knowledge of the basics of sequential circuits and automata

- Ability to synthesize and analyse sequential systems

- Knowledge of Basic laws and theorems of Boolean algebra

- Solving problems of Boolean algebra

Applicability in this and other degree programmes

In this programme: EM-05, EM-06, EM-07, EM-08, EM-10, EM-11, EM-12, EM-13, EM-14, EM-15, EM-16, EM-17, EM-18, EM-19, EM-20, EM-22, EM-24, EM-31, EM-32, EM-33

In other programmes:

Electrical Engineering and Information Technology (B.Eng.): ET-02, ET-04, ET-06, ET-10, ET-11, ET-12, ET-13, ET-14, ET-15, ET-16, ET-17, ET-18, ET-19, ET-26, ET-27, ET-28, ET-29, ET-30, ET-33, ET-34, ET-35, ET-36, ET-37, ET-38, ET-39, ET-40, ET-41, ET-42, ET-43, ET-44, ET-45, ET-46

Admission and/or recommended requirements

Basics of Electrical Engineering 1:

Formally: none

In terms of content: none

Basics of Digital Technology:

Formally: none

In terms of content: none

Learning content

Basics of Electrical Engineering 1:

1 Basic terms

- 1.1 Charge, current, voltage
- 1.2 Power, energy, efficiency
- 1.3 Sources
- 1.4 Ohm's Law

2 Electrical circuits

- 2.1 Kirchhoff's laws
- 2.2 Series and parallel connection
- 2.3 Mesh Current Analysis, Nodal Potential Analysis
- 2.4 Network Theorems
- 2.3 Nonlinear Networks

3 AC networks

- 3.1 Characteristics of AC signals
- 3.2 Linear network elements
- 3.3 Complex AC calculation
- 3.4 Multiphase systems

Basics of Digital Technology

1 Switching function
- 1.1 Normal forms of switching functions (SF)
- 1.2 Minimization of switching functions

2 Combinatorial circuits, switching networks
- 2.1 General Design Guidelines
- 2.2 Code Converter
- 2.3 Comparators
- 2.3 Multiplexers and Demultiplexers
- 2.4 Adder
- 2.5 Dynamic behaviour of combinatorial circuits

Teaching and learning methods

Basics of Electrical Engineering 1

Seminar-based classes, weekly supervised exercises with the possibility to reflect your own knowledge and to ask questions. The lecture introduces software tools such as LTspice and Python, which can support self-study very well.

Basics of Digital Technology

Seminar-based classes and internship.

In class, the content is developed with the involvement of the students, documented with the help of a gap script, illustrated by examples and flanked and practiced by comprehension questions and 5-minute tasks. Exercises, control questions, tips and sample solutions serve the student for reworking and appropriation of the contents. Through application-oriented examples and tasks, the usefulness of terms and methods for the synthesis and analysis of sequential systems becomes clear.

Recommended reading

Basics of Electrical Engineering 1

Schüßler: Netzwerke, Signale und Systeme I. Springer Verlag 1991.

Weißgerber: Elektrotechnik für Ingenieure I, 11th edition. Springer/Vieweg, Wiesbaden 2018.

Weißgerber: Elektrotechnik für Ingenieure II, 10th edition. Springer/Vieweg, Wiesbaden 2018.

Weißgerber: Elektrotechnik für Ingenieure Klausurrechnen, 7th edition. Springer/Vieweg, Wiesbaden 2018.

M. und N. Marinescu: Elektrotechnik für Studium und Praxis: Gleich-, Wechsel- und Drehstrom, Schalt- und nichtsinusförmige Vorgänge. Springer/Vieweg 2016.

Basics of Digital Technology

Dirk Hoffmann: Grundlagen der Technischen Informatik: Im Internet: Lösungen zu den Übungsaufgaben, Übungsblätter und weiteres Zusatzmaterial; Hanser
K. Fricke: Digitaltechnik: Lehr- und Übungsbuch für Elektrotechniker und Informatiker, Springer Verlag

EMI-03 GERMAN 1

Module code	EMI-03
Module coordinator	Tanja Mertadana
Course number and name	EMI1104 German 1
Lecturer	Lecturers for language and elective (AWP) courses
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	8
ECTS	10
Workload	Contact hours: 120 hours self-study: 120 hours Total: 240 hours
Type of Examination	See examination schedule AWP and languages, written ex. 120 min.
Duration of Examination	120 min.
Weighting of grades	10/240
Language of Instruction	German

Module objective

German 1 (German A2) module aims to enable students to understand basic information communicated orally and in writing.

It aims to enable students to read and understand elementary texts and dialogues. They will simultaneously develop their listening skills so as to allow them to hold conversations and oral presentations. Students will improve their verbal communication skills, enabling them to deal with everyday topics, and will develop the ability to write simple texts and brief statements.

The module also builds a basic vocabulary range and knowledge of basic grammar. Students will also apply the acquired linguistic knowledge in practical activities, such as discussions, presentations or role plays. Intercultural skills will also be developed.

Specifically, students completing the module will achieve the following learning outcomes:

Subject-specific skills

At Level A2, students should be able to:

- Comprehend and respond to basic instructions, questions and enquiries.
- Engage in conversations on basic everyday topics.
- Read short texts and grasp basic information contained in such texts.
- Write texts in a basic form, e.g. descriptions or expressions of opinion.

Methodological skills

Methodological skills here refer to students' ability to apply a variety of learning and working methods so that they may further build on their linguistic and subject-specific knowledge.

- Application of basic learning strategies in order to learn and consolidate vocabulary and grammar structures.
- The use of dictionaries and online resources in order to understand unknown terms and expressions.
- Completion of elementary written exercises and tasks in order to consolidate what they have learned.
- Comprehend elementary listening exercise.
- Discuss and exchange views with other students in learning groups.

Social skills

Social skills here refer to students' ability to conduct themselves appropriately, communicating effectively and working successfully in groups when engaging in social interactions.

- Polite, respectful communication in elementary everyday situations, e.g. when asking for information or exchanging views and opinions.
- Collaboration when completing group exercises and working with a partner in order to solve tasks.
- Participating in basic discussions and sharing their own experiences and ideas.

Personal skills

Personal skills here refer to students' individual abilities, attitudes and traits that enable them to achieve their goals, further their personal development and to work successfully.

- Motivation for and commitment to learning German.

- Openness and curiosity to tackle new topics.
- Sense of responsibility for their own learning development and achievement of the learning goals.
- Ability to self-reflect and identify their own strengths and weaknesses.
- Willingness to ask questions in order to resolve uncertainties.

Applicability in this and other degree programmes

Not applicable in other degree programmes.

Admission and/or recommended requirements

To successfully participate in this module, students must be able to furnish proof that they have attained Level A1 German proficiency.

Learning content

Grammar and vocabulary form the core elements of this course. The following key aspects are covered during the course: regional studies, intercultural skills and pronunciation. Media, functions and events, jobs, transport sport and leisure are just some of the topics treated in this course. Additional topics will furthermore be incorporated in keeping with current literature and real-life developments. The following is an extract of the grammar topics that will be covered:

- Past tense
- Subordinate clauses
- Declension of adjectives
- Dual-case prepositions
- Indirect questions

Teaching and learning methods

The teaching methods applied will focus on improving the four main language skills (listening, speaking, reading and writing). Examples of the applied learning methods include various forms of group, individual and collaborative work, mini-presentations, exercises involving intensive reading and listening, role plays and grammar games, loci method, dictation exercises, translations, peer feedback, working with learning stations, and various writing activities designed to consolidate the content learnt. It is also envisaged that projects will be carried out using the scenario method.

Students will be given weekly assignments for self-study.

Remarks

In all language courses, students will be required to meet a minimum compulsory attendance rate of 75%.

Recommended reading

Netzwerk neu A2.1, Kurs- und Übungsbuch mit Audios und Videos, Klett Verlag, Lektionen 1-6 (ISBN 978-3-12-607162-8)

Netzwerk neu A2.1, Kurs- und Übungsbuch mit Audios und Videos, Klett Verlag, Lektionen 7-12 (ISBN 978-3-12-607163-5)

Grammatik Intensivtrainer A2. Langenscheidt (ISBN 978-3126063609)

A-Grammatik (Niveau A1-A2). Schubert (ISBN 978-3-941323-09-4)

Einfach Grammatik Übungsgrammatik Deutsch A1 - B1. Langenscheidt (ISBN 978-3-12-606368-5)

Wortschatz & Grammatik A2: Buch, Hueber (ISBN 978-3198574935)

Deutsch intensiv Wortschatz A2: Das Training, Klett (ISBN 978-3126750745)

Prüfungstraining DaF: A2 - Fit in Deutsch 2, Cornelsen Verlag (ISBN 978-3-06-121261-2)

EMI-04 SELF-ORGANISATION DURING YOUR STUDIES

Module code	EMI-04
Module coordinator	Prof. Dr. Franz Daiminger
Course number and name	EMI1105 Self-organisation during your study
Lecturer	Yoldascan Altun
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	undergraduate
Semester hours per week (SWS)	2
ECTS	3
Workload	Contact hours: 30 hours self-study: 60 hours Total: 90 hours
Type of Examination	null
Weighting of grades	3/210
Language of Instruction	English

Module objective

The transition from school to higher education presents many students with challenges right at the start of their degree programme. They have to move away from prescribed schedules and curricula and towards independence, autonomy and responsibility.

The self-organisation module during the programme is designed to prepare students for these challenges, particularly with regard to digitalisation and the economic aspect (internship in the 5th semester).

For international students, the acquisition of the German language creates an additional challenge. The module is designed to help students structure their schedule in order to meet these diverse requirements.

Students will acquire the following skills

Professional skills

Students learn the basics of self-organisation for a successful course of study.

Methodological skills

Students are familiar with the various key aspects of self-organisation while pursuing a degree.

Personal skills

Students acquire a sense for a structured approach to both language acquisition and scientific engineering content. They can organise in teams for effective group study.

Applicability in this and other degree programmes

In this degree programme: The ability to organise oneself is beneficial for all courses

In other degree programmes: General elective subject of a general academic nature (AWP)

Admission and/or recommended requirements

none

Learning content

1. Organising 101 - Creating structures.
   Self-organisation for beginners: Calendars and to-do lists

   Lectures and seminars: Take good notes

   During examination phases: Make a plan
2. Find the right study method
3. Use digital resources effectively
4. Collaborate with your peers

Teaching and learning methods

Seminars, group work, self-study

Remarks

none

Recommended reading

Barbara Messing, Das Studium: Vom Start zum Ziel, Springer, 2012

EMI-05 MATHEMATICS 2

Module code	EMI-05
Module coordinator	Prof. Dr. Reinhard Schlosser
Course number and name	EMI2101 Mathematics 2
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	6
ECTS	7
Workload	Contact hours: 90 hours self-study: 120 hours Total: 210 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	7/240
Language of Instruction	English

Module objective

Primary learning objective: Students should be capable of applying mathematical concepts and methods to technical tasks in both their studies and later in their professional lives. In addition, students will acquire the following competencies:

They are able to apply differential and integral calculations to spatial curves, areas and ranges. In particular, they are capable of determining tangents and tangent planes. They are familiar with the definition of gradient, divergence, and rotation and their geometric as well as physical significance. They are thereby capable of applying these concepts in more advanced courses (electrodynamics).

Students will achieve the following learning objectives:

Professional skills

Students will be familiar with the kinematics and dynamics of point masses in one, two and three dimensional space. They are also familiar with the concepts of free, forced and damped linear harmonic oscillations. Students are able to work conceptually and methodically. They know the main physical models and relationships and have applied them in practical exercises. In particular, they understand the basic assumptions and theories behind the phenomena to be described. They are also able to select appropriate mathematical methods on the basis of a problem description and systematically work

out the solution. They know how to interpret the results in a relevant context. In summary, students will be able to apply their acquired knowledge to practical engineering problems.

Methodological skills

Students are able to identify and successfully apply the corresponding calculation methods from a range of calculation methods depending on the task at hand. They will be able to use a scientific calculator and, if necessary, computer algebra software. Students are able to carry out independent research on the basis of extensive exercises and develop their existing knowledge independently.

Personal skills

Students are aware of their responsibility as future engineers. They are able to debate and scrutinise problems, justify their solutions and critically evaluate the results of their calculations.

Applicability in this and other degree programmes

In this programme: EM-10, EM-11, EM-12, EM-13, EM-14, EM-15, EM-16, EM-17, EM-18, EM-19, EM-20, EM-22, EM-24, EM-31, EM-32, EM-33

In other programmes:

Electrical Engineering and Information Technology (B.Eng.):

ET-11, ET-12, ET-13, ET-14, ET-15, ET-16, ET-17, ET-18, ET-19, ET-26, ET-27, ET-28, ET-29, ET-30, ET-33, ET-34, ET-35, ET-36, ET-37, ET-38, ET-39, ET-40, ET-41, ET-42, ET-43, ET-44, ET-45, ET-46

Admission and/or recommended requirements

Formally: none

In terms of content: EM-01, EM-02, EM-03

Learning content

1. **Linear Algebra**
   - 1.1. Linear Functions and Characteristic Values
   - 1.2. Symmetric Matrices and Quadratic Forms
2. **Functions of Multiple Variables: Differentiation**
   - 2.1. Curves in IRn
   - 2.2. Real-valued Functions with Multiple Real Variable
   - 2.3. Applications of Differentiation

2.4. Functions with Vectorial Values

3. **Functions of Multiple Variables: Integration**

3.1. Parameter Integrals

3.2. Curve Integrals

3.3. Integration over Flat Ranges

3.4. Integration over Surfaces in Space

3.5. Integration over 3-Dimensional Spaces

Teaching and learning methods

Seminar-based lessons. In class, the content is developed with the involvement of the students, documented with the help of a gap script, illustrated by examples and flanked and practiced by comprehension questions and 5-minute tasks. Exercises, control questions, tips and sample solutions serve the student for reworking and appropriation of the contents. Application-oriented examples and tasks demonstrate the usefulness of mathematical concepts and methods and build bridges to the foundations of electrical engineering, physics and electrodynamics.

Recommended reading

K. Meyberg / P. Vachenauer: Höhere Mathematik I, 6. Auflage. Springer Verlag, Berlin 2001.

EMI-06 BASICS OF ELECTRICAL ENGINEERING AND INFORMATION TECHNOLOGY 2

Module code	EMI-06
Module coordinator	Prof. Dr. Günter Keller
Course number and name	EMI2102 Basics of Electrical Engineering 2 EMI2103 Computer Science 1
Lecturer	Prof. Dr. Günter Keller
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	8
ECTS	10
Workload	Contact hours: 120 hours self-study: 180 hours Total: 300 hours
Type of Examination	Pr. course attendance 80%, written ex. 90 min.
Duration of Examination	180 min.
Weighting of grades	10/240
Language of Instruction	English

Module objective

The course deals with the basics of electrical engineering and information technology studies, in particular with transfer functions transformers and transient phenomena.

Students learn how to independently apply transfer functions, transient phenomena and the description of transformers.

The students achieve the following learning objectives in the course Basics of Electrical Engineering 2:

Professional Skills

Students apply the basics of electrical engineering I to electrical networks with transformers. They analyse both simple and complex networks in terms of transient phenomena with and without initial conditions.

Furthermore, the students learn the abstract description of electrical networks in terms of transfer functions and their graphical representation with linear and logarithmic

scaling.

Methodological skills

The subject is strongly mathematically oriented. For this purpose, the students will get an introduction to their mathematical procedures and their application in theory and examples. The methods are each subdivided and presented in a series of process steps.

Personal Skills

Personal competence lies in the detailed application of mathematical and graphical procedures.

The students achieve the following learning objectives in the course Computer Science 1:

The students should be able to substantiate theoretical and practical contents of the lecture within tasks.

The subject is divided into two parts:

1 Basics of Number Systems

Knowledge of the basics of number representations (decimal, dual, hexadecimal, floating-point numbers), as well as knowledge in the calculation of these number systems.

Ability to convert numbers into different number systems.

2 Programming in C

This includes the partitioning of a task into informal algorithms, the implementation into a realization, as well as testing and troubleshooting in the implementation.

