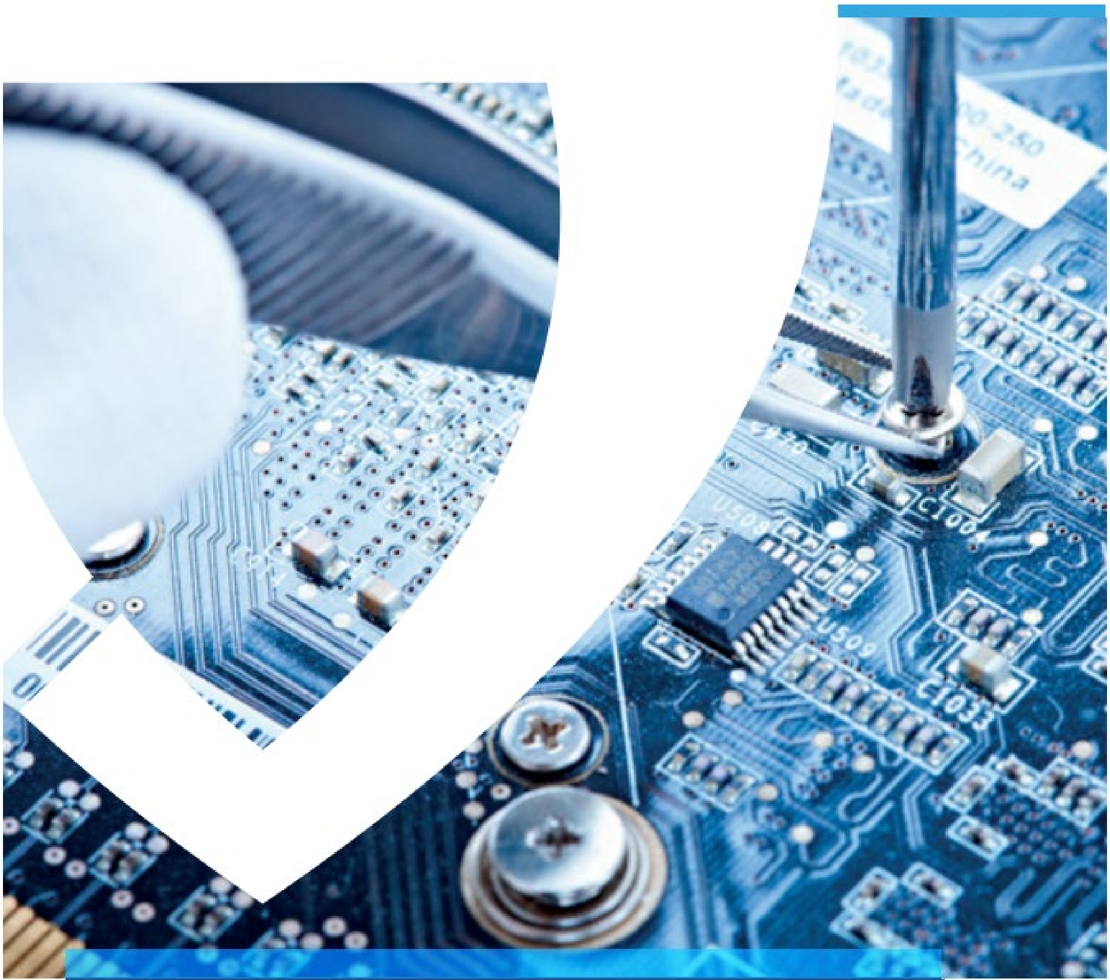
JACOBS UNIVERSITY



Study Program Handbook

Electrical and Computer Engineering

Bachelor of Science

Subject-specific Examination Regulations for Electrical and Computer Engineering (Fachspezifische Prüfungsordnung)

The subject-specific examination regulations for Electrical and Computer Engineering are defined by this program handbook and are valid only in combination with the General Examination Regulations for Undergraduate degree programs (General Examination Regulations = Rahmenprüfungsordnung). This handbook also contains the program-specific Study and Examination Plan (Chapter 6).

Upon graduation, students in this program will receive a Bachelor of Science (BSc) degree with a scope of 180 ECTS credits (for specifics see Chapter 6 of this handbook).

Version	**Valid as of**	**Decision**	**Details**
Fall 2022 – V1	Sep 01, 2022	Mar 18, 2020.	V1 Originally approved by the Academic Senate
		Feb 01, 2022	V1.1 Correction of Typos
		Aug 03, 2022	V.1.2 Change in BQ-Modules „Ethics in Science and Technology", "Global Health" and "Global Existential Risks"
		Aug 18, 2022	V1.3 Changes in "Admission Requirements" and "Internship / Startup and Career Skills"
		Sep 19, 2022	V1.4 Editorial change uniform specialization module text

Content

1 Program Overview

1.1 Concept

1.1.1 The Jacobs University Educational Concept

Jacobs University aims to educate students for both an academic and a professional career by emphasizing four core objectives: academic quality, self-development/personal growth, internationality, and the ability to succeed in the working world (employability). Hence, study programs at Jacobs University offer a comprehensive, structured approach to prepare students for graduate education as well as career success by combining disciplinary depth and interdisciplinary breadth with supplemental skills education and extra-curricular elements.

In this context, it is Jacobs University's aim to educate talented young people from all over the world, regardless of nationality, religion, and material circumstances, to become citizens of the world who are able to take responsible roles for the democratic, peaceful, and sustainable development of the societies in which they live. This is achieved through a high-quality teaching as well as manageable study loads and supportive study conditions. Study programs and related study abroad programs convey academic knowledge as well as the ability to interact positively with other individuals and groups in culturally diverse environments. The ability to succeed in the working world is a core objective for all study programs at Jacobs University, both in terms of actual disciplinary subject matter and also to the social skills and intercultural competence. Study-program-specific modules and additional specializations provide the necessary depth, interdisciplinary offerings and the minor option provide breadth while the university-wide general foundation and methods modules, mandatory German language requirements, and an extended internship period strengthen the employability of students. The concept of living and learning together on an international campus with many cultural and social activities supplements students' education. In addition, Jacobs University offers professional advising and counseling.

Jacobs University's educational concept is highly regarded both nationally and internationally. While the university has consistently achieved top marks over the last decade in Germany's most comprehensive and detailed university ranking by the Center for Higher Education (CHE), it has also been listed by the renowned Times Higher Education (THE) magazine as one of the top 300 universities worldwide in 2018. The THE ranking is considered as one of the most widely observed university rankings. It is based on five major indicators: research, teaching, research impact, international orientation, and the volume of research income from industry.

1.1.2 Program Concept

The extensive developments in microelectronics over recent decades have triggered a digital revolution where computers take center stage. While we still think of a computer as a desktop or a laptop, digital computing and digital signal processing have become vital for many of the products in our everyday life such as cars, mobile phones, tablets, cameras, household appliances, and more. The Electrical and Computer Engineering program focuses on the areas of communications and digital signal processing, including the enabling digital processing elements and their programming. Those enabling technologies are mostly subsumed under the headline of embedded systems.

The first two years of the ECE program offer a rigorous theoretic foundation together with lab experiments that illustrate the principles practically and already show the programming of digital signal processors, printed circuit board design, and advanced measurement tools and procedures. The theoretical education with corresponding labs covers analog and digital circuitry, deterministic and random signal processing, probability and information theory, and communication. Signals covered start from DC and single sinusoids and move over to general deterministic or random functions and also specific ones like audio, speech, and video, enabling students to treat them with the corresponding mathematical and algorithmic tools. Different transmission media are characterized, be it wireline or wireless, and the suitable transmission methods and algorithms are covered together with them. The education in the first two years provides a solid foundation enabling students to do internships in research environments and professionally contribute to industrial projects. Specialization modules in the 3rd year finally guide to the frontiers of current knowledge and technology.

The third year exposes students to advanced topics giving also the chance to already pick graduate level modules, such as protocol aspects and coding theory, also rounds up the knowledge with radio frequency engineering aspects and the programming of FPGAs (Field Programmable Gate Arrays).

During the three-year program, we make students discover over-arching relations between the central concepts, pointing them to links between subjects and modules. This should allow the students to develop a holistic view, e.g., recognizing that all linear transforms are directly linked to each other, hence, show tightly related properties; algorithms in error-correction coding are similar to those in signal processing; a complex baseband signal description for modulation shows links to the basic complex descriptions of sinusoidal signals introduced in the first study year. Students shall be capable to recognize the `string' linking topics vertically between their study years as well as horizontally between lectures and labs in the same semester. A rigid sequence of contents has been created, ensuring topics following each other smoothly in the right order.

Apart from the major-specific education, the program offers room for orientation and specialization, e.g., by choosing specific minors, offering views into other fields and majors. Additionally, due to the teaching in relatively small groups, many lab modules, the direct relation between students and faculty, and the very individual support in theses and also optional projects, mandatory modules from very different fields, and finally, internship and social activities, provide ample opportunities for interacting with fellow students and faculty, supporting organizational and presentation skills and fostering personal development.

1.2 Specific Advantages of the Electrical and Computer Engineering Program at Jacobs University

- Focus on signal processing, communications, and corresponding implementation: The ECE program at Jacobs University is designed to reflect the dynamic changes of electrical and computer engineering in industry and society. With a sharp focus on signal processing, communications, and implementation, students will be ready to face the challenges of emerging areas such as Cyber-physical Systems, Internet of Things, Connected Vehicles, Secure Communication, and more.
- Early involvement in research: ECE at Jacobs University is strongly research-oriented. Each professor in the department has an independent research group including not only senior, but also junior students, even at the Bachelor studies level, some of whom

have their first scientific publication together with ECE faculty at well-recognized journals or conferences.

- Advanced topics in Signal Processing and Communications are treated very early on, making ECE students prepared for advanced internship or research tasks after the 2nd year. The third year then offers some graduate-level modules, making students fit for any graduate school world-wide or professional jobs early on.
- Wide cooperation and open access to instructors: Jacobs University as a whole is a flat institution, where professors, research staff, and students engage in open dialog and co-operation without barriers.

1.3 Program-Specific Educational Aims

1.3.1 Qualification Aims

The main subject-specific qualification aim is to enable students to take up a qualified employment in electrical and computer engineering environments, be it manufacturers, providers, sales organizations, consultants, agencies, research centers, or academia itself. Although the program focus is on signal processing and telecommunications, graduates will be prepared for a manifold of ECE environments and others, like, e.g., automotive and energy.

- Electrical and Computer Engineering competence

  Graduates are able to understand, measure, and analyze properties and theoretically describe tasks and possible solutions in signal processing and communications, plan, design, and implement realizations in hard- and software on modern signal processing and FPGA platforms.

- Communication competence

  Graduates are able to communicate subject-specific topics convincingly in both spoken and written form to other ECE graduates, to engineers in general, to industrial or academic colleagues with different backgrounds, as well as to a more general audience, such as non-technical administrators and decision makers or customers.

- Teamwork and project management competences

  Graduates are able to efficiently individually and also in a team, especially when carrying out lab experiments and doing corresponding lab reports jointlyThey are able to organize their work and work flows. They are familiar with supporting tools for analysis, development, design, measurement, and testing. Graduate should be able to plan and take decisions in a constructive and well justified way and also convey the corresponding reasoning convincingly.

- Learning competence

  Graduates have acquired a solid foundation enabling them to assess their own knowledge and skills, learn effectively and to stay up to date with the latest developments in the fast-changing field of Electrical and Computer Engineering.

- Personal and professional competence

  Graduates are able to develop a professional profile, justify professional decisions on the basis of theoretical and methodical knowledge, and critically reflect their behavior, also with respect to its consequences for society.

During the design of the program, corresponding national guidelines (Leitlinien für Bachelor und Master) by VDE (Verein Deutscher Elektrotechniker), ZVEI, Bitcom, and VDEW have been incorporated, as well as experiences of faculty from teaching at other universities in Europe, the US, and Japan.

1.3.2 Intended Learning Outcomes

By the end of the program, students will be able to

- describe the underlying natural physical foundation, especially Maxwell' equations; describe and apply mathematical basics and tools;
- describe the underlying theoretical concepts of deterministic and random signals in time and frequency domain;
- compare results to theoretical limits, e.g., provided by Information Theory;
- explain and implement signal processing components, methods, and algorithms, having studied the theoretical foundation and having learned programming languages Matlab, C, C++, assembler, VHDL for general-purpose, signal processor platforms, or FPGAs;
- treat signals with dedicated algorithms, be it audio, video, or from other origin, e.g., by filtering, prediction, compression;
- design suitable transmission methods for diverse channels, wireline and wireless on the basis of channel properties and models, knowing an almost complete set of transmission methods;
- know typical electronic components and their standard base circuits and to implement dedicated circuitry, be it analog or digital, including the printed circuit board layout;
- use advanced measurement equipment, like high-end scopes, spectrum and network analyzers including their remote control;
- design MAC and higher protocols, error correcting codes, and compression schemes, also know major security schemes and their implementation;
- use academic or scientific methods as appropriate in the field of Electrical and Computer Engineering such as defining research questions, justifying methods, collecting, assessing and interpreting relevant information, and drawing scientifically-founded conclusions that consider social, scientific, and ethical insights;
- develop and advance solutions to problems and arguments in Electrical and Computer Engineering and defend these in discussions with specialists and non-specialists;

- engage ethically with academic, professional and wider communities and to actively contribute to a sustainable future, reflecting and respecting different views;
- take responsibility for their own learning, personal and professional development, and role in society, evaluating critical feedback and self-analysis;
- apply their knowledge and understanding to a professional context;
- take on responsibility in a diverse team;
- adhere to and defend ethical, scientific, and professional standards.

1.4 Career Options

A recent survey by a German engineering association showed high demand for EE and ECE engineers. Currently, inside Germany alone, there are twice as many positions than graduates, hence, ample job opportunities.

Higher demands for ECE engineers are to be expected. This is partly due to general economic trends, but especially related to unusually low student numbers in recent years. Especially, due to rapid developments, fundamental principles and cross-boundary knowledge become increasingly important. In addition, the required qualification profiles and personal attitudes differ for academic versus industrial careers. The ECE program at Jacobs University responds to all of these conditions for a successful career through the flexibility of the program and the trans-disciplinary education. Jacobs University ECE graduates start their careers in very diverse companies, successfully continue at renowned universities, or stay with Jacobs University for graduate education or a PhD.

Career paths after graduation are very diverse. Jacobs ECE alumni work in the aerospace industry, telecommunications, the automotive and energy sector, and in the field of information technology, in academia, at research centers, in management and in consultancy, even in finance. Having checked exemplary career paths of 75 former Jacobs ECE students, we found an enormous manifold of companies, research centers, and universities, where our alumni went or are currently working. It starts from well-known big companies, like Bosch, Continental, Deutsche Telekom, E.on, Ericsson, Google, Infineon, Intel, Nokia Bell Labs, Texas Instruments, Volkswagen, midsize ones, like Kapsch, Hirschmann, OHB, Rohde & Schwartz, to numerous small ones and start-ups like DSI, Snips, to consulting companies like McKinsey, Business Technology Consulting, Deloutte, financial institutions like PricewaterhouseCoopers, OpenLink Financial, even to companies like Fresenius and Proctor and Gamble, that would not come to mind immediately as typical work places for ECE graduates. Interestingly, also after intermediate further education steps or employments in other countries, a high percentage of alumni have found their long-term home in Germany and also Bremen.

Further graduate education that our students chose, is also covering a wide spectrum. Graduates have been accepted by universities like TUM, EPFL, ETH, Univ. of Edinburgh, KTH, Eindhoven, KU Leuven, Lauvain, Politecnico di Torino, Berkeley, Rice, UCSD, Jacobs University itself.

After PhD, some of our students followed research paths at universities and research centers, like Fraunhofer, DLR, OFFIS, some are already teaching as professors or lecturers. A few earlier students already received prestigious industrial and research awards, like Forbes 30 under 30 and the Donald P. Eckman Award.

In line with the high demand for engineers, all ECE graduates successfully found employment. Likewise, they were able to easily adapt at many graduate schools as the preparation during Bachelor's had already covered contents of graduate modules to the advantage of our students.

Already during their studies the Jacobs University Career Services Center (CSC) as well as the Alumni Office, and, of course, faculty itself, help students in their career development. The CSC provides students with high quality training and coaching in CV creation, cover letter formulation, interview preparation, effective presenting, business etiquette, and employer research as well as in many other aspects, thus helping students identify and follow up rewarding careers after their time at Jacobs University. Furthermore, the Alumni Office helps students establish a long-lasting and worldwide network which comes in handy when exploring job options in academia, industry, and elsewhere.

1.5 Admission Requirements

Admission to Jacobs University is selective and based on a candidate's school and/or university achievements, recommendations, self-presentation, and performance on required standardized tests. Students admitted to Jacobs University demonstrate exceptional academic achievements, intellectual creativity, and the desire and motivation to make a difference in the world.

The following documents need to be submitted with the application:

- Recommendation Letter
- Official or certified copies of high school/university transcripts
- Educational History Form
- Standardized test results (SAT/ACT) if applicable
- ZeeMee electronic resume (optional)
- Language proficiency test results (TOEFL, IELTS or equivalent)

Formal admission requirements are subject to higher education law and are outlined in the Admission and Enrollment Policy of Jacobs University.

For more detailed information about the admission visit: https://www.jacobs-university.de/study/undergraduate/application-information

1.6 More Information and Contact

For more information please contact the study program chair:

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or visit our website: ELECTRICAL AND COMPUTER ENGINEERING | Jacobs University - Inspiration is a Place (jacobs-university.de)

2 The Curricular Structure

2.1 General

The curricular structure provides multiple elements for enhancing employability, interdisciplinarity, and internationality. The unique Jacobs Track, offered across all undergraduate study programs, provides comprehensive tailor-made modules designed to achieve and foster career competency. Additionally, a mandatory internship of at least two months after the second year of study and the possibility to study abroad for one semester give students the opportunity to gain insight into the professional world, apply their intercultural competences and reflect on their roles and ambitions for employment and in a globalized society.

All undergraduate programs at Jacobs University are based on a coherently modularized structure, which provides students with an extensive and flexible choice of study plans to meet the educational aims of their major within the regular period.

The framework policies and procedures regulating undergraduate study programs at Jacobs University can be found on the website (https://www.jacobs-university.de/academic-policies).

2.2 The Jacobs University 3C Model

Jacobs University offers study programs that comply with the regulations of the European Higher Education Area. All study programs are structured according to the European Credit Transfer System (ECTS), which facilitates credit transfer between academic institutions. The three-year under-graduate program involves six semesters of study with a total of 180 ECTS credit points (CP). The undergraduate curricular structure follows an innovative and student-centered modularization scheme - the 3C-Model - that groups the disciplinary content of the three study years according to overarching themes:

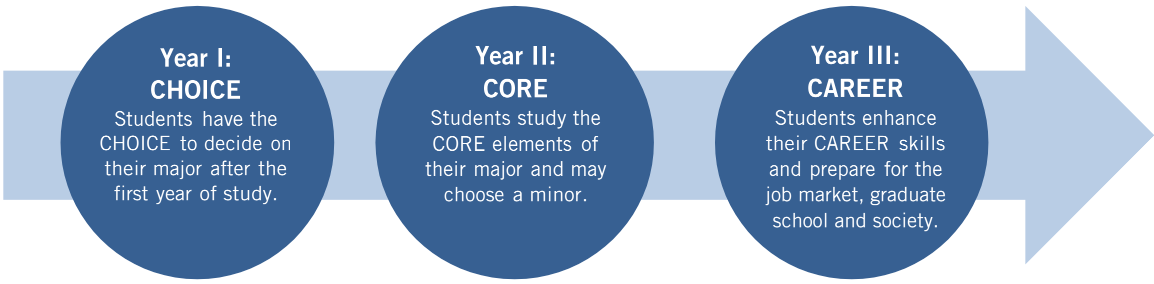

Figure 1: The Jacobs University 3C-Model

2.2.1 Year 1 – CHOICE

The first study year is characterized by a university-specific offering of disciplinary education that builds on and expands upon the students' entrance qualifications. Students select introductory modules for a total of 45 CP from the CHOICE area from which 37.5 CP will be from their major ECE. A unique feature of our curriculum structure allows students to select their major freely upon entering Jacobs University. The Academic Advising Coordinator offers curricular counseling to all Bachelor students independently of their major, while Academic

Advisors support students in their decision-making regarding their major study program as contact persons from the faculty.

To pursue ECE as a major, the following CHOICE modules (37.5 CP) need to be taken as mandatory modules:

- CHOICE Module: General Electrical Engineering I (7.5 CP)
- CHOICE Module: General Electrical Engineering II (7.5 CP)
- CHOICE Module: Module: Programming in C and C++ (7.5 CP)
- CHOICE Module: Classical Physics (7.5 CP)
- CHOICE Module: Introduction to Computer Science (7.5 CP)

ECE students can further choose between the two mandatory elective modules:

- CHOICE Module: Introduction to Robotics and Intelligent Systems (7.5 CP)
- CHOICE Module: Applied Mathematics (7.5 CP)

2.2.1.1 Major Change Option

ECE Students can still change to another major at the beginning of their second semester, if they have taken the corresponding mandatory CHOICE modules in their first year of studies. All students must participate in a seminar on the major change options in the O-Week and consult their Academic Advisor in the first year of studies prior to changing their major.

ECE students have the option to option for a major change after their first semester to

- Robotics and Intelligent Systems (RIS)
- Physics (Phys)
- Computer Science (CS)

2.2.2 Year 2 – CORE

In their second year, students take a total of 45 CP from a selection of in-depth, discipline-specific CORE modules. Building on the introductory CHOICE modules and applying the methods and skills acquired so far (see 2.3.1), these modules aim to expand the students' critical understanding of the key theories, principles, and methods in their major for the current state of knowledge and best practice.

ECE students take the following CORE modules:

- CORE Module: Signals and Systems (7.5 CP)
- CORE Module: Digital Signal Processing (7.5 CP)
- CORE Module: Communications Basics (5 CP)
- CORE Module: Electromagnetics (5 CP)
- CORE Module: Electronics (5 CP)
- CORE Module: Wireless Communication (5 CP)
- CORE Module: Information Theory (5 CP)
- CORE Module: PCB design and measurement automation (5 CP)

2.2.2.1 Minor Option

Since Electrical and Computer Engineering has a strongly sequential structure where course contents build onto each other, ECE students will not have the option of a minor in another study program within the 180 CP required for the Bachelor's degree.

2.2.3 Year 3 – CAREER

During their third year, students prepare and make decisions for their career after graduation. To explore available choices fitting individual interests, and to gain professional experience, students take a mandatory summer internship (see 2.2.3.1). The third year of studies allows ECE students to take Specialization modules within their discipline, but also focuses on the responsibility of students beyond their discipline (see Jacobs Track).

The 5th semester also opens a mobility window for a diverse range of study abroad options. Finally, the 6th semester is dedicated to fostering the students' research experience by involving them in an extended Bachelor thesis project.

