JACOBS
UNIVERSITY

School of Engineering and Science

Electrical and Computer Engineering (BSc)

Bachelor's Degree Program

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1 Electrical and Computer Engineering

1.1 Concept

Students of Electrical and Computer Engineering at Jacobs University will receive an education in modern fields of ECE focusing on digital signal processing, communications, control, electronics, and computer architecture.

The courses offered in the first year provide a general overview over a broad range of ECE topics, as well as an intensive training of programming skills. With suitable choices of general lectures in the first year, students can still easily change to the sister majors EECS or CS. Even changes to other majors are possible, but usually require to fill a gap in lab courses in the second year. This flexibility is uncommon at most state universities in Germany. In years two and three, students will on the one hand increasingly specialize within ECE, and on the other hand benefit from the transdisciplinary openness that is the hallmark of Jacobs University and take courses from neighboring disciplines, complementing their in-depth ECE training. Students thus learn to adapt their knowledge and expertise to a variety of tasks. This is an invaluable asset in a student's future career.

Research is an essential part of student education at Jacobs University. Enabled by a very low student to faculty ratio, students will participate in real research work even during bachelor education. Faculty is working in exciting areas of modern electrical engineering, for example: digital signal processing, digital communications, coding theory, wireless and wireline communications, reliability studies in VLSI, organic devices.

1.2 Cooperation with Other Universities

The faculty members of the ECE Major at Jacobs University have excellent working cooperations with leading Electrical Engineering and ECE Departments worldwide. Specifically, students with ambitious academic career plans can be efficiently recommended to renown research labs for their (mandatory) practicals.

Part of the faculty of ECE are part-time teaching at Jacobs University and other international universities thereby providing personal links. Jacobs University is housing external students from other universities worldwide and we also support students doing a thesis in industry or external universities.

1.3 Job Prospects and Career Options

It is almost needless to say that our modern life is determined by ECE technology, especially VLSI and communications. These are also the major orientations of ECE studies at Jacobs University. In the foreseeable future, there will always be a demand for electrical and computer engineers worldwide. Especially in developing countries, we see dramatically increasing markets for communications infrastructure. In electronics, optical components, and flexible

semiconductor circuits will change everyday life. Jacobs University has focused on such subfields that are seen as the driving force of the foreseeable future.

Cross-disciplinary breadth and flexibility, as well as social and work organization skills 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.

The main elements to make this possible are:

- The program concentrates on the sub-disciplines that combine a "mainstream" breadth with a high potential for future innovations. It thus focuses on modern aspects of digital signal processing, communications, coding, control, VLSI, and computer architecture. Traditional fields like power engineering and machinery have been completely excluded, others are limited to the essential contents.
- ECE faculty was carefully recruited from modern, integrative areas of electrical and computer engineering, and for a record of interdisciplinary research.
- Extensive laboratory courses for practical ECE (and some CS) training and the acquisition of social and workflow skills enable the student to work in large-scale joint project teams.
- Jacobs University is generally an exquisite place to acquire great social skills, simply because our undergraduate students come from more than 80 countries and live together in college buildings. This unique circumstance can hardly be over-rated.
- Since mathematical tools are at the core of today's ECE applications and research, an early and rigorous systematic training in the relevant mathematical disciplines is ensured.
- The practical aspects of training are deepened in the mandatory 2-3 months industry or academic internship. Students are helped to find a host organization with electrical engineering as its core competency.

As to the academic vs. industrial career decision, there are two principal career options for a student graduating in electrical and computer engineering. The first option is entering a non-academic position directly. In line with the expectations and demands of a majority of potential employers, Jacobs University electrical and computer engineering graduates will be able to start a career in industry / business / the public sector after studying for three years. Our graduates will enter their job at a young age of 21-22, so that there is ample time for job specific training at the future employer.

The alternative option is to continue on the academic track with graduate studies, possibly with a long-term goal of a higher entry qualification for industry positions. The ECE major will prepare students for graduate studies, in particular for

- our own Communications, Systems & Electronics graduate program in Electrical and Computer Engineering at Jacobs University,
- the same subject at other institutions of higher education,
- more business oriented fields for those seeking a management career in high-tech enterprises.

After finalizing their B.Sc., the majority of Jacobs' ECE students went on to study for a Master's degree. The best among them could promptly enlist in the world's leading institutions in their specialization areas (EPFL Lausanne, Urbana-Champaign, Cornell, University of Montreal, ...), witnessing the high quality of the training they received at Jacobs University. The ones who opted for a direct industrial career faced no difficulties in finding qualified employments, a gratifyingly large portion among them in the wider Bremen area.

Students with a degree in ECE will find themselves at the very heart of modern developments in industry and the public sector. There is hardly a field which has not been affected by the revolutionary development of signal processing, communications, and micro-electronics, which has for example resulted in the ubiquitous use of telecommunication devices and the VLSI circuitry around us that we mostly do not even realize anymore, but that control almost all the devices we use in our everyday life. We will soon even see small devices that autonomously connect to networks. Modern ECE graduates will work in an environment determined by hardware that is mostly software developed or that can be adapted by software changes. Thus, there is sophisticated hardware on one side and sophisticated algorithms to make use of it on the other. This hardware and application relation distinguishes ECE from CS. Shorter development cycles will require more and more experts that are able to think in algorithmic realizations making the most out of a mixed analog/digital design. The pace of change will not slow down. It is predicted that the share of the electronics and information technology industries in the gross national product will further increase. Hence there is, from a national economics perspective, an urgent need for excellent ECE graduates, and it appears certain that job prospects will remain excellent for at least more than a decade.