In detail, the objectives are:

Ability to program tasks with the C programming language
Ability to analyse tasks for implementation in C
Ability to test and troubleshoot implementations

Applicability in this and other degree programmes

In this programme: EM-10, EM-11, EM-12, EM-13, EM-14, EM-16, EM-17, EM-18, EM-19, EM-22, EM-24, EM-31, EM-32, EM-33

In other degree programmes:

Electrical Engineering and Information Technology (B.Eng.): ET-11, ET-12, ET-13, ET-14, ET-16, ET-17, ET-18, ET-19, ET-26, ET-30, ET-33, ET-34, ET-35, ET-36, ET-37, ET-38, ET-39, ET-40, ET-41, ET-42, ET-43, ET-44, ET-45, ET-46

Admission and/or recommended requirements

Formally: none

In terms of content: EMI-02

Learning content

Basics of Electrical Engineering 2

1 Transfer Functions

1.1 Representation of transfer functions
1.2 Characteristics
1.3 Frequency Response, Bode plots

2 Transformers

2.1 Structure and functioning
2.2 Measurement on transformers
2.3 Loaded transformers

3 Transient phenomena

3.1 Linear differential equations
3.2 Laplace transform
3.3 Application of the Laplace transform
3.4 Impulse response, step response
3.5 Initial states

Computer Science 1

Basics

1 Number systems

2 Computing in the dual system

3 Computing in the hexadecimal system

4 Negative numbers

5 Binary Coded Decimal Numbers (BCD)

6 Floating point numbers

Programming in C

1 Main program, main ()

2 Instructions

3 Comments

4 Input / Output

5 Data types

6 Variables

7 Constants

8 Operators

9 Type conversion

10 Control structures

11 Functions, subprograms

12 Characters, strings

13 Mathematical functions

14 Pointers

15 Memory, dynamic memory management

16 Preprocessor instructions

17 Command processor

18 Recursion

19 Structures, further data types

20 Files

21 ASCII table

Teaching and learning methods

Basics of Electrical Engineering 2

Lecture, supervised exercises every week with the opportunity to reflect on one?s own level of knowledge and ask questions. Software tools such as LTspice and Python, which can support self-study very well, are introduced in the lectures.

Computer Science 1

Seminar-based instruction.

After presenting the contents of the lectures and presenting the theoretical background, suitable model tasks are worked through step by step.

In the part number systems, the solution of tasks with paper and pencil without a calculator is particularly emphasized, as this creates a feeling for the numbers. This is urgently needed in the later programming part.

The process of learning programming techniques is done by reworking a lot of illustrative material practically on the computing system, which develops a good autonomy in the course of the semester. The development of the ability to work independently is achieved by various projects, which can then be solved almost independently with the support of the lecturer

The types of media used are blackboard, script, exercises collection, beamer, personal computer, overhead projectors and secondary literature.

Recommended reading

Basics of Electrical Engineering 2

Büttner: Grundlagen der Elektrotechnik II, 2nd edition. Oldenbourg, München 2009.

Schüßler: Netzwerke, Signale und Systeme I. Springer Verlag 1991.

Weißgerber: Elektrotechnik für Ingenieure II, 10th edition . Springer/Vieweg, Wiesbaden 2018.

Weißgerber: Elektrotechnik für Ingenieure III, 9th edition. Springer/Vieweg, Wiesbaden 2015.

Weißgerber: Elektrotechnik für Ingenieure Klausurrechnen, 7th edition. Springer/Vieweg, Wiesbaden 2018.

U. Weber: Laplace-Transformation für Ingenieure der Elektrotechnik, 9th edition. Vieweg/Teubner, Wiesbaden 2012.

M. Marinescu / N. Marinescu: Elektrotechnik für Studium und Praxis: Gleich-, Wechsel- und Drehstrom, Schalt- und nichtsinusförmige Vorgänge. Springer/Vieweg 2016.

Computer Science 1

H. Erlenkötter: C Programmieren von Anfang an. Rowohlt Taschenbuch 1999.

EMI-07 GERMAN 2

Module code	EMI-07
Module coordinator	Tanja Mertadana
Course number and name	EMI2104 German 2
Lecturer	Lecturers for language and elective (AWP) courses
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	8
ECTS	10
Workload	Contact hours: 120 hours self-study: 120 hours Total: 240 hours
Type of Examination	See examination schedule AWP and languages, written ex. 120 min.
Duration of Examination	120 min.
Weighting of grades	10/240
Language of Instruction	German

Module objective

The German 2 (German B1) module focuses on improving students' communication skills and expanding their vocabulary range. It also aims to broaden their comprehension of more complex texts communicated in writing and orally, such as articles and reports. The module furthermore trains their ability to comprehend and engage in longer conversations and discussions on a variety of topics.

The main emphasis of the module is to improve students' verbal skills so as to enable them to express opinions, ideas and experiences. By writing coherent texts, such as reports, letters or argumentation will be applied as means of further enhancing their writing skills. The module will also involve deepening students' grammar knowledge and expanding their range of vocabulary. This will enable them to apply the acquired linguistic skills to practical situations, such as in presentations, role plays or group discussions. Their intercultural skills will be broadened, enabling them to communicate in international environments. The course incorporates a diverse range of activities; group work, pair work, role plays, discussions, listening and reading comprehension. The aim of the module is to prepare students for real-life situations.

Specifically, students completing the module will achieve the following learning outcomes:

Professional skills

At Level B1, students should be able to:

- Read texts of a more complex nature and comprehend specific information contained in them.
- Actively engage in discussions and conversations, exchange views and opinions and present arguments.
- Give an account of a variety of topics, both orally and in writing, such as advantages and disadvantages, technological developments or future trends.
- Apply and comprehend subject-specific terminology and vocabulary.
- Hold basic presentations and answer questions on these.

Methodological skills

Methodological skills here refer to students' ability to apply a variety of learning and working methods so that they may further build on their linguistic and subject-specific knowledge.

- Application of various learning strategies in order to broaden and deepen their vocabulary and knowledge of grammatical structures in the context of electromobility.
- Use of authentic materials, such as specialist articles, presentations or videos for self-research and learning purposes.
- Independently plan, organise and carry out written tasks and projects.
- Treat complex listening exercises, e.g. expert interviews or discussions.
- Work in collaboration and interactively with other students in group work and projects.

Social skills

Social skills here refer to students' ability to conduct themselves appropriately, communicate effectively and work in groups when engaging in social interactions.

- Effective oral communication in a variety of contexts, e.g. in presentations, discussions or group work.

- Ability to actively listen and respond appropriately to opinions and viewpoints expressed by other students.
- Collaboration in group projects and teamwork in order to collectively solve tasks.
- Intercultural sensitivity and the ability to work with students of various cultural backgrounds.

Personal skills

Personal skills here refer to students' individual abilities, attitudes and traits that enable them to achieve their goals, further their personal development and operate successfully.

- Independence and personal initiative when learning German.
- Organisational skills in order to plan and accomplish tasks and projects.
- Tenacity and perseverance on the road to achieving the learning goals and overcoming challenges.
- Critical thinking and the ability to form and uphold their own opinions.
- Confidence in their own abilities and their application of learnt knowledge.

Applicability in this and other degree programmes

Not applicable in other degree programmes.

Admission and/or recommended requirements

To successfully participate in this module, students must be able to furnish proof that they have attained Level A2 German proficiency.

Learning content

Grammar and vocabulary form the core elements of this course. The following key aspects are covered during the course: regional studies, intercultural skills and pronunciation. Holidays/travel, technology/devices, complaints, job hunting and the environment are just some of the areas covered during this course. Additional topics will furthermore be incorporated in keeping with current literature and real-life developments. The following is an extract of the grammar topics that will be covered:

- Infinitive clauses
- Subordinate clauses
- Passive voice

- Connectors
- Prepositions
- Pronominal adverbs
- n-declension
- Subjunctive II

Teaching and learning methods

The teaching methods applied will focus on improving the four main language skills (listening, speaking, reading and writing). Examples of the applied learning methods include various forms of group, individual and collaborative work, mini-presentations, exercises involving intensive reading and listening, role plays and grammar games, loci method, dictation exercises, translations, peer feedback, working with learning stations, and various writing activities designed to consolidate the content learnt. It is also envisaged that projects will be carried out using the scenario method.

Students will be given weekly assignments for self-study.

Remarks

In all language courses, students will be required to meet a minimum compulsory attendance rate of 75%.

Recommended reading

Netzwerk neu B1.1, Kurs- und Übungsbuch mit Audios und Videos, Klett Verlag Lessons 1-6 (ISBN 978-3-12-607170-3)

Netzwerk neu B1.1, Kurs- und Übungsbuch mit Audios und Videos, Klett Verlag Lessons 7-12 (ISBN 978-3-12-607171-0)

Grammatik aktiv: A1-B1, Cornelsen Verlag (ISBN 978-3-06-122964-1)

Übungsgrammatik für die Grundstufe: Lösungsheft, Hueber Verlag (ISBN 978-3-922989-70-7)

Fit in Grammatik B1, Hueber Verlag (ISBN 978-3-19-607493-2)

Deutsch als Fremdsprache, Übungsgrammatik für die Grundstufe Niveau A2-B2, Liebaug-Dartmann (ISBN 978-3-922989-70-7)

Wortschatz & Grammatik B1: Buch (deutsch üben), Hueber (ISBN 978-3194874930)

Deutsch intensiv Wortschatz B1: Das Training, Klett (ISBN 978-3126750769)

EMI-08 COMPULSORY ELECTIVE SUBJECT OF A GENERAL ACADEMIC NATURE (AWP) 1

Module code	EMI-08
Module coordinator	Tanja Mertadana
Course number and name	EMI2105 Compulsory Elective Subject of a General Academic Nature (AWP) 1
Lecturer	Lecturers for language and elective (AWP) courses
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	Core subject / compulsory elective course
Level	Undergraduate
Semester hours per week (SWS)	2
ECTS	2
Workload	Contact hours: 30 hours self-study: 30 hours Total: 60 hours
Type of Examination	See examination schedule AWP and languages
Weighting of grades	2/240
Language of Instruction	German

Module objective

This AWP (compulsory elective subject of a general academic nature) elective module enables students to acquire knowledge and skills in subject areas beyond the scope of their chosen degree programme.

Students can choose both face-to-face courses and courses offered by the Virtuelle Hochschule Bayern (VHB). Students acquire knowledge and skills in the following areas:

- in a foreign language (language skills)
- in the didactic-pedagogical area (methodological skills)
- in the social sciences (social skills)
- in the psychological-sociological field (social skills)
- in the technical and scientific field (professional skills)
- in the philosophical-social-ethical area (personal skills)

Students are free to choose their courses from the list of elective (AWP) courses offered to expand their knowledge according to their own preferences.

Applicability in this and other degree programmes

Applicable in other degree programmes.

Admission and/or recommended requirements

In order to attend advanced language courses, students need to present the required language skills (e.g. by successfully completing of the previous level).

Elective (AWP) courses may not have any overlapping content with the student's current degree programme.

Learning content

The course content can be found in the corresponding course description on the homepage of the Language Centre:
https://www.th-deg.de/en/students/language-electives#languages

Teaching and learning methods

The teaching and learning methods can be found in the corresponding course description on the homepage of the Language Centre:
https://www.th-deg.de/en/students/language-electives#languagesFormularende

Remarks

For course-specific details, please refer to the corresponding course description on the homepage of the Language Centre:
https://www.th-deg.de/en/students/language-electives#languages

All language courses require a compulsory attendance rate of 75% in order to be allowed to take the examination.

Recommended reading

Recommended reading can be found in the corresponding course description on the homepage of the Language Centre:
https://www.th-deg.de/en/students/language-electives#languages

EMI-09 BASICS OF ELECTRICAL ENGINEERING AND INFORMATION TECHNOLOGY 3

Module code	EMI-09
Module coordinator	Prof. Dr. Günter Keller
Course number and name	EMI3101 Basics of Electrical Engineering 3 EMI3102 Computer Science 2
Lecturer	Prof. Dr. Günter Keller
Semester	3
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	undergraduate
Semester hours per week (SWS)	8
ECTS	8
Workload	Contact hours: 120 hours self-study: 120 hours Total: 240 hours
Type of Examination	Pr. course attendance 80%, written ex. 90 min.
Duration of Examination	180 min.
Weighting of grades	8/240
Language of Instruction	English

Module objective

The course deals with the basics of electrical engineering and information technology studies, in particular with transfer functions transformers and transient phenomena.

Students learn how to independently apply transfer functions, transient phenomena and the description of transformers.

The students achieve the following learning objectives in Basics of Electrical Engineering 3:

Professional Skills

Students apply the principles of electrical engineering I and principles of electrical engineering to electrical networks. They analyse both simple and complex networks in terms of frequency response, as low-pass filter, high-pass filter, bandpass filter as well as band stop filter, in passive or active circuits.

Furthermore, the students learn the abstract description of electrical networks in terms of state-space representation using matrix conventions. and their graphical representation in signal flow charts.

Additionally the students learn to use quadripole description for four terminal networks and their circuits interconnections and operating parameters.

Methodological skills

The subject is strongly mathematically oriented. For this purpose, the students will get an introduction to their mathematical procedures and their application in theory and examples. The methods are each subdivided and presented in a series of process steps.

Personal Skills

Personal competence lies in the detailed application of mathematical and graphical procedures.

The students achieve the following learning objectives in Computer Science 2:

Students should be able to implement theoretical and practical contents of the lecture in complex tasks in a well-founded way.

This includes breaking up a task into informal algorithms, implementing it in a machine-oriented realisation, and carrying out testing and troubleshooting in the implementation.

In detail, the goals are:

- Ability to programme tasks using the object-oriented programming language C++
- Ability to analyse tasks for implementation in the programming language C++
- Ability to implement data bases in the programming language C++
- Ability to carry out testing and troubleshooting in complex systems

Applicability in this and other degree programmes

In this programme: EM-10, EM-11, EM-12, EM-13, EM-14, EM-16, EM-17, EM-18, EM-19, EM-22, EM-24, EM-31, EM-32, EM-33

In other degree programmes:

Electrical Engineering and Information Technology (B.Eng.): ET-11, ET-12, ET-13, ET-14, ET-16, ET-17, ET-18, ET-19, ET-26, ET-30, ET-33, ET-34, ET-35, ET-36, ET-37, ET-38, ET-39, ET-40, ET-41, ET-42, ET-43, ET-44, ET-45, ET-46

Admission and/or recommended requirements

Formally: none

In terms of content: EMI-02 and EMI-06

Learning content

Basics of Electrical Engineering 3:

1 Electrical filters

1.1 Theoretical basics
1.2 Transformations
1.3 Passive realisation
1.4 Active realisation

2 State space representation

2.1 Setting up of state equations
2.2 Structures of state space representation
2.3 Solution of state space representation
2.4 Applications

3 Quadripole theory

3.1 Quadripole equations
3.2 Quadripoles
3.3 Operating parameters

Computer Science 2:

1 Demarcation to the programming language C

2 Input/Output

2.1 Comments
2.2 Main programme, main()
2.3 Precompiler instructions
2.4 Namespaces:
2.5 cin, cout

3 Classes and objects

3.1 Object instances
3.2 Elementary objects int, float, char
3.3 Objects of class string
3.4 Creation of new classes
3.5 Copying of objects
3.6 Static properties of a class

3.7 Static methods of a class
3.8 Inheritance, derived classes:
3.9 Polymorphism, virtual functions
3.10 Overloading of operators
3.11 Templates
3.12 Fields

4 Block monitoring

5 References

5.1 Subprogramme calls

6 Friendly classes, ?friend?

7 Run Time Type Information, RTTI

8 Type conversions 'type cast'

8.1 Implicit and explicit type conversions
8.2 'Type casts' in C++

9 Files

10 Linked lists

Teaching and learning methods

Basics of Electrical Engineering 3:

Seminar-based class, supervised exercises every week with the opportunity to reflect on one's own level of knowledge and ask questions. Software tools such as LTspice and Python, which can support self-study very well, are introduced in class.