2.2.3.1 Internship / Start-up and Career Skills Module

As a core element of Jacobs University's employability approach students are required to engage in a mandatory two-month internship of 15 CP that will usually be completed during the summer between the second and third years of study. This gives students the opportunity to gain first-hand practical experience in a professional environment, apply their knowledge and understanding in a professional context, reflect on the relevance of their major to employment and society, reflect on their own role in employment and society, and find a professional orientation. The internship can also establish valuable contacts for the students' Bachelor's thesis project, for the selection of a Master program graduate school or further employment after graduation. This module is complemented by career advising and several career skills workshops throughout all six semesters that prepare students for the transition from student life to professional life. As an alternative to the full-time internship, students interested in setting up their own company can apply for a start-up option to focus on developing of their business plans.

For further information, please contact the Career Services Center (https://www.jacobs-university.de/career-services)

2.2.3.2 Specialization Modules

In the third year of their studies, students take 15 CP from major-specific or major-related, advanced Specialization Modules to consolidate their knowledge and to be exposed to state-of-the-art research in the areas of their interest. This curricular component is offered as a portfolio of modules, from which students can make free selections during their fifth and sixth semester. The default Specialization Module size is 5 CP, with smaller 2.5 CP modules being possible as justified exceptions.

To pursue ECE as a major, at least 15 CP from the following mandatory major-specific Specialization Modules need to be taken:

- ECE Specialization: Wireless Communication II (5 CP)
- ECE Specialization: Coding Theory (5 CP)
- ECE Specialization: Digital Design (5 CP)

- ECE Specialization: Radio-Frequency (RF) Design (5 CP)

2.2.3.3 Study Abroad

Students have the opportunity to study abroad for a semester to extend their knowledge and abilities, broaden their horizons and reflect on their values and behavior in a different context as well as on their role in a global society. For a semester abroad (usually the 5th semester), modules related to the major with a workload equivalent to 22.5 CP must be completed. Modules recognized as study abroad CP need to be pre-approved according to Jacobs University study abroad procedures. Several exchange programs allow students to directly enroll at prestigious partner institutions worldwide. Jacobs University's participation in Erasmus+, the European Union's exchange program, provides an exchange semester at a number of European universities that include Erasmus study abroad funding.

For further information, please contact the International Office (https://www.jacobs-university.de/study/international-office).

ECE students that wish to pursue a study abroad in their 5th semester are required to select their modules at the study abroad partners such that they can be used to substitute between 10-15 CP of major-specific Specialization modules and between 5-15 CP of modules equivalent to the non-disciplinary Big Questions modules or the Community Impact Project (see Jacobs Track). In their 6th semester, according to the study plan, returning study-abroad students complete the Bachelor Thesis/Seminar module (see next section), they take any missing Specialization modules to reach the required 15 CP in this area, and they take any missing Big Questions modules to reach 15 CP in this area. Study abroad students are allowed to substitute the 5 CP Community Impact Project (see Jacobs Track below) with 5 CP of Big Questions modules.

2.2.3.4 Bachelor Thesis/Seminar Module

This module is a mandatory graduation requirement for all undergraduate students. It consists of two module components in the major study program guided by a Jacobs faculty member: the Bachelor Thesis (12 CP) and a Seminar (3 CP). The title of the thesis will appear on the students' transcripts.

Within this module, students apply the knowledge skills, and methods they have acquired in their major discipline to become acquainted with actual research topics, ranging from the identification of suitable (short-term) research projects, preparatory literature searches, the realization of discipline-specific research, and the documentation, discussion, and interpretation of the results.

With their Bachelor Thesis students demonstrate mastery of the contents and methods of their major-specific research field. Furthermore, students show the ability to analyze and solve a well-defined problem with scientific approaches, a critical reflection of the status quo in scientific literature, and the original development of their own ideas. With the permission of a Jacobs Faculty Supervisor, the Bachelor Thesis can also have an interdisciplinary nature. In the seminar, students present and discuss their theses in a course environment and reflect on their theoretical or experimental approach and conduct. They learn to present their chosen research topics concisely and comprehensively in front of an audience and to explain their methods, solutions, and results to both specialists and non-specialists.

2.3 The Jacobs Track

The Jacobs Track, an integral part of all undergraduate study programs, is another important feature of Jacobs University's educational model. The Jacobs Track runs parallel to the disciplinary CHOICE, CORE, and CAREER modules across all study years and is an integral part of all undergraduate study programs. It reflects a university-wide commitment to an in-depth training in scientific methods, fosters an interdisciplinary approach, raises awareness of global challenges and societal responsibility, enhances employability, and equips students with augmented skills desirable in the general field of study. Additionally, it integrates (German) language and culture modules.

2.3.1 Methods and Skills Modules

Methods and skills such as mathematics, statistics, programming, data handling, presentation skills, academic writing, and scientific and experimental skills are offered to all students as part of the Methods and Skills area in their curriculum. The modules that are specifically assigned to each study programs equip students with transferable academic skills. They convey and practice specific methods that are indispensable for each students' chosen study program. Students are required to take 20 CP in the Methods and Skills area. The size of all Methods and Skills modules is 5 CP.

To pursue ECE as a major, the following mandatory Methods and Skills modules (20 CP) need to be taken:

- Methods: Calculus and Elements of Linear Algebra I (5 CP)
- Methods: Calculus and Elements of Linear Algebra II (5 CP)
- Methods: Probability and Random Processes (5 CP)
- Methods: Numerical Methods (5CP)

2.3.2 Big Questions Modules

The modules in the Big Questions area (10 CP) intend to broaden students' horizons with applied problem solving between and beyond their chosen disciplines. The offerings in this area comprise problem-solving oriented modules that tackle global challenges from the perspectives of different disciplinary backgrounds that allow, in particular, a reflection of acquired disciplinary knowledge in economic, societal, technological, and/or ecological contexts. Working together with students from different disciplines and cultural backgrounds, these modules cross the boundaries of traditional academic disciplines.

Students are required to take 10 CP from modules in the Area. This curricular component is offered as a portfolio of modules, from which students can make free selections during their 5th and 6th semester with the aim of being exposed to the full spectrum of economic, societal, technological, and/or ecological contexts. The size of Big Questions Modules is either 2.5 or 5 CP.

2.3.3 Community Impact Project

In their 5th semester students are required to take a 5 CP Community Impact Project (CIP) module. Students engage in on-campus or off-campus activities that challenge their social responsibility, i.e., they typically work on major-related projects that make a difference in the community life on campus, in the campus neighborhood, Bremen, or on a cross-regional level. The project is supervised by a faculty coordinator and mentors.

Study abroad students are allowed to substitute the 5-CP Community Impact Project with 5 CP of Big Questions modules.

2.3.4 Language Modules

Communication skills and foreign language abilities foster students' intercultural awareness and enhance their employability in an increasingly globalized and interconnected world. Jacobs University supports its students in acquiring and improving these skills by offering a variety of language modules at all proficiency levels. Emphasis is put on fostering the German language skills of international students as they are an important prerequisite for non-native students to learn about, explore, and eventually integrate into their host country and its professional environment. Students who meet the required German proficiency level (e.g., native speakers) are required to select modules in any other modern foreign language offered (Chinese, French or Spanish). Hence, acquiring 10 CP in language modules, with German mandatory for non-native speakers, is a requirement for all students. This curricular component is offered as a four-semester sequence of foreign language modules. The size of the Language Modules is 2.5 CP.

3 ECE as a Minor

ECE as minor offers the central circuitry and major descriptions of signals and their processing together with the corresponding lab experiments. This would be a perfect combination to related majors like RIS, CS, Physics, and Mathematics, either providing them with complementary descriptions, like with the pairing of Digital Signal Processing and Control (ECE/RIS) or the ECE foundation to mathematical or physical concepts. A CS student might be interested to see algorithms and programming from the boundary conditions of a signal-processing application and signal processing hardware. For other majors, different aspects could be of importance, e.g., a biologist that has to understand signals and their measurement.

3.1 Qualification Aims

ECE as a major will offer the central concepts of linear circuits, periodic and non-periodic, time-continuous and time-discrete deterministic signals, and all linear transforms of signals. In the labs, simple circuits will be built and measured and finally digital signal processors will be programmed for signal processing tasks.

3.1.1 Intended Learning Outcomes

With a minor in ECE, students will be able to

- describe typical electronic components and their standard base circuits and implement analog circuitry;
- describe the underlying theoretical concepts of deterministic signals in time and frequency domain;
- explain and implement signal processing components, methods, and algorithms, having studied the theoretical foundation and having learned to program signal processor platforms;
- treat signals with dedicated algorithms, be it audio, video, or from other origin, e.g., by filtering, prediction, compression.

3.2 Module Requirements

A minor in ECE requires 30 CP. The default option to obtain a minor in ECE is marked in the Study and Examination Plans in Chapter 6. It includes the following CHOICE and CORE modules:

- CHOICE Module: General Electrical Engineering I (7.5 CP)
- CHOICE Module: General Electrical Engineering II (7.5 CP)
- CORE Module: Signals and Systems (7.5 CP)
- CORE Module: Digital Signal Processing (7.5 CP)

3.3 Degree

After successful completion, the minor in ECE will be listed on the final transcript under PROGRAM OF STUDY and BA/BSc – [name of the major] as “(Minor: ECE)”.

4 ECE Undergraduate Program Regulations

4.1 Scope of these Regulations

The regulations in this handbook are valid for all students who entered the ECE undergraduate program at Jacobs University in Fall 2021. In case of conflict between the regulations in this handbook and the general Policies for Bachelor Studies, the latter applies (see http://www.jacobs-university.de/academic-policies).

In exceptional cases, certain necessary deviations from the regulations of this study handbook might occur during the course of study (e.g., change of the semester sequence, assessment type, or the teaching mode of courses).

In general, Jacobs University Bremen reserves therefore the right to change or modify the regulations of the program handbook also after its publication at any time and in its sole discretion.

4.2 Degree

Upon successful completion of the study program, students are awarded a Bachelor of Science degree in Electrical and Computer Engineering.

4.3 Graduation Requirements

In order to graduate, students need to obtain 180 CP. In addition, the following graduation requirements apply:

Students need to complete all mandatory components of the program as indicated in the mandatory study and examination in Chapter 6 of this handbook.

5 Schematic Study Plan for ECE

Figure 2 shows schematically the sequence and types of modules required for the study program. A more detailed description, including the assessment types, is given in the Study and Examination Plans in the following section.

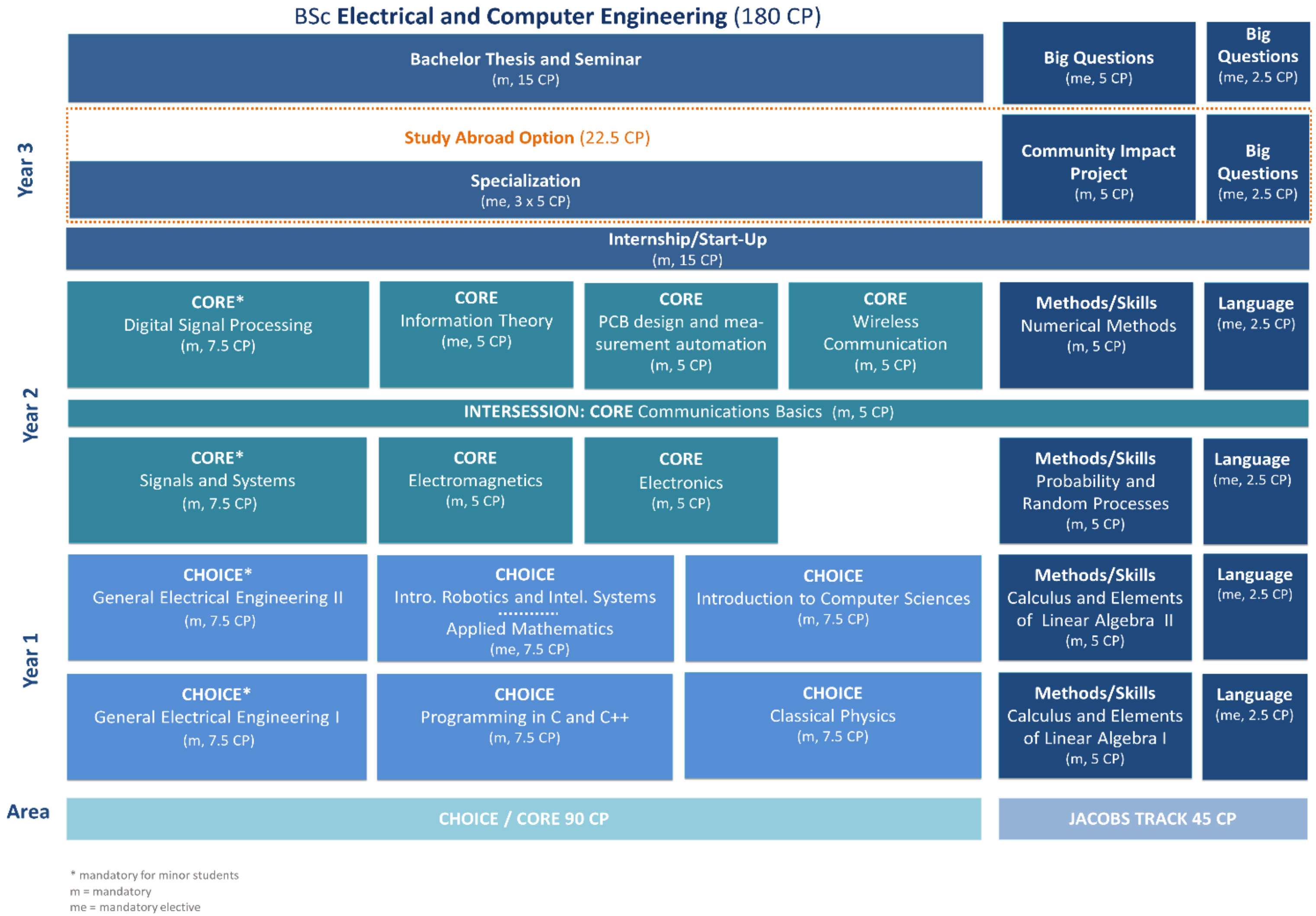

Figure 2: Schematic Study Plan

Electrical and Computer Engineering (ECE) BSc

Matriculation Fall 2022

	Program-Specific Modules	Type	Assessment	Period	Status[1]	Sem.	CP
Year 1 - CHOICE *Take the mandatory CHOICE modules listed below, this is a requirement for the ECE program.*							**45**
	Unit: General Electrical Engineering (default minor)						**15**
CH-210	**Module: General Electrical Engineering I**				**m**	**1**	**7.5**
CH-210-A	General Electrical Engineering I Lecture	Lecture	Written exam	Examination period			5
CH-210-B	General Electrical Engineering Lab I	Lab	Lab report	During the semester			2.5
CH-211	**Module: General Electrical Engineering II** (pre-requisites GenEE I)				**m**	**2**	**7.5**
CH-211-A	General Electrical Engineering II Lecture	Lecture	Written exam	Examination period			5
CH-211-B	General Electrical Engineering Lab II	Lab	Lab report	During the semester			2.5
							30
CH-230	**Module: Programming in C and C++**				**m**	**1**	**7.5**
CH-230-A	Programming in C and C++	Lecture	Written examination	Examination period			2.5
CH-230-A	Programming in C and C++ Tutorial	Turorial	Practical Assessment	During the semester			5
CH-140	**Module: Classical Physics**				**m**	**1**	**7.5**
CH-140-A	Classical Physics	Lecture	Written exam	Examination period			5
CH-140-B	Classical Physics Lab	Lab	Lab report	During the semester			2.5
CH-232	**Module: Introduction to Computer Science**				**m**	**2**	**7.5**
CH-232-A	Introduction to Computer Science	Lecture	Written examination	Examination period			
Take one of the two listed mandatory elective CHOICE modules:							
CH-220	**Module: Introduction to Robotics and Intelligent Systems**				**me**	**2**	**7.5**
CH-220-A	Introduction to Robotics and Intelligent Systems	Lecture	Written exam	Examination period			5
CH-220-B	Introduction to Robotics and Intelligent Systems Lab	Lab	Lab report				2.5
CH-202	**Module: Applied Mathematics**				**me**	**2**	**7.5**
CH-202-A	Advanced Calculus	Lecture	Written exam	Examination period			5
CH-202-B	Numerical Software Lab	Lab	Lab report				2.5
Year 2 - CORE *Take all CORE modules listed below*							**45**
	Unit: Signal Processing (default minor)						**15**
CO-520	**Module: Signals and Systems**				**m**	**3**	**7.5**
CO-520-A	Signals and Systems Lecture	Lecture	Written exam	Examination period			5
CO-520-B	Signals and Systems Lab	Lab	Lab report	During the semester			2.5
CO-521	**Module: Digital Signal Processing**				**m**	**4**	**7.5**
CO-521-A	Digital Signal Processing Lecture	Lecture	Written exam	Examination period			5
CO-521-B	Digital Signal Processing Lab	Lab	Lab report	During the semester			2.5
	Unit: Communications						**10**
CO-522	**Module: Communications Basics**				**m**	**3**	**5**
CO-522-A	Communications Basics Lecture	Lecture	Written exam	Examination period			2.5
CO-522-B	Communications Basics Lab	Lab	Lab report	During the semester			2.5
CO-523	**Module: Wireless Communication**				**m**	**4**	**5**
CO-523-A	Wireless Communication I	Lecture	Written exam	Examination period			5
	Unit: Electromagnetics and Information Theory						**10**
CO-524	**Module: Electromagnetics**				**m**	**3**	**5**
CO-524-A	Electromagnetics	Lecture	Written exam	Examination period			5
CO-525	**Module: Information Theory**				**m**	**4**	**5**
CO-525-A	Information Theory	Lecture	Written exam	Examination period			5
	Unit: Hardware						**10**
CO-526	**Module: Electronics**				**m**	**3**	**5**
CO-526-A	Electronics Lecture	Lecture	Written exam	Examination period			2.5
CO-526-B	Electronics Lab	Lab	Lab report	During the semester			2.5
CO-527	**Module: PCB design and measurement automation**				**m**	**4**	**5**
CO-527-A	PCB design and measurement automation	Lab	Written exam Lab report	Examination period During the semester			5
Year 3 - CAREER							**45**
CA-INT-900	**Module: Internship / Startup and Career Skills**				**m**	**4/5**	**15**
CA-INT-900-0	Internship / Startup and Career Skills	Internship	Report or Businessplan	During the 5th semester			15
CA-ECE-800	**Module: Thesis / Seminar ECE**				**m**	**6**	**15**
CA-ECE-800-T	Thesis ECE	Thesis	Thesis	15th of May			12
CA-ECE-800-S	Seminar ECE	Seminar	Presentation	During the semester			3
	Unit: Specialization ECE				**m**	**5/6**	**15**
Take a total of 15 CP of specializatopn modules							
CA-S-ECE-801	Wireless Communication II	Lecture	Written exam	Examination period	me	5	5
CA-S-ECE-802	Coding Theory	Lecture	Written exam	Examination period	me	5	5
CA-S-ECE-803	Digital Design	Lecture/Lab	Written exam	Examination period	me	5	5
CA-S-ECE-804	Radio-Frequency (RF) Design	Lecture	Written exam	Examination period	me	6	5

	Jacobs Track Modules (General Education)	Type	Assessment	Period	Status[1]	Sem.	CP
Year 1							**15**
	Unit: Methods / Skills						**10**
JTMS-MAT-09	**Module: Calculus and Elements of Linear Algebra I**				**m**	**1**	**5**
JTMS-09	Calculus and Elements of Linear Algebra I	Lecture	Written exam	Examination period			
JTMS-MAT-10	**Module: Calculus and Elements of Linear Algebra II**				**m**	**2**	**5**
JTMS-10	Calculus and Elements of Linear Algebra II	Lecture	Written exam	Examination period			
	Unit: Language				**m**		**5**
	German is the default language. Native German speakers take modules in another offered language.						
JTLA	**Module: Language 1**				**m**	**1**	**2.5**
JTLA-xxx	Language 1	Seminar	Various	Various	me		
JTLA-xxx	**Module: Language 2**				**m**	**2**	**2.5**
JTLA-xxx	Language 2	Seminar	Various	Various	me		
Year 2							**15**
	Unit: Methods / Skills						**10**
JTMS-MAT-12	**Module: Probability and Random Processes**				**m**	**3**	**5**
JTMS-12	Probability and Random Processes	Lecture	Written exam	Examination period			
JTMS-MAT-13	**Module: Numerical Methods**				**m**	**4**	**5**
JTMS-13	Numerical Methods	Lecture	Written exam	Examination period			
	Unit: Language						**5**
	German is the default language. Native German speakers take modules in another offered language.						
JTLA	**Module: Language 3**				**m**	**3**	**2,5**
JTLA-xxx	Language 3	Seminar	Various	Various	me		
JTLA	**Module: Language 4**				**m**	**4**	**2,5**
JTLA-xxx	Langauge 4	Seminar	Various	Various	me		
Year 3							**15**
	Unit: Big Questions						**10**
JTBQ	**Module: Big Questions**				**m**	5/6	
Take a total of 10 CP of Big Questions modules with each 2.5 - 5 CP		Lecture	Various	Various	me		10
	Unit: Community Impact Project						**5**
JTCI-CI-950	**Module: Community Impact Project**				**m**	**5**	**5**
JTCI-950	Community Impact Project	Project	Project	Examination period			
Total CP							**180**

[1] Status (m = mandatory, me = mandatory elective)

[2] For a full listing of all CHOICE / CORE / CAREER / Jacobs Track modules please consult the CampusNet online catalogue and /or the study program handbooks.

Figure 3: Schematic Study and Examination Plan

7 Electrical and Computer Engineering Modules

7.1 General Electrical Engineering I

Module Name	*Module Code*	*Level (type)*	*CP*
General Electrical Engineering I	CH-210	Year 1 (CHOICE)	7.5

Module Components

Number	*Name*	*Type*	CP
CH-210-A	General Electrical Engineering I	Lecture	5
CH-210-B	General Electrical Engineering Lab I	Lab	2.5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Prof. Dr. Giuseppe Abreu	• Electrical and Computer Engineering (ECE)	Mandatory for ECE and RIS

Entry Requirements

Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*
☒ None	☒ None	• Basic mathematics, including notions of vectors, matrices functions, and complex numbers

Frequency	*Forms of Learning and Teaching*
Annually (Fall)	• Lecture (35 hours) • Lab (25.5 hours) • Private Study (127)

Duration	*Workload*
1 semester	187.5 hours

Recommendations for Preparation

It is highly recommended that students familiarize themselves with the contents of the appendices of a typical introductory textbook on Electrical Engineering (e.g. "*Fundamentals of Electric Circuits"*, by Alexander and Sadiku and *"Basic Engineering Circuit Analysis"*, by Irwin and Nelms), including Complex Numbers and basic Linear Algebra (in particular the solution of simultaneous linear equations). In addition, it is recommended that students acquire Calculus basics (differentiation and integration of simple functions).