1.4 Curriculum Development Process

This curriculum has been developed from the ECE specialization of the EECS curriculum, which was run very successfully from the start. The greatest challenge for curriculum design was to bind into a short 3-year program all the requirements of practical and theoretical training, social and work organization skills, as well as interdisciplinary openness, coverage of all essential ECE basics, and offering a broad scope of specialization courses. This led to the following general design of the program:

- In the first year, the program offers (i) overview lectures and lab courses that expose the student to (almost) all ECE aspects at a simple level, (ii) a training in a standard programming language, (iii) an essential mathematical training in calculus and linear algebra, (iv) introductory courses from other natural science fields, (v) transdisciplinary courses. For (i) – (iii), all courses are mandatory.
- After the first year, the student may ultimatively enroll in ECE if s/he meets threshold marks in mandatory courses. A change of major is possible at this point at the latest.
- In the second year, the program offers an in-depth treatment of carefully selected mainstream topics of ECE which requires a set of mandatory courses somewhat limiting the flexibility in this year. The programming and mathematical education (probability and statistics, advanced linear algebra, numerics) is continued. Room is left for one transdisciplinary course.

- During the summer break after the second year, a 2-3 month internship in industry or academic labs is mandatory.
- From the second year onward, students are offered opportunities to work in (paid) student assistant jobs within funded projects or as teaching assistants.
- In the third year, the program offers choices of specialization courses that lead the student close to the frontier of research. Again, the program leaves room for a transdisciplinary course. In the first half of the third year, the student will select a guided research project and show in a proposal a sufficient level of understanding. In the second half of the third year, this project will then lead to a Bachelor thesis finalizing the B.Sc. studies.

The curriculum will be continuously scrutinized as to whether it ensures a sound academic education (i.e., successful applications of students at graduate schools) and also fulfills the expectations of potential employers (i.e., rate to find a job in the field within a few months).

The adaptation of the curricula of the individual lectures will not be left to the instructor of record alone. In yearly reviews, the faculty members of the EECS group agree and commit on necessary changes and updates.

Specifically, the third year specialization courses are directly linked to ongoing research of faculty members. By their nature, they will continuously change, always reflecting the most recent advances in research.

2 Modules: Electrical and Computer Engineering

For greater transparency of the logics and as guidance for the (prospective) student, we have structured the respective major programs in terms of modules. A module is defined as a combination of courses (lectures, lab units or other types of courses) interconnected by the same learning goals (Lernziel). Before listing the individual courses and describing their contents, these modules are presented and characterized by the skills and abilities that the student is expected to acquire. Irrespective of this overarching modular structure, the learning progress will be documented with credit points and grades attributed to the individual courses or lab units. This facilitates the control of the student's progress through the student as well as the university on a semester basis, while the modules may extend over a year or, in exceptional cases, even over longer periods. Only the core content of a major program is suited for modularization. The freely choosable Home School Electives and transdisciplinary courses fall outside this structure.

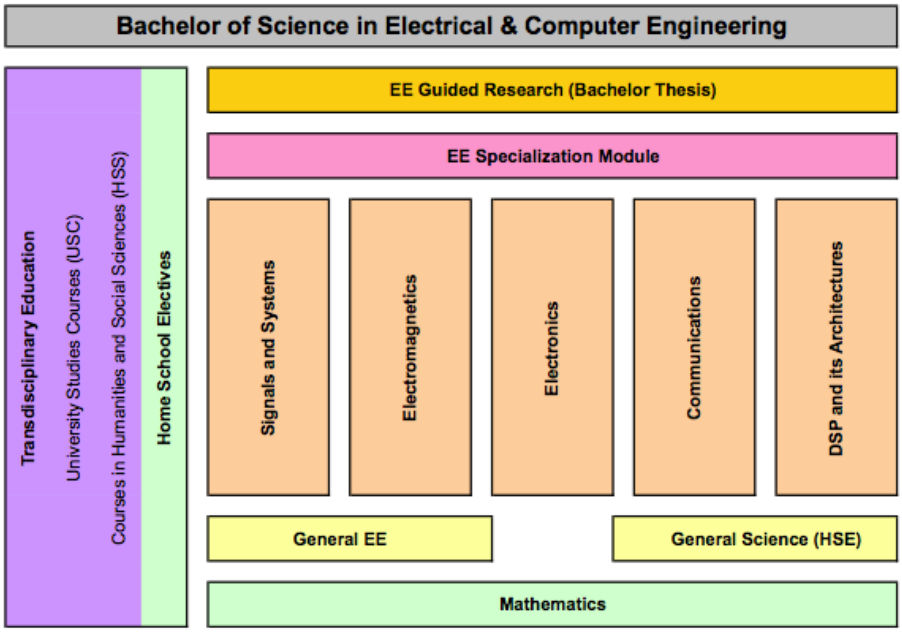

Figure 1: ECE Module Structure

Subsequently the individual modules are being defined with respect to learning goals and acquired competencies. The listed course numbers constitute a reference to the individual courses and the descriptions of their contents.

2.1 General Science

Home School Electives and transdisciplinary courses are not listed as modules. Some further home school (Engineering and Science, ECs) courses are required which is visible in the figure, but are not separately listed since they are electives. In the 3rd year, all courses are for further specialization in a direction chosen by the student and modules there directly represent single courses. We represent them as ECE specialization module.

120130 – ESM for Electrical and Computer Engineering

Short Name: ESM for ECE
Semester: 1 – 4
Credit Points: 20 ECTS

General Information Students of Electrical Engineering are required to take four semesters of Engineering and Science Mathematics; the courses listed below are mandatory for the ECE major. Students with an interest in theory are encouraged to take *ESM 1B Multivariable Calculus and Ordinary Differential Equations* as well; this course is not a graduation requirement.

Learning goals

- Working skills in differential and integral calculus, linear algebra, probability, and statistics