Computer Science 2:

The teaching method is seminar-based instruction.

After presenting the contents of the lectures and presenting the theoretical background, suitable model tasks are worked through step by step.

The process of learning programming techniques is done by reworking a lot of illustrative material practically on the computing system, which develops a good autonomy in the course of the semester. The development of the ability to work independently is achieved by various projects, which can then be solved almost independently with the support of the lecturer. An example is the creation of a telephone book on the basis of a self-programmed database.

The types of media used are blackboard, script, exercises collection, beamer, personal computer, overhead projectors and secondary literature.

Recommended reading

Principles of Electrical Engineering 3:

Büttner: Grundlagen der Elektrotechnik II, 2nd edition. Oldenbourg, München 2009.

Schüßler: Netzwerke, Signale und Systeme I. Springer Verlag 1991.

Weißgerber: Elektrotechnik für Ingenieure II, 10th edition. Springer/Vieweg, Wiesbaden 2018.

Weißgerber: Elektrotechnik für Ingenieure III, 9th edition. Springer/Vieweg, Wiesbaden 2015.

Weißgerber: Elektrotechnik für Ingenieure Klausurrechnen, 7th edition. Springer/Vieweg, Wiesbaden 2018.

U. Weber: Laplace-Transformation für Ingenieure der Elektrotechnik, 9th edition. Vieweg/Teubner, Wiesbaden 2012.

M. Marinescu / N. Marinescu: Elektrotechnik für Studium und Praxis: Gleich-, Wechsel- und Drehstrom, Schalt- und nichtsinusförmige Vorgänge. Springer/Vieweg 2016.

Computer Science 2:

H. Erlenkötter: C Programmieren von Anfang an. Rowohlt Taschenbuch 1999.

H. Erlenkötter: C++ Objektorientiertes Programmieren von Anfang an. Rowohlt Taschenbuch 2000.

EMI-10 MATERIALS SCIENCE

Module code	EMI-10
Module coordinator	Prof. Dr. Michael Sternad
Course number and name	EMI3103 Materials Science
Semester	3
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	5/240
Language of Instruction	English

Module objective

Students internalise the properties and applications of important classes of materials, as well as their manufacture, testing and potential error patterns.

Students will achieve the following learning objectives:

Professional skills

Understanding of the structure and properties of important functional and construction materials and typical fields of application in vehicle construction. Students are able to assign these materials to groups such as metals, plastics, ceramics or glasses based on their molecular structure and are able to apply their knowledge in simple example exercises.

Methodological skills

Students know important material parameters and can research such parameters for materials they have not yet encountered. Ultimately, students will have empirically internalised the most common material parameters and properties and will be able to apply them without research.

Personal skills

Students recognise their current abilities and deficits, accept their deficits and work on perfecting these deficits. Students experience recognition, e.g. through positive feedback or by solving difficult tasks. The recognition they experience motivates them to continue and intensify their work on personal deficits.

Applicability in this and other degree programmes

In this degree programme EM-11, EM-14, EM-19, EM-22

In other degree programmes:

Electrical Engineering and Information Technology (B.Eng.): ET-11, ET-14, ET-27, ET-30, ET-34, ET-39, ET-40, ET-41, ET-42

Admission and/or recommended requirements

Formally: none

In terms of content: EM-01, EM-02, EM-03

Learning content

1. **Metals and alloys**
   - 1.1. Steel
   - 1.2. Aluminium
   - 1.3. Magnesium
   - 1.4. Copper
2. **Glasses**
3. **Ceramics**
   - 3.1. Piezoceramics
   - 3.2. Magneto ceramics
   - 3.3. Solid ionic conductors
4. **Plastics**
5. **Optional chapters**

Teaching and learning methods

Seminar-based lesson

Blackboard/board, visualiser/video projector

Recommended reading

Bargel, H. J.; Schulze, G., Werkstoffkunde, 12th edition. Springer-Verlag: 2018.

Gottstein, G., Materialwissenschaft und Werkstofftechnik: Physikalische Grundlagen, 4th edition. Springer-Verlag: Berlin, Heidelberg, 2014.

Furger, A. R., Antike Stahlerzeugung-Ein Nachweis der Aufkohlung von Eisen aus Augusta Raurica. 2nd ed.; Dr. h. c. Alfred Mutz-Stiftung: Basel, 2019

EMI-11 PHYSICS 1

Module code	EMI-11
Module coordinator	Prof. Dr. Johann Plankl
Course number and name	EMI3104
Semester	3
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	5
ECTS	6
Workload	Contact hours: 75 hours self-study: 105 hours Total: 180 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	6/240
Language of Instruction	English

Module objective

Students essentially deal with methods of classical physics of a point mass. They learn the necessary steps to work out independent solutions for corresponding problems in the field of engineering, whereby they are especially enabled to critically question the selection of the corresponding methods and calculation procedures.

The students get to know typical models, methods and problems from engineering practice, which can be processed with the kinematics and dynamics of a mass point, together with corresponding solution methods and strategies. The physical way of thinking of mechanics is anchored.

Students achieve the following learning objectives:

Professional Skills

The students have knowledge of the kinematics and dynamics of point masses in one-, two- and three-dimensional space. In addition, they know the concepts of free, forced and damped linear harmonic oscillation. Students are able to work conceptually and methodically. They know the most important physical models and correlations and have applied them in practical exercises. In particular, they know the basic assumptions and theories behind the phenomena to be described. They are also able to select suitable mathematical methods on the basis of a problem description and to systematically work out the solution on the basis of these methods. They have the knowledge to interpret

the results in a subject-specific way. In summary, the students can apply their acquired knowledge to engineering tasks in a practice-oriented way.

Methodological Skills

Depending on the problem, students are able to identify and successfully apply appropriate calculation methods from a range of calculation methods. They can use scientific calculators and, if necessary, computer algebra software. The students have the ability to carry out independent research on the basis of more extensive exercises and to develop their existing knowledge independently.

Soft Skills

The students are aware of their responsibility as future engineers. They are in a position to discursively question problems among themselves, to justify the solutions argumentatively and to critically evaluate the results of their calculations.

Applicability in this and other degree programmes

In this programme: EM-05, EM-06, EM-07, EM-08, EM-10, EM-11, EM-12, EM-13, EM-14, EM-15, EM-16, EM-17, EM-18, EM-19, EM-20, EM-22, EM-24, EM-31, EM-32, EM-33

In other programmes:

Electrical Engineering and Information Technology (B.Eng.): ET-02, ET-04, ET-06, ET-10, ET-11, ET-12, ET-13, ET-14, ET-15, ET-16, ET-17, ET-18, ET-19, ET-26, ET-27, ET-28, ET-29, ET-30, ET-33, ET-34, ET-35, ET-36, ET-37, ET-38, ET-39, ET-40, ET-41, ET-42, ET-43, ET-44, ET-45, ET-46

Admission and/or recommended requirements

Formally: none

In terms of content: none

Learning content

0. Crash course mathematics (differential, integral and vector calculus)

1. Kinematics of a mass point

1.1. Basic kinematic variables
1.2. The one-dimensional motion
1.3. Motions in two- and three-dimensional space
1.4. Falling and throwing motions
1.5. Uniform rotation
1.6. Kinematics in polar coordinates

2. Dynamics of a mass point

2.1. Mass and force
2.2. Newtonian Axioms
2.3. Forces that are easy to describe
2.4. Work and energy
2.5. Conservative forces and potential
2.6. Impact and impulse
2.7. The problem of mass variation over time
2.8. Shock processes
2.9. Torque and angular momentum of mass points

3. Oscillations and vibrations

3.1. free undamped linear harmonic oscillation
3.2. Damped linear harmonic oscillation
3.3. forced linear oscillation
3.4. Non-linear vibration

Teaching and learning methods

Lectures and seminar-based lessons in alternation, solving tasks during the lecture and independent extended training of the computing competence on the basis of weekly exercise sheets, detailed solutions to the exercise sheets are each given with a time delay of one week and are to be compared with the own solutions, if questions arise these are clarified in the lecture.

The active participation of the students during the lecture and in the processing of the exercise sheets is particularly important through a discursive style. Challenge and encourage is the motto, so that they are catapulted from an initial passive attitude into a mode of activity.

Recommended reading

F. Kuypers: Physik für Ingenieure, Volume 1. Wiley-VCH 2012.

P. Tipler: Physik für Wissenschaftler und Ingenieure. Springer Spektrum 2015.

S. Roth / A. Stahl: Mechanik und Wärmelehre ? Experimentalphysik anschaulich erklärt. Springer Spektrum 2016.

W. Pfeiler: Experimentalphysik, Band 1 ? Mechanik, Schwingungen, Wellen. De Gruypter Verlag 2016.

EMI-12 GERMAN 3

Module code	EMI-12
Module coordinator	Tanja Mertadana
Course number and name	EMI3105 German 3
Lecturer	Lecturers for language and elective (AWP) courses
Semester	3
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	8
ECTS	10
Workload	Contact hours: 120 hours self-study: 120 hours Total: 240 hours
Type of Examination	See examination schedule AWP and languages, written ex. 120 min.
Duration of Examination	120 min.
Weighting of grades	10/240
Language of Instruction	German

Module objective

The German 3 (German B2) module seeks to enable students to improve their communication skills and expand their range of vocabulary in the context of electromobility. This process will also involve understanding and interpreting complex written texts, such as technical reports, research papers and specialist literature.

It broadens their ability to follow and actively engage in longer and demanding oral presentations, lectures and discussions. Students' verbal skills will also be improved. Through this, students will be able to use specialist terminology and complex ideas in conversations and discussions. They will practice writing structured and argumentative texts, such as reports of a general scientific nature, project documentation or specialist articles, and consolidate this skill. The module additionally expands their vocabulary range and knowledge of grammar structures. The course is structured around a variety of activities, such as group discussions, case studies, role plays, presentations and project-based learning, At the same time, authentic materials will be used in addition to the course book so as to give students a realistic insight into the realm of electromobility.

Specifically, students completing the module will achieve the following learning outcomes:

Subject-specific skills

At Level B2, students should be able to:

- Read, understand and analyse complex texts, such as articles of a general scientific nature or technical reports.
- Communicate orally and in writing on specialised topics relating to electromobility, such as battery technologies, charging infrastructure or intelligent mobility systems.
- Explain and discuss subject-specific concepts and linkages.
- Participate in work-related discussions and negotiations and convincingly convey their own standpoints.
- Hold presentations on complex topics and provide comprehensive answers to questions.

Methodological skills

Methodological skills here refer to students' ability to apply a variety of learning and working methods so that they may further build on their linguistic and subject-specific knowledge.

- Application of effective learning strategies in order to use subject-specific vocabulary and grammar structures.
- Fostering of self-regulated learning by having students read specialist literature, analyse scientific articles and systematically compile and acquire specialist vocabulary.
- Independent planning, structuring and presentation of complex written tasks, such as research reports or project work.
- Active participation in subject-specific discussions and debates concerning electromobility by presenting arguments and giving constructive feedback.
- Critical reflection on their own learning progress and strategies.

Social skills

Social skills here refer to students' ability to conduct themselves appropriately, communicating effectively and working in groups when engaging in social interactions.

- Ability to apply effective oral communication skills in demanding situations, e.g. in expert discussions, presentations or negotiations.
- Empathy and the ability to understand other viewpoints and opinions and to respond appropriately to these.
- Effective collaboration in demanding group projects and teamwork where different abilities and views need to be brought together.
- Ability to resolve conflicts constructively and to liaise between deviating viewpoints.

Personal skills

Personal skills here refer to students' individual abilities, attitudes and traits that enable them to achieve their goals, further their personal development and work successfully.

- Self-reflection and continuous further development of one's own abilities.
- Flexibility and adaptability in order to be prepared to respond to new requirements and changes.
- Problem-solving skills and the ability to find innovative solutions.
- Resilience and the ability to work under pressure and deal with complex situations.

Applicability in this and other degree programmes

Not applicable in other degree programmes.

Admission and/or recommended requirements

To successfully participate in this module, students must be able to furnish proof that they have attained Level B1 German proficiency.

Learning content

Grammar and vocabulary form the core elements of this course. The following key aspects are covered during the course: regional studies, intercultural skills and pronunciation. Relationships, work, history, communication, technology and health are just some of the areas covered during this course. Additional topics will furthermore be incorporated in keeping with current literature and real-life developments. The following is an extract of the grammar topics that will be covered:

- Connectors
- Alternatives to passive voice

- Noun+verb compounds
- Indirect speech

Teaching and learning methods

The teaching methods applied will focus on improving the four main language skills (listening, speaking, reading and writing). Examples of the applied learning methods include various forms of group, individual and collaborative work, mini-presentations, exercises involving intensive reading and listening, role plays and grammar games, loci method, dictation exercises, translations, peer feedback, working with learning stations, and various writing activities designed to consolidate the content learnt.

Students will be given weekly assignments for self-study.

Remarks

In all language courses, students will be required to meet a minimum compulsory attendance rate of 75%.

Recommended reading

Kontext B2.1, Kurs- und Übungsbuch mit Audios und Videos, Klett Verlag
Lessons 1-6 (ISBN 978-3-12-605340-2)

Kontext B2.2, Kurs- und Übungsbuch mit Audios und Videos, Klett Verlag
Lessons 7-12 (ISBN 978-3-12-605341-9)

Grammatik aktiv - Deutsch als Fremdsprache - 1. Ausgabe - B2/C1: Verstehen, Üben, Sprechen Übungsgrammatik, Klett (ISBN 978-3060214822)

Deutsch als Fremdsprache, Übungsgrammatik für die Grundstufe Niveau A2-B2. Liebaug-Dartmann (ISBN 978-3-922989-70-7)

Wortschatz & Grammatik B2: Buch, Hueber (ISBN 978-3194274938)

Deutsch intensiv Wortschatz B2, Klett (ISBN 978-3-12-675078-3)

EMI-13 COMPULSORY ELECTIVE SUBJECT OF A GENERAL ACADEMIC NATURE (AWP) 2

Module code	EMI-13
Module coordinator	Tanja Mertadana
Course number and name	EMI3106 Compulsory Elective Subject of a General Academic Nature (AWP) 2
Lecturer	Lecturers for language and elective (AWP) courses
Semester	3
Duration of the module	1 semester
Module frequency	annually
Course type	Core subject / compulsory elective course
Level	Undergraduate
Semester hours per week (SWS)	2
ECTS	2
Workload	Contact hours: 30 hours self-study: 30 hours Total: 60 hours
Type of Examination	See examination schedule AWP and languages
Weighting of grades	2/240
Language of Instruction	German

Module objective

This AWP (compulsory elective subject of a general academic nature) elective module enables students to acquire knowledge and skills in subject areas beyond the scope of their chosen degree programme.

Students can choose both face-to-face courses and courses offered by the Virtuelle Hochschule Bayern (VHB). Students acquire knowledge and skills in the following areas:

- in a foreign language (language skills)
- in the didactic-pedagogical area (methodological skills)
- in the social sciences (social skills)
- in the psychological-sociological field (social skills)
- in the technical and scientific field (professional skills)
- in the philosophical-social-ethical area (personal skills)

Students are free to choose their courses from the list of elective (AWP) courses offered to expand their knowledge according to their own preferences.

Applicability in this and other degree programmes

Applicable in other degree programmes.

Admission and/or recommended requirements

In order to attend advanced language courses, students need to present the required language skills (e.g. by successfully completing of the previous level).

Elective (AWP) courses may not have any overlapping content with the student's current degree programme.

Learning content

The course content can be found in the corresponding course description on the homepage of the Language Centre:
https://www.th-deg.de/en/students/language-electives#languages

Teaching and learning methods

The teaching and learning methods can be found in the corresponding course description on the homepage of the Language Centre:
https://www.th-deg.de/en/students/language-electives#languagesFormularende

Remarks

For course-specific details, please refer to the corresponding course description on the homepage of the Language Centre:
https://www.th-deg.de/en/students/language-electives#languages

All language courses require a compulsory attendance rate of 75% in order to be allowed to take the examination.