Content and Educational Aims

The module, consisting of a lecture, supported by corresponding lab experiments, comprises the classical introduction to Electrical and Computer Engineering (ECE), starting from the basics of the electric phenomenon, its fundamental elements (charge, current, potential, energy, etc.), its interaction with materials (conductivity, capacitance, inductance, etc.) and its manipulation by man-made structures (electronic components and circuits). The module then develops into a wide set of general principles, laws and analytical tools to understand electric circuits and electric systems in general. The module also offers a solid foundation on which specialization areas in EE (*e.g.* Communications, Control, etc.) are built. The emphasis is the analysis of circuits in DC steady state and transient modes. Classic material include (but are not limited to): Kirchhoff's Laws, Volta's Law (capacitance), Faraday's Law (inductance), Thevenin and Norton's Theorem, Tellegen's Theorem, delty-wye transformation, source transformations, basics of non-linear electronic components (diodes and transistors), OpAmp circuits, State-space Method, Laplace Transform applied to the analysis of higher-order circuits, Laplace impedances and transfer functions. In the lab portion of the module, users will familiarize themselves with electronic components (resistors, capacitors, inductors, diodes, OpAmps, transistors, etc.) and circuits, and learn how to utilize typical lab equipment (such as breadboards, digital multimeters, voltage and current sources and function generators) required for the assembly and analysis of electric circuits.

Intended Learning Outcomes

By the end of this module, students should be able to

1. describe the fundamental physical principles of electric quantities (charge, current, potential, energy and its conservation, etc.);
2. explain how the aforementioned quantities relate to each other and interact with matter, including corresponding mathematical models;
3. explain how the aforementioned models can be utilized to manipulate electric quantities and phenomenon in the form of electric and electronic circuits or machines that perform several tasks and functions according to intended designs;
4. employ various theoretical and practical tools to analyze electric circuits including resistive circuits, reactive circuits, and OpAmp circuits, both in DC steady-state and transient modes.

In addition to the aforementioned outcomes, fundamental to a career in ECE, students will also have acquired:

5. analytical and mathematical modeling skills useful to study other physical systems (*e.g.* in other areas of Engineering, Physics, Robotics, etc.)
6. the ability to work in a lab environment and operate lab equipment, as required in other professions (e.g. Physics, Biology, Chemistry etc.).

Usability and Relationship to other Modules

- Prerequisite to General Electrical Engineering 2
- Mandatory for a major and minor in ECE.
- Mandatory for a major in RIS.

Indicative Literature

Charles K. Alexander and Matthew N. O. Sadiku, Fundamentals of Electric Circuits, 3rd ed., McGraw-Hill, 2008 (Primary Textbook).

J. David Irwin and R. Mark Nelms, Basic Engineering Circuit Analysis, 10th ed., Wiley, 2010 (Recommended Reference).

James Nilsson and Susan Riedel, Electric Circuits, 10th ed., Pearson, 2015 (Extra Reference).

A. Agarwal and J. Lang, Foundations of Analog and Digital Electronic Circuits, 1st ed., Elsevier, 2005 (Advanced Reference for selected topics).

Examination Type: Module Component Examinations

Module Component 1: Lecture

Assessment Type: Written examination — Duration: 120 min; Weight: 67%

Scope: Intended learning outcomes of the lecture (1-3,5)

Module Component 2: Lab

Assessment Type: Lab reports — Length: 5-10 pages per experiment session; Weight: 33%

Scope: Intended learning outcomes of the lab (3-4, 6).

Completion: To pass this module, the examination of each module component has to be passed with at least 45%.

7.2 General Electrical Engineering II

<table>
<tr><td colspan="3">Module Name
General Electrical Engineering II</td><td>Module Code
CH-211</td><td>Level (type)
Year 1 (CHOICE)</td><td>CP
7.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CH-211-A</td><td colspan="3">General Electrical Engineering II</td><td>Lecture</td><td>5</td></tr>
<tr><td>CH-211-B</td><td colspan="3">General Electrical Engineering Lab II</td><td>Lab</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Giuseppe Abreu</td><td colspan="3">Program Affiliation

• Electrical and Computer Engineering (ECE)</td><td colspan="2">Mandatory Status

Mandatory for ECE students</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ CH-210 General Electrical Engineering I
Co-requisites: ☒ None
Knowledge, Abilities, or Skills: • Basic mathematics, including notions of Calculus and Linear Algebra</td><td>Frequency

Annually (Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (35 hours)
• Lab (25.5 hours)
• Private Study (127)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

187.5 hours</td></tr>
</table>

Recommendations for Preparation

Review Basic mathematics, including notions of Calculus and Linear Algebra.

Content and Educational Aims

This module continues with the classical introduction to Electrical and Computer Engineering (ECE), developing beyond the contents introduced in CH10-GenEE11, towards building the foundations upon which modern specialization areas in ECE such as Signal Processing, Communications, and Control are based. We start with the concepts of Impedance and Phasors, followed by the introduction of the Fourier Trigonometric and Exponential Series, and later, the Fourier Transform. Using these tools as a basis, we revise various elementary circuits first studied in CH10-GenEE1 under the Laplace framework, this time emphasizing the notions of frequency (oscillation rate) and phase (rotation), thus establishing the fundamental concepts required to understand Signals and Systems, and Digital Signal Processing, to be studied in the second year. Besides the already mentioned fundamental tools of Fourier analysis, some of the classical material covered in the module include, but is not limited to: Impedances and Phasors (in the frequency domain), the Parseval Theorem (in the context of power analysis), magnetic coupling, Bode plots (in amplitude and phase), spectral graphs, the Convolution Integral and more.

Intended Learning Outcomes

By the end of this module, students should be able to

1. explain the fundamental physical principle of oscillation and its frequency representation, in particular in the context of AC circuits;
2. explain how to mathematically model the oscillatory (or periodic) phenomena in the frequency domain, in light of Fourier Analysis;
3. explain how the latter Fourier tool extends beyond periodic phenomena, building the basic framework of general spectral analysis of physical systems, with emphasis on electric systems and signals;

4. design and analyze electronic circuits and their signals (e.g. time-varying voltages and currents) requiring certain tasks and functions according to intended objectives.

In addition to the aforementioned outcomes, fundamental to a career in ECE, students will also have acquired:

5. Analytical and mathematical modeling skills useful to study other physical systems (*e.g.* in other areas of Engineering, Physics, Robotics, etc.)
6. Ability to work in a lab environment and operate lab equipment, as required in other professions (e.g. Physics, Biology, Chemistry etc.).

Indicative Literature

Charles K. Alexander and Matthew N. O. Sadiku, Fundamentals of Electric Circuits, 3rd ed., McGraw-Hill, 2008 (Primary Textbook).

J. David Irwin and R. Mark Nelms, Basic Engineering Circuit Analysis, 10th ed., Wiley, 2010 (Recommended Reference).

James Nilsson and Susan Riedel, Electric Circuits, 10th ed., Pearson, 2015 (Extra Reference).

A. Agarwal and J. Lang, Foundations of Analog and Digital Electronic Circuits, 1st ed., Elsevier, 2005 (Advanced Reference for selected topics).

Usability and Relationship to other Modules

- Prerequisite to Signals and Systems
- Mandatory for a major and minor in ECE

Examination Type: Module Component Examinations

Module Component 1: Lecture

Assessment Type: Written examination — Duration: 120 min, Weight: 67%

Scope: Intended learning outcomes of the lecture (1-3,5).

Module Component 2: Lab

Assessment Type: Lab reports — Length: 5-10 pages per experiment session, Weight: 33%

Scope: Intended learning outcomes of the lab (4, 6).

Completion: To pass this module, the examination of each module component has to be passed with at least 45%.

7.3 Programming in C and C++

Module Name	*Module Code*	*Level (type)*	*CP*
Programming in C and C++	CH-230	Year 1 (CHOICE)	7.5

Module Components

Number	*Name*	*Type*	*CP*
CH-230-A	Programming in C and C++	Lecture	2.5
CH-230-B	Programming in C and C++ - Tutorial	Tutorial	5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Dr. Kinga Lipskoch	• Computer Science (CS)	Mandatory for CS, RIS and ECE

Entry Requirements

Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*
☒ None	☒ None	☒ None

Frequency

Annually (Fall)

Forms of Learning and Teaching

- Lecture attendance (17,5 hours)
- Tutorial attendance (35 hours)
- Independent study (115 hours)
- Exam preparation (20 hours)

Duration	*Workload*
1 semester	187.5 hours

Recommendations for Preparation

It is recommended that students install a suitable programming environment on their notebooks. It is recommended to install a Linux system such as Ubuntu, which comes with open-source compilers such as gcc and g++ and editors such as vim or emacs. Alternatively, the open-source Code: Blocks integrated development environment can be installed to solve programming problems.

Content and Educational Aims

This course offers an introduction to programming using the programming languages C and C++. After a short overview of the program development cycle (editing, preprocessing, compiling, linking, executing), the module presents the basics of C programming. Fundamental imperative programming concepts such as variables, loops, and function calls are introduced in a hands-on manner. Afterwards, basic data structures such as multidimensional arrays, structures, and pointers are introduced and dynamically allocated multidimensional arrays and linked lists and trees are used for solving simple practical problems. The relationships between pointers and arrays, pointers and structures, and pointers and functions are described, and they are illustrated using examples that also introduce recursive functions, file handling, and dynamic memory allocation.

The module then introduces basic concepts of object-oriented programming languages using the programming language C++ in a hands-on manner. Concepts such as classes and objects, data abstractions, and information hiding are introduced. C++ mechanisms for defining and using objects, methods, and operators are introduced and the relevance of constructors, copy constructors, and destructors for dynamically created objects is explained. Finally, concepts such as inheritance, polymorphism, virtual functions, and overloading are introduced. The learned concepts are applied by solving programming problems.

Intended Learning Outcomes

By the end of this module, students will be able to

- explain basic concepts of imperative programming languages such as variables, assignments, loops, and function calls;
- write, test, and debug programs in the procedural programming language C using basic C library functions;
- demonstrate how to use pointers to create dynamically allocated data structures such as linked lists;
- explain the relationship between pointers and arrays;
- illustrate basic object-oriented programming concepts such as objects, classes, information hiding, and inheritance;
- give original examples of function and operator overloading and polymorphism;
- write, test, and debug programs in the object-oriented programming language C++.

Indicative Literature

Brian Kernighan, Dennis Ritchie: The C Programming Language, 2nd edition, Prentice Hall Professional Technical Reference, 1988.

Steve Oualline: Practical C Programming, 3rd edition, O'Reilly Media, 1997.

Bruce Eckel: Thinking in C++: Introduction to Standard C++, Prentice Hall, 2000.

Bruce Eckel, Chuck Allison: Thinking in C++: Practical Programming, Prentice Hall, 2004.

Bjarne Stroustrup: The C++ Programming Language, 4th edition, Addison Wesley, 2013.

Michael Dawson: Beginning C++ Through Game Programming, 4th edition, Delmar Learning, 2014.

Usability and Relationship to other Modules

- Mandatory for a major in CS, RIS, and ECE
- Mandatory for a minor in CS and RIS
- Pre-requisite for the CHOICE module Algorithms and Data Structures
- Elective for all other undergraduate study programs
- This module introduces the programming languages C and C++ and several other modules build on this foundation. Certain features of C++ such as templates and generic data structures and an overview of the standard template library will be covered in the Algorithms and Data Structures module.

Examination Type: Module Component Examinations

Component 1: Lecture

Assessment types: Written examination

Duration: 120 min
Weight: 33%

Scope: All theoretical intended learning outcomes of the module

Component 2: Tutorial

Assessment: Practical assessment (Programming assignments)

Weight: 67%

Scope: All practical intended learning outcomes of the module

Completion: To pass this module, the examination of each module component has to be passed with at least 45%.

7.4 Classical Physics

<table>
<tr><td colspan="3">Module Name
Classical Physics</td><td>Module Code
CH-140</td><td>Level (type)
Year 1
(CHOICE)</td><td>CP
7.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CH-140-A</td><td colspan="3">Classical Physics</td><td>Lecture</td><td>5</td></tr>
<tr><td>CH-140-B</td><td colspan="3">Classical Physics Lab</td><td>Lab</td><td>2.5</td></tr>
<tr><td>CH-140-C</td><td colspan="3">Technical Mechanics Lab (for RIS students only)</td><td>Lab</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Jürgen Fritz</td><td colspan="3">Program Affiliation

• Physics</td><td colspan="2">Mandatory Status

Mandatory for Physic, ECE and RIS</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ None
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• High school physics
• High school math</td><td>Frequency

Annually
(Fall)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (35 hours)
• Lab (25.5 hours)
• Homework (42 hours)
• Private study (85 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

187.5 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

A revision of high school math (especially calculus, analytic geometry, and vector algebra) and high school physics (basics of motion, forces, and energy) is recommended. The level and content follow standard textbooks for calculus-based first-year university physics such as Young & Freedman: University Physics, Halliday & Resnick & Walker: Fundamentals of Physics, and Tipler & Mosca: Physics.</td></tr>
<tr><td colspan="6">Content and Educational Aims
This module introduces students to basic physical principles, facts, and experimental evidence in the fields of classical mechanics, thermodynamics, and optics. It lays the foundations for more advanced physics modules and for other science and engineering disciplines. It is intended for students who already have reasonably solid knowledge of basic physics and mathematics at the high school level.
Emphasis is placed on general physical principles and general mathematical concepts for a thorough understanding of physical phenomena. The lectures are complemented by hands-on work in a teaching lab where students apply their theoretical knowledge by performing experiments as well as related data analysis and presentation. Calculus and vector analysis will be used to develop a scientifically sound description of physical phenomena. An optional tutorial is offered to discuss homework or topics of interest in more detail.
Topics covered in the module include an introduction to mechanics using calculus, vectors, and coordinate systems; concepts of force and energy, momentum and rotational motion, and gravitation and oscillations; and concepts of thermodynamics such as temperature, heat, ideal gas, and kinetic gas theory up to heat engines and entropy. The module content concludes with an introduction to classical optics including refraction and reflection, lenses and optical instruments, waves, interference, and diffraction.
The lectures are complemented by hands-on work in a teaching lab where students apply their theoretical knowledge by performing experiments as well as related data analysis and presentation. The default lab of this module is the Classical Physics Lab offering experiments in mechanics, thermodynamics, and optics. For students</td></tr>
</table>

majoring in RIS a Technical Mechanics Lab is offered with a focus on technical mechanics experiments. Calculus and vector analysis."

Intended Learning Outcomes

By the end of the module, students will be able to

- recall basic facts and experimental evidence in classical mechanics, thermodynamics, and optics;
- understand the basic concepts of motion, force, energy, oscillations, heat, and light and apply them to physical phenomena;
- describe and understand natural and technical phenomena in mechanics, thermodynamics, and optics by reducing them to their basic physical principles;
- apply basic calculus and vector analysis to describe physical systems;
- examine basic physical problems, find possible solutions, and assess them critically;
- set up experiments, analyze their outcomes by using error analysis, and present them properly;
- record experimental data using basic experimental techniques and data acquisition tools;
- use the appropriate format and language to describe and communicate the outcomes of experiments and the solutions to theoretical problems.

Indicative Literature

H. Young & R. Freedman (2011). University Physics, with modern physics. Upper Saddle River: Prentice Hall.

or

D. Halliday, R. Resnick, J. Walker (2018). Fundamentals of Physics, extended version. Hoboken: John Wiley & Sons Inc.

Or

P. Tipler & G. Mosca (2007). Physics for Scientists and Engineers. New York: WH Freeman.

Usability and Relationship to other Modules

- Mandatory for a major in Physics, ECE and RIS
- Mandatory for a minor in Physics
- Prerequisite for first year Physics CHOICE module “Modern Physics”
- Prerequisite for second year Physics CORE modules “Analytical Mechanics” and “Renewable Energy”
- Elective for all other undergraduate study programs

Examination Type: Module Component Examinations

Module Component 1: Lecture

Assessment Type: Written examination (Lecture), Duration: 120 min
Weight: 67%

Scope: Intended learning outcomes of the lecture (1-5).

Module Component 2: Lab (Classical Physics Lab/ Classical Mechanics Lab)

Assessment Type: Lab Reports (Lab), Length: 8-12 pages
Weight: 33%

Scope: Intended learning outcomes of the lab (1, 6-8).

Module achievement: 40% of homework points necessary as prerequisite to take the final exam.

Completion: To pass this module, both module component examinations have to be passed with at least 45%.

7.5 Introduction to Computer Science

Module Name		*Module Code*	*Level (type)*	*CP*
Introduction to Computer Science		CH-232	Year 1 (CHOICE)	7.5
Module Components				
Number	*Name*		*Type*	*CP*
CH-232-A	Introduction to Computer Science		Lecture	7.5
Module Coordinator Prof. Dr. Jürgen Schönwälder	*Program Affiliation* • Computer Science (CS)		*Mandatory Status* Mandatory for CS, ECE and RIS	
Entry Requirements *Pre-requisites* ☒ None	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills*	*Frequency* Every semester (Fall/Spring)	*Forms of Learning and Teaching* • Class (52.5 hours) • Independent study (115 hours) • Exam preparation (20 hours)
			Duration 1 semester	*Workload* 187.5 hours

Recommendations for Preparation

It is recommended that students install a Linux system such as Ubuntu on their notebooks and that they become familiar with basic tools such as editors (vim or emacs) and the basics of a shell. The Glasgow Haskell Compiler (GHC) will be used for implementing Haskell programs.

Content and Educational Aims

The module introduces fundamental concepts and techniques of computer science in a bottom-up manner. Based on clear mathematical foundations (which are developed as needed), the course discusses abstract and concrete notions of computing machines, information, and algorithms, focusing on the question of representation versus meaning in Computer Science.

The module introduces basic concepts of discrete mathematics with a focus on inductively defined structures, to develop a theoretical notion of computation. Students will learn the basics of the functional programming language Haskell because it treats computation as the evaluation of pure and typically inductively defined functions. The module covers a basic subset of Haskell that includes types, recursion, tuples, lists, strings, higher-order functions, and finally monads. Back on the theoretical side, the module covers the syntax and semantics of Boolean expressions and it explains how Boolean algebra relates to logic gates and digital circuits. On the technical side, the course introduces the representation of basic data types such as numbers, characters, and strings as well as the von Neuman computer architecture. On the algorithmic side, the course introduces the notion of correctness and elementary concepts of complexity theory (big O notation).

Intended Learning Outcomes

By the end of this module, students will be able to

- explain basic concepts such as the correctness and complexity of algorithms (including the big O notation);
- illustrate basic concepts of discrete math (sets, relations, functions);
- recall basic proof techniques and use them to prove properties of algorithms;
- explain the representation of numbers (integers, floats), characters and strings, and date and time;
- summarize basic principles of Boolean algebra and Boolean logic;
- describe how Boolean logic relates to logic gates and digital circuits;
- outline the basic structure of a von Neumann computer;
- explain the execution of machine instructions on a von Neumann computer;
- describe the difference between assembler languages and higher-level programming languages;
- define the differences between interpretation and compilation;
- illustrate how an operating system kernel supports the execution of programs;
- determine the correctness of simple programs;
- write simple programs in a pure functional programming language.

Indicative Literature

Eric Lehmann, F. Thomson Leighton, Albert R. Meyer: Mathematics for Computer Science, online 2018.

David A. Patterson, John L Hennessy: Computer Organization and Design: The Hardware/Software Interface, 4th edition, Morgan Kaufmann, 2011.

Miran Lipovaca: Learn You a Haskell for Great Good!: A Beginner's Guide, 1st edition, No Starch Press, 2011.

Usability and Relationship to other Modules

- Mandatory for a major in CS, ECE and RIS
- Pre-requisite for the CORE modules Automata, Computability, and Complexity and Operating Systems
- This module introduces key mathematical concepts and various notions of computing machines and computing abstractions and is in particularly important for subsequent courses covering theoretical aspects of computer science. This module is also important for courses that require a basic understanding of computer architecture and program execution at the hardware level.

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of the module

Module achievement: 50% of the assignments correctly solved

This module introduces the functional programming language Haskell. Students develop their functional programming skills by solving programming problems. The module achievement ensures that a sufficient level of practical programming and problem-solving skills has been obtained.

7.6 Introduction to Robotics and Intelligent Systems

<table>
<tr><td colspan="2">Module Name
Introduction to Robotics and Intelligent Systems</td><td>Module Code
CH-220</td><td>Level (type)
Year 1
(CHOICE)</td><td>CP
7.5</td></tr>
<tr><td colspan="5">Module Components</td></tr>
<tr><td>Number</td><td colspan="2">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CH-220-A</td><td colspan="2">Introduction to Robotics and Intelligent Systems</td><td>Lecture</td><td>5</td></tr>
<tr><td>CH-220-B</td><td colspan="2">Introduction to Robotics and Intelligent Systems - Lab</td><td>Lab</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Francesco Maurelli</td><td colspan="2">Program Affiliation

• Robotics and Intelligent Systems (RIS)</td><td colspan="2">Mandatory Status

Mandatory for RIS, CS and ECE
Mandatory elective for Physics</td></tr>
<tr><td colspan="2" rowspan="2">Entry Requirements

Pre-requisites
☒ None

Co-requisites
☒ None

Knowledge, Abilities, or Skills
None</td><td>Frequency

Annually
(Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (35 hours)
• Lab (17.5 hours)
• Private study (115 hours)
• Exam preparation (20 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

187.5 hours</td></tr>
<tr><td colspan="5">Recommendations for Preparation

Review basic linear algebra concepts, vector and matrix operations.</td></tr>
<tr><td colspan="5">Content and Educational Aims

This module represents an initial introduction to robotics and intelligent systems, starting from the basics of mathematics and physics applied to simple robotics scenarios. It will cover transformation matrices and quaternions for reference systems. Students will then learn and the basics of trajectory planning and robotic systems. The second part of the module offers an introduction to the modeling and design of linear control systems in terms of ordinary differential equations (ODEs). Students learn how to analyze and solve systems of ODEs using state and frequency space methods. The concepts covered include time and frequency response, stability, and steady-state errors. This part culminates with a discussion on P, PI, PD, and PID controllers. The lab is designed to guide students through practical hands-on work with various components of intelligent systems. It will focus on the interfacing of a microcontroller with commonly used sensors and actuators.</td></tr>
</table>

Intended Learning Outcomes

By the end of this module, successful students will be able to

- compute 3D transformations;
- understand and apply quaternion operations;
- apply trajectory planning techniques;
- model common mechanical and electrical systems;
- understand and apply the unilateral Laplace transform and its inverse;
- explore linear systems and tune their behavior;
- program the open-source electronic prototyping platform Arduino;
- interface Arduino to several different sensors and actuators.

Indicative Literature

R. V. Roy, Advanced Engineering Dynamics. R. V. Roy, 2015.

R. N. Jazar, Theory of Applied Robotics. Springer, 2010.

N.S. Nise, Control Systems Engineering. Wiley, 2010.

Usability and Relationship to other Modules

- Mandatory for a major in RIS, CS, ECE
- Mandatory for a minor in RIS.
- Mandatory elective for a major in Physics.
- This module is the foundation of the CORE modules in the following years.

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of the module

Module achievement: Lab report

7.7 Applied Mathematics

Module Name Applied Mathematics		*Module Code* CH-202	*Level (type)* Year 1 (CHOICE)	*CP* 7.5
Module Components				
Number	*Name*		*Type*	*CP*
CH-202-A	Advanced Calculus and Methods of Mathematical Physics		Lecture	5
CH-202-B	Numerical Software Lab		Lab	2.5
Module Coordinator Prof. Dr. Marcel Oliver, Prof. Dr. Ulrich Kleinekathöfer	*Program Affiliation* • Mathematics		*Mandatory Status* Mandatory for Mathematics Mandatory elective for ECE and Physics	
Entry Requirements *Pre-requisites* ☒ None	*Co-requisites* ☒ None *Knowledge, Abilities, or Skills* • Single-variable Calculus at the level achieved in “Calculus and Elements of Linear Algebra I”	*Frequency* Annually (Spring) *Duration* 1 semester	*Forms of Learning and Teaching* • Lectures (35 hours) • Lab (17.5 hours) • Private study (135 hours) *Workload* 187.5 hours	

Recommendations for Preparation

Recapitulate single variable Calculus at a level of at least “Calculus and Elements of Linear Algebra I”

Content and Educational Aims

This module covers advanced topics from calculus that are part of the core mathematics education of every Physicist and also forms a fundamental part of the mathematics major. It features examples and applications from the physical sciences. The module is designed to be taken with minimal pre-requisites and is tightly coordinated with the parallel module Calculus and Elements of Linear Algebra II. The style of development strives for rigor, but avoids abstraction and prefers simplicity over generality.

Topics covered include:

- Taylor series, power series, uniform convergence
- Advanced concepts from multivariable differential calculus, here mainly the inverse and implicit function theorem; elementary vector calculus and Lagrange multipliers are covered in Calculus and Elements of Linear Algebra II
- Riemann integration in several variables, and line integrals
- The Gauss and Stokes integral theorems

- Change of variables and integration in polar coordinates
- Fourier integrals and distributions
- Applications to partial differential equations that are important in physics (Laplace, Poisson, diffusion, wave equations)
- Very brief introduction to complex analysis (Cauchy formula and residue theorem)

The lecture part is complemented by a lab course in Numerical Software (Scientific Python), which has become an essential tool for numerical computation and data analysis in many areas of mathematics, physics, and other sciences. Topics include:

- Writing vectorized code using NumPy arrays
- An introduction to SciPy for special functions and black-boxed algorithms (root solvers, quadrature, ODE solvers, and fast Fourier transform)
- Visualization using Matplotlib, including a general introduction to the effective visualization of scientific data and concepts
- The lab also includes a very brief comparative introduction to MATLAB, another standard numerical tool.

Intended Learning Outcomes

By the end of the module, students will be able to

1. apply series expansions in a variety of mathematical and scientific contexts;
2. solve, simplify, and transform integrals in several dimensions;
3. explain the intuition behind the major theorems;
4. use the major theorems in an application context;
5. compute Fourier transforms and apply them to problems in Calculus and Partial Differential Equations;
6. distinguish differentiability in a complex from a real variable;
7. use numerical software to support simple numerical tasks and to visualize data.

Indicative Literature

S. Kantorovitz (2016). Several Real Variables, Berlin: Springer.
K. Riley, M. Hobson, S. Bence (2006). Mathematical Methods for Physics and Engineering, third edition. Cambridge: Cambridge University Press.
D.J. Pine (2018). Introduction to Python for Science and Engineering. Boca Raton: CRC Press.

Usability and Relationship to other Modules

- This module is a mandatory part of the core education in Mathematics.
- Mandatory elective for a major in Physics and ECE
- The curriculum is tightly integrated with the curriculum of the modules “Calculus and Elements of Linear Algebra I and II”.
- It is also valuable for students in Computer Science, RIS, either as part of a minor in Mathematics, or as an elective module.
- This module is an elective for students of all other undergraduate studies.

Examination Type: Module Component Examinations

Module Component 1: Lecture

Assessment Type: Written examination — Duration: 120 min, Weight: 67%

Scope: Intended learning outcomes of the lecture (5, 7).

Module Component 2: Lab

Assessment Type: Lab report Length: Approx. 30 pages, Weight: 33%

Scope: Intended learning outcomes of the lab (1-6).

Completion: To pass this module, both module component examinations have to be passed with at least 45%.

7.8 Signals and Systems

<table>
<tr><td colspan="3">Module Name
Signals and Systems</td><td>Module Code
CO-520</td><td>Level (type)
Year 2 (CORE)</td><td>CP
7.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-520-A</td><td colspan="3">Signals and Systems</td><td>Lecture</td><td>5</td></tr>
<tr><td>CO-520-B</td><td colspan="3">Signals and Systems - Lab</td><td>Lab</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Werner Henkel</td><td colspan="3">Program Affiliation

• Electrical and Computer Engineering (ECE)</td><td colspan="2">Mandatory Status

Mandatory for ECE</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ General Electrical Engineering I General Electrical Engineering II
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• Linear Circuits
• Complex description for sinusoidal sources
• Some concepts of linear transforms / convolution
• Matlab</td><td>Frequency

Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (35 hours)
• Lab (25.5 hours)
• Private Study (127)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

187.5 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Revise linear circuits and transforms and Matlab from your 1st year, and get textbook & lab material. See dedicated Module Web pages for details (links on CampusNet).</td></tr>
<tr><td colspan="6">Content and Educational Aims

This module offers a comprehensive exploration of signals and systems which is the key knowledge for almost all electrical engineering tasks. Continuous-time and discrete-time concepts/methods are developed in parallel, highlighting their similarities and differences. Central is the coverage of all linear transforms.
Introductory treatments of the applications of these basic methods in such areas as filtering, communication, sampling, discrete-time processing of continuous-time signals, and feedback, will be discussed. We are also covering stability, minimum and maximum phase, delay, group delay and characteristic impedance of two-ports to build cascades of filter blocks. The module contains also a short treatment of analog modulation methods, such as amplitude, single-sideband and vestigial-sideband, frequency, and phase modulation.

The practical lab contains experiments addressing transient and frequency response with some RLC circuits, Fourier series and transform, sampling, AM and FM modulation.</td></tr>
</table>

Intended Learning Outcomes

By the end of this module, students should be able to

1. explain all linear transforms with all their properties and the links between them;
2. apply linear transforms to time-continuous and time-discrete problems;
3. describe the function of poles and zeros, and the meaning of stability, minimum phase, delay and group delay functions;
4. describe the link between pole and zero locations and the resulting transfer function;
5. apply the major concepts of the module (such as time and frequency-domain, sampling, and analog modulation) to practical problems using function generators, digital scopes, and Matlab.

Indicative Literature

Alan V. Oppenheim, Alan S. Willsky, with S. Hamid Nawab, *Signals and Systems*, 2^{nd} ed., Pearson, 2017.

Usability and Relationship to other Modules

- Pre-requisite for Digital Signal Processing (CO-521) and also many other 2^{nd} & 3^{rd} year ECE modules
- Elective for all other study programs
- This module builds on the GenEE1 and GenEE2 modules and prepares the students for advanced modules in their 2^{nd} & 3^{rd} year
- Mandatory for a major and minor in ECE.

Examination Type: Module Component Examinations

Module Component 1: Lecture

Assessment Type: Written examination
Duration: 120 min
Weight: 67%

Scope: Intended learning outcomes of the lecture (1-4).

Module Component 2: Lab

Assessment Type: Lab reports
Length: 5-10 pages per experiment session
Weight: 33%

Scope: Intended learning outcomes of the lab (2,5).

Completion: To pass this module, the examination of each module component has to be passed with at least 45%.

7.9 Digital Signal Processing

<table>
<tr><td colspan="3">Module Name
Digital Signal Processing</td><td>Module Code
CO-521</td><td>Level (type)
Year 2 (CORE)</td><td>CP
7.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-521-A</td><td colspan="3">Digital Signal Processing</td><td>Lecture</td><td>5</td></tr>
<tr><td>CO-521-B</td><td colspan="3">Digital Signal Processing Lab</td><td>Lab</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Werner Henkel</td><td colspan="3">Program Affiliation

• Electrical and Computer Engineering (ECE)</td><td colspan="2">Mandatory Status

Mandatory for ECE</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ General Electrical Engineering I; ☒ General Electrical Engineering II; ☒ Signals and Systems

Co-requisites: ☒ None

Knowledge, Abilities, or Skills:
• Signal description with linear transforms,
• Linear circuits and their description with linear transforms
• Familiarity with bilateral and unilateral Laplace transforms
• Matlab and C programming</td><td>Frequency

Annually (Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (35 hours)
• Private study for lecture (90 hours)
• Lab (24 hours)
• Private Study for lab (38.5)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

187.5 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Revise linear transforms, especially Laplace transforms, get textbook & lab material. See dedicated module Web pages for details (links on CampusNet).</td></tr>
<tr><td colspan="6">Content and Educational Aims

The module is a combination of standard Digital Signal Processing (DSP) contents and applications in digital communications. The standard DSP contents are linear transforms, sampling theorem, quantization, networks with delay elements, difference equations, filter structures (implementations in C/Matlab), z-transform, frequency-domain characterization (Parseval), DFT, window functions, frequency response of frequency-selective filters, fast convolution (overlap save, overlap add), power spectral density, periodogram, design of poles and zeros, least squares identification and prediction (LPC, Toeplitz algorithms), design of digital filters (short introduction to wave digital filters), sampling rate conversion, subband coding, FFT algorithms, quadrature mirror filters, filter banks, two-dimensional transforms, discrete cosine transform, (wavelets) and an introduction to video coding. The communications part is essentially an introduction to digital communications with channel properties, passband and complex baseband description, PAM, QAM, matched filter, whitened matched filter, equalizer structures and its adaptation with LMS and ZF. An introduction to multicarrier transmission (OFDM, DMT) and the relation to filter banks will be given, too. OFDM and DMT are the transmission methods used in every current wireless and wireline system (LTE, DSL, DVB-t, etc.). Overall, the module provides a complete coverage of digital signal processing and the essential basics of digital communications. The module is hence mandatory for ECE and central for students with a focus towards signal processing, video and audio, and communications.</td></tr>
</table>

This lab component compliments the lecture by providing hands-on experience in practical development of a communications system using Digital Signal Processors. Note that although the focus is on DSP in this module, many of the concepts learned also apply to embedded development, which is also becoming increasingly important in our electronic world.

Intended Learning Outcomes

By the end of this module, students should be able to

1. model and analyze signals mathematically, enable their manipulation (filtering, recovery, sampling, etc.) and design various engineering applications;
2. apply digital signal processing methods to speech, audio, and video signal processing, automation, and control systems;
3. understand all major digital communications methods, be it baseband, single-carrier, multi-carrier, or spread spectrum;
4. understand the essential components of a transmission chain from the transmitter to detection at a receiver, including multiple-input and multiple-output systems;
5. implement digital signal processing and digital communications methods;
6. be familiar with digital signal processors.

Indicative Literature

John G. Proakis and Dimitris G. Manolakis, *Digital Signal Processing*, 3rd ed., Prentice Hall, 1996.

Alan V. Oppenheim, Ronald W. Schafer, *Digital Signal Processing*, Pearson, 1974.

Edward A. Lee, David G. Messerschmitt, *Digital Communication*, 2nd ed., Kluwer, 1994.

John G. Proakis and Massoud Salehi, 5th ed., *Digital Communications*, 2007.

Usability and Relationship to other Modules

- Important basis for all advanced modules in Signal Processing and Communications.
- Wireless Communication (CO-523) together with DSP and the earlier introductory Communications Basics module (CO-522) will provide a wide coverage of analog and digital communications methods.
- In Coding Theory (CA-ECE-802), some interesting links will become visible, e.g., using convolution in so-called convolutional codes, other conceptually similar Toeplitz algorithm, the DFT to define Reed-Solomon codes.
- The Module Control Systems (CO-545 / RIS) is a nice counterpart of Signals and Systems plus Digital Signal Processing, especially, adding aspects of stability from a different angle.
- Mandatory for a major and minor in ECE.

Examination Type: Module Component Examinations

Module Component 1: Lecture

Assessment Type: Written examination — Duration: 120 min, Weight: 67%

Scope: Intended learning outcomes of the lecture (1-4).

Module Component 2: Lab

Assessment Type: Lab reports — Length: 5-10 pages per experiment session, Weight: 33%

Scope: Intended learning outcomes of the lab (5-6).

Completion: To pass this module, the examination of each module component has to be passed with at least 45%.

7.10 Communication Basics

<table>
<tr><td colspan="3">Module Name
Communication Basics</td><td>Module Code
CO-522</td><td>Level (type)
Year 2 (CORE)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-522-A</td><td colspan="3">Communications Basics</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>CO-522-B</td><td colspan="3">Communications Basics Lab</td><td>Lab</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Dr. Mathias Bode</td><td colspan="3">Program Affiliation

• Electrical and Computer Engineering (ECE)</td><td colspan="2">Mandatory Status

Mandatory for ECE students</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ General Electrical Engineering I&II
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• Linear Transforms (Fourier)
• Matlab</td><td>Frequency

Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (35 hours)
• Lab (25.5 hours)
• Private study (64.5)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Revise linear transforms and Matlab from your 1st year, and get textbook & lab material. See dedicated module Web pages for details (links on CampusNet).</td></tr>
<tr><td colspan="6">Content and Educational Aims

The module comprises the basis for analog and digital communication, and prepares the students for more advanced modules on wireless communication and information theory. Starting from first steps to understand modulation and demodulation procedures with and without noise, students will learn the basics of binary data transmission. The lab course provides hands-on experience with practical development of a communications system using Simulink and Matlab simulations. This includes the design and the implementation of the typical building blocks of a digital transmitter and receiver chain. Topics covered are: BPSK, QPSK, pulse shape, up-conversion, matched filter, PLL, carrier recovery, symbol timing recovery, and demodulation.</td></tr>
<tr><td colspan="6">Intended Learning Outcomes

By the end of this module, students should be able to

1. explain fundamental blocks of a communication chain;
2. model the blocks based on Matlab and Simulink;
3. characterize wide sense stationary random (noise) processes and their transformation by LTI systems;
4. analyze and design basic linear and nonlinear modulation and demodulation blocks;
5. analytically compare different designs with regard to their performance figures like required bandwidth and signal-to-noise ratio;</td></tr>
</table>

6. numerically evaluate performance figures of simulated communication chains.

Indicative Literature

Rodger E. Ziemer, William H. Tranter, *Principles of Communications*, 7th ed., Wiley 2014.

Usability and Relationship to other Modules

- Pre-requisite for 2nd & 3rd year ECE modules on Wireless Communication I + II, and Information Theory
- Elective for all other study programs
- This module builds on the Gen EE I+II modules and prepares the students for advanced modules in their 2nd & 3rd year
- Mandatory for major in ECE.

Examination Type: Module Component Examinations

Module Component 1: Lecture

Assessment Type: Written examination Duration: 120 min
Weight: 50%

Scope: Intended learning outcomes of the lecture (1,3,4,5).

Module Component 2: lab

Assessment Type: Lab reports Length: 5-10 pages per experiment session
Weight: 50%

Scope: Intended learning outcomes of the lab (2,4,5).

Completion: To pass this module, the examination of each module component has to be passed with at least 45%.

7.11 Wireless Communication I

<table>
<tr><td colspan="3">Module Name
Wireless Communication I</td><td>Module Code
CO-523</td><td>Level (type)
Year 2 (CORE)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-523-A</td><td colspan="3">Wireless Communication I</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Giuseppe Abreu</td><td colspan="3">Program Affiliation

• Electrical and Computer Engineering (ECE)</td><td colspan="2">Mandatory Status

Mandatory for ECE</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ Signals & Systems, Comm. Lecture & Lab, Electromagnetics
Co-requisites: ☒ Data Signal Processing, Information Theory
Knowledge, Abilities, or Skills: • Notions of signals and systems, digital communications, and probability.</td><td>Frequency

Annually (Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lectures (35 hours)
• Private Study (90 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

It is recommended that students are in good standing with respect to the listed pre-requistite modules and are capable of writing simple programs, as well as to perform basic operations, in Matlab.</td></tr>
<tr><td colspan="6">Content and Educational Aims

This module builds upon the knowledge gained in Signals and Systems, Electromagnetics, and Communications, developing those further into the set of required tools to analyze and design wireless communications systems. Starting from notions of propagating waves learned in Electromagnetics, and relying on tools studied in Probability, the dedicated theory to mathematically model the various complex phenomena undergone by signals as they propagate in an open medium (e.g. vacuum, air, or water) is described. Within such a theory, the various forms of distortion and impairments suffered by wireless signals, including, e.g., noise, propagation losses, polarization, spectral and temporal dispersion, selectivity and fading, as well as interference are studied, and techniques to engineer signals so as to withstand such hindrances while retaining the ability to convey information are described. Overall, the focus is on classical narrowband point-to-point wireless communications, but occasional incursions into modern methods such as multiple-input multiple-output (MIMO) systems and ultra-wideband communications (UWB) – to cite only a few – are also made. Topics covered include, but are not limited to, statistical characterization of fading (Rayleigh, Rice, Hoyt, and Nakagami) channels, coherent and differential digital modulation, pairwise, symbol and bit-error probabilities, water-filling transmit power optimization, and more. In the process, several tools including probability bounds (e.g. the union bound, Gaussian Q-functions, Chernoff, Chebychev, and Bonferroni bounds) and optimization methods (e.g. Lagrange Multiplier Method, Maximum Ratio Combining, Kullback Leibler Divergence minimization, and Maximum-Entropy Methods) are also introduced, which are useful not only to Wireless Communications, but to the analysis and design of virtually any system afflicted by uncertainties.</td></tr>
</table>

Intended Learning Outcomes

Scope: All intended learning outcomes of the module.

- explain the physical nature of, and the corresponding mathematical/statistical models suitable to describe, the fundamental phenomena afflicting wireless signals;
- describe qualitatively, and quantify statistically, the effects of the aforementioned phenomena on the ability to convey information over various kinds of wireless channels;
- perform essential design steps for modern wireless communications systems taking into account the aforementioned properties and phenomena of wireless communcation.

In addition to the aforementioned outcomes, fundamental to a career in ECE, students will also have acquired:

- analytical and mathematical tools useful to study various systems in which statistical uncertainty plays a major role, examples of which are hypothesis testing methods widely used in experimental sciences (also, e.g., in Biology and Psychology).

Indicative Literature

A. Goldsmith, *Wireless Communications*, 3rd ed., Cambridge, 2005.

D. Tse and P. Vishawanath, *Fundamentals of Wireless Communications*, Cambridge University Press, 2005.

J. Proakis, *Digital Communications*, McGraw-Hill Education, 2007.

M. Simon and M.-S. Alouini, *Digital Communication over Fading Channels*, Willey-IEEE Press, 2004.

T. Rappaport, *Wireless Communications: Principles and Practice,* Pearson, 2014.

Usability and Relationship to other Modules

- Prerequisite for Wireless Communication II
- Mandatory for a major in ECE

Examination Type: Module Examination

Assessment Type: Written examination — Duration: 120 min, Weight: 100%

Scope: All intended learning outcomes of the module.

7.12 Electromagnetics

Module Name Electromagnetics			*Module Code* CO-524	*Level (type)* Year 2 (CORE)	*CP* 5
Module Components					
Number	*Name*			*Type*	*CP*
CO-524-A	Electromagnetics			Lecture	5
Module Coordinator Prof. Dr.-Ing. Werner Henkel	*Program Affiliation* • Electrical and Computer Engineering (ECE)			*Mandatory Status* Mandatory for ECE	
Entry Requirements			*Frequency* Annually (Fall)	*Forms of Learning and Teaching* • Lectures (35 hours) • Private Study (90 hours)	
Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*			
☒ General Electrical Engineering I ☒ General Electrical Engineering II	☒ None	• Basic knowledge of electrical and magnetical fields • Description of resistor, capacitor, inductor	*Duration* 1 semester	*Workload* 125 hours	
Recommendations for Preparation Students should come with a sound understanding of electromagnetic fields and elementary passive components.					

Content and Educational Aims

Unlike other engineering disciplines, the complete theory of electrical engineering can be summarized in four fundamental equations known as Maxwell's equations. This module gives an introduction to the electric and magnetic field theory, leading to Maxwell's equations. The theory is applied to wave propagation problems and guided waves on transmission lines. This knowledge enables us to understand the physics behind electrical signals travelling through lines and electronic devices.

Contents:

- Electric Field: Electric charge, charge distributions, Coulomb's law, electric field, dipoles, electric flux, Gauss' law, potential, capacitance;
- Currents: current density, conductance, superconductors, semiconductors;
- Magnetic Field: magnetic force, magnetic flux, Ampere's law, inductance, Faraday's law, Lenz' law, displacement current, boundary conditions;
- Electromagnetic Waves: Maxwell's equations, electromagnetic waves, radiation, waves on transmission lines.

Intended Learning Outcomes

By the end of this module, students should be able to

- apply Maxwell‘s equations in integral and differential form;
- use vector operators grad, div, curl;
- compute capacity and inductance for given geometries using symmetries and possibly coordinate transformations;

- explain and apply the principle of waves on wave guides (cables and hollow wave guides) and emitted from dipole antennas.

Indicative Literature

Md. Abdus Salam, *Electromagnetic Field Theories for Engineering*, Springer, 2014.

Nathan Ida, *Engineering Electromagnetics*, 2nd ed., Springer, 2004.

William H. Hayt and John A. Buck, *Engineering Electromagnetics*, 8th ed., McGraw-Hill, 2012.

Constantine A. Balanis, *Advanced Engineering Electromagnetics*, 2nd Edition, Wiley, 2012.

David Grifiths, *Introduction to Electrodynamics*, 4th ed., Cambridge University Press, 2017.

Matthew Sadiku, *Elements of Electromagnetics*, 6th ed., Oxford Press, 2014.

Fawwaz T. Ulaby, Eric Michielssen, and Umberto Ravaioli. *Fundamentals of Applied Electromagnetism*, 6th ed., Prentice Hall, 2010.

Usability and Relationship to other Modules

- The module conveys basic knowledge for the lab "PCB design and measurement automation" and for RF-oriented specialization modules
- Mandatory for a major in ECE

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of the module.