Recommended reading

Recommended reading can be found in the corresponding course description on the homepage of the Language Centre:
https://www.th-deg.de/en/students/language-electives#languages

EMI-14 STATISTICS AND STOCHASTICS

Module code	EMI-14
Module coordinator	Prof. Dr. Franz Daiminger
Course number and name	EMI4101 Statistics and Stochastics
Semester	4
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	5/240
Language of Instruction	English

Module objective

Module objectives

Professional skills

Students know the concept of probability and can calculate the probability of events in different systems. They are able to recognise the importance of the parameters expected value, variance and standard deviation and to calculate them in different systems. The students are able to estimate the parameters expected value, variance and standard deviation through suitable statistical procedures. They can develop hypotheses and evaluate them by means of statistical surveys.

Methodological expertise

Students can apply their knowledge of probability and statistics to actual circumstances relevant to engineers. They abstract the system in order to be able to apply the methods they have learned. For example, one important application is the error calculation.

Personal and social skills

The students develop a self-concept as engineers, view facts critically and rationally. They are able to present facts clearly to other engineers and to discuss problems critically with them.

Applicability in this and other degree programmes

In this programme: EM-12, EM-13, EM-18

Admission and/or recommended requirements

Formally: none

In terms of content: EM-01, EM-03

Learning content

1. Descriptive statistics
    - 1.1. Data collection
    - 1.2. Graphical representation of data
    - 1.3. Key figures for the average
    - 1.4. Relationships between characteristics
2. Probability calculation
    - 2.1. Classic probability calculation
    - 2.2. Random variables and their distributions
    - 2.3. Frequently used distributions
    - 2.4. Normal distribution
3. Statistical inference
    - 3.1. Parameter estimation
    - 3.2. Hypothesis testing
4. Error analysis
    - 4.1. Measurement error
    - 4.2. Error propagation
    - 4.3. Least-squares method
5. Stochastic processes

5.1. Markov processes

5.2. Time-series analysis

5.3. Kalman Filter

Teaching and learning methods

Seminar-based lessons

Recommended reading

N. Henze, Arbeitsbuch Stochastik, 1st edition, Springer Verlag Berlin, 2019.

E. Behrends, Elementare Stochastik, 1st edition, Vieweg + Teubner Verlag, 2013.

Ch. Maas, Statistik für Ingenieure, 1st edition, Wiley, 2018.

H. Matthäus, W. G. Matthäus, Statistik und Excel, 1st edition, Springer Spektrum Wiesbaden, 2016.

R. Marchthaler, Kalman-Filter: Einführung in die Zustandsschätzung und ihre Anwendungen für eingebettete Systeme, 1st edition, Springer Fachmedien Wiesbaden, 2017.

EMI-15 ELECTRONIC COMPONENTS

Module code	EMI-15
Module coordinator	Prof. Dr. Günther Benstetter
Course number and name	EMI4102 Electronic Components
Semester	4
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Pr. course attendance 80%, written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	5/240
Language of Instruction	English

Module objective

Students learn the necessary steps to understand the functioning of the most important discrete semiconductor components and passive components. They acquire the ability to depict electronic components in simplified models and to use them in practice.

Students will achieve the following learning objectives:

Professional skills

Knowledge:

1. Basic understanding of the structure of semiconductors and charge transport processes in solids
2. Understanding the elementary physical relationships in electronic devices and their effects on functioning
3. Knowledge of the typical applications of electronic devices

Skills:

1. Ability to depict the behaviour of real electronic devices in simplified models

2. Ability to calculate and dimension semiconductor devices and to use them in simple circuits

Competences:

1. Competency for the application-oriented selection and practical use of electronic devices

Methodological skills

Using acquired skills to analyse electronic devices and depict them in models during tasks and problems outside of solid-state electronics.

Personal skills

Students can solve problems individually, as well as within working groups, to understand electronic devices, to depict them in models and to use them.

Applicability in this and other degree programmes

In this degree programme EM-16, EM-17, EM-19

In other degree programmes:

Electrical Engineering and Information Technology (B.Eng.): ET-14, ET-17, ET-19, ET-27, ET-30, ET-31, ET-34, ET-35, ET-36, ET-37, ET-38, ET-39, ET-40, ET-42, ET-44

Admission and/or recommended requirements

Lecture:

Formally: none

In terms of content: EM-01, EM-02, EM-03, EM-05, EM-06, EM-07, EM-08

Internship:

Formally: at least 42 ECTS points

Passed examinations of at least two of the modules Mathematics I (EM01), Physics I (EM02) and Basics of Electrical Engineering I (EM03)

In terms of content: EM-01, EM-02, EM-03, EM-05, EM-06, EM-07, EM-08

Learning content

1 Passive components

1.1 Resistors
1.2 Capacitors
1.3 Coils

2 Basics of semiconductor physics

2.1 Band model
2.2 Intrinsic and extrinsic conduction
2.3 Equations for semiconductors in thermodynamic equilibrium
2.4 Charge carrier transport
2.5 Disruption of thermodynamic equilibrium
2.6 Fermi level in the case of current flow

3 p-n junction

3.1 p-n junction in thermodynamic equilibrium
3.2 p-n junction when electric voltage is applied
3.3 Current-voltage characteristic
3.4 Equivalent circuit diagrams
3.5 Switching behaviour
3.6 Temperature behaviour
3.7 Breakdown behaviour

4 Bipolar transistor

4.1 Structure and operation modes
4.2 Transistor mechanism
4.3 Transistor characteristics
4.4 Second order effects
4.5 BJT modelling

5 Field-effect transistor (FET)

5.1 Properties of the MOS structure, capacity behaviour
5.2 Structure and mechanism of FETs
5.3 Derivation of transistor equations
5.4 MOS-FET characteristics
5.6 MOS-FET modelling

6 Multilayer semiconductors

6.1 Four-layer diode
6.2 Thyristor
6.3 Triac

7 Optoelectronic components

7.1 Basics
7.2 Photo sensors
7.3 Optical emitting components

Teaching and learning methods

Seminar-based lessons

Blackboard/board, visualiser/video projector, pc simulations

Recommended reading

H. Göbel: Einführung in die Halbleiter-Schaltungstechnik, 6th edition. Springer Lehrbuch 2019.

H. Göbel / H. Siemund: Übungsaufgaben zur Halbleiter-Schaltungstechnik , 4th edition. Springer Lehrbuch 2018.

M. Reisch: Halbleiter-Bauelemente, 2nd edition. Springer Lehrbuch 2011.

R. Müller: Grundlagen der Halbleiter-Elektronik, 7th edition. Springer Verlag, Berlin 1995.

R. Müller: Bauelemente der Halbleiter-Elektronik. Springer Verlag, Berlin 1995.

Streetman / Banerjee: Solid State Electronic Devices, 7th edition. Prentice Hall 2014.

S.M. Sze: Physics of Semiconductor Devices, 3th edition. Wiley 2006.

EMI-16 CONTROL TECHNOLOGY 1

Module code	EMI-16
Module coordinator	Prof. Dr. Nikolaus Müller
Course number and name	EMI4103 Control Technology 1
Semester	4
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Pr. course attendance 80%, written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	5/240
Language of Instruction	English

Module objective

The aim is to make the students aware of the effects of feedback and making them familiar with the basic concepts of control technology.

After completing the module, students will have achieved the following learning objectives:

Professional skills:

1. They can graphically sketch control loops
2. They know the basic rules of model building and identification
3. They can determine control loop properties
4. They can choose a suitable controller structure
5. They can calculate controller parameters and implement them in software or hardware
6. They can use the Bode diagram for analysis and controller synthesis

Methodological skills: Students develop graphical illustrations of complex problems and in doing so achieve a breakdown into smaller and simpler issues.

Personal and professional development: Students independently organise their weekly preparation of the next teaching unit. They also carry out transfer tasks under time pressure.

Social skills: Students organise cooperation among themselves to carry out a practical experiment.

Applicability in this and other degree programmes

In this degree programme EM-15, EM-18, EM-19, EM-22

In other degree programmes:

Electrical Engineering and Information Technology (B.Eng.): ET-15, ET-16, ET-26, ET-27, ET-30, ET-31, ET-41, ET-44

Admission and/or recommended requirements

Formally: none

In terms of content: EM-01, EM-02, EM-03, EM-05, EM-06, EM-07, EM-11, EM-13

Learning content

1 Introduction

2 Description of dynamic systems

2.1 Block diagram
2.2 Linearisation around an operating point

3 Properties of control loops

3.1 Stationary behaviour
3.2 Stability

4 Controller design

4.1 Classic controller design
4.2 Parameter optimisation
4.3 Structure optimisation

5 Application of the Bode diagram

Teaching and learning methods

Blended learning, Seminar-based lessons, exercises, lab work

Recommended reading

J. Lunze: Regelungstechnik I, 12th edition. Springer Vieweg 2020.

H. Lutz / W. Wendt: Taschenbuch der Regelungstechnik, 12th edition. Verlag Harri Deutsch 2021.

H. Mann / H. Schiffelgen / R. Froriep / K.Webers: Einführung in die Regelungstechnik, 12th edition. Hanser Verlag 2019.

M. Reuter / S. Zacher: Regelungstechnik für Ingenieure, 15th edition. Springer/Vieweg 2017.

W. Schneider / B. Heinrich: Praktische Regelungstechnik, 4th edition. Springer/Vieweg 2017.

G. Schulz / K. Graf : Regelungstechnik I. DeGruyter Studium 2015.

EMI-17 ELECTRICAL MEASUREMENT TECHNOLOGY

Module code	EMI-17
Module coordinator	Prof. Dr. Stefan Zorn
Course number and name	EMI4104 Electrical Measurement Technology EMI4105 Practical Course Electrical Measurement Technology
Semester	4
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	undergraduate
Semester hours per week (SWS)	8
ECTS	6
Workload	Contact hours: 75 hours self-study: 105 hours Total: 180 hours
Type of Examination	TN, written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	6/240
Language of Instruction	English

Module objective

Students fundamentally deal with electrical metrology and sensors. They learn the necessary steps to develop independent solutions for corresponding problems from the engineering field, whereby they are also particularly enabled to critically question the selection of corresponding methods and calculation procedures.

Students learn typical models, methods and tasks from engineering practice, how different measuring tasks can be carried out, along with corresponding solution methods and solution strategies.

Students will achieve the following learning objectives:

Professional skills

Students are familiar with the linearisation of measuring instruments and sensors. They learn how to deal with error calculation and its statistics as well as possible causes of measurement errors and their compensation. The limits and tolerances of a measurement are also learnt In addition, the basics of measuring current, voltage and power are taught. The complete chain of a measuring unit is discussed. Students are able to dimension a measurement chain and know all the components. Special emphasis is placed on operational amplifiers. The handling and application of this Swiss army

knife of electrical engineering is derived from the basics to simple basic circuits to frequency-dependent second-order circuits. The underlying mathematics is taught and enables students to design and calculate any operational amplifier circuit. Furthermore, measurement instruments, such as multimeters, oscilloscopes or power meters are covered. The transition from analogue measurement technology to digital is also described via analogue-digital or digital-analogue converters. The lecture is rounded off by the teaching of various sensor principles and their application in practice. Students will have the knowledge to apply what they have learned in a subject-specific manner. In summary, the students are able to apply their acquired knowledge to practical engineering tasks.

Methodological skills

Students are able to identify and successfully apply appropriate calculation methods from a range of calculation techniques, depending on the task at hand. They can handle scientific calculators and use computer algebra software, if necessary. The students solve exercises in the lecture independently and thereby gain confidence and experience in dealing with engineering problems. In addition, an atmosphere of openness is created to encourage students to question existing knowledge and to actively apply and combine their knowledge in new tasks.

Personal skills

The students are aware of their responsibility as future engineers. They are able to carry out measurement tasks cooperatively and as part of a team and can also critically evaluate the results.

Applicability in this and other degree programmes

In this degree programme EM-16, EM-17, EM-18

In other degree programmes:

Electrical Engineering and Information Technology (B.Eng.): ET-19, ET-26, ET-27, ET-31, ET-33, ET-41, ET-42, ET-45

Admission and/or recommended requirements

Lecture:

Formally: none

In terms of content: EM-01, EM-02, EM-03, EM-05, EM-06, EM-07

Internship:

Formally: at least 42 ECTS points

Passed examinations of at least two of the modules Mathematics I (EM-01), Physics I (EM-02) and Basics of Electrical Engineering I (EM-03)

In terms of content: EM-01, EM-02, EM-03, EM-05, EM-06, EM-07

Learning content

Introduction

1. Basics

2. Characteristic curve and sensitivity of measurement instruments

3. Error computation

4. Error correction/compensation

Analogue measurement technology

5. Measurement of current and voltage

6. Bridge circuit

7. Inductive transducers

8. Operational amplifier

9. Frequency-dependent circuits / active filters

Digital measurement technology

10. Electron beam oscilloscope

11. Analogue-to-digital converter

12. Digital-to-analogue converter

13. Sensor principles

14. Strain gauges

Teaching and learning methods

Alternate lecture and seminar-based lessons, solving problems during the lecture, blackboard notes, prepared slides, instructions for the practical course; in addition, every second week 90 min. tutorial in which only exercises are calculated. The lecture is accompanied by a practical course in which the acquired knowledge can be directly applied in a laboratory environment.

Great importance is placed on the active participation of students in the lecture and in the processing of exercises. Instead of receiving merely teacher-centred teaching, the maxim is to participate and work on the learning content together.

Recommended reading

W.-J. Becker (Ed.): *Handbuch elektrische Meßtechnik*. Hüthig, Heidelberg, 2nd edition, 2000.

A. Haug, F. Haug: *Angewandte elektrische Messtechnik*. 3rd edition, Vieweg, Braunschweig, 2000.

R. Lerch: *Elektrische Meßtechnik*. Springer, Berlin, Heidelberg, New York, 1st edition, 1996

R. Lerch: *Elektrische Meßtechnik*. Springer, Berlin, Heidelberg, New York, 3rd edition, 2007

Th. Mühl: *Grundlagen der elektrischen Messtechnik*. Vieweg+Teubner, Wiesbaden, 3rd edition, 2008

W. Pfeiffer: *Elektrische Meßtechnik*. VDE-Verlag, Berlin, 1999.

E. Schrüfer: *Elektrische Meßtechnik*. 9th edition, Hanser, München, 2007

H.-R. Tränkler*: Taschenbuch der Meßtechnik*. 4th edition, Oldenbourg, München, Wien, 1996

U. Tietze, Ch.Schenk: *Halbleiter-Schaltungstechnik.* 13th edition, Springer, 2009

G. Engeln-Müllges, K. Niederdrenk, R. Wodicka: *Numerik-Algorithmen.* 9th edition, Springer, Berlin, 2005

EMI4104 ELECTRICAL MEASUREMENT TECHNIQUE

Type of Examination

written ex. 90 min.

EMI4105 PRACTICAL COURSE ELECTRICAL MEASUREMENT TECHNIQUE

Type of Examination

TN

EMI-18 PHYSICS 2

Module code	EMI-18
Module coordinator	Prof. Dr. Johann Plankl
Course number and name	EMI4106 Physics 2
Lecturer	Prof. Dr. Johann Plankl
Semester	4
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	5
ECTS	5
Workload	Contact hours: 75 hours self-study: 75 hours Total: 150 hours
Type of Examination	Pr. course attendance 80%, written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	5/240
Language of Instruction	English

Module objective

Students deal with methods of classical physics. They learn the necessary steps to work out independent solutions for corresponding problems in the field of engineering, whereby they are especially enabled to critically question the selection of the corresponding methods and calculation procedures. The module also includes a practical course in physics in which the students learn how to carry out and evaluate experiments.

In the module Physics 2 students get to know typical models, methods and problems, as well as experiments from engineering practice, which can be processed within the framework of classical physics, together with corresponding solution methods and strategies. The physical way of thinking of classical physics is anchored.