7.13 Information Theory

Module Name Information Theory		*Module Code* CO-525	*Level (type)* Year 2 (CORE)	*CP* 5
Module Components				
Number	*Name*		*Type*	*CP*
CO-525-A	Information Theory		Lecture	5
Module Coordinator Prof. Dr.-Ing. Werner Henkel	*Program Affiliation* - Electrical and Computer Engineering (ECE)		*Mandatory Status* Mandatory for ECE Mandatory elective for CS and RIS	
Entry Requirements *Pre-requisites* ☒ None	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • Signals and Systems contents, such as DFT and convolution • Notion of probability, combinatorics basics as taught in Methods module “Probability and Random Processes"	*Frequency* Annually (Spring) *Duration* 1 semester	*Forms of Learning and Teaching* • Lectures (35 hours) • Private Study (90 hours) *Workload* 125 hours

Recommendations for Preparation

Some basic knowledge of communications and sound understanding of probability is recommended. Hence, it is strongly advised to take the methods and skills course Probability and Random Processes prior to this module. Nevertheless, probability basics will also be revised within the module.

Content and Educational Aims

Information theory serves as the most important foundation for communication systems. The module provides an analytical framework for modeling and evaluating point-to-point and multi-point communication. After a short rehearsal of probability and random variables and some excursion to random number generation, the key concept of information content of a signal source and information capacity of a transmission medium are precisely defined, and their relationships to data compression algorithms and error control codes are examined in detail. The module aims to install an appreciation for the fundamental capabilities and limitations of information transmission schemes and to provide the mathematical tools for applying these ideas to a broad class of communications systems.

The module contains also a coverage of different source-coding algorithms like Huffman, Lempel-Ziv-(Welch), Shannon-Fano-Elias, Arithmetic Coding, Runlength Encoding, Move-to-Front transform, PPM, and Context Tree Weighting. In Channel coding, finite fields, some basic block and convolutional codes, and the concept of iterative decoding will be introduced. Aside from source and channel aspects, an introduction to security is given, including public-key cryptography. Information theory is a standard module in every communications-oriented Bachelor’s program.

Intended Learning Outcomes

By the end of this module, students should be able to

- explain what is understood as the information content of data and the corresponding limits of data compression algorithms;
- design and apply fundamental algorithms in data compression;
- explain the information theoretic limits of data transmission;
- apply the mathematical basics of channel coding and cryptography;
- implement some channel coding schemes;
- differentiate the principles of encryption and authentication schemes and implement discussed procedures.

Indicative Literature

Thomas M. Cover, Joy A. Thomas, *Elements of Information Theory*, 2nd ed., Wiley, Sept. 2006.

David Salomon, *Data Compression, The Complete Reference*, 4th ed., Springer, 2007.

Usability and Relationship to other Modules

- Although not a mandatory prerequisite, this module is ideally taken before Coding Theory (CA-ECE-802)
- All communications-related modules are naturally based on information theory
- Students from Computer Science or related programs, also students taking Bio-informatics modules, profit from information-theoretic knowledge and source coding (compression) algorithms. Students from Computer Science would also be interested in the algebraic basics for error-correcting codes and cryptology, fields which area also introduced shortly.
- Mandatory for a major in ECE.
- Serves as a mandatory elective 3rd year Specialization module for CS and RIS major students.

Examination Type: Module Examination

Assessment Type: Written examination — Duration: 120 min, Weight: 100%

Scope: All intended learning outcomes of the module.

7.14 Electronics

Module Name		Module Code	Level (type)	CP
Electronics		CO-526	Year 2 (CORE)	5

Module Components

Number	*Name*	*Type*	*CP*
CO-526-A	Electronics	Lecture	2.5
CO-526-B	Electronics Lab	Lab	2.5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Dr. Mathias Bode	• Electrical and Computer Engineering (ECE)	Mandatory for ECE Mandatory elective for Physics

Entry Requirements			*Frequency*	*Forms of Learning and Teaching*
Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	Annually (Fall)	• Lecture (17,5 hours) • Lab (25.5 hours) • Private Study (82.00)
☒ General Electrical Engineering I&II Or ☒Electrodynamics (Physics)	☒ None	• Linear circuits • Basic Calculus • Basic Linear Algebra	*Duration* 1 semester	*Workload* 125 hours

Recommendations for Preparation

Revise linear circuits from your 1st year, and get textbook & lab material. See dedicated module Web pages for details (links on CampusNet).

Content and Educational Aims

Electronics and circuits are at the core of modern technology. This module comprises a lecture and a lab component. It builds on the 1st year General Electrical Engineering modules and provides a more in-depth coverage of the analysis and, in particular, the design of linear and nonlinear analog circuits. After a recap on linear circuits techniques, the lecture gives an introduction to fundamental nonlinear electronic devices, and electronic circuits. Starting from semiconductor properties, the operation principles and various applications of diodes, bipolar junction transistors (BJTs), and field-effect transistors (MOSFETs) are discussed. Different electronic circuits are analyzed and designed including rectifiers, voltage doublers, single- and multi-stage amplifiers, and operational amplifier (OpAmp) stages. While the lecture emphasizes theoretical concepts, the lab provides practical experience and allows the students to relate concrete hardware to device and circuit models. LTSpice are used for the simulation of the basic components and circuits. Experiments include RLC circuits, filters and resonators, diodes, pn-junctions and their application, bipolar junction transistors (BJT) and elementary transistor circuits including amplifiers, differential amplifiers and the basics of operational amplifiers, application of operational amplifiers. MOS field effect transistors and their application in amplifiers and inverter circuits.

Intended Learning Outcomes By the end of this module, students should be able to 1. explain fundamental electronic devices; 2. analyze and design electronic circuits, in particular linear networks, amplifiers, and operational amplifier circuits, based on a modular approach; 3. compare different designs with regard to their performance figures like voltage gain, current gain, band width; 4. operate lab equipment (oscilloscopes, electric sources, voltmeters) to investigate DC and AC circuits.
Indicative Literature David Comer and Donald Comer, *Fundamentals of Electronic Circuit Design*, Wiley, 2002.
Usability and Relationship to other Modules • Pre-requisite for the 2nd year PCB design lab and 3rd year ECE specialization modules Embedded Systems and Digital Design • This module builds on the GenEE1 and GenEE2 modules (as well as on physics CORE module Electrodynamics) and prepares the students for practical specializations in their 3rd year. • Mandatory elective 3rd year Specialization module for Physics major students. • Mandatory for major in ECE.
Examination Type: Module Component Examination **Module Component 1: Lecture** Assessment Type: Written examination — Duration: 120 min Weight: 50% Scope: Intended learning outcomes of the lecture (1-3). **Module Component 2: Lab** Assessment Type: Lab reports — Length: 5-10 pages per experiment session Weight: 50% Scope: Intended learning outcomes of the lab (2-4). Completion: To pass this module, the examination of each module component has to be passed with at least 45%.

7.15 PCB design and measurement automation

<table>
<tr><td colspan="3">Module Name
PCB Design and Measurement Automation</td><td>Module Code
CO-527</td><td>Level (type)
Year 2 (CORE)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-527-A</td><td colspan="3">PCB Design and Measurement Automation</td><td>Lab</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr.-Ing. Werner Henkel</td><td colspan="3">Program Affiliation

- Electrical and Computer Engineering (ECE)</td><td colspan="2">Mandatory Status

Mandatory for ECE
Mandatory elective for RIS</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites

☒ General Electrical Engineering I
☒ General Electrical Engineering II

OR

Introduction to RIS (RIS)</td><td>Frequency

Annually (Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lab (59.5 hours)
• Private Study (65.5 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

125 hours</td></tr>
<tr><td colspan="3">Co-requisites

☒ None

Knowledge, Abilities, or Skills

• Knowledge of Fourier series and transforms
• Basic knowledge of electronics components and circuits
• Matlab</td><td colspan="3"></td></tr>
<tr><td colspan="6">Recommendations for Preparation

Download material from corresponding Web pages and get to know the tasks and how the tools and equipment works.</td></tr>
<tr><td colspan="6">Content and Educational Aims

The module (lab) covers mainly two aspects that are seen to be important for employability. One share of the lab deals with measurement automation. Similar tasks, one also finds in industrial automation or monitoring, sometimes using the same tools. Students will learn to use Matlab and Labview for measurement automation tasks. In there, students will also get acquainted with more advanced measurement equipment, like high-end digital scopes, network, and spectrum analyzers. The students will measure standard telephone cables in their properties, which will require a treatment of transmission line theory and transformers/baluns. These theoretical aspects will also be covered.

The second major aspect handled in the lab makes students aware that electrical/electronic components have non-ideal behaviors, e.g., that a capacitor can act as an inductor in some frequency range. It makes students also aware of the problems in selecting the right component for a certain function inside a circuit, caring not just for the frequency range and the variation of properties with frequency, but also power, current, and voltage limits.
Then, a typical circuit design path will be taught, starting from schematics to placement of components and routing. Important aspects of printed circuit board design are treated, like how analog and digital power supplies have to be realized, how mass connections should look like, what measures have to be taken to block unwanted signal coupling is avoided, e.g., blocking capacitors, star-like power supply wiring.

Students also practice scientific writing in line with scientific writing rules as a preparation for their BSc thesis.</td></tr>
</table>

Intended Learning Outcomes

By the end of this module, students should be able to

1. use vector network analyzers, spectrum analyzers, and more advanced digital scopes;
2. learn how to program with LabVIEW;
3. remotely control measurement equipment using Matlab or LabVIEW;
4. describe principles of remote control;
5. know transmission line theory and how transformers/baluns are modeled;
6. measure and determine line parameters;
7. taking non-ideal behavior of passive and active components into account and be able to select components according to their parameters and limitations;
8. design printed circuit boards (PCB) with typical tools and a typical design cycle consisting of schematics, placement, and routing;
9. design analog and digital power routes, shielding ground connections, use measures to block unwanted ingress and coupling;
10. organize work contributions of group members in the lab and in reporting;
11. write reports in line with scientific writing rules as a preparation for their BSc thesis.

Usability and Relationship to other Modules

- This module builds on previous electronics knowledge and rounds this knowledge up with the final PCB design.
- Having learned to use Matlab in earlier modules, mostly for signal processing tasks, this module shows another application and provides a view into graphical programming as another option which they have seen earlier in the form of Simulink
- The module prepares students for a thesis with PCB design aspects.
- Mandatory for major in ECE.
- Serves as a mandatory elective 3rd year Specialization module for RIS major students.

Indicative Literature

Hank Zumbahlen Ed., *Basic Linear Design*, Analog Devices, 2007.

Walt Jung Ed., *Op Amp Applications*, Analog Devices, 2005.

Tim Williams, *The Circuit Designer's Companion*, 3rd ed., Newnes, 2012.

National Instruments, *LabVIEW, Getting Started with LabVIEW*, 2007.

Examination Type: Module Examination

Assessment Component 1: Written examination — Duration: 120 min, Weight: 50%

Scope: Intended learning outcomes of the lecture/theory component (4, 5, 7, 9).

Assessment Component 2: Lab reports — Length: 5-10 pages per experiment session, Weight: 50%

Scope: Intended learning outcomes of the lab (1-3, 6-11).

Completion: This module is passed with an assessment-component weighted average grade of 45% or higher.

7.16 Wireless Communication II

Module Name Wireless Communication II	*Module Code* CA-S-ECE-801	*Level (type)* Year 3 (Specialization)	*CP* 5

Module Components			
Number	*Name*	*Type*	*CP*
CA-ECE-801	Wireless Communication II	Lecture	5

Module Coordinator Prof. Dr. Giuseppe Abreu	*Program Affiliation* • Electrical and Computer Engineering (ECE)	*Mandatory Status* Mandatory elective for ECE

Entry Requirements			*Frequency*	*Forms of Learning and Teaching*
Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	Annually (Fall)	• Lectures (35 hours) • Private study (90 hours)
☒ Probability and Random Process	☒ None	• Notions of signals and systems and of digital communications	*Duration* 1 semester	*Workload* 125 hours

Recommendations for Preparation

At a minimum, it is recommended that students are in good standing with respect to the contents of Signals and Systems, Communications, and Probability. In addition, it is desirable that students are capable of writing simple programs, as well as to perform basic operations, in Matlab.

Content and Educational Aims

This complements the knowledge gained in Signals and Systems, Communications, and Wireless Communications I, focusing on the multi-access aspect of wireless systems. To elaborate, while Wireless Communications I is mostly concerning the fundamental technologies to design and optimize modern communications systems from a single user (point-to-point) perspective, this module focuses on techniques employed to enable multiple users to communicate simultaneously. Specifically, the module covers the mechanisms to mitigate or manage interference that arises when multiple users share the same wireless channel. Within this general theme, the 3 classical multi-access methods, namely: time division multiple access (TDMA), code division multiple access (CDMA), and orthogonal frequency division multiple access (OFDMA) are covered. As part of the latter, various mathematical tools essential to the understanding of multi-access schemes are also introduced (at the depth allowed by time), including, but not limited to: optimization theory, queueing theory, graph theory, fast-Fourier transform and more. In passing, modern technologies based on the extension or combination of the latter with multi-antenna systems (i.e. MIMO) are also touched upon. With the complementation of the preceding Wireless Communications I, the module brings the student to the level required to understand research articles on modern Wireless Communications, helping lay the foundation for a Bachelor’s Thesis towards a specialization in the area.

Intended Learning Outcomes

By the end of this module, students should be able to

- describe the key features and principles of the three classic multi-access approaches (TDMA, CDMA, and OFDMA) for wireless systems;

- explain qualitatively, and quantify statistically, the effects of limitations particular to each of the aforementioned approaches (*e.g.* packet collision in TDMA, out-of-phase and cross-correlation in CDMA, and frequency offset and sampling mismatch in OFDMA) on the performance of multi-access wireless schemes;
- describe the techniques utilized to design modern wireless communications systems so as to circumvent the aforementioned effects;

In addition to the aforementioned outcomes, fundamental to a career in ECE, students will also acquire:

- Analytical and mathematical tools useful to study various systems in which similar problems appear. A case in point is Markov Chains, which find applications in a wide range of sciences, including Physics, Chemistry, Computer Science, and Social Sciences.

Indicative Literature

J. H. Schiller, *Mobile Communications,* Pearson Education, 2003.

D. Bertsekas and R. Gallager, *Data Networks*, Prentice Hall, 1992.

M. K. Simon, J. K. Okumura, R. A. Scholtz, and B. K. Levitt, *Spread Spectrum Communications Handbook*,

Mc-Graw-Hill, 2002.

A. J. Viterbi, *Principles of Spread Spectrum Communications*, Addison-Wesley, 1995.

Y. G. Li and G. Stuber, *Orthogonal Frequency Division Multiplexing for Wireless Communications*, Springer, 2006.

Usability and Relationship to other Modules

- Mandatory elective 3rd year Specialization module for ECE major students.

Examination Type: Module Examination

Assessment Type: Written examination — Duration: 120 min
Scope: All intended outcomes of the module — Weight: 100%

7.17 Coding Theory

<table>
<tr><td colspan="3">Module Name
Coding Theory</td><td>Module Code
CA-S-ECE-802</td><td>Level (type)
Year 3
(Specialization)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CA-ECE-802</td><td colspan="3">Coding Theory</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr.-Ing. Werner Henkel</td><td colspan="3">Program Affiliation

• Electrical and Computer Engineering (ECE)</td><td colspan="2">Mandatory Status

Mandatory elective for ECE</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites
☒ Signals and Systems
☒ Digital Signal Processing
☒ Probability

Co-requisites
☒ None

Knowledge, Abilities, or Skills
• Signals and Systems contents, such as DFT and convolution
• Notion of probability, combinatorics basics</td><td>Frequency

Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching

• Lectures (35 hours)
• Private study (90 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

At a minimum, it is recommended that students are in good standing with respect to the contents of Signals and Systems, Communications and Probabilities. Although not a mandatory pre-requisite, having heard a Digital Signal Processing course provides some additional insights and links. Information Theory is, of course, the underlying basis of Coding Theory and should have been taken, but the module will be self-contained introducing major information-theoretic concepts where needed.</td></tr>
<tr><td colspan="6">Content and Educational Aims

Error correcting codes (convolutional codes, block codes, Turbo codes, LDPC codes, etc.) play an essential role in modern digital high data-rate transmission systems. They are part of almost every modern communication, storage, or recording device, like a CD player, your DSL home Internet access, and your mobile phone, to name just a few. This module will focus on theory, construction, and algorithms for error correcting codes, and will highlight the application in communication systems. For modern communications, coding knowledge is a must.</td></tr>
</table>

Intended Learning Outcomes

By the end of this module, students will be able to

- understand all major code classes, like convolutional, Block, Turbo, LDPC, and Polar codes, rateless coding and network coding;
- to compute in finite fields, the mathematical structure used in coding and cryptology;
- understand the interplay between blocks of the transmission chain, especially, between modulation and coding;
- understand that lattices can be obtained from coding schemes;
- realize that information theoretic results define practical solutions, e.g., that the optimum distribution for a Gaussian channel is Gaussian as well, which is then practically obtained by Shaping methods;
- understand the limits of code design and application;
- select and optimize codes for a certain application;
- implement coding schemes.
- implement encoding and decoding algorithms and evaluate code performances.

Indicative Literature

William E. Ryan and Shu Lin, *Channel Codes, Classical and Modern*, Cambridge, 2009.

Shu Lin and Danial J, Costello, *Error Control Coding: Fundamentals and Applications*, Prentice-Hall, 1983.

Richard E. Blahut, *Theory and Practice of Error Control Codes*, Addison-Wesley, 1984.

Tom Richardson and Rüdiger Urbanke, *Modern Coding Theory*, Cambridge, 2008.

Usability and Relationship to other Modules

- All Communications modules (Communications Basics/ Communications Lab, , Wireless Communications, Wireless Communications II) are naturally linked to Coding Theory
- Digital Signal Processing (CO-521) has many links to Coding Theory
- Information Theory (CO-525) is the theoretical foundation of Coding Theory
- In some computer science programs, coding theory is considered a branch of theoretical computer science and hence, the module is also a possibly choice for computer scientists
- Mandatory elective 3rd year Specialization module for ECE and RIS major students.

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 min
Weight: 100 %

Scope: All intended learning outcomes of the module

7.18 Digital Design

Module Name	Module Code	Level (type)	CP
Digital Design	CA-S-ECE-803	Year 3 (Specialization)	5

Module Components

Number	Name	Type	CP
CA-ECE-803	Digital Design	Lecture/Lab	5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Dr. Fangning Hu	• Electrical and Computer Engineering (ECE)	Mandatory elective for ECE, RIS and CS

Entry Requirements			*Frequency*	*Forms of Learning and Teaching*
Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	Annually (Fall)	• Lecture/Lab (35 hours) • Private study (90 hours)
☒ None	☒ None		*Duration*	*Workload*
			1 semester	125 hours

Recommendations for Preparation

Students may prepare themselves with books like "Brent E. Nelson, Designing Digital Systems, 2005" and "Pong P. Chu, RTL Hardware Design Using VHDL, A John Wiley & Sons, Inc, Publication, 2006"

Content and Educational Aims

The current trend of digital system design is towards hardware description languages (HDLs) that allow compact description of very complex hardware constructs. The module provides a sound introduction to basic components of a digital system such as logic gates, multiplexers, decoders, flip-flops and registers as well as VHDLs such as types, signals, sequential and concurrent statements. Methods and principle of designing complex digital systems such as finite state machines, hierarchical design, pipelined design, RTL design methodology and parameterized design will also be introduced. Students will learn VHDL for programming FPGA boards to realize small digital systems in hardware (i.e. on FPGA boards). Such digital systems could be adders, multiplexers, control units, multipliers, asynchronous serial communication modules (UART). At the end of the module, the students should be able to design a simple digital system by VHDL on an FPGA board.

Intended Learning Outcomes

By the end of this module, students will be able to

- understand the principle of digital system design based on standard building blocks and components;
- design a complex digital system;
- understand the limitations of a given hardware platform (here FPGAs), modify algorithms where necessary, and structure them suitably in order to optimize performance and complexity;
- use a typical development system;
- program in VHDL;
- program an FPGA board.

Indicative Literature

Brent E. Nelson, *Designing Digital Systems with SystemVerilog*, 2018, ISBN-13: 978-1980926290

Pong P. Chu, *RTL Hardware Design Using VHDL*, Wiley-IEEE Press, 2006, ISBN-13: 978-0471720928

Usability and Relationship to other Modules

- This module introduces how to design digital systems and how to realize them on a FPGA board which could also serve as a specialization module for students from Computer Science and Robotics and Intelligent Systems.
- Mandatory elective 3rd year Specialization module for ECE, CS and RIS major students.

Examination Type: Module Examination

Assessment Type: written examination Duration: 120 min
Scope: All intended learning outcomes of the module Weight: 100%

7.19 Radio-Frequency (RF) Design

<table>
<tr><td colspan="3">Module Name
Radio-Frequency (RF) Design</td><td>Module Code
CA-S-ECE-804</td><td>Level (type)
Year 3
(Specialization)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CA-ECE-804</td><td colspan="3">Radio-Frequency (RF) Design</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr.-Ing. Werner Henkel</td><td colspan="3">Program Affiliation

• Electrical and Computer Engineering (ECE)</td><td colspan="2">Mandatory Status

Mandatory elective for ECE</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ Electromagnetics
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• Knowledge of electric and magnetic fields
• Knowledge of wave propagation and transmission line theory</td><td>Frequency

Annually (Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lectures (35 hours)
• Private study (90 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Student should come with a good understanding of fields and wave propagation covered in an Electromagnetics module.</td></tr>
</table>

Content and Educational Aims

The objective of this module is to gain an understanding of today's design process of active and passive microwave circuits. After a review of the transmission line theory and microwave-related network theory, the operational principles of basic building block of microwave circuits are discussed. Additionally, the module provides an overview of typical microwave circuit applications for modern wireless communication systems. Especially, the module will cover

- Transmission-line theory (recap)
- Skin effect
- Network theory for microwave circuits
- Microstrip circuit design
- Smith diagram and its application
- Couplers and power splitters
- Non-reciprocal components
- Noise in microwave circuits
- Active components
- Large-signal effects
- Antennas and free space propagation

Intended Learning Outcomes

By the end of this module, students will be able to:

- characterize passive and active RF components;
- understand and apply RF circuit design methods;
- design antennas and characterize their radiation patterns;
- understand wave propagation;
- understand and design the interface between baseband signal processing and actual RF transmission;
- realize analog front-end circuitry.

Indicative Literature

Ludwig, G. Bogdanov, *RF Circuit Design: Theory and Practice*, 2nd ed., Prentice Hall, 2009.

David M. Pozar, *Microwave and RF Design of Wireless Systems*, Wiley, 1st ed., 2000.

Behzad Razavi, *RF Microelectronics*, Prentice Hall, 2nd ed., 2011.

Cotter Sayre, *Complete Wireless Design*, McGraw-Hill Professional, 2008.

Sorin Voinigescu, *High-Frequency Integrated Circuits*, Cambridge University Press, 2013.

Usability and Relationship to other Modules

- The module rounds up the knowledge from the earlier Electromagnetics module (CO-524) and completes the contents of the wireless communications module (CO-523) from an RF perspective.
- Mandatory elective 3rd year Specialization module for ECE major students.