Students achieve the following learning objectives:

Professional Skills

The students have knowledge of coupled oscillations and waves (including acoustics), the mechanics of the rigid body, classical thermodynamics, and electromagnetism. In addition, they can carry out and evaluate physical experiments in a professional manner. The students are able to work conceptually and methodically. They know the

most important physical models and correlations and have applied them in practical exercises. In particular, they know the basic assumptions and theories behind the phenomena to be described. They are also able to select suitable mathematical methods on the basis of a problem description and to systematically work out the solution on the basis of these methods. They have the knowledge to interpret the results in a subject-specific way. In summary, the students can apply their acquired knowledge to engineering problems in a practice-oriented way.

Methodological Skills

Depending on the problem, students are able to identify and successfully apply appropriate calculation methods from a range of calculation methods. They can use scientific calculators and, if necessary, computer algebra software. The students have the ability to carry out independent research on the basis of more extensive exercises and to further develop their existing knowledge independently. In addition, they are familiar with the interplay of theory and experiment, as well as with the procedure for carrying out and evaluating physical experiments.

Soft Skills

The students are aware of their responsibility as future engineers. They are able to discursively question problems among themselves, to argue for solutions and to critically evaluate the results of their calculations and experiments.

Applicability in this and other degree programmes

In this programme: EM-10, EM-11, EM-12, EM-13, EM-14, EM-15, EM-16, EM-17, EM-18, EM-19, EM-20, EM-22, EM-24, EM-31, EM-32, EM-33

In other programmes:

Electrical Engineering and Information Technology (B.Eng.): ET-11, ET-12, ET-17, ET-18, ET-19, ET-27, ET-28, ET-29, ET-30, ET-33, ET-34, ET-35, ET-36, ET-37, ET-38, ET-40, ET-41, ET-42, ET-43, ET-44, ET-46

Admission and/or recommended requirements

Formally: none

In terms of content: EM-01, EM-02, EM-03

Learning content

1. **Coupled oscillations and waves**

    1.1. Lissajus figures
    1.2. Parallel superposition of oscillations
    1.3. The eigenvalue problem with coupled oscillators
    1.4. Waves

1.5. Acoustics

2. **The rigid body**

2.1. Model of the rigid body
2.2. Centre of mass
2.3. Motion of a free rigid body
2.4. Pairs of force
2.5. Moment of inertia
2.6. Motion around a fixed axis

3. **Thermodynamics**

3.1. Concept of heat
3.2. Temperature and model of the ideal gas
3.3. Thermal expansion of bodies
3.4. The laws of thermodynamics
3.5. Heat transport processes
3.6. Changes of state of ideal gases
3.7. Circular processes
3.8. Kinetic gas theory
3.9. Real gases and phase transformations

4. **Student lab work: physical experiments**

4.1. Introduction to experimental training and error calculation
4.2. Dielectric constant
4.3. Induction law for sinusoidal alternating currents
4.4. Hysteresis
4.5. Helmholtz coil pair
4.6. Hall Effect
4.7. Solar collector and heat pump
4.8. Natural radioactivity
4.9. Double pendulum
4.10. Gyroscope

Teaching and learning methods

Lecture and seminar-based lessons in alternation, plus a one-hour practical course, which is held every two weeks for two hours; solving exercises during the lecture and independent extended training of calculation skills through weekly exercise sheets, detailed solutions to the exercise sheets are handed out after one week and are to be compared with the students' own solutions; if questions arise, these are clarified in the lecture. An experiment is usually carried out and later analysed in teams of two; the return and discussion of the analysis also occur at a later time.

Recommended reading

F. Kuypers: Physik für Ingenieure, Band 1 und 2. Wiley-VCH 2012.

P. Tipler: Physik für Wissenschaftler und Ingenieure. Springer Spektrum 2015.

S. Roth / A. Stahl: Mechanik und Wärmelehre ? Experimentalphysik anschaulich erklärt. Springer Spektrum 2016.

S. Roth / A. Stahl: Elektrizität und Magnetismus ? Experimentalphysik anschaulich erklärt. Springer Spektrum 2018.

W. Pfeiler: Experimentalphysik, Band 2 ? Wärme, Nichtlinearität, Relativität. De Gruypter Verlag 2016.

W. Pfeiler: Experimentalphysik, Band 3 ? Elektrizität und Magnetismus, De Gruypter Verlag 2016.

EMI-19 SUBJECT-SPECIFIC ELECTIVE (FWP) 1

Module code	EMI-19
Module coordinator	Prof. Dr. Nikolaus Müller
Course number and name	EMI4107 Subject-specific Elective (FWP) 1
Semester	4
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Weighting of grades	5/240
Language of Instruction	English

Module objective

The learning outcomes for this module can be found in the course description provided in the module handbook for the degree programme in question to which the course pertains.

Applicability in this and other degree programmes

Applicability of this module can be found in the course description provided in the module handbook for the degree programme in question to which the course pertains.

Admission and/or recommended requirements

The requirements for taking this module can be found in the course description provided in the module handbook for the degree programme in question to which the course pertains.

Learning content

Selection of modules at Deggendorf Institute of Technology for the subject-specific compulsory elective modules FWP 1 and FWP 2:

Teaching and learning methods

Seminar-based lessons, exercises, seminars, internship

Recommended reading

A list of recommended literature for this module can be found in the course description provided in the module handbook for the degree programme in question to which the course pertains.

EMI-20 COMPUTER TECHNOLOGY

Module code	EMI-20
Module coordinator	Prof. Dr. Andreas Penningsfeld
Course number and name	EMI5101 Microcomputer Technology EMI5102
Lecturers	Prof. Dr. Robert Bösnecker Prof. Dr. Andreas Penningsfeld
Semester	5
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	undergraduate
Semester hours per week (SWS)	7
ECTS	9
Workload	Contact hours: 105 hours self-study: 165 hours Total: 270 hours
Type of Examination	PStA (research project), written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	4/210
Language of Instruction	German

Module objective

See submodule description

Applicability in this programme

EMI-20 Computer Technology

Applicability in this and other degree programmes

See submodule description

Admission and/or recommended requirements

See submodule description

Learning content

See submodule description

Teaching and learning methods

See submodule description

Remarks

See submodule description

Recommended reading

G. Schmitt: Programmierung in Assembler und C - Schaltungen und Anwendungen. Oldenbourg-Verlag.

K. Wüst: Mikroprozessortechnik: Grundlagen, Architekturen, Schaltungstechnik und Betrieb von Mikroprozessoren und Mikrocontrollern. Vieweg/Teubner Verlag.

Prof. Penningsfeld Skript Mikrocomputertechnik.

EMI5101 MICROCOMPUTER TECHNOLOGY

Objectives

Upon completion of the module **microcomputer technology**, students will have achieved the following learning objectives:

Professional skills

The students are able to implement the theoretical and practical content of the lecture within a microcomputer system ("embedded system").

This includes dealing with the development systems, implementing them into machine-level implementation, as well as testing and troubleshooting in real target systems.

An essential component is the use of real-time operating systems and programming in the languages C and C++. The students are able to integrate operating system functions and understand object-oriented programming paradigms.

The learning results can be used directly in professional life.

Methodological skills

The students are able to implement extensive projects in a goal-oriented manner. It is possible to select the most favourable implementation from various processes and methods. The students have the ability to carry out independent research using extensive practice tasks and to further develop their existing knowledge independently.

Personal skills

The students are aware of their responsibility as future engineers. You are able to carry out development activities in a cooperative and team-oriented manner and can critically evaluate the results.

Learning content

- Introduction to experimental setup

Experiments:

- Time slice operating system
- Control of peripherals
- Communication between computer systems IoT
- Remote control of components
- Simulation

Admission and/or recommended requirements

Formally:

- Digital technology
- Computer science 1
- Computer science 2

Content:

- Numerical systems
- Programming in C
- Programming in C++
- Digital technology
- Circuit technology

Type of Examination

PStA (project assignment)

Methods

The teaching method is half seminar teaching and half internship.

After presenting the teaching content and presenting the theoretical background, suitable sample tasks are worked through step by step, and then small projects are carried out independently. The lecturer's instructions are communicated individually to the groups' work progress.

The process of learning programming techniques in 'Embedded Systems' involves a lot of illustrative material being practically reworked on the target system, which means that good independence develops over the course of the semester. The development of the ability to work independently is achieved through a variety of projects, which can then be solved almost independently with the support of the lecturer. An example is the speed control of a stepper motor.

The media forms are development setups with PCs, programming devices and target systems, blackboards, scripts, collections of exercises, projectors, PCs and secondary literature.

Remarks

PStA research project assignment:
A given project is worked on by the students for a week and their level of knowledge and their personal ability to solve spontaneous tasks are tested and evaluated in an oral exam.

Recommended reading

G. Schmitt: Programmierung in Assembler und C - Schaltungen und Anwendungen. Oldenbourg-Verlag.

K. Wüst: Mikroprozessortechnik: Grundlagen, Architekturen, Schaltungstechnik und Betrieb von Mikroprozessoren und Mikrocontrollern. Vieweg/Teubner Verlag.

Prof. Penningsfeld Skript Mikrocomputertechnik.

EMI5102 REAL-TIME SYSTEMS

Learning content

First, the basic hardware properties of the currently available components of a system will be discussed. Afterwards, different algorithms and their implementations in the C language are shown with practical examples in order to understand the interaction between hardware and software in real-time critical systems.

Systems (hardware)

Structure and concepts of computing units (CPU Central Processing Unit)

- Von Neumann Architecture, CISC based
- Harvard architecture, RISC based (ARM, MIPS, RISC-V and many more)
- DSP architecture, MACC based (Analog Devices, TI, Motorola)

Analysis of computing speed (MIPS or FLOPS), comparison and discussion on the basis of typical tasks and areas of application, limits of CPU architectures

Storage concepts and timing

- SRAM memories and their timing
- DRAM memories and their timing
- FIFO memories and their timing
- LIF (stack) memories and their timing
- FLASH (EEPROM) memories and their timing

Analysis of storage speeds (GByte/sec), comparison and discussion on the basis of typical tasks and areas of application, limits of storage systems

Interface concepts and timing

- SPI interface and its timing
- I2C interface and its timing
- Bluetooth interface and its timing
- LAN interface and its timing

Analysis of transfer data rates (MBsec/sec, GByte/sec), comparison and discussion based on typical tasks and areas of application, limits of interface systems

Hardware modelled systems

- ASIC (Application Specific Integrated Circuit)
- FPGA (Field Programable Gate Arrays), example: Xilinx
- CPLD (Complex Programable Logic Device), example: Lattice

Analysis of the design possibilities (sea of gates), timing and simulation, comparison and discussion on the basis of typical tasks and areas of application, limits of FPGAs and CPLDs in comparison with ASIC systems

Systems (firmware)

Introduction to VHDL and ARM

- Concept of behavioural description
- Basics of the description language
- Combinatorial logic versus sequential logic
- Finite state machines (FSM in hardware)
- Embedded CPU cores (ARM)

Analysis of description possibilities (hierarchical design vs. flat design), timing and simulation in VHDL, comparison and discussion on the basis of typical tasks and areas of application, limits of hardware description,

Introduction to embedded C

- Editing and compiling
- Definition of variables
- Pointers and fields
- Output and input
- Operators and functions
- Control structures
- Functions for fields and strings
- Compound data types
- Files and directories
- Interactions with the operating system
- Modularisation
- Pre-processor, compiler and linker
- Running times of algorithms
- Dynamic data structures
- The C standard library
- finite state machines (FSM in software)
- Cache behaviour vs. programming style
- Use of data buffers (software FIFOs or stacks)

Analysis of programming options (C vs. Assembler), runtime acquisition using oscilloscopes, comparison and discussion based on typical tasks and areas of application, structured programming vs. spaghetti code,

Real-time systems (hard and firmware)

Introduction to the basics of real-time systems

- What does real-time mean?
- Which tools are available?

- How can you trace the software process?

Overview of real-time theory (according to current literature), technical term and its meaning, comparison and discussion based on typical tasks and areas of application,

Introduction in real-time operating systems

- RTOS
- QNX
- Embedded Linux
- When is a real-time operating system needed?

Analysis of the programming possibilities under the real-time operating systems mentioned (C, RUST, etc.), runtime acquisition by trigger signals and oscilloscopes, comparison and discussion on the basis of typical tasks and areas of application.

Real-time systems (application)

Application of real-time systems and real-time programming using selected examples

- Numerical algorithms in C
- Real-time measuring, control and regulation
- DSP algorithms (correlation, FIR filter, etc.)
- KI algorithms (pattern recognition, reinforcement learning, etc.)

Overview of the possible applications of real-time programming using selected examples, technical terms and their meaning, comparison and discussion using typical tasks and areas of application.

Admission and/or recommended requirements

Practical Course Real-Time Systems (Exercises)

Selected programming exercises on the above topics on embedded systems and Raspberry Mini computers
Lecture: = 2 SWS plus practical course = 1 SWS equals 90 hrs., i.e. 7.5 hrs per week.
divided into: 1.5 hrs. lecture, 1.5 hrs. video preparation,
1.5 hrs. practical course and 3.0 hrs. follow-up (independent practice)

EMI-21 CONTROL TECHNOLOGY 2

Module code	EMI-21
Module coordinator	Prof. Dr. Nikolaus Müller
Course number and name	EMI5103 Control Technology 2
Semester	5
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Pr. course attendance 80%, written ex. 120 min.
Duration of Examination	120 min.
Weighting of grades	5/240
Language of Instruction	German

Module objective

The aim is to broaden students' knowledge of control technology and to prepare them for typical tasks in industry.

After completing the module, students will have achieved the following learning objectives:

Professional skills:

- They construct root locus curves and use them to develop controllers
- They can explain the special effects of a digital controller
- They know the basic features of analysing control loops with switching controllers
- They represent controlled systems in the state space
- They model dynamic systems in Matlab/Simulink and analyse their behaviour

Methodological skills: Students work on systems engineering tasks with suitable graphical or procedural programmes.

Personal and professional development: Students independently organise their weekly preparation of the next teaching unit. They also carry out transfer tasks under time pressure.

Social skills: Students organise cooperation among themselves to carry out a practical experiment.

Applicability in this and other degree programmes

In this degree programme: none

In other degree programmes: none

Admission and/or recommended requirements

Formally: none

In terms of content: EM-01, EM-02, EM-03, EM-05, EM-07, EM-12, EM-13

Learning content

1 Root locus curves

1.1 Design rules
1.2 Analysis and synthesis of control loops

2 Digital control

2.1 Description in the z-domain
2.2 Quasi-continuous design

3 Switching controller

3.1 Analysis for first-order systems
3.2 Analysis for second-order systems

4 Control in the state space

4.1 Setting up of state equations
4.2 Design as per the full state feedback method

Teaching and learning methods

Seminar-based lessons / Exercises

Recommended reading

J. Lunze: Regelungstechnik 1, 12th edition. Springer/Vieweg 2020.

H. Lutz / W. Wendt: Taschenbuch der Regelungstechnik, 12th edition. Verlag Harri Deutsch 2021.

H. Mann / H. Schiffelgen / R. Froriep / K. Webers: Einführung in die Regelungstechnik, 12th edition. Hanser Verlag 2019.

M. Reuter / S. Zacher: Regelungstechnik für Ingenieure, 15th edition. Springer Vieweg 2017.

G. Schulz / K. Graf : Regelungstechnik 1, 5th edition. DeGruyter Studium 2015.

G. Schulz / K. Graf : Regelungstechnik 2, 3rd edition. DeGruyter Studium 2013.

R.C. Dorf / R.H. Bishop: Modern Control Systems, 13th edition. Pearson, 2017

EMI-22 POWER ELECTRONICS 1

Module code	EMI-22
Module coordinator	Prof. Dr. Otto Kreutzer
Course number and name	EMI5104
Semester	5
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Pr. course attendance 80%, written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	5/240
Language of Instruction	German

Module objective

The course deals with power electronics, its components, circuits and applications. In the Power Electronics subject, students learn how to use the components and circuits of power electronics and about their possible applications.
In the Power Electronics course, students learn how to use the components and circuits of power electronics and about their possible applications.

Students will achieve the following learning objectives:

Professional skills

Students learn the structure and mechanism of passive and active power electronics components and the basic topologies and their applications.
Circuits are subdivided into line-commutated and self-commutated circuits. Here, students learn not only about circuits but also about their mechanism and design Self-commutated circuits form the core of the course.