Examination Type: Module Examination

Assessment Type: Written examination — Duration: 120 min
Scope: All intended learning outcomes of the module — Weight: 100 %

7.21 Internship / Startup and Career Skills

<table>
<tr><td colspan="3">Module Name
Internship / Startup and Career Skills</td><td>Module Code
CA-INT-900</td><td>Level (type)
Year 3
(CAREER)</td><td>CP
15</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CA-INT-900-0</td><td colspan="3">Internship</td><td>Internship</td><td>15</td></tr>
<tr><td>Module Coordinator

Sinah Vogel & Dr. Tanja Woebs (CSC Organization); SPC / Faculty Startup Coordinator (Academic responsibility)</td><td colspan="3">Program Affiliation

• CAREER module for undergraduate study programs</td><td colspan="2">Mandatory Status

Mandatory for all undergraduate study programs except IEM</td></tr>
<tr><td colspan="3">Entry Requirements</td><td>Frequency

Annually (Spring/Fall)</td><td colspan="2">Forms of Learning and Teaching

• Internship/Start-up
• Internship event
• Seminars, info-sessions, workshops and career events
• Self-study, readings, online tutorials</td></tr>
<tr><td>Pre-requisites

☒ at least 15 CP from CORE modules in the major</td><td>Co-requisites

☒ None</td><td>Knowledge, Abilities, or Skills

• Information provided on CSC pages (see below)
• Major specific knowledge and skills</td><td>Duration
1 semester</td><td colspan="2">Workload

375 Hours consisting of:
• Internship (308 hours)
• Workshops (33 hours)
• Internship Event (2 hours)
• Self-study (32 hours)</td></tr>
<tr><td colspan="6">Recommendations for Preparation

• Please see the section “Knowledge Center” at JobTeaser Career Center for information on Career Skills seminar and workshop offers and for online tutorials on the job market preparation and the application process. For more information, please see https://www.jacobs-university.de/employability/career-services
• Participating in the internship events of earlier classes</td></tr>
<tr><td colspan="6">Content and Educational Aims

The aims of the internship module are reflection, application, orientation, and development: for students to reflect on their interests, knowledge, skills, their role in society, the relevance of their major subject to society, to apply these skills and this knowledge in real life whilst getting practical experience, to find a professional orientation, and to develop their personality and in their career. This module supports the programs’ aims of preparing students for gainful, qualified employment and the development of their personality.</td></tr>
</table>

The full-time internship must be related to the students' major area of study and extends lasts a minimum of two consecutive months, normally scheduled just before the 5th semester, with the internship event and submission of the internship report in the 5th semester. Upon approval by the SPC and CSC, the internship may take place at other times, such as before teaching starts in the 3rd semester or after teaching finishes in the 6th semester. The Study Program Coordinator or their faculty delegate approves the intended internship a priori by reviewing the tasks in either the Internship Contract or Internship Confirmation from the respective internship institution or company. Further regulations as set out in the Policies for Bachelor Studies apply.

Students will be gradually prepared for the internship in semesters 1 to 4 through a series of mandatory information sessions, seminars, and career events.
The purpose of the Career Services Information Sessions is to provide all students with basic facts about the job market in general, and especially in Germany and the EU, and services provided by the Career Services Center.
In the Career Skills Seminars, students will learn how to engage in the internship/job search, how to create a competitive application (CV, Cover Letter, etc.), and how to successfully conduct themselves at job interviews and/or assessment centers. In addition to these mandatory sections, students can customize their skill set regarding application challenges and their intended career path in elective seminars.
Finally, during the Career Events organized by the Career Services Center (e.g. the annual Jacobs Career Fair and single employer events on and off campus), students will have the opportunity to apply their acquired job market skills in an actual internship/job search situation and to gain their desired internship in a high-quality environment and with excellent employers.

As an alternative to the full-time internship, students can apply for the StartUp Option. Following the same schedule as the full-time internship, the StartUp Option allows students who are particularly interested in founding their own company to focus on the development of their business plan over a period of two consecutive months. Participation in the StartUp Option depends on a successful presentation of the student's initial StartUp idea. This presentation will be held at the beginning of the 4th semester. A jury of faculty members will judge the student's potential to realize their idea and approve the participation of the students. The StartUp Option is supervised by the Faculty StartUp Coordinator. At the end of StartUp Option, students submit their business plan. Further regulations as outlined in the Policies for Bachelor Studies apply.

The concluding Internship Event will be conducted within each study program (or a cluster of related study programs) and will formally conclude the module by providing students the opportunity to present on their internships and reflect on the lessons learned within their major area of study. The purpose of this event is not only to self-reflect on the whole internship process, but also to create a professional network within the academic community, especially by entering the Alumni Network after graduation. It is recommended that all three classes (years) of the same major are present at this event to enable networking between older and younger students and to create an educational environment for younger students to observe the "lessons learned" from the diverse internships of their elder fellow students.

Intended Learning Outcomes

By the end of this module, students should be able to

- describe the scope and the functions of the employment market and personal career development;
- apply professional, personal, and career-related skills for the modern labor market, including self-organization, initiative and responsibility, communication, intercultural sensitivity, team and leadership skills, etc.;
- independently manage their own career orientation processes by identifying personal interests, selecting appropriate internship locations or start-up opportunities, conducting interviews, succeeding at pitches or assessment centers, negotiating related employment, managing their funding or support conditions (such as salary, contract, funding, supplies, work space, etc.);
- apply specialist skills and knowledge acquired during their studies to solve problems in a professional environment and reflect on their relevance in employment and society;
- justify professional decisions based on theoretical knowledge and academic methods;
- reflect on their professional conduct in the context of the expectations of and consequences for employers and their society;
- reflect on and set their own targets for the further development of their knowledge, skills, interests, and values;
- establish and expand their contacts with potential employers or business partners, and possibly other students and alumni, to build their own professional network to create employment opportunities in the future;

- discuss observations and reflections in a professional network.

Indicative Literature

Not specified

Usability and Relationship to other Modules

- Mandatory for a major in BCCB, CBT, CS, EES, GEM, IBA, IRPH, ISCP, Math, MCCB, Physics, RIS, and SMP.
- This module applies skills and knowledge acquired in previous modules to a professional environment and provides an opportunity to reflect on their relevance in employment and society. It may lead to thesis topics.

Examination Type: Module Examination

Assessment Type: Internship Report or Business Plan and Reflection — Length: approx. 3.500 words

Scope: All intended learning outcomes — Weight: 100%

7.22 Bachelor Thesis and Seminar

Module Name			*Module Code*	*Level (type)*	*CP*
Bachelor Thesis and Seminar			CA-ECE-800	Year 3 (CAREER)	15
Module Components					
Number	*Name*			*Type*	*CP*
CA-ECE-800-T	Thesis			Thesis	12
CA-ECE-800-S	Thesis Seminar			Seminar	3
Module Coordinator Study Program Chair	*Program Affiliation* • All undergraduate programs			*Mandatory Status* Mandatory for all undergraduate programs	
Entry Requirements			*Frequency* Annually (Spring)	*Forms of Learning and Teaching* • Self-study/lab work (350 hours) • Seminars (25 hours)	
Pre-requisites ☒ Students must be in their third year and have taken at least 30 CP from CORE modules in their major.	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • comprehensive knowledge of the subject and deeper insight into the chosen topic; • ability to plan and undertake work independently; • skills to identify and critically review literature.	*Duration* 1 semester	*Workload* 375 hours	
Recommendations for Preparation • Identify an area or a topic of interest and discuss this with your prospective supervisor in a timely manner. • Create a research proposal including a research plan to ensure timely submission. • Ensure you possess all required technical research skills or are able to acquire them on time. • Review the University's Code of Academic Integrity and Guidelines to Ensure Good Academic Practice.					

Content and Educational Aims

This module is a mandatory graduation requirement for all undergraduate students to demonstrate their ability to address a problem from their respective major subject independently using academic/scientific methods within a set time frame. Although supervised, this module requires students to be able to work independently and systematically and set their own goals in exchange for the opportunity to explore a topic that excites and interests them personally and that a faculty member is interested in supervising. Within this module, students apply their acquired knowledge about their major discipline and their learned skills and methods for conducting research, ranging from the identification of suitable (short-term) research projects, preparatory literature searches, the realization of discipline-specific research, and the documentation, discussion, interpretation, and communication of research results.

This module consists of two components, an independent thesis and an accompanying seminar. The thesis component must be supervised by a Jacobs University faculty member and requires short-term research work, the results of which must be documented in a comprehensive written thesis including an introduction, a justification of the methods, results, a discussion of the results, and a conclusion. The seminar provides students with the opportunity to practice their ability to present, discuss, and justify their and other students' approaches, methods, and results at various stages of their research in order to improve their academic writing, receive and reflect on formative feedback, and therefore grow personally and professionally.

Intended Learning Outcomes

On completion of this module, students should be able to

1. independently plan and organize advanced learning processes;
2. design and implement appropriate research methods, taking full account of the range of alternative techniques and approaches;
3. collect, assess, and interpret relevant information;
4. draw scientifically-founded conclusions that consider social, scientific, and ethical factors;
5. apply their knowledge and understanding to a context of their choice;
6. develop, formulate, and advance solutions to problems and debates within their subject area, and defend these through argument;
7. discuss information, ideas, problems, and solutions with specialists and non-specialists.

Indicative Literature

Justin Zobel, *Writing for Computer Science, 3rd edition,* Springer, 2015.

Usability and Relationship to other Modules

- This module builds on all previous modules in the undergraduate program. Students apply the knowledge, skills, and competencies they have acquired and practiced during their studies, including research methods and their ability to acquire additional skills independently as and if required.

Examination Type: Module Component Examinations

Module Component 1: Thesis
Assessment type: Thesis
Scope: All intended learning outcomes, mainly 1-6.
Weight: 80%

Length: approx. 10,000 – 14,000 words (25–35 pages), excluding front and back matter.

Module Component 2: Seminar
Assessment type: Presentation

Duration: approx. 15 to 30 minutes
Weight: 20%

Scope: The presentation focuses mainly on ILOs 6 and 7, but by nature of these ILOs it also touches on the others.

Completion: To pass this module, the examination of each module component has to be passed with at least 45%.

Two separate assessments are justified by the size of this module and the fact that the justification of solutions to problems and arguments (ILO 6) and discussion (ILO 7) should at least have verbal elements. The weights of the types of assessments are commensurate with the sizes of the respective module components.

7.23 Jacobs Track Modules

7.23.1 Methods and Skills Modules

7.23.1.1 Calculus and Elements of Linear Algebra I

Module Name			*Module Code*	*Level (type)*	*CP*
Calculus and Elements of Linear Algebra I			JTMS-MAT-09	Year 1 (Methods)	5
Module Components					
Number	*Name*			*Type*	*CP*
JTMS-09	Calculus and Elements of Linear Algebra I			Lecture	5
Module Coordinator	*Program Affiliation*			*Mandatory Status*	
Prof. Dr. Marcel Oliver, Prof. Dr. Tobias Preußer	• Jacobs Track – Methods and Skills			Mandatory for CS, ECE, RIS, MATH and Physics Mandatory elective for EES	
Entry Requirements			*Frequency*	*Forms of Learning and Teaching*	
Pre-requisites ☒ None	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • Knowledge of Pre-Calculus at High School level (Functions, inverse functions, sets, real numbers, polynomials, rational functions, trigonometric functions, logarithm and exponential function, parametric equations, tangent lines, graphs, elementary methods for solving systems of linear and nonlinear equations) • Knowledge of Analytic Geometry at High School level (vectors, lines, planes, reflection, rotation, translation, dot product, cross product, normal vector, polar coordinates) • Some familiarity with elementary Calculus (limits, derivative) is helpful, but not strictly required.	Annually (Fall)	• Lectures (35 hours) • Private study (90 hours)	
			Duration 1 semester	*Workload* 125 hours	

Recommendations for Preparation

Review all of higher-level High School Mathematics, in particular the topics explicitly named in "Entry Requirements – Knowledge, Ability, or Skills" above.

Content and Educational Aims

This module is the first in a sequence introducing mathematical methods at the university level in a form relevant for study and research in the quantitative natural sciences, engineering, Computer Science, and Mathematics. The emphasis in these modules is on training operational skills and recognizing mathematical structures in a problem context. Mathematical rigor is used where appropriate. However, a full axiomatic treatment of the subject is provided in the first-year modules "Analysis I" and "Linear Algebra".

The lecture comprises the following topics

- Brief review of number systems, elementary functions, and their graphs
- Brief introduction to complex numbers
- Limits for sequences and functions
- Continuity
- Derivatives
- Curve sketching and applications (isoperimetric problems, optimization, error propagation)
- Introduction to Integration and the Fundamental Theorem of Calculus
- Review of elementary analytic geometry
- Vector spaces, linear independence, bases, coordinates
- Matrices and matrix algebra
- Solving linear systems by Gauss elimination, structure of general solution
- Matrix inverse

Intended Learning Outcomes

By the end of the module, students will be able to

- apply the methods described in the content section of this module description to the extent that they can solve standard text-book problems reliably and with confidence;
- recognize the mathematical structures in an unfamiliar context and translate them into a mathematical problem statement;
- recognize common mathematical terminology used in textbooks and research papers in the quantitative sciences, engineering, and mathematics to the extent that they fall into the content categories covered in this module.

Indicative Literature

S.I. Grossman (2014). Calculus of one variable, 2nd edition. Cambridge: Academic Press.
S.A. Leduc (2003). Linear Algebra. Hoboken: Wiley.
K. Riley, M. Hobson, S. Bence (2006). Mathematical Methods for Physics and Engineering, third edition. Cambridge: Cambridge University Press.

Usability and Relationship to other Modules

- The module is a mandatory / mandatory elective module of the Methods and Skills area that is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- The module is followed by "Calculus and Elements of Linear Algebra II". All students taking this module are expected to register for the follow-up module.
- A rigorous treatment of Calculus is provided in the module "Analysis I". All students taking "Analysis I" are expected to either take this module or exceptionally satisfy the conditions for advanced placement as laid out in the Jacobs Academic Policies for Undergraduate Study.
- The second-semester module "Linear Algebra" will provide a complete proof-driven development of the theory of Linear Algebra. Students enrolling in "Linear Algebra" are expected to have taken this module; in particular, the module "Linear Algebra" will assume that students are proficient in the operational aspects of Gauss elimination, matrix inversion, and their elementary applications.
- This module is a prerequisite for the module "Applied Mathematics" which develops more advanced theoretical and practical mathematical tools essential for any physicist or mathematician.
- Mandatory for a major in CS, ECE, RIS, MATH and Physics

- Mandatory elective for a major in EES.
- Pre-requisite for Calculus and Elements of Linear Algebra II
- Elective for all other study programs.

Examination Type: Module Examination

Assessment type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of this module

7.23.1.2 Calculus and Elements of Linear Algebra II

<table>
<tr><td colspan="3">Module Name
Calculus and Elements of Linear Algebra II</td><td>Module Code
JTMS-MAT-10</td><td>Level (type)
Year 1 (Methods)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>JTMS-10</td><td colspan="3">Calculus and Elements of Linear Algebra II</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator
Prof. Dr. Marcel Oliver, Prof. Dr. Tobias Preußer</td><td colspan="3">Program Affiliation
Jacobs Track – Methods and Skills</td><td colspan="2">Mandatory Status
Mandatory for CS, ECE, MATH, Physics and RIS</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements
Pre-requisites: ☒ Calculus and Elements of Linear Algebra I
Co-requisites: ☒ None
Knowledge, Abilities, or Skills
None beyond formal pre-requisites</td><td>Frequency
Annually (Spring)</td><td colspan="2">Forms of Learning and Teaching
Lectures (35 hours)
Private study (90 hours)</td></tr>
<tr><td>Duration
1 semester</td><td colspan="2">Workload
125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation
Review the content of Calculus and Elements of Linear Algebra I</td></tr>
<tr><td colspan="6">Content and Educational Aims
This module is the second in a sequence introducing mathematical methods at the university level in a form relevant for study and research in the quantitative natural sciences, engineering, Computer Science, and Mathematics. The emphasis in these modules is on training operational skills and recognizing mathematical structures in a problem context. Mathematical rigor is used where appropriate. However, a full axiomatic treatment of the subject is provided in the first-year modules “Analysis I” and “Linear Algebra”.

The lecture comprises the following topics
Directional derivatives, partial derivatives
Linear maps
The total derivative as a linear map
Gradient and curl (elementary treatment only, for more advanced topics, in particular the connection to the Gauss and Stokes’ integral theorems, see module “Applied Mathematics”
Optimization in several variables, Lagrange multipliers
Elementary ordinary differential equations
Eigenvalues and eigenvectors
Hermitian and skew-Hermitian matrices
First important example of eigendecompositions: Linear constant-coefficient ordinary differential equations
Second important example of eigendecompositions: Fourier series
Fourier integral transform
Matrix factorizations: Singular value decomposition with applications, LU decomposition, QR decomposition</td></tr>
</table>

Intended Learning Outcomes

By the end of the module, students will be able to

- apply the methods described in the content section of this module description to the extent that they can solve standard text-book problems reliably and with confidence;
- recognize the mathematical structures in an unfamiliar context and translate them into a mathematical problem statement;
- recognize common mathematical terminology used in textbooks and research papers in the quantitative sciences, engineering, and mathematics to the extent that they fall into the content categories covered in this module.

Indicative Literature

S.I. Grossman (2014). Calculus of one variable, 2nd edition. Cambridge: Academic Press.
S.A. Leduc (2003). Linear Algebra. Hoboken: Wiley.
K. Riley, M. Hobson, S. Bence (2006). Mathematical Methods for Physics and Engineering, third edition. Cambridge: Cambridge University Press.

Usability and Relationship to other Modules

- The module is a mandatory / mandatory elective module of the Methods and Skills area that is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- A more advanced treatment of multi-variable Calculus, in particular, its applications in Physics and Mathematics, is provided in the second-semester module "Applied Mathematics". All students taking "Applied Mathematics" are expected to take this module as well as the module topics are closely synchronized.
- The second-semester module "Linear Algebra" provides a complete proof-driven development of the theory of Linear Algebra. Diagonalization is covered more abstractly, with particular emphasis on degenerate cases. The Jordan normal form is also covered in "Linear Algebra", not in this module.
- Mandatory for CS, ECE, MATH, Physics and RIS.
- Elective for all other study programs.

Examination Type: Module Examination

Assessment type: Written examination — Duration: 120 min; Weight: 100%

Scope: All intended learning outcomes of this module

7.23.1.3 Probability and Random Processes

Module Name			*Module Code*	*Level (type)*	*CP*
Probability and Random Processes			JTMS-MAT-12	Year 2 (Methods)	5
Module Components					
Number	*Name*			*Type*	*CP*
JTMS-12	Probability and random processes			Lecture	5
Module Coordinator Prof. Dr. Marcel Oliver, Prof. Dr. Tobias Preußer	*Program Affiliation* • Jacobs Track – Methods and Skills			*Mandatory Status* Mandatory for CS, ECE, MATH, Physics and RIS Mandatory elective for EES	
Entry Requirements			*Frequency* Annually (Fall)	*Forms of Learning and Teaching* • Lectures (35 hours) • Private study (90 hours)	
Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	*Duration* 1 semester	*Workload* 125 hours	
☒ Calculus and Elements of Linear Algebra I & II	☒ None	• Knowledge of calculus at the level of a first year calculus module (differentiation, integration with one and several variables, trigonometric functions, logarithms and exponential functions). • Knowledge of linear algebra at the level of a first year university module (eigenvalues and eigenvectors, diagonalization of matrices). • Some familiarity with elementary probability theory at the high school level.			
Recommendations for Preparation Review all of the first year calculus and linear algebra modules as indicated in "Entry Requirements – Knowledge, Ability, or Skills" above.					
Content and Educational Aims This module aims to provide a basic knowledge of probability theory and random processes suitable for students in engineering, Computer Science, and Mathematics. The module provides students with basic skills needed for formulating real-world problems dealing with randomness and probability in mathematical language, and methods for applying a toolkit to solve these problems. Mathematical rigor is used where appropriate. A more advanced treatment of the subject is deferred to the third-year module *Stochastic Processes*.					

The lecture comprises the following topics

- Brief review of number systems, elementary functions, and their graphs
- Outcomes, events and sample space.
- Combinatorial probability.
- Conditional probability and Bayes' formula.
- Binomials and Poisson-Approximation
- Random Variables, distribution and density functions.
- Independence of random variables.
- Conditional Distributions and Densities.
- Transformation of random variables.
- Joint distribution of random variables and their transformations.
- Expected Values and Moments, Covariance.
- High dimensional probability: Chebyshev and Chernoff bounds.
- Moment-Generating Functions and Characteristic Functions,
- The Central limit theorem.
- Random Vectors and Moments, Covariance matrix, Decorrelation.
- Multivariate normal distribution.
- Markov chains, stationary distributions.

Intended Learning Outcomes

By the end of the module, students will be able to

- command the methods described in the content section of this module description to the extent that they can solve standard text-book problems reliably and with confidence;
- recognize the probabilistic structures in an unfamiliar context and translate them into a mathematical problem statement;
- recognize common mathematical terminology used in textbooks and research papers in the quantitative sciences, engineering, and mathematics to the extent that they fall into the content categories covered in this module.

Indicative Literature

J. Hwang and J.K. Blitzstein (2019). Introduction to Probability, second edition. London: Chapman & Hall.

S. Ghahramani. Fundamentals of Probability with Stochastic Processes, fourth edition. Upper Saddle River: Prentice Hall.

Usability and Relationship to other Modules

- The module is a mandatory / mandatory elective module of the Methods and Skills area that is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- Students taking this module are expected to be familiar with basic tools from calculus and linear algebra.
- Mandatory for a major in CS, ECE, MATH, Physics and RIS.
- Mandatory elective for a major in EES (if pre-requisites are met).
- Elective for all other study programs.

Examination Type: Module Examination

Assessment type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of this module

7.23.1.4 Numerical Methods

<table>
<tr><td colspan="3">Module Name
Numerical Methods</td><td>Module Code
JTMS-MAT-13</td><td>Level (type)
Year 2 (Methods)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>JTMS-13</td><td colspan="3">Numerical Methods</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Marcel Oliver, Prof. Dr. Tobias Preußer</td><td colspan="3">Program Affiliation

• Jacobs Track – Methods and Skills</td><td colspan="2">Mandatory Status

Mandatory for ECE, MATH and Physics
Mandatory elective for CS and RIS</td></tr>
<tr><td rowspan="2">Entry Requirements

Pre-requisites

☒ None</td><td rowspan="2">Co-requisites

☒ None</td><td rowspan="2">Knowledge, Abilities, or Skills

• Knowledge of Calculus (functions, inverse functions, sets, real numbers, sequences and limits, polynomials, rational functions, trigonometric functions, logarithm and exponential function, parametric equations, tangent lines, graphs, derivatives, anti-derivatives, elementary techniques for solving equations)
• Knowledge of Linear Algebra (vectors, matrices, lines, planes, n-dimensional Euclidean vector space, rotation, translation, dot product (scalar product), cross product, normal vector, eigenvalues, eigenvectors, elementary techniques for solving systems of linear equations)</td><td>Frequency

Annually (Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lectures (35 hours)
• Private study (90 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Taking Calculus and Elements of Linear Algebra II before taking this module is recommended, but not required. A thorough review of Calculus and Elements of Linear Algebra, with emphasis on the topics listed as “Knowledge, Abilities, or Skills” is recommended.</td></tr>
</table>

Content and Educational Aims

This module covers calculus-based numerical methods, in particular root finding, interpolation, approximation, numerical differentiation, numerical integration (quadrature), and a first introduction to the numerical solution of differential equations.