Methodological skills

Students learn the structural composition of components in circuit technology and system technology. They can apply the component design methodology to a variety of circuits.

Personal skills

Personal skills lie in the detailed application of mathematical and technical methods.

Applicability in this and other degree programmes

In this degree programme EM-29

In other degree programmes:

Electrical Engineering and Information Technology (B.Eng.): ET-31

Admission and/or recommended requirements

Formally: none

In terms of content: EM-01, EM-02, EM-05, EM-06, EM-10, EM-11

Learning content

1. **Components**
    - 1.1. Capacitors
    - 1.2. Inductances
    - 1.3. Diodes
    - 1.4. Circuit breakers
2. **Integrated circuit packaging**
    - 2.1. Cooling and thermal management
    - 2.2. Passive components
    - 2.3. Active components
3. **Topologies of power electronics**
    - 3.1. DC/DC conversion
    - 3.2. AC/DC conversion
    - 3.3. DC/AC conversion
    - 3.4. AC/AC conversion
    - 3.5. Isolating topologies
4. **Application areas of power electronics**

Teaching and learning methods

Lecture as seminar-based lessons

Recommended reading

U. Probst: Leistungselektronik für Bachelors: Grundlagen und praktische Anwendungen. 3rd edition. Carl Hanser Verlag, München 2015.

R. Felderhoff / U. Busch: Leistungselektronik, 4th edition. Carl Hanser Verlag, München 2006.

J. Specovius: Grundkurs Leistungselektronik: Bauelemente, Schaltungen und Systeme. 9th edition, Springer/Vieweg Verlag, Wiesbaden 2018.

EMI-23 AUTOMOTIVE BUS SYSTEMS

Module code	EMI-23
Module coordinator	Prof. Dr. Andreas Grzemba
Course number and name	EMI5105 Automotive Bus Systems
Semester	5
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Pr. course attendance 80%, written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	5/240
Language of Instruction	German

Module objective

Primary learning objective: Students should be able to apply data networks in vehicles to technical tasks in their studies and profession.
For this purpose, students acquire the following professional skills: Knowledge of the basics of digital communication systems; automotive Ethernet systems; CAN bus systems; subordinate bus systems.

The acquisition of methodological, personal and social skills is defined by the future lecturer.

Applicability in this and other degree programmes

In this degree programme EM-32, EM-7105

In other degree programmes:

Electrical Engineering and Information Technology (B.Eng.): ET-31

Admission and/or recommended requirements

Formally: none

In terms of content: EM-04, EM-09, EM-15

Learning content

1. **Basics of digital data communication**
   - 1.1. ISO/OSI model
   - 1.2. Access method
   - 1.3. Error protection
2. **Automotive network architectures**
   - 2.1. Architectures with central gateway
   - 2.2. Switched Ethernet architectures
3. **CAN bus**
   - 3.1. Data link layer
   - 3.2. Physical layer
4. **Automotive Ethernet physical layer**
   Higher protocol layer in automotive Ethernet systems
   - 4.1. SOME/IP
   - 4.2. IP/UDP/TCP/DHCP
5. **AVB/TSN**
   - 5.1. Standards
   - 5.2. Time synchronisation protocols (IEEE1588)
   - 5.3. Real-time categories in Ethernet
   - 5.4. Shaper
6. **Subordinate bus systems**
   - 6.1. LIN
   - 6.2. PSI-5
   - 6.3. SENT

Teaching and learning methods

Seminar-based lessons and laboratory exercises with the corresponding bus systems.

Recommended reading

W. Zimmermann / R. Schmidgall: Bussysteme in der Fahrzeugtechnik, 3rd edition. Vieweg 2008.

W. Lawrenz / Nils Obermöller: CAN: Controller Area Network: Grundlagen, Design, Anwendungen, Testtechnik. VDE-Verlag.

K. Matheus / T. Königseder: Automotive Ethernet. Cambridge University Press

AVB/TSN IEEE802.3 Standard-Familie

EMI-24 SUBJECT-SPECIFIC ELECTIVE (FWP) 2

Module code	EMI-24
Module coordinator	Prof. Dr. László Juhász
Course number and name	EMI5106 Subject-specific Elective (FWP) 2
Semester	5
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Weighting of grades	5/240
Language of Instruction	German

Module objective

The learning outcomes for this module can be found in the course description provided in the module handbook for the degree programme in question to which the course pertains.

Applicability in this and other degree programmes

Applicability of this module can be found in the course description provided in the module handbook for the degree programme in question to which the course pertains.

Admission and/or recommended requirements

The requirements for taking this module can be found in the course description provided in the module handbook for the degree programme in question to which the course pertains.

Learning content

Selection of modules at Deggendorf Institute of Technology for the subject-specific compulsory elective modules FWP 1 and FWP 2:

Teaching and learning methods

Seminar-based lessons, exercises, seminars, internship

Recommended reading

A list of recommended literature for this module can be found in the course description provided in the module handbook for the degree programme in question to which the course pertains.

EMI-25 INTERNSHIP

Module code	EMI-25
Module coordinator	Prof. Dr. Detlef Brumbi
Course number and name	EMI6101 Internship EMI6102 Internship Seminar
Semester	6
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	undergraduate
Semester hours per week (SWS)	2
ECTS	25
Workload	Contact hours: 30 hours self-study: 720 hours Total: 750 hours
Type of Examination	PrB (internship report), presentation 15 - 45 min.
Weighting of grades	25/240
Language of Instruction	German

Module objective

Students are to gain experience in independent, engineering work.

The internship should introduce the work and working methods of an engineer through concrete tasks. It must include engineering-related activities, e.g., from the areas of production, development (hardware, software), measurement and testing technology, commissioning, service, project planning.

The internship should primarily be carried out at companies in Germany and abroad. Students can also do internships in the form of project work at Deggendorf Institute of Technology.

Students will achieve the following learning objectives:

Professional skills

- Application of theoretical and practical knowledge in a technical project
- Work independently on a complex task in an industrial environment

Methodological skills

- Integrating personal skills and competences into a project assignment

- Dealing with realistic challenges in a company
- Development and implementation of solutions

Personal skills

- Insight into company structures
- Experiencing operational processes in a company
- Collaboration with other employees involved in the project
- Building teamwork, conversation and presentation skills

Applicability in this and other degree programmes

In this degree programme: in all specialisations

In other degree programmes: none

Admission and/or recommended requirements

Formally: at least 70 ECTS points

In terms of content: none

Learning content

See subject description

Teaching and learning methods

See subject description

Remarks

Before carrying out the in-company internship, students must register online in the university's internship management system and upload their internship contract, which is then approved online by the internship commissioner. After completing all required performances, the internship commissioner acknowledges the passing of the in-company internship by means of an online entry in the internship management system.

Passing the PLV module is a prerequisite for the Internship module to be recognised.

Further details are regulated in the guidelines: Internship semester ET Bachelor

Recommended reading

See subject description

EMI6101 INTERNSHIP

Objectives

During their 18-week internships, students gain experience in independent, engineering-related work. See module description.

Learning content

Individual topics as specified by the internship company and as approved by the internship commissioner.

Type of Examination

part of module exam, PrB (internship report)

Methods

Types of examination

Internship certificate from the company

Remarks

An internship assessment must be carried out online in the internship management system.

Recommended reading

Varies from case to case depending on topics of the practical tasks

EMI6102 INTERNSHIP SEMINAR

Objectives

In the practical seminar, students compose a written report about their internship and give a presentation.

Learning content

Varies from case to case depending on the activities performed during the internship.

Admission and/or recommended requirements

Format: completion of the internship

In terms of content: none

Type of Examination

part of the module exam, presentation 15 - 45 min.

Methods

Types of examination

Report and presentation, course work certificate (LN)

Remarks

Remarks

Successful completion of the practical seminar is a prerequisite for passing the 'Internship' module and thus for the recognition of the ECTS points obtained for the internship.

An internship assessment must be carried out online in the internship management system.

Recommended reading

Recommended reading

Hering / Heine: Technische Berichte: Verständlich gliedern, gut gestalten, überzeugend vortragen, 8th edition. Springer/Vieweg 2019.

EMI-26 PLV - PRACTICAL COURSES

Module code	EMI-26
Module coordinator	Prof. Dr. Detlef Brumbi
Course number and name	EMI6103 PVL - Practical Course (Seminar) EMI6104 PVL - Practical Course (Seminar)
Semester	6
Duration of the module	1 semester
Module frequency	each semester
Course type	PLV
Level	undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Weighting of grades	5/240
Language of Instruction	German

Module objective

In the complementary practice specialisation, there are four seminars from 'Study and Personal Skills' and three seminars from 'Professional Skills".

The module spans several semesters. Students are to learn contents that are directly or indirectly related to the practical work of electrical engineers.

The students achieve the following learning objectives, depending on the selected seminars (professional skills, methodological skills and personal skills are defined there):

1. Acquisition of academic and personal skills
2. Acquisition of professional skills
3. Expanding what has been learned during the course of study
4. Establishing contacts with various companies
5. Insights into the practice of engineering activities
6. Presentation of work results

Applicability in this and other degree programmes

In this degree programme

In other degree programmes:

Admission and/or recommended requirements

Formally: none

In terms of content: none

Learning content

Individual depending on the selected seminars of the Career Service of Deggendorf Institute of Technology.

Teaching and learning methods

Lecture, practical exercises, individual and group work, presentation

Remarks

Remarks

Successfully completing the PLV module is a prerequisite for the Internship module to be recognised.

Students must be registered online in the university's internship administration in order to have the complementary practice specialisation subjects recognised.

Further details are regulated in the guidelines: Internship semester ET/ EM Bachelor's degree

Recommended reading

Individual depending on the selected seminars of the Career Service of Deggendorf Institute of Technology.

EMI-27 ELECTRIC MACHINES

Module code	EMI-27
Module coordinator	Prof. Dr. Peter Firsching
Course number and name	EMI7101 Electric Machines
Semester	7
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Pr. course attendance 80%, written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	5/240
Language of Instruction	German

Module objective

After completing this module, the students know the relevant properties and functional principles of electrical machines as an important component of industrial and automotive applications. They are also able to configure a modern single-axis or multi-axis drive system electrically and, for essential parameters, also mechanically.

Professional skills:

Students understand the technical principles of electrical machines and the physical principles of electromagnetic power conversion. Furthermore, they understand the functional characteristics and the operating behaviour of industrially relevant variants of electrical machines and can assess their usability in different application scenarios.

Methodological skills:

Students know the physical/technical principles for the mechanical and electrical design of a drive and can apply these to the machine variants covered. Furthermore, they apply the methods for speed and torque control to all industrially relevant machine variants.

Personal skills:

Students work on content in groups, e.g. using examples of interpretation.

They can research technical issues alone or in groups and present them in a structured way.

Social skills:

Students are able to reflect on the requirements in the field of electrical machines and drives and transfer them to relevant application scenarios.

Applicability in this and other degree programmes

In this degree programme: none

In other degree programmes: none

Admission and/or recommended requirements

Formally: none

In terms of content: EM-02, EM-03, EM-06, EM-07, EM-12

Learning content

1 Basics of electrical machines and drives

a. General drive system
b. Power consideration
c. Operation modes
d. Designs, nameplate, protection classes
e. Magnetic circuit
f. Torque and voltage formation in the e-machine

2 DC motor

a. Structure and functional principle
b. Equivalent circuit diagram and operating behaviour
c. Speed control, starting and braking
d. Dynamic behaviour

3 Basics of induction machines

a. Three-phase windings
b. Rotating magnetic fields
c. Space-vector description

4 Synchronous machines

a. Structure and functional principle
b. Operation as electronically commutated motor
c. Equivalent circuit diagram, operating behaviour, pointer diagram
d. Structure and functioning of brushless DC motors

5 Asynchronous motors

a. Functional principle
b. Equivalent circuit diagram and operating behaviour
c. Speed control
d. Starting and braking

6 Stepper motors

a. Functional principle
b. Designs
c. Activation

7 Servo drivers

a. Electronic drive control
b. Drive regulations

Teaching and learning methods

Blackboard notes, prepared slides, trial software, simulations in Matlab / Simulink

Seminar-based lessons 3.5 SWS

Practical lab course in groups 0.5 SWS

Recommended reading

Fischer R.: Elektrische Maschinen, 17th edition. Hanser Verlag 2017.

Stölting H.: Handbuch Elektrische Kleinantriebe, 4th edition. Hanser Verlag 2011.

Schröder D., Kennel R.: Elektrische Antriebe ? Grundlagen. Springer-Vieweg-Verlag, 2021.

Probst U.: Leistungselektronik für Bachelors. Hanser-Verlag, 2015.

P. Brosch: Moderne Stromrichterantriebe. Vogel Verlag 1998.

EMI-28 ELECTROMAGNETIC COMPATIBILITY

Module code	EMI-28
Module coordinator	Prof. Dr. Günter Keller
Course number and name	EMI7102 Electromagnetic Compatibility
Semester	7
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Pr. course attendance 80%, written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	5/240
Language of Instruction	German

Module objective

The course deals with electromagnetic compatibility (EMC) of electrical and electronic devices, with legal conditions and EMC design.

Students learn to assess and avoid electromagnetic interference between electrical devices.

Students will achieve the following learning objectives:

Professional skills

Students learn the basic correlations, such as terms, definitions and coupling mechanisms. One of the focus points is EMC-compliant device design, such as wiring, filters, shielding and ground systems.

In addition to technical aspects, students also learn about legal boundary conditions.

Methodological skills

The subject is oriented towards Maxwell's equations. As a result, students are introduced to the application of basic equations to components, circuit boards, devices and systems. They apply the basics to application-related examples in theory and practice.

Personal skills

Personal skills lie in the detailed application of mathematical and technical methods.

Applicability in this and other degree programmes

In this degree programme: none

In other degree programmes: none

Admission and/or recommended requirements

Formally: none

In terms of content: EM-01, EM-02, EM-03, EM-06, EM-07, EM-11, EM-13

Learning content

1 Basic concepts

1.1 Phenomena
1.2 Forms of depiction
1.3 Signals and properties
1.4 EMC work

2 Coupling mechanisms

2.1 Overview
2.2 Galvanic coupling
2.3 Capacitive coupling
2.4 Inductive coupling
2.5 Electromagnetic coupling

3 Standards and tests

3.1 European directives and EMC law
3.2 Standards
3.3 Emission measurements
3.4 Immunity tests

4 EMC-compatible circuit board design

4.1 Boundary conditions
4.2 Parasitic properties
4.3 Current loops
4.4 Ground systems

5 EMC-compatible device design

5.1 Zone concept
5.2 Wiring
5.3 Plugs
5.4 Shielding

6 EMC filter

6.1 Components
6.2 Filter design
6.3 Dimensioning

7 Shielding

7.1 Mechanism
7.2 Design possibilities

Teaching and learning methods

Lecture as seminar-based lesson, three practical experiments.

In the lectures, software tools such as LTspice and Python, which can support self-study very well, are used.

Recommended reading

Franz: EMV, 5th edition. Springer/Vieweg 2013.

Schwab: Elektromagnetische Verträglichkeit, 6th edition. Springer/Verlag, Heidelberg 2011.

Montrose: EMC made simple. Montrose Compliance Services 2014.

Williams: EMC for Product Designers. Newnes 2017.

EMI-29 IMAGING

Module code	EMI-29
Module coordinator	Prof. Dr. Martin Jogwich
Course number and name	EMI7103
Semester	7
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Pr. course attendance 80%, written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	5/240
Language of Instruction	German

Module objective

This module aims to provide students with a thorough knowledge of analogue and digital image acquisition, pre-processing and processing from both a device and a software perspective.

After completing the module, students will have achieved the following learning objectives:

Professional skills:

1. Ability to calculate or estimate lighting parameters.
2. Knowledge of the most important technical camera parameters and their effects on image acquisition.
3. Ability to calculate and set camera lens settings for a given image processing job.
4. Ability to apply various basic image processing algorithms.
5. Ability to apply various basic image pre-processing algorithms.

Methodological skills:

Students separately develop solutions of image acquisition, pre-processing and processing, first theoretically, then practically with appropriate hardware and software.

Personal and professional development:

Students implement the theoretical knowledge into the creation of an image processing programme (following fixed tasks) in workshops under tight time constraints.

Social skills: Students organise cooperation among themselves to carry out a practical laboratory experiment.

Applicability in this and other degree programmes

In this degree programme: none

In other degree programmes: none

Admission and/or recommended requirements

Formally: none

In terms of content: EM-01, EM-02, EM-03, EM-05, EM-06, EM-08, EM-11, EM-13

Learning content

E Introduction

E.1 Literature on the lecture
E.2 Definitions of terms
E.3 Examples of non-industrial image processing applications

H Hardware

H.1 Human vision
H.2 Image acquisition
H.2.1 Light generation and photometry
H.2.2 Lighting
H.2.3 Applied optics
H.2.4 Signal generation
H.3 Industrial image processing [machine vision]
H.3.1 Areas of application
H.3.2 Market
H.3.3 Case studies

S Software

S.1 Image pre-processing
S.1.1 Image presentation
S.1.2 Homogeneous (monadic) point operations
S.1.3 Inhomogeneous (dyadic) point operations
S.1.4 Local operations (local filter)

S.2 Image processing
S.2.1 Size check
S.2.2 Location check
S.2.3 Segmentation process

If the numbering specified by Reinhard is mandatory, it would be quite short:

1 Introduction
1.1 Literature on the lecture
1.2 Definitions of terms
1.3 Examples of non-industrial image processing applications

2 Hardware

2.1 Human vision
2.2 Image acquisition
2.3 Industrial image processing

3 Software

3.1 Image pre-processing
3.2 Image processing

Teaching and learning methods

Slides, blackboard, PowerPoint script, video projector, image processing programmes, cameras, various lighting systems

Recommended reading

J. Beyerer / F.P. Leon / Chr. Frese: Automatische Sichtprüfung, 2nd edition, Springer Verlag, Berlin Heidelberg 2016.

Chr. Demant / B. Streicher-Abel / A. Springhoff: Industrielle Bildverarbeitung, 3rd edition, Springer Verlag, Heidelberg 2011.

A. Erhardt: Einführung in die Digitale Bildverarbeitung, 1st edition, Vieweg + Teubner, Wiesbaden 2008.

B. Jähne: Digitale Bildverarbeitung und Bildgewinnung, 7th edition, Springer Vieweg Verlag, Berlin 2012.

L. Priese: Computer Vision - Einführung in die Verarbeitung und Analyse digitaler Bilder, 1st edition, Springer Verlag, Berlin Heidelberg 2015.

EMI-30 BACHELOR'S THESIS

Module code	EMI-30
Module coordinator	Prof. Dr. László Juhász
Course number and name	EMI8101 Bachelor's Thesis EMI8102 Seminar
Semester	8
Duration of the module	1 semester
Module frequency	each semester
Course type	compulsory course
Level	undergraduate
Semester hours per week (SWS)	2
ECTS	14
Workload	Contact hours: 30 hours self-study: 390 hours Total: 420 hours
Type of Examination	oral ex. 30 min., bachelor thesis
Weighting of grades	14/240
Language of Instruction	German

Module objective

Students are able to apply the knowledge and skills acquired during studies methodically and in context in a project from the field of electrical engineering and information technology. They are expected to independently structure a problem, systematically process it using scientific methods and, finally, document it transparently within a given period of time.

In the concluding presentation, the project and work results must be presented in a way that is appropriate for the target group.

Applicability in this and other degree programmes

In this degree programme: none

In other degree programmes: none

Admission and/or recommended requirements

Formally: at least 160 ECTS

In terms of content:

Learning content

Individual topics

Teaching and learning methods

Guidance on independent work according to academic methods

Remarks

Applicability in this degree programme

EM-28 Bachelor's module

Remarks

The results of the bachelor’s thesis are to be held as a presentation.

EMI-31 SENSOR TECHNOLOGY AND OPTICS

Module code	EMI-31
Module coordinator	Prof. Dr. Franz Daiminger
Course number and name	EMI8103 Sensor Technology and Optics
Semester	8
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Pr. course attendance 80%, written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	5/240
Language of Instruction	German

Module objective

Professional skills

Students know the basics of technical optics including the most important optical instruments. They acquire knowledge of modern light sources, such as light-emitting diodes and lasers. They know the most important sensors for the detection of light, measurement of geometric and mechanical quantities, and in particular measurement of geometric distances for position recognition. They are familiar with the physical laws on which these sensors are based.

Methodological expertise

Students have the ability to select the right sensors for different measurement problems and to use them in an appropriate way and estimate their accuracy in the respective context.

Personal and social skills

The students develop a self-concept as engineers, view facts critically and rationally. They are able to present facts clearly to other engineers and to discuss problems critically with them.

Applicability in this and other degree programmes

In this degree programme EM-12, EM-13, EM-17, EM-18

Admission and/or recommended requirements

Formally: none

In terms of content: EM-01, EM-02, EM-03, EM-05, EM-06, EM-07

Learning content

1. **Basics of optical metrology**
    - 1.1. Technical optics
    - 1.2. Optical instruments, telescope, magnifying glass, microscope
    - 1.3. Wave optics, diffraction and interference
    - 1.4. Quantum optics
    - 1.5. Aberration
    - 1.6. Photometry
2. **Optical sensor technology**
    - 2.1. Light emitting diodes, laser diodes, laser
    - 2.2. Photodiodes
    - 2.3. Photomultiplier
    - 2.4. CCD chip
    - 2.5. Optical fibre
    - 2.6. LIDAR (Light Detection And Ranging)
    - 2.7. Various optical sensor systems
3. **Physical effects of sensor use**
    - 3.1. Piezoelectric and piezoresistive effect
    - 3.2. Magnetic-field-based effect
    - 3.3. Effects of induction, capacitance and electrical resistance
    - 3.4. Thermoelectric effect

3.5. Doppler effect

4. **Sensors**

4.1. Mechano-resistive sensors

4.2. Capacitive sensors

4.3. Magnetic-inductive sensors

4.4. Triangulation sensors

4.5. Interferometric sensors

4.6. Time-based sensors

4.7. Doppler-effect-based sensors

Teaching and learning methods

Seminar-based lessons / Practical course

Recommended reading

E. Hering, G. Schönfelder: Sensoren in Wissenschaft und Technik, 1st edition, Vieweg + Teubner Verlag, 2012.

M. Löffler-Mang: Optische Sensorik, 1st edition, Vieweg + Teubner Verlag, 2012.

M. Wolff: Sensor Technologien Volume 1, 1st edition, De Gruyter Oldenburg, 2016.

M. Wolff: Sensor Technologien Volume 2, 1st edition, De Gruyter Oldenburg, 2018.

T. Tille: Automobil-Sensorik 2, 1st edition, Springer-Verlag, Berlin Heidelberg 2018.

EMI-32 COMPULSORY ELECTIVE SUBJECT OF A GENERAL ACADEMIC NATURE (AWP) 3

Module code	EMI-32
Module coordinator	Tanja Mertadana
Course number and name	EMI8104 Compulsory Elective Subject of a General Academic Nature (AWP) 3
Lecturer	Lecturers for language and elective (AWP) courses
Semester	8
Duration of the module	1 semester
Module frequency	annually
Course type	Core subject / compulsory elective course
Level	Undergraduate
Semester hours per week (SWS)	2
ECTS	2
Workload	Contact hours: 30 hours self-study: 30 hours Total: 60 hours
Type of Examination	See examination schedule AWP and languages
Weighting of grades	2/240
Language of Instruction	German

Module objective

This AWP (compulsory elective subject of a general academic nature) elective module enables students to acquire knowledge and skills in subject areas beyond the scope of their chosen degree programme.

Students can choose both face-to-face courses and courses offered by the Virtuelle Hochschule Bayern (VHB). Students acquire knowledge and skills in the following areas:

- in a foreign language (language skills)
- in the didactic-pedagogical area (methodological skills)
- in the social sciences (social skills)
- in the psychological-sociological field (social skills)
- in the technical and scientific field (professional skills)
- in the philosophical-social-ethical area (personal skills)

Students are free to choose their courses from the list of elective (AWP) courses offered to expand their knowledge according to their own preferences.

Applicability in this and other degree programmes

Applicable in other degree programmes.

Admission and/or recommended requirements

In order to attend advanced language courses, students need to present the required language skills (e.g. by successfully completing of the previous level).

Elective (AWP) courses may not have any overlapping content with the student's current degree programme.

Learning content

The course content can be found in the corresponding course description on the homepage of the Language Centre:
https://www.th-deg.de/en/students/language-electives#languages

Teaching and learning methods

The teaching and learning methods can be found in the corresponding course description on the homepage of the Language Centre:
https://www.th-deg.de/en/students/language-electives#languagesFormularende

Remarks

For course-specific details, please refer to the corresponding course description on the homepage of the Language Centre:
https://www.th-deg.de/en/students/language-electives#languages

All language courses require a compulsory attendance rate of 75% in order to be allowed to take the examination.

Recommended reading

Recommended reading can be found in the corresponding course description on the homepage of the Language Centre:
https://www.th-deg.de/en/students/language-electives#languages

EMI-33 KEY QUALIFICATIONS

Module code	EMI-33
Module coordinator	Prof. Dr. Thomas Geiß
Course number and name	EMI8105 Business Administration EMI8106 Scientific Working Methods EMI8107 Sustainable Mobility
Semester	8
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Undergraduate
Semester hours per week (SWS)	6
ECTS	9
Workload	Contact hours: 90 hours self-study: 180 hours Total: 270 hours
Type of Examination	PStA (project assignment), oral examination, written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	9/240
Language of Instruction	German

Module objective

Primary objective

Students recognise business topics in the professional field and apply them to their profession. They are familiar with the basic theories and knowledge of business management for their own profession.

After completing the module, students will have achieved the following learning objectives:

Recognising the importance of business management mentality and action of company employees. Students can assess fundamental business management issues in a company.

Professional skills:

1. Students know the structure of the balance sheet and profit and loss account. They can distinguish between P&L figures (turnover, costs) and liquidity figures (cash, investment).

2. They can assign accounts to P&L and balance sheet and know what charts of accounts are.
3. They know how to open a balance sheet. They can also make simple entries and close the P&L and balance sheet.
4. Building on the basics of accounting, they can analyse company balance sheets and identify the most important key figures.
5. They know formulas for calculating interest, present value, future value, recovery factor and recuperation factor.
6. They can apply their knowledge for evaluating investments and calculating simple loans.
7. They can assess the effect of investment and financing measures on the balance sheet and P&L.

Methodological skills

Students

1. deal with academic texts on the respective topic
2. carry out group and individual work with the aim of a short presentation in the plenary

Personal skills:

Students

1. reflect on their own entrepreneurial perspective in the context of ?company performance and company value?
2. are made aware of the importance and meaning of ?business administration? in their future field of activity

Social skills

Students

1. develop critical faculties and the ability to discuss and work in a team
2. are able to bring their strengths into the development process
3. are creative and self-confident

Applicability in this and other degree programmes

In this degree programme

In other degree programmes:

Admission and/or recommended requirements

Formally:

In terms of content:

Learning content

Subject matter of business administration

Ways to classify companies and determine their size

Basics of investment theory

Overview of the basics of company accounting

Criteria for selecting a business location

Criteria for selecting the legal form of a company

Types of organisational structures of a company

Selected aspects of strategic planning

Functional areas in a company and their essential decisions

1 Accounting

1.1 Balance sheet and P&L
1.2 Accounts and charts of accounts
1.3 Accounts
1.4 Opening and closing of accounts
1.5 Entries
1.6 Special business transactions

2 Financial mathematical basics

2.1 Interest calculations
2.2 Annuity computation

3 Investment

3.1 Static investment models
3.2 Dynamic investment models

4 Financing

4.1 Debt financing
4.2 Equity financing

5 Summary

Teaching and learning methods

Lecture with exercises, seminar, writing workshop, discussions, smaller case studies

Remarks

Remarks

Self-study with materials on iLearn

Submission of exercises

Recommended reading

G. Wöhe: Einführung in die Allgemeine Betriebswirtschaftslehre, 25th edition. Vahlen Verlag, München 2013.

P. Mertens / F. Bodendorf: Programmierte Einführung in die Betriebswirtschaftslehre. Gabler Verlag, Wiesbaden 2001.

J. Drukarczyk / S. Lobe: Finanzierung, 11th edition. Stuttgart 2014.

L. Perridon / M. Steiner / A. Rathgeber: Finanzwirtschaft der Unternehmung, 16th edition. München 2012.

G. Wöhe / J. Bilstein / D. Ernst / J. Hächer: Grundzüge der Unternehmensfinanzierung, 10th edition. München 2009.

EMI8105 BUSINESS ADMINISTRATION

Type of Examination

written ex. 90 min.

EMI8106 SCIENTIFIC WORKING METHODS

Type of Examination

PStA (project assignment)

EMI8107 SUSTAINABLE MOBILITY

Type of Examination

PStA (project assignment), oral examination, written examination

EMI-EM 34 POWER ELECTRONICS 2

Module code	EMI-EM 34
Module coordinator	Prof. Dr. Otto Kreutzer
Area of specialisation	Electromobility
Course number and name	EMI-EM7104 Power Electronics 2
Semester	7
Duration of the module	1 semester
Module frequency	annually
Course type	Core subject / compulsory elective course
Level	Undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Pr. course attendance 80%, written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	5/240
Language of Instruction	German

Module objective

The course builds on the knowledge of Power Electronics 1 and specifically deals with power electronic components in electromobility.

It deals with the individual components of electric vehicles and examines special optimisation for efficiency and construction volume, which is immanent to resource-saving usage.

Students will achieve the following learning objectives:

Professional skills

Students learn the special requirements of the automotive industry, and the design and optimisation goals of power electronic components in electric vehicles.

The basic circuits from Power Electronics 1 are extended to include the special topologies and application fields of electromobility. This should enable students to develop power electronics for electric vehicles independently.

Methodological skills

The application of fundamental knowledge to specific problems is practised by transferring the basic topologies of power electronics to the special applications of electromobility. This enables students to develop power electronic components in other industrial sectors as well and to optimise them for the respective application.

Personal skills

Personal skills primarily lie in practical intelligence, i.e., transferring the basic theoretical knowledge of mathematics and power electronics to specific hardware and practical set-ups.

Applicability in this and other degree programmes

In this degree programme: none

In other degree programmes: none

Admission and/or recommended requirements

Formally: 80 ECTS

In terms of content: EM-19

Learning content

1. **Supplementary components of power electronics**
    - 1.1. Driver circuits
    - 1.2. Current and voltage measurement
    - 1.3. Control and regulation of power electronics
    - 1.4. Circuit feedback of power electronics
2. **Optimisation potentials in electromobility**
    - 2.1. Loss calculations of components
    - 2.2. Maximising efficiency
    - 2.3. Reduction of construction volume
3. **Power electronic components of electric vehicles**
    - 3.1. Battery chargers
    - 3.2. On-board converter
    - 3.3. Driver inverter

3.4. Traction converter

3.5. Fuel cell converter

3.6. Special requirements for motor vehicles

3.7. Special requirements for hybrid vehicles

Teaching and learning methods

Lecture as seminar-based lessons

Recommended reading

J. Müller / E. Schmidt / W. Steber: Electromobility: Hochvolt- und 48-Volt-Systeme, 1. Auflage. Vogel Business Media Verlag, Würzburg 2017.

U. Schlienz: Schaltnetzteile und ihre Peripherie: Dimensionierung, Einsatz, EMV.

M. Albach: Induktivitäten in der Leistungselektronik: Spulen, Trafos und ihre parasitären Eigenschaften, 1. Auflage. Springer/Vieweg Verlag, Wiesbaden 2017.