The lecture comprises the following topics

- number representations
- Gaussian elimination
- LU decomposition
- Cholesky decomposition
- iterative methods
- bisection method
- Newton's method
- secant method
- polynomial interpolation
- Aitken's algorithm
- Lagrange interpolation
- Newton interpolation
- Hermite interpolation
- Bezier curves
- De Casteljau's algorithm
- piecewise interpolation
- Spline interpolation
- B-Splines
- Least-squares approximation
- polynomial regression
- difference schemes
- Richardson extrapolation
- Quadrature rules
- Monte Carlo integration
- time stepping schemes for ordinary differential equations
- Runge Kutta schemes
- finite difference method for partial differential equations

Intended Learning Outcomes

By the end of the module, students will be able to

- describe the basic principles of discretization used in the numerical treatment of continuous problems;
- command the methods described in the content section of this module description to the extent that they can solve standard text-book problems reliably and with confidence;
- recognize mathematical terminology used in textbooks and research papers on numerical methods in the quantitative sciences, engineering, and mathematics to the extent that they fall into the content categories covered in this module;
- implement simple numerical algorithms in a high-level programming language;
- understand the documentation of standard numerical library code and understand the potential limitations and caveats of such algorithms.

Indicative Literature

D. Kincaid and W. Cheney (1991). Numerical Analysis: Mathematics of Scientific Computing. Pacific Grove: Brooks/Cole Publishing.

W. Boehm and H. Prautzsch (1993). Numerical Methods. Natick: AK Peters.

Usability and Relationship to other Modules

- The module is a mandatory / mandatory elective module of the Methods and Skills area that is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).

- This module is a co-recommendation for the module “Applied Dynamical Systems Lab”, in which the actual implementation in a high-level programming language of the learned methods will be covered.
- Mandatory for a major in ECE, MATH, and Physics.
- Mandatory elective for a major in CS and RIS.
- Elective for all other study programs.

Examination Type: Module Examination

Assessment type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of this module.

7.23.2 Big Questions Modules

7.23.2.1 Water: The Most Precious Substance on Earth

<table>
<tr><td colspan="3">Module Name
Water: The Most Precious Substance on Earth</td><td>Module Code
JTBQ-BQ-002</td><td>Level (type)
Year 3 (Jacobs Track)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>JTBQ-002</td><td colspan="3">Water: The Most Precious Substance on Earth</td><td>Lecture/Tutorial</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Michael Bau and Dr. Doris Mosbach</td><td colspan="3">Program Affiliation

• Big Questions Area: All undergraduate study programs except IEM</td><td colspan="2">Mandatory Status

Mandatory elective for students of all undergraduate study programs, except IEM</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ None
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• The ability and openness to engage in interdisciplinary issues of global relevance
• Media literacy, critical thinking, and a proficient handling of data sources</td><td>Frequency

Annually (part I: Fall; part II: Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lectures (17.5 hours)
• Project work (90 hours)
• Private study (17.5 hours)</td></tr>
<tr><td>Duration

2 semesters</td><td colspan="2">Workload

125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Critically following media coverage on the module’s topics in question.</td></tr>
</table>

Content and Educational Aims

All "Big Questions" (BQ) modules deal with the economic, technological, societal, and environmental contexts of the global issues and challenges of the coming decades. BQ modules intend to raise awareness of those challenges and broaden students' horizons with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules support students in their development to become informed and responsible citizens in a global society.
Water is the basic prerequisite for life on our planet, but it has become a scarce resource and a valuable commodity. Water is of fundamental importance to the world's economy and global food supply, in addition to being a driving force behind geopolitical conflict. In this module, the profound impact of water on all aspects of human life will be addressed from very different perspectives: from the natural and environmental sciences and engineering, and from the social and cultural sciences.
Following topical lectures in the Fall semester, students will work on projects on the occasion of the World Water Day (March 22) in small teams comprised of students from various disciplines and with different cultural backgrounds. This teamwork will be accompanied by related tutorials.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, students will be able to

- use their disciplinary factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
- advance a knowledge-based opinion on the complex module topics: on the physio-chemical properties of water, its origin and history, on the importance of water as a resource, on physical and economic freshwater scarcity, on the risks of water pollution and the challenges faced by waste water treatment, on the concept of virtual water, on the bottled water industry, and on the cultural values and meanings of water;
- formulate coherent written and oral contributions (e.g., to panel discussions) on the topic;
- perform well-organized teamwork;
- present a self-designed project in a university-wide context.

Indicative Literature

Finney, John (2015). Water. A Very Short Introduction. Oxford: Oxford University Press.

Zetland, David (2011). The End of Abundance: Economic Solutions to Water Scarcity. California: Aguanomics Press.

United Nation (January 2016): Sustainable Development Goals. Retrieved from https://www.ipcc.ch

Usability and Relationship to other Modules

- This module is a mandatory elective module in the Big Questions area, which is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute their knowledge and competencies to class discussions and activities.

Examination Type: Module Examination

Assessment Component 1: Written examination — Duration: 60 min, Weight: 50%

Assessment Component 2: Team project — Weight: 50%

Scope: All intended learning outcomes of the module
Completion: This module is passed with an assessment-component weighted average grade of 45% or higher.

7.23.2.2 Ethics in Science and Technology

Module Name Ethics in Science and Technology			*Module Code* JTBQ-BQ-003	*Level (type)* Year 3 (Jacobs Track)	*CP* 5
Module Components					
Number	*Name*			*Type*	*CP*
JTBQ-003	Ethics in Science and Technology			Lecture	5
Module Coordinator Prof. Dr. Alexander Lerchl	*Program Affiliation* • Big Questions Area: All undergraduate study programs, except IEM			*Mandatory Status* Mandatory for CBT Mandatory elective for students of all undergraduate study programs, except IEM	
Entry Requirements *Pre-requisites* ☒ None	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • The ability and openness to engage in interdisciplinary issues of global relevance • Media literacy, critical thinking, and a proficient handling of data sources	*Frequency* Each semester (Fall & Spring) *Duration* 1 semester	*Forms of Learning and Teaching* • Lectures (35 hours) • Private study (90 hours) *Workload* 125 hours	
Recommendations for Preparation Critically following media coverage of the scientific topics in question.					
Content and Educational Aims All "Big Questions" (BQ) modules deal with the economic, technological, societal, and environmental contexts of the global issues and challenges of the coming decades. BQ modules intend to raise awareness of those challenges and broaden students' horizons with applied problem solving that extends beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules support students in their development to become informed and responsible citizens in a global society. Ethics is an often neglected, yet essential part of science and technology. Our decisions about right and wrong influence the way in which our inventions and developments change the world. A wide array of examples will be presented and discussed, e.g., the foundation of ethics, individual vs. population ethics, artificial life, stem cells, animal rights, abortion, pre-implantation diagnostics, legal and illegal drugs, the pharmaceutical industry, gene modification, clinical trials and research with test persons, weapons of mass destruction, data fabrication, and scientific fraud.					

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, students will be able to

- use their disciplinary factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
- summarize and explain ethical principles;
- critically look at scientific results that seem too good to be true;
- apply the ethical concepts to virtually all areas of science and technology;
- discover the responsibilities of society and of the individual for ethical standards;
- understand and judge the ethical dilemmas in many areas of the daily life;
- discuss the ethics of gene modification at the level of cells and organisms;
- reflect on and evaluate clinical trials in relation to the Helsinki Declaration;
- distinguish and evaluate the ethical guidelines for studies with test persons.

Indicative Literature

Not specified.

Usability and Relationship to other Modules

- Mandatory for CBT
- This module is a mandatory elective module in the Big Questions area that is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute their knowledge and competencies to class discussions and activities.

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 min

Weight: 100%

Scope: All intended learning outcomes of the module.

7.23.2.3 Global Health – Historical context and future challenges

Module Name			*Module Code*	*Level (type)*	*CP*
Global Health – Historical context and future challenges			JTBQ-BQ-004	Year 3 (Jacobs Track)	5
Module Components					
Number	*Name*			*Type*	*CP*
JTBQ-004	Global Health – Historical context and future challenges			Lecture	5
Module Coordinator Dr. Andreas M. Lisewski	*Program Affiliation* • Big Questions Area: All undergraduate study programs, except IEM			*Mandatory Status* Mandatory elective for students of all undergraduate study programs, except IEM	
Entry Requirements *Pre-requisites* ☒ None	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • The ability and openness to engage in interdisciplinary issues of global relevance • Media literacy, critical thinking, and a proficient handling of data sources	*Frequency* Annually (Fall) *Duration* 1 semester	*Forms of Learning and Teaching* • Lectures (35 hours) • Private study (90 hours) *Workload* 125 hours	
Recommendations for Preparation Critically following media coverage on the module's topics in question.					

Content and Educational Aims

All "Big Questions" (BQ) modules deal with the economic, technological, societal and environmental contexts of the global issues and challenges of the coming decades. The BQ modules intend to raise awareness of those challenges and broaden the students' horizon with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules are relevant for every university graduate in order to become an informed and responsible citizen in a global society.

The module gives a historical, societal, technical, and medicinal overview over the past, present and future milestones and challenges of global health. Main topics include health systems, public health, health/disease monitoring and response, past and recent breakthroughs in medicine and healthcare, as well as recent health-related developments in technology and economy. Special focus is put on children, maternal and adolescent health, as their health is critical to the well-being of next generations. Further topics cover epidemiology and demographics, such as the connection between a society's economic development level and its population health status, demographic and epidemiologic transitions, measures of health status and disease burden, and health-related global development goals. An overall guiding aspect is human health in our increasingly interconnected civilization that is however reaching its global limits on key resources and that is therefore becoming more prone to disruptions. Discussed in this context are today's urgent global health issues, such as newly emergent and reemergent infectious diseases, biosafety and complex humanitarian crises caused by unforeseen epidemics and pandemics.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, students will be able to

- use their disciplinary factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
- identify the historical context and today's function of global health institutions, surveillance and response systems;
- evaluate and compare global indicators of disease burden, especially by using online databases and repositories
- break down global development goals directly related to global health
- discuss and differentiate present and future challenges of public and global health responses to novel disease outbreaks in a global society network context

Indicative Literature

- Richard Skolnik, Global Health 101, 4th Edition, Jones & Bartlett Publishers, 2019
- Solomon Benatar (*Editor*), Global Health - Ethical Challenges, 2nd Edition, Cambridge University Press, 2021

Usability and Relationship to other Modules

- The module is a mandatory elective module of the Big Questions area, that is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules)
- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute such knowledge and competences to class discussions and activities.

Examination Type: Module Examination

Assessment Type: Written examination — Duration: 120 min.
Scope: All intended learning outcomes of the module — Weight: 100%

Module achievement: Oral presentation of selected literature and media topics on global health (topics are given but can also be suggested by students for approval).
The module achievement ensures sufficient knowledge about key global health concepts, challenges and current topics

7.23.2.4 Global Existential Risks

Module Name Global Existential Risks			*Module Code* JTBQ-BQ-005	*Level (type)* Year 3 (Jacobs Track)	*CP* 5
Module Components					
Number	*Name*			*Type*	*CP*
JTBQ-005	Global Existential Risks			Lecture	5
Module Coordinator Dr. Andreas M. Lisewski	*Program Affiliation* • Big Questions Area: All undergraduate study programs except IEM			*Mandatory Status* Mandatory elective for students of all undergraduate study programs except IEM	
Entry Requirements *Pre-requisites* ☒ None	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • The ability and openness to engage in interdisciplinary issues of global relevance • Media literacy, critical thinking, and a proficient handling of data sources	*Frequency* Annually (Spring) *Duration* 1 semester	*Forms of Learning and Teaching* • Lectures (35 hours) • Tutorial of the lecture (10 hours) • Private study (80 hours) *Workload* 125 hours	
Recommendations for Preparation Critically following media coverage on the module's topics in question.					
Content and Educational Aims All "Big Questions" (BQ) modules deal with the economic, technological, societal, and environmental contexts of the global issues and challenges of the coming decades. BQ modules intend to raise awareness of those challenges and broaden students' horizons with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules support students in their development to become informed and responsible citizens in a global society. The more we develop science and technology, the more we also learn about catastrophic and, in the worst case, even existential global dangers that put the entire human civilization at risk of collapse. These doomsday scenarios therefore directly challenge humanity's journey through time as an overall continuous and sustainable process that progressively leads to a more complex but still largely stable human society. The module presents the main known varieties of existential risks, including, for example, astrophysical, planetary, biological, and technological events or critical transitions that have the capacity to severely damage or even eradicate earth-based human civilization as we know it. Furthermore, this module offers a description of the characteristic features of these risks in comparison to more conventional risks, such as natural disasters, and a classification of global existential risks based on parameters such as range, intensity, probability of occurrence, and imminence. Finally, this module					

reviews several hypothetical monitoring and early warning systems as well as analysis methods that could potentially be used in strategies, if not to eliminate, then at least to better understand and ideally to minimize imminent global existential risks. This interdisciplinary module will allow students to look across relevant and diverse subject fields, thus enabling them to initiate and to contribute substantially to discussions about these special risks.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, students will be able to

- identify and explain the known spectrum of global existential risks, including physical, biological, and technological risks
- differentiate and classify these risks according to their characteristics in range (scope), intensity (severity), probability of occurrence, and imminence
- distinguish and identify main directions and potential biases in media coverage of global existential risks
- prepare, present, explain and discuss today's key topics in global existential risks from both academic literature and from public media

Indicative Literature

Nick Bostrom, Milan M. Cirkovic (eds.):. Global Catastrophic Risks,Oxford University Press,2011.

Martin Rees: Our Final Hour – A Scientist's Warning,Basic Books,2009.

Martin Rees: On the Future – Prospects for Humanity, Princeton University Press, 2021.

Usability and Relationship to other Modules

- This module is a mandatory elective module in the Big Questions area, which is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute their knowledge and competencies to class discussions and activities.

Examination Type: Module Examination

Assessment Type: Written examination — Duration: 120 min.
Scope: All intended learning outcomes of the module — Weight: 100%

Module achievement: Oral presentation of selected literature and media topics on our civilization's existential risks (topics are given but can also be suggested by students for approval)

The module achievement ensures sufficient knowledge about key risks and challenges for humanity's survival.

7.23.2.5 Future: From Predictions and Visions to Preparations and Actions

<table>
<tr><td colspan="3">Module Name
Future: From Predictions and Visions to Preparations and Actions</td><td>Module Code
JTBQ-BQ-006</td><td>Level (type)
Year 3 (Jacobs Track)</td><td>CP
2.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>JTBQ-006</td><td colspan="3">Future: From Predictions and Visions to Preparations and Actions</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Joachim Vogt</td><td colspan="3">Program Affiliation

• Big Questions Area: All undergraduate study programs, except IEM</td><td colspan="2">Mandatory Status

Mandatory elective for students of all undergraduate study programs, except IEM</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ None
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• The ability and openness to engage in interdisciplinary issues of global relevance
• Media literacy, critical thinking, and a proficient handling of data sources</td><td>Frequency

Annually (Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (17.5 hours)
• Private study (45 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

62.5 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Critically following media coverage of the module's topics in question.</td></tr>
<tr><td colspan="6">Content and Educational Aims

All "Big Questions" (BQ) modules deal with the economic, technological, societal, and environmental contexts of the global issues and challenges of the coming decades. BQ modules intend to raise awareness of those challenges and broaden students' horizons with applied problem solving that extend beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules support students in their development to become informed and responsible citizens in a global society.
This module addresses selected topics related to the future as a general concept in science, technology, culture, literature, ecology, and economy, and it consists of three parts. The first part (Future Continuous) discusses forecasting methodologies rooted in the idea that key past and present processes are understood and continue to operate such that future developments can be predicted. General concepts covered in this context include determinism, uncertainty, evolution, and risk. Mathematical aspects of forecasting are also discussed. The second part (Future Perfect) deals with human visions of the future as reflected in the arts and literature, ranging from ideas of utopian societies and technological optimism to dystopian visions in science fiction. The third part (Future Now) concentrates on important current developments—such as trends in technology, scientific breakthroughs, the evolution of the Earth system, and climate change—and concludes with opportunities and challenges for present and future generations.</td></tr>
</table>

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, student should be able to

- use their factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
- distinguish and qualify important approaches to forecasting and prediction;
- summarize the history of utopias, dystopias, and the ideas presented in classical science fiction;
- characterize current developments in technology, ecology, society, and their implications for the future.

Indicative Literature

United Nations (2015, September) Millennium Development Goals. Retrieved from http://www.un.org/millenniumgoals.
United Nation (2016, January): Sustainable Development Goals. Retrieved from http://catalog.jacobs-university.de/search~S0
United Nations University. https://unu.edu
US National Intelligence Council (2017). Global Trends. Retrieved from https://www.dni.gov/index.php/global-trends-home.
International Panel on Climate Change. Retrieved from https://www.ipcc.ch.
World Inequality Lab (2017, December). World Inequality Report 2018. Retrieved from https://wir2018.wid.world.
World Health Organization. Retrieved from http://www.who.int.
World Trade Organization. Retrieved from *https://www.wto.org*
Gapminder. Retrieved from https://www.gapminder.org.
World Bank. Retrieved from http://www.worldbank.org.

Usability and Relationship to other Modules

- This module is a mandatory elective module in the Big Questions area, which is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute their knowledge and competencies to class discussions and activities.

Examination Type: Module Examination

Assessment Type: Written examination — Duration: 60 min, Weight: 100%

Scope: All intended learning outcomes of the module

7.23.2.6 Climate Change

Module Name Climate Change		*Module Code* JTBQ-BQ-007	*Level (type)* Year 3 (Jacobs Track)	*CP* 2.5
Module Components				
Number	*Name*		*Type*	*CP*
JTBQ-007	Climate Change		Lecture	2.5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Prof. Dr. Laurenz Thomsen and Prof. Dr. Vikram Unnithan	• Big Questions Area: All undergraduate study programs, except IEM	Mandatory elective for students of all undergraduate study programs, except IEM

Entry Requirements			*Frequency*	*Forms of Learning and Teaching*
Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	Annually (Spring)	• Lecture (17.5 hours) • Private study (45 hours)
☒ None	☒ None	• The ability and openness to engage in interdisciplinary issues of global relevance • Media literacy, critical thinking, and a proficient handling of data sources	*Duration* 1 semester	*Workload* 62.5 hours

Recommendations for Preparation

Critically following media coverage of the module's topics in question.

Content and Educational Aims

All "Big Questions" (BQ) modules deal with the economic, technological, societal, and environmental contexts of the global issues and challenges of the coming decades. BQ modules intend to raise awareness of those challenges and broaden students' horizon with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules support students in their development to become informed and responsible citizens in a global society.

This module will give a brief introduction into the development of the atmosphere throughout Earth's history from the beginning of the geological record up to modern times, and will focus on geological, cosmogenic, and anthropogenic changes. Several major events in the evolution of the Earth that had a major impact on climate will be discussed, such as the evolution of an oxic atmosphere and ocean, the onset of early life, snowball Earth, and modern glaciation cycles. In the second part, the module will focus on the human impact on present climate change and global warming. Causes and consequences, including case studies and methods for studying climate change, will be presented and possibilities for climate mitigation (geo-engineering) and adapting our society to climate change (such as coastal protection and adaption of agricultural practices to more arid and hot conditions) will be discussed.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, students should be able to

- use their disciplinary factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
- advance a knowledge-based opinion on the complex module topics, including: impact of climate change on the natural environment over geological timescales and since the industrial revolution, and the policy framework in which environmental decisions are made internationally;
- work effectively in a team environment and undertake data interpretation;
- discuss approaches to minimize habitat destruction.

Indicative Literature

The course is based on a self-contained, detailed set of online lecture notes.

Ruddiman, William F. Earth's Climate (2001). Past and future. New York: Macmillan.

Usability and Relationship to other Modules

- This module is a mandatory elective module in the Big Questions area, which is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute their knowledge and competencies to class discussions and activities.

Examination Type: Module Examination

Assessment Type: Written examination — Duration: 60 min.
Scope: All intended learning outcomes of the module — Weight: 100%

7.23.2.7 Extreme Natural Hazards, Disaster Risks, and Societal Impact

<table>
<tr><td colspan="3">Module Name
Extreme Natural Hazards, Disaster Risks, and Societal Impact</td><td>Module Code
JTBQ-BQ-008</td><td>Level (type)
Year 3 (Jacobs Track)</td><td>CP
2.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>JTBQ-008</td><td colspan="3">Extreme Natural Hazards: Disaster Risks, and Societal Impact</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Laurenz Thomsen</td><td colspan="3">Program Affiliation

• Big Questions Area: All undergraduate study programs, except IEM</td><td colspan="2">Mandatory Status

Mandatory elective for students of all undergraduate study programs, except IEM</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ None
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• The ability and openness to engage in interdisciplinary issues of global relevance
• Media literacy, critical thinking, and a proficient handling of data sources</td><td>Frequency

Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (17.5 hours)
• Private study (45 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

62.5 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Critically following media coverage of the module’s topics in question.</td></tr>
<tr><td colspan="6">Content and Educational Aims

All “Big Questions” (BQ) modules deal with the economic, technological, societal, and environmental contexts of the global issues and challenges of the coming decades. BQ modules intend to raise awareness of those challenges and broaden students’ horizons with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules support students in their development to become informed and responsible citizens in a global society.
Extreme natural events increasingly dominate global headlines, and understanding their causes, risks, and impacts, as well as the costs of their mitigation, is essential to managing hazard risk and saving lives. This module presents a unique, interdisciplinary approach to disaster risk research, combining natural science and social science methodologies. It presents the risks of global hazards and natural disasters such as volcanoes, earthquakes, landslides, hurricanes, precipitation floods, and space weather, and provides real-world hazard and disaster case studies from Latin America, the Caribbean, Africa, the Middle East, Asia, and the Pacific.</td></tr>
</table>

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, student should be able to

- use their disciplinary factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
- advance a knowledge-based opinion on the complex module topics, including how natural processes affect and interact with our civilization, especially those that create hazards and disasters;
- distinguish the methods scientists use to predict and assess the risk of natural disasters;
- discuss the social implications and policy framework in which decisions are made to manage natural disasters;
- work effectively in a team environment.

Indicative Literature

The course is based on a self-contained, detailed set of online lecture notes.

Ismail-Zadeh, Alik, et al., eds (2014). Extreme natural hazards, disaster risks and societal implications. In *Special Publications of the International Union of Geodesy and Geophysics Vol. 1.* Cambridge: Cambridge University Press.

Usability and Relationship to other Modules

- The module is a mandatory elective module of the Big Questions area, that is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules)
- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute such knowledge and competences to class discussions and activities.

Examination Type: Module Examination

Assessment Type: Written examination — Duration: 60 min.
Scope: All intended learning outcomes of the module — Weight: 100%

7.23.2.8 International Development Policy

Module Name International Development Policy			*Module Code* JTBQ-BQ-009	*Level (type)* Year 3 (Jacobs Track)	*CP* 2.5
Module Components					
Number	*Name*			*Type*	*CP*
JTBQ-009	International Development Policy			Lecture	2.5
Module Coordinator Prof. Dr. Claas Knoop	***Program Affiliation*** • Big Questions Area: All undergraduate study programs, except IEM			***Mandatory Status*** Mandatory elective for students of all undergraduate study programs, except IEM	
Entry Requirements *Pre-requisites* ☒ None	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • The ability and openness to engage in interdisciplinary issues of global relevance • Media literacy, critical thinking, and a proficient handling of data sources	***Frequency*** Annually (Fall) ***Duration*** 1 semester	***Forms of Learning and Teaching*** • Lecture (17.5 hours) • Presentations • Private study (45 hours) ***Workload*** 62.5 hours	
Recommendations for Preparation Critically following media coverage of the module's topics in question.					

Content and Educational Aims

All "Big Questions" (BQ) modules deal with the economic, technological, societal, and environmental contexts of the global issues and challenges of the coming decades. BQ modules intend to raise awareness of those challenges and broaden students' horizon with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules support students in their development to become informed and responsible citizens in a global society.

We live in a world where still a large number of people still live in absolute poverty without access to basic needs and services, such as food, sanitation, health care, security, and proper education. This module provides an introduction to the basic elements of international development policy, with a focus on the relevant EU policies in this field and on the Sustainable Development Goals/SDGs of the United Nations. The students will not only learn about the tools applied in modern development policies, but also about the critical aspects of monitoring and evaluating the results of development policy. Module-related oral presentations and debates will enhance the students' learning experience.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, the student should be able to

- use their disciplinary factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
- breakdown the complexity of modern development policy;
- identify, explain, and evaluate the tools applied in development policy;
- formulate well-justified criticism of development policy;
- summarize and present a module-related topic in an appropriate verbal and visual form.

Indicative Literature

Francis Fukuyama (2006). The end of history and the last man. New York: Free Press.

Kingsbury, McKay, Hunt (2008). International Development.Issues and challenges. London: Palgrave.

A.Sumner, M.Tiwari (2009) After 2015: International Development Policy at a crossroad. New York: Palgrave Macmillan.

Graduate Institute of International Development, G. Carbonnier eds. (2001). International Development Policy: Energy and Development. New York:Palgrave Macmillan.

John Donald McNeil. International Development: Challenges and Controversy. Sentia Publishing,e-book.

Usability and Relationship to other Modules

- This module is a mandatory elective module in the Big Questions area, which is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute their knowledge and competencies to class discussions and activities.

Examination Type: Module Examination

Assessment Type: Presentation — Duration: 10 minutes per student
Scope: All intended learning outcomes of the module — Weight: 100%

7.23.2.9 Sustainable Value Creation with Biotechnology. From Science to Business

Module Name			*Module Code*	*Level (type)*	*CP*
Sustainable Value Creation with Biotechnology. From Science to Business			JTBQ-BQ-011	Year 3 (Jacobs Track)	2.5
Module Components					
Number	*Name*			*Type*	*CP*
JTBQ-011	Sustainable Value Creation with Biotechnology. From Science to Business			Lecture /Tutorial	2.5
Module Coordinator N.N.	*Program Affiliation* • Jacobs Track - Big Questions			*Mandatory Status* Mandatory elective for students of all undergraduate study except IEM	
Entry Requirements *Pre-requisites* ☒ None	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • The ability and openness to engage in interdisciplinary issues on bio-based value creation • media literacy, critical thinking and a proficient handling of data sources	*Frequency* Annually (Spring)	*Forms of Learning and Teaching* • Lecture and Tutorial (17.5 hours) • Private study (45 hours)	
			Duration 1 semester	*Workload* 62.5 hours	
Recommendations for Preparation https://www.ctsi.ucla.edu/researcher-resources/files/view/docs/EGBS4_Kolchinsky.pdf https://link.springer.com/article/10.1057/jcb.2008.27 https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf					

Content and Educational Aims

All "Big Questions" (BQ) modules deal with the economic, technological, societal and environmental contexts of the global issues and challenges of the coming decades. The BQ modules intend to raise awareness of those challenges and broaden the students' horizon with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules support students in their development to become an informed and responsible citizen in a global society.
This module has a particular focus on the role that Biotechnology and Biorefining is expected to play in social, economic and environmental contexts.
To deliver such a vision the module will prepare students to extract value form Biotechnology and associated activities. This will be done in the form of business cases that will be systematically developed by students alongside the development of the module. In this way, students will develop entrepreneurial skills while understanding basic business-related activities that are not always present in a technical curriculum. Case development will also provide students with the possibility of understanding the social, economic, environmental impact that Biotechnology and Biorefining can deliver in a Bio-Based Economy. The knowledge and skills gained through this module are in direct and indirect support of the UN 2030 Agenda for Sustainable Development: "Transforming our World".

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, the students should be able to

- design and develop a Business Case based on the tools provided by modern Biotechnology;
- explain the interplay between Science, Technology and Economics / Finance;
- use their disciplinary factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
- work effectively in a team environment and undertake data interpretation and analysis;
- discuss approaches to value creation in the context of Biotechnology and Sustainable Development;
- explain the ethical implications of technological advance and implementation;
- demonstrate presentation skills.

Indicative Literature

Springham, D., V. Moses & R.E. Cape (1999). Biotechnology – The Science and the Business. 2nd. Ed. Boca Raton: CRC Press.

Kornberg, Arthur (2002). The Golden Helix: Inside Biotech Ventures. Sausalito, CA: University Science Books.

UNESCO, Director-General. (2017). UNESCO moving forward the 2030 Agenda for Sustainable Development. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000247785

Usability and Relationship to other Modules

- The module is a mandatory elective module in the Big Questions area, which is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute their knowledge and competencies to class discussions and activities.

Examination Type: Module Examination

Assessment Component 1: Term Paper	Length:1.500 – 3.000 words Weight: 75%
Scope: Intended learning outcomes of the module (1-6)	
Assessment Component 2: Presentation	Duration: 10-15 min. Weight: 25%
Scope: Intended learning outcomes of the module (2-7)	

7.23.2.10 Gender and Multiculturalism. Debates and Trends in Contemporary Societies

<table>
<tr><td colspan="2">Module Name
Gender and Multiculturalism. Debates and Trends in Contemporary Societies</td><td>Module Code
JTBQ-BQ-013</td><td>Level (type)
Year 3 (Jacobs Track)</td><td>CP
5</td></tr>
<tr><td colspan="5">Module Components</td></tr>
<tr><td>Number</td><td colspan="2">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>JTBQ-013</td><td colspan="2">Gender and Multiculturalism: Debates and Trends in Contemporary Societies</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Dr. Jessica Price</td><td colspan="2">Program Affiliation

• Big Questions Area: All undergraduate study programs</td><td colspan="2">Mandatory Status

Mandatory elective for students of all undergraduate study programs, except IEM</td></tr>
<tr><td colspan="2" rowspan="2">Entry Requirements

Pre-requisites: ☒ None
Co-requisites: ☒ None
Knowledge, Abilities, or Skills
• The ability and openness to engage in interdisciplinary issues of global relevance
• Media literacy, critical thinking and a proficient handling of data sources</td><td>Frequency

Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching

• Lectures (17.5 hours)
• Project work (90 hours)
• Private study (17.5 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

125 hours</td></tr>
<tr><td colspan="5">Recommendations for Preparation

Critical following of the media coverage on the module's topics in question.</td></tr>
<tr><td colspan="5">Content and Educational Aims

All "Big Questions" (BQ) modules deal with the economic, technological, societal and environmental contexts of the global issues and challenges of the coming decades. The BQ modules intend to raise awareness of those challenges and broaden the students' horizon with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules are relevant for every university graduate in order to become an informed and responsible citizen in a global society.
The objective of this module is to introduce and familiarize students with the current debates, trends and analytical frameworks pertaining how gender is socially constructed in different cultural zones. Through lectures, group discussions and reflecting upon cultural cases, students will familiarize themselves with the current trends and the different sides of ongoing cultural and political debates that shape cultural practices, policies and discourses. The module will zoom-in on topics such as: cultural identity; the social construction of gender; gender fluidity and its backlash; gender and human rights; multiculturalism as a perceived threat in plural societies, among others. Students will be provided with opportunities for reflection and to ultimately develop informed opinions concerning topics that are continue to define some of the most contested cultural debates of</td></tr>
</table>

contemporary societies. Furthermore, participants will engage their ideas in "hands on" projects aimed at moving the needle from mere reflection by conducting "action-research" that will inform the outcomes of their course projects.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, students will be able to

- use their disciplinary factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
- summarize and evaluate the current cultural, political and legal debates concerning the social construction of gender in contemporary societies;
- reflect and develop informed opinions concerning the current debates and trends that are shaping ideas of whether multiculturalism ideals are realistic in pluralist western societies, or whether multiculturalism is a failed project;
- identify, explain and evaluate the role that societal forces, such as religion, socio-economic, political and migratory factors play in the construction of gendered structures in contemporary societies;
- develop a well-informed perspective concerning the interplay of science and culture in the debates around gender fluidity;
- deconstruct and reflect on the intersectionality between populist/nationalist discourses and gender discrimination;
- reflect and propose societal strategies and initiatives that attempt to answer the big questions presented in this module regarding gendered and cross-culturally-based inequalities;
- complete a self-designed project, collect and distill information from an "action-research" perspective;summarizing the process in a suitable reporting format;
- consider the application of an algorithm for group formation (not mandatory);
- overcome general teamwork problems in order to perform well-organized project work.

Indicative Literature

Biological Limits of Gender Construction Author(s): J. Richard Udry

Source: American Sociological Review , Jun., 2000, Vol. 65, No. 3 (Jun., 2000), pp. 443- 457. Published by: American Sociological Association Stable URL: https://www.jstor.org/stable/2657466

The Development of Gendered Interests and Personality Qualities From Middle Childhood Through Adolescence: A Biosocial Analysis. Susan M. McHale, Aryn M. Dotterer, Ji-Yeon Kim, Ann C. Crouter and Alan Booth. Child Development, March/April 2009, Volume 80, Number 2, Pages 482–495

Factors influencing attitudes to violence against women. Michael Flood and Bob Pease. Trauma, Violence, & ABuse, Vol. 10, No. 2, April 2009 125-142 dOi: 10.1177/1524838009334131. 2009 sAge Publications

Gender and Anti-immigrant Attitudes in Europe. Aaron Ponce (2017) Socius: Sociological Research for a Dynamic World. Volume 3: 1–17. Reprints and permissions: sagepub.com/journalsPermissions.nav

Usability and Relationship to other Modules

- The module is a mandatory elective module of the Big Questions area, that is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules)
- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute such knowledge and competences to class discussions and activities.

Examination Type: Module Examination

Assessment Type: Team Project

Weight: 100%

Scope: All intended learning outcomes of the module

7.23.2.11 The Challenge of Sustainable Energy

Module Name		*Module Code*	*Level (type)*	*CP*
The Challenge of Sustainable Energy		JTBQ-BQ-014	Year 3 (Jacobs Track)	2.5
Module Components				
Number			*Type*	*CP*
JTBQ-014	The Challenge of Sustainable Energy		Lecture	2.5
Module Coordinator Prof. Dr. Karen Smith Stegen	***Program Affiliation*** • Big Questions Area: All undergraduate study programs		***Mandatory Status*** Mandatory elective for students of all undergraduate study programs, except IEM	
Entry Requirements *Pre-requisites* ☒ None	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • Ability to read texts from a variety of disciplines	***Frequency*** Annually (Spring)	***Forms of Learning and Teaching*** • Lectures and Group Exercises
			Duration 1 semester	***Workload*** 62.5 hours
Recommendations for Preparation				
Reflect on their own behavior and habits with regard to sustainability.				

Content and Educational Aims

All "Big Questions" (BQ) modules deal with the economic, technological, societal and environmental contexts of the global issues and challenges of the coming decades. The BQ modules intend to raise awareness of those challenges and broaden the students' horizon with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules are relevant for every university graduate in order to become an informed and responsible citizen in a global society.
How can wide-scale social, economic and political change be achieved? This module examines this question in the context of encouraging "sustainability". To address global warming and environmental degradation, humans must adopt more sustainable lifestyles. Arguably, the most important change is the transition from conventional fuels to renewable sources of energy, particularly at the local, country and regional levels. The main challenge to achieving an "energy transition" stems from human behavior and not from a lack of technology or scientific expertise. This module thus examines energy transitions from the perspective of the social sciences, including political science, sociology, psychology, economics and management. To understand the drivers of and obstacles to technology transitions, students will learn the "Multi-Level Perspective". Some of the key questions explored in this module include: What is meant by sustainability? Are renewable energies "sustainable"? How can a transition to renewable energies be encouraged? What are the main social, economic, and political challenges? How can these (potentially) be overcome? The aim of the course is to provide students with the tools for reflecting on energy transitions from multiple perspectives.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, students will be able to

- articulate the history of the sustainability movement and the major debates;
- identify different types of renewable energies;
- explain the multi-level perspective (MLP), which models technology innovations and transitions;
- summarize the obstacles to energy transitions;
- compare a variety of policy mechanisms for encouraging renewable energies.

Usability and Relationship to other Modules

- The module is a mandatory elective module of the Big Questions area that is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- For students interested in sustainability issues, this module complements a variety of modules from different programs, such as "International Resource Politics" (IRPH/SMP), "Environmental Science" (EES), "General Earth and Environmental Sciences" (EES), and "Renewable Energies" (Physics).

Examination Type: Module Examination

Assessment Type: Written Examination — Duration: 60 min, Weight: 100%

Scope: All intended learning outcomes of the module

7.23.2.12 State, Religion and Secularism

Module Name State, Religion and Secularism			*Module Code* JTBQ-BQ-015	*Level (type)* Year 3 (Jacobs Track)	*CP* 2.5
Module Components					
Number				*Type*	*CP*
JTBQ-015	State, religion and secularism			Lecture	2.5
Module Coordinator Prof. Dr. Manfred O. Hinz	*Program Affiliation* • Big Questions Area: All undergraduate study programs			*Mandatory Status* Mandatory elective for students of all undergraduate study programs, except IEM	
Entry Requirements *Pre-requisites* ☒ None	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • Ability to read texts from a variety of disciplines	*Frequency* Annually (Spring)	*Forms of Learning and Teaching* • Lectures and Group Exercises	
			Duration 1 semester	*Workload* 62.5 Hours	
Recommendations for Preparation Reflect on the situation and role in respective home-country					

Content and Educational Aims

The relationship between state and religion has been a matter of concern in most if not all societies. Is religion above the state, or is it to the state to determine the place of religion? What does secularity mean? To what extent will religion accept secularity? Where does the idea of secularity come from? The course State, religion, secularism will search for answers to questions of this nature. After introducing to the topic and looking at some legal attempts to regulate the relationship between state and religion, the focus will be, on the one hand, on Christianity and secularity and, on Islam and secularity, on the other. Depending on the interest of participants, other religions and their relationships to states of relevance can be added.

Intended Learning Outcomes

By the end of this course, students should be able

- To understand the basic problems that have led to different models to regulate the relationship between the state and religion;
- To reflect critically the situation of state and religion in selected countries;
- To assess the values behind the concept of democracy and human rights;
- To use the acquired knowledge to strengthen the capacity towards respect for others and tolerance.

Usability and Relationship to other Modules

- The module is a mandatory elective module of the Big Questions area that is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- For students interested in State, Religion and secularism, this module complements modules from other programmes, such as IRPH and SMP

Examination Type: Module Examination

Assessment Type: Term paper

Length:1.500 – 3.000 words
Weight: 100%

Scope: All intended learning outcomes of the module.

7.23.3 Community Impact Project

<table>
<tr><td colspan="3">Module Name
Community Impact Project</td><td>Module Code
JTCI-CI-950</td><td>Level (type)
Year 3 (Jacobs Track)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>JTCI-950</td><td colspan="3">Community Impact Project</td><td>Project</td><td>5</td></tr>
<tr><td>Module Coordinator

CIP Faculty Coordinator</td><td colspan="3">Program Affiliation

• All undergraduate study programs except IEM</td><td colspan="2">Mandatory Status

Mandatory for all undergraduate study programs except IEM</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ at least 15 CP from CORE modules in the major
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• Basic knowledge of the main concepts and methodological instruments of the respective disciplines</td><td>Frequency

Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching

• Introductory, accompanying, and final events: 10 hours
• Self-organized teamwork and/or practical work in the community: 115 hours</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Develop or join a community impact project before the 5th semester based on the introductory events during the 4th semester by using the database of projects, communicating with fellow students and faculty, and finding potential companies, organizations, or communities to target.</td></tr>
<tr><td colspan="6">Content and Educational Aims

CIPs are self-organized, major-related, and problem-centered applications of students’ acquired knowledge and skills. These activities will ideally be connected to their majors so that they will challenge the students’ sense of practical relevance and social responsibility within the field of their studies. Projects will tackle real issues in their direct and/or broader social environment. These projects ideally connect the campus community to other communities, companies, or organizations in a mutually beneficial way.
Students are encouraged to create their own projects and find partners (e.g., companies, schools, NGOs), but will get help from the CIP faculty coordinator team and faculty mentors to do so. They can join and collaborate in interdisciplinary groups that attack a given issue from different disciplinary perspectives.
Student activities are self-organized but can draw on the support and guidance of both faculty and the CIP faculty coordinator team.</td></tr>
<tr><td colspan="6">Intended Learning Outcomes

The Community Impact Project is designed to convey the required personal and social competencies for enabling students to finish their studies at Jacobs as socially conscious and responsible graduates (part of the Jacobs mission) and to convey social and personal abilities to the students, including a practical awareness of the societal context and relevance of their academic discipline.

By the end of this project, students should be able to</td></tr>
</table>

- understand the real-life issues of communities, organizations, and industries and relate them to concepts in their own discipline;
- enhance problem-solving skills and develop critical faculty, create solutions to problems, and communicate these solutions appropriately to their audience;
- apply media and communication skills in diverse and non-peer social contexts;
- develop an awareness of the societal relevance of their own scientific actions and a sense of social responsibility for their social surroundings;
- reflect on their own behavior critically in relation to social expectations and consequences;
- work in a team and deal with diversity, develop cooperation and conflict skills, and strengthen their empathy and tolerance for ambiguity.

Indicative Literature

Not specified

Usability and Relationship to other Modules

- Students who have accomplished their CIP (6th semester) are encouraged to support their fellow students during the development phase of the next year's projects (4th semester).

Examination Type: Module Examination

Project, not numerically graded (pass/fail)
Scope: All intended learning outcomes of the module

7.23.4 Language Modules

The descriptions of the language modules are provided in a separate document, the "Language Module Handbook" that can be accessed from here: https://www.jacobs-university.de/study/learning-languages

8 Appendix

8.1 Intended Learning Outcomes Assessment Matrix

Electrical and Computer Engineering (ECE) B.Sc					Module 1 (GENEE1)	Module 2 (GENEE2)	Module 3 (C and C++)	Module 4 (Classical Physics)	Module 5 (Intro RIS)	Module 6 (Intro CS)	Module 7 (Applied Math.)	Module 8 (Signals & Systems)	Module 9 (DSP)	Module 10 (Communication Basics)	Module 11 (Wireless Comm.)	Module 12 (Electromagnetics)	Module 13 (Information Th.)	Module 14 (Electronics)	Module 15 (PCB & Meas.)	SPEC: Wireless Communication II	SPEC Coding Theory	SPEC Digital Design	SPEC Radio-Frequency (RF) Design	Internship	Bachelor Thesis	JT Methods & Skills	JT Langauge	JT Comm. Impact Project	JT Big Questions
Semester					1	2	1	1	2	2	2	3	4	3	4	3	4	5	4	5/6	5/6	5/6	5/6	5	6	1-4	1-4	5	5/6
Mandatory/ optional					m	m	m	m	me	me	me	m	m	m	m	m	m	m	m	me	me	me	me	m	m	m	m	m	m
Credits					7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	5	5	5	5	5	5	5	5	5	5	15	15	20	10	5	10
	Competencies*																												
Program Learning Outcomes	**A**	**E**	**P**	**S**																									
ILO 1 (physical, mathematical foundation)	x	x			x	x		x	x	x	x	x	x	x	x	x	x	x	x				x		x	x			
ILO 2 (theory time/freq dom.)	x	x			x	x						x	x	x			x			x	x				x				
ILO 3 (compare to info theory and limits)	x	x	x										x	x	x	x	x	x	x	x	x				x				
ILO 4 (explain and implement signal proc)	x	x					x		x		x	x	x	x	x		x	x	x	x	x	x			x				
ILO 5 (dedicated alg. For audio, video, …)	x	x											x	x	x		x		x	x	x	x			x				
ILO 6 (design transmission methods)	x	x	x									x	x	x	x	x	x			x	x	x	x		x				
ILO 7 (know electronics and implement)	x	x	x		x	x						x	x			x		x	x			x	x		x				
ILO 8 (measurements)	x	x			x	x						x	x	x				x	x			x	x		x				
ILO 9 (understand and design MAC, …)	x	x															x			x	x	x	x		x				
ILO 10 (use methods)	x	x																	x						x				
ILO 11 (develop solutions)	x	x			x	x						x	x	x					x						x				x
ILO 12 (engage ethically)	x	x	x	x	x	x	x					x	x	x					x					x	x		x	x	x
ILO 13 (responsibility for own learning)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
ILO 14 (apply knowledge)	x	x			x	x		x				x	x	x										x	x		x	x	x
ILO 15 (diverse team)		x	x		x	x	x	x				x	x	x					x					x			x	x	x
ILO 16 (adhere to standards)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Assessment Type																													
Oral examination																													
Written examination					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x			
Project																									x			x	
Term paper																									x				
Lab report					x	x		x				x	x	x					x					x					
Poster presentation																													
Presentation																									x				
Various																											x		x
Module achievements/bonus achievements								x	x																		x		

*Competencies: A-scientific/academic proficiency; E-competence for qualified employment; P-development of personality; S-competence for engagement in society

Figure 4: Intended Learning Outcomes Assessment Matrix