EMI-EM 35 BATTERY TECHNOLOGY

Module code	EMI-EM 35
Module coordinator	Prof. Dr. Michael Sternad
Area of specialisation	Electromobility
Course number and name	EMI-EM7105 Battery Technology
Semester	7
Duration of the module	1 semester
Module frequency	annually
Course type	Core subject / compulsory elective course
Level	Undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Pr. course attendance 80%, written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	5/240
Language of Instruction	German

Module objective

Module objectives

Students internalise the properties and applications of important versions of electrochemical energy storage systems, as well as their structure, function and typical area of application.

Students will achieve the following learning objectives:

Professional skills

Knowledge of the structure, function and typical fields of application of primary and secondary electrochemical energy storage systems. Students are able to assign these energy storage systems to groups such as rechargeable and non-rechargeable systems based on their structure and are able to apply their knowledge in simple example exercises.

Methodological skills

Students know important parameters for energy storage (e.g. voltage, capacity, gavimetric and volumetric energy density) and can research these for unknown systems. Ultimately, students will have empirically internalised the most common

parameters for both aqueous and non-aqueous systems and will be able to apply them without research.

Personal skills

Students recognise their current abilities and deficits, accept their deficits and work on perfecting these deficits. Students experience recognition, e.g. through positive feedback or by solving difficult tasks. The recognition they experience motivates them to continue and intensify their work on personal deficits.

Applicability in this and other degree programmes

In this degree programme: none

In other degree programmes: none

Admission and/or recommended requirements

Formally: 80 ECTS

In terms of content:

Learning content

1. History, basics and definitions

2. Primary cells

2.1. Alkaline manganese batteries
2.2. Zinc air batteries
2.3. Lithium manganese dioxide batteries
2.4. Lithium carbon monochloride batteries
2.5. Lithium-iron sulphide batteries
2.6. Lithium thionyl chloride batteries
2.7. Lithium iodine batteries

3. Secondary cells

3.1. Lead acid batteries
3.2. Nickel metal hydride batteries
3.3. Lithium-ion batteries

4. Super capacitors

Teaching and learning methods

Seminar-based lessons

Recommended reading

Reddy, T. B.; Linden, D., Linden's Handbook of Batteries, 4th ed. Reddy. 2011.

Daniel, C.; Besenhard, J. O., Handbook of Battery Materials. 2nd ed.; 2011.

Hamann, C. H.; Vielstich, W., Elektrochemie. John Wiley & Sons Australia, Limited: 2005.

EMI-EM 36 CHARGING UNITS AND HYDROGEN TECHNOLOGY

Module code	EMI-EM 36
Module coordinator	Prof. Dr. Frank Denk
Area of qualification	Electromobility
Course number and name	EMI-EM7106 Charging Units and Hydrogen Technology
Semester	7
Duration of the module	1 semester
Module frequency	annually
Course type	Core subject / compulsory elective course
Level	Undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Pr. course attendance 80%, written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	5/240
Language of Instruction	German

Module objective

The worldwide political and technological topic of electromobility continues to be accelerated by the parallel digitisation and the expansion of regenerative sources As a result, there is now a need for centralised and decentralised charging infrastructure planning and its expansion in both national and international sectors. This is accompanied by the need for standardisation of the charging structure systems. This lecture forms, among other things, the foundation for this system design and its planning.

The current energy situation appears in a new frame, such as decarbonisation and hydrogen economy. In the context of the focus on necessary alternative drives and consequently the turning away from the pure use of fossil fuels with simultaneously growing global mobility of people, new concepts, such as the fuel cell vehicle, are emerging.

Professional skills

- Historical review and subsequent explanation of the state of the art of charging systems.

- The technologically different solutions such as DC, AC, conductive and inductive are analysed on the infrastructure side and structured with regard to their requirements.
- Alternative charging options such as capacitive charging offer further possibilities that are technically questioned in terms of their feasibility.
- Regenerative connection possibilities of the technical solutions are presented and analysed.
- The national and international norms and standards of electrical charging form a mesh of the most diverse requirements to be considered.
- This provides an outlook on the topic of requirement engineering.
- Understanding of the technical development of motor vehicles with electric motors and their connection with the different emission regulations worldwide, explaining the benefits and use of alternative drive systems.
- In-depth understanding of the structure of current fuel cell technologies.
- Application of the mobile fuel cell solution in the electric vehicle.
- Understanding of powertrain management

Methodological skills

- It is demonstrated that requirements/demands on the charging system methodically lead to solutions in the domains of hardware, software and mechanics.
- Based on this, different development methods are worked on in a fictitious project.
- In a cross-domain approach, the next step is to consider the economic efficiency of the system in the context of different regions.
- The methodologies of the system solutions are systematically studied through requirement engineering by forming sub-solutions in the technology areas of hardware/electronics, software and mechanics.
- As a result, the different variation possibilities of system solutions become visible to the participants.
- Within the framework of the background of series solution realisations, necessary economic efficiency considerations are realised.

Personal skills:

- The thematic discussion of the planning and development of charging systems leads technically and economically to project management which, through the

methodology, leads to a fundamental understanding of the necessity of a project team.

- This demonstrates the perception of a personnel project structure and the identification of the individual project staff.
- Participants recognise through this methodology the necessity of a project team with different role assignments in order to jointly develop a series solution.
- Individuals are enabled to perceive their own 'correct' role assignment as a project team member.

Social skills

- Technical problems and their solution through 'team building' are presented.
- Identification with the project team and their benefits for the project are promoted.

Applicability in this and other degree programmes

Applicability in this degree programme:
There is no dependence on the technological aspect and the topics of national and international standardisation.

Applicability in other degree programmes:

Since this module represents a key technological requirement for electromobility, it can be used for all degree programmes that deal with energy transfer, energy storage and system solutions for electric and hybrid vehicles. In addition, this module can be used for an extended representation in terms of electromobility infrastructure and hydrogen systems.

Admission and/or recommended requirements

Formally: 80 ECTS

In terms of content:

Learning content

Charging systems

- Basics of requirement engineering
- Relationship between requirements and solutions
- Electrical basics AC, DC, 1-phase, 3-phase and their power classes
- Basic charging concepts conductive and inductive

- Alternative charging concepts
- Renewable energy and its integration possibilities
- National and international norms and standard
- Basics of project management
- Solutions at local regional level
- Site selection
- Fare concepts
- Project planning

Hydrogen technology

- Technological developments of fuel cell vehicles.
- Basics of hydrolysis.
- Current electrochemical hydrolysis systems.
- The chemistry of cold combustion of hydrogen.
- The current fuel cell systems.
- The PEFC as a reversible system in electric vehicles.
- Possibilities and limits of use in motor vehicles.
- Technical implementation for use in motor vehicles.

Teaching and learning methods

Seminar-based lesson

Recommended reading

T. Gehrlein: Ladesäulen-Infrastruktur, 2nd revised edition. Praxishandbuch, 2018.

A. Karle: Electromobility ? Grundlagen und Praxis, 3rd rev. edition. Hanser Verlag, 2018.

J.Töpler / J. Lehmann: Wasserstoff und Brennstoffzelle, 2nd edition. Springer Verlag, 2017.

P. Hofmann: Hybridfahrzeuge, 2nd edition. Springer Verlag, 2014.

EMI-MR 34 MODEL-BASED CONTROL DESIGN AND TESTING

Module code	EMI-MR 34
Module coordinator	Prof. Dr. László Juhász
Area of qualification	Autonomous Driving / Mobile Robotics
Course number and name	EMI-MR7104 Model-based Control Design and Testing
Semester	7
Duration of the module	1 semester
Module frequency	annually
Course type	Core subject / compulsory elective course
Level	Undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	5/240
Language of Instruction	German

Module objective

The course covers model-based controller design and validation according to the V-cycle, as well as parameter identification of technical systems. Students learn to independently analyse, synthesis and testing control loops using model-based methods.

Students will achieve the following learning objectives:

Professional skills

Students know the basic methods for the parameter identification of technical and mechatronic systems and have applied these in practical exercises. They know how to create parametric models of technical systems and verify them experimentally.

Students know the individual elements of model-based function design and protection according to the V-cycle and can understand the special features and commonalities of individual elements of the V-cycle. Furthermore, they can validate the designed controllers in a model-based manner using offline and real-time simulations according to the specifications of the V-cycle and thus detect design errors at an early stage.

Students learn about software tool chains from MathWorks and dSPACE and then apply them independently to tasks in the field of model-based controller design and validation.

Methodological skills

Students are familiar with the most important methods and tools of model-based digital simulation and use them appropriately. In particular, they can correctly derive and evaluate the stability conditions of digital simulation methods for continuous and discrete systems. They know the guidelines for a good foundation for functions that are realised on a model-basis ? related to their subsequent application in RCP, HIL and production code generation ? and can apply these guidelines independently. Students elucidate and consolidate the mentioned approaches through modelling, simulation and control of an exemplary application.

Students understand what real-time requirements mean and are familiar with their impact on the function design using rapid control prototyping. They are familiar with both the hardware and software requirements and application possibilities of RCP and use them successfully. They can also successfully perform and validate function development using rapid control prototyping for CPU-based systems. They pay special attention to the problems of tasking, I/O configuration and real-time conditions.

Students are aware of the challenges of production code generation and independently apply optimisation methods and number representation in the digital computer to achieve a positive impact on computing time and memory usage. They can independently convert a general simulation model into a model suitable for production code generation and successfully carry out the steps necessary for this (scaling, optimisation). They are familiar with the validation and analysis of the generated production code using code coverage, MIL, SIL and PIL simulation, as well as with the integration of the overall control unit code.

Students know the reasons for HIL simulation and the techniques used in such a simulation. They are well-versed in the creation and operation of an HIL application and know the synergies between rapid control prototyping and HIL. They also successfully apply test automation and virtualisation methods.

Students acquire knowledge of parameter identification methods in both the time and frequency domains and subsequently apply these to practical problems.

Personal skills

Students are aware of their responsibility as development engineers for model-based controller design and validation. They can justify work steps and results argumentatively and evaluate them critically. They can work together in teams and give each other feedback.

Applicability in this and other degree programmes

In this degree programme: none

In other degree programmes: none

Admission and/or recommended requirements

Formally: 80 ECTS

Contently: EM-03, EM-04, EM-07, EM-09, EM-12, EM-18, EM-19, EM-20

Learning content

1. **Introduction to model-based controller design and validation**
   - 1.1. Comparison of traditional and model-based methods
   - 1.2. The V-model
2. **Elements of the V-model**
   - 2.1. Offline simulation
   - 2.2. Rapid control prototyping
   - 2.3. Production code generation
   - 2.4. Hardware-in-the-loop simulation
   - 2.5. Measuring and calibrating
3. **Parameter identification**
   - 3.1. Overview and classification of parameter identification methods
   - 3.2. Parameter identification in the time domain
   - 3.3. Parameter identification in the frequency domain
4. **Sample projects**

Teaching and learning methods

Lecture, practical computer work, practical exercises with real-time systems, individual and group work

Recommended reading

D. Abel / A. Bollig: Rapid Control Prototyping -Methoden und Anwendungen, Springer Verlag, Berlin 2006.

J. Schäuffele / T. Zurawka: Automotive Software Engineering, 6th edition, Springer Vieweg, Wiesbaden 2016.

H. Winner / S. Hakuli / F. Lotz / C. Singer: Handbuch Fahrerassistenzsysteme, 3rd edition, Springer Vieweg, Wiesbaden 2015.

Isermann R.: Grundlegende Methoden (Identifikation dynamischer Systeme, Bd.1), Springer-Verlag, 1992

EMI-MR 35 AUTONOMOUS DRIVING

Module code	EMI-MR 35
Module coordinator	Prof. Dr. Nikolaus Müller
Area of qualification	Autonomous Driving / Mobile Robotics
Course number and name	EMI-MR7105 Autonomous Driving
Semester	7
Duration of the module	1 semester
Module frequency	annually
Course type	Core subject / compulsory elective course
Level	Undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	5/240
Language of Instruction	German

Module objective

The primary objective is to learn the model and data-based methods that enable automated driving.

After completing the module, students will have achieved the following learning objectives:

Professional skills:

- They know the description of vehicle and driving dynamics.
- They know the models of longitudinal and lateral movement of vehicles as well as suitable roadway models.
- They simulate movement models using suitable computer-based tools.
- They plan suitable trajectories.
- They know algorithms for model-based image sequence processing in real time.
- They know the basics of machine learning.
- They apply suitable techniques to solve a task.

Methodological skills:

Students work on tasks from this field using suitable tools, e.g. Python or Matlab

Social skills:

In the simulation of a race, teams compete against each other in fair competition.

Applicability in this and other degree programmes

none

Admission and/or recommended requirements

Formally: 80 ECTS

In terms of content: Basic modules EM-01 to EM-16

Learning content

- o Overview
- o Dynamic modelling of driving
  - 4.1. Vehicular model
  - 4.2. Model of the road
  - 4.3. Movement model of other traffic participants

5. Recursive estimation procedures
   - 5.1. Kalman filter
   - 5.2. The 4D approach
6. Machine learning
   - 6.1. Approaches
   - 6.2. Outlook

Teaching and learning methods

Seminar-based lessons and exercises

Recommended reading

M. Ersoy / S. Gies: Fahrwerkhandbuch, Springer, 2017.

E.D. Dickmanns: Dynamic Vision for Perception and Control of Motion, Springer, 2007.

M. Maurer et. al (Hrsg.): Autonomes Fahren, Springer, 2015.

M. Maurer (Hrsg.): Autonomes Fahren: Technische, rechtliche und gesellschaftliche Aspekte, Springer, 2015.

T. Bertram (Hrsg.): Automatisiertes Fahren, Springer, 2020.

V. Johanning: Car IT kompakt. Das Auto der Zukunft: Vernetzt und autonom fahren. Springer, 2015.

EMI-MR 36 MOBILE ROBOTICS

Module code	EMI-MR 36
Module coordinator	Prof. Dr. Nikolaus Müller
Area of qualification	Autonomous Driving / Mobile Robotics
Course number and name	EMI-MR7106 Mobile Robotics
Semester	7
Duration of the module	1 semester
Module frequency	annually
Course type	Core subject / compulsory elective course
Level	Undergraduate
Semester hours per week (SWS)	4
ECTS	5
Workload	Contact hours: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of grades	5/240
Language of Instruction	German

Module objective

The aim is to learn the essential design methods for controlling mobile robots. After completing the module, students will have achieved the following learning objectives:

Professional skills:

1. They know how different path planning algorithms work
2. They can calculate suitable trajectories
3. They know methods that can be used to estimate the space requirements of tugger trains
4. You know relevant standards for the design of safe mobile robots
5. They assess the requirement level for safety engineering

Methodological skills:

They can research in standardisation and literature databases

Social skills:

They form a team to solve a given task

Applicability in this and other degree programmes

In this degree programme: none

In other degree programmes: none

Admission and/or recommended requirements

Formally: 80 ECTS

Content related: EM-01, EM-02, EM-04, EM-05, EM-06, EM-09, EM-12, EM-13, EM-14, EM-15, EM-17, EM-18

Learning content

1. **Introduction to mobile robots**
    - 1.1. Sensor technology
    - 1.2. Actuator engineering
    - 1.3. Control structure
2. **Path planning**
    - 2.1. Path planning with topographic maps
    - 2.2. Path planning in open spaces
3. **Trajectory planning**
    - 3.1. Point-to-point connections
    - 3.2. Curves with intermediate points
4. **Vehicle paths**
    - 4.1. Determination of space requirement
5. **Introduction to safety engineering**
    - 5.1. Safety regulations
    - 5.2. Calculation of safety levels

Teaching and learning methods

Seminar-based lessons, project work, internship

Recommended reading

M. Haun: Handbuch Robotik: Programmieren und Einsatz intelligenter Roboter. Springer/Vieweg 2013.

U. Nehmzow: Mobile Robotik: eine praktische Einführung. Springer 2002.

T. Bräunl: Embedded Robotics: Mobile robot design and applications with embedded systems. Springer 2008.

J.J. Craig: Introduction to Robotics, 3rd edition. Pearson Education 2014.

Telemecanique - Handbuch für Sicherheitsanwendungen. ZXHBSI01, 2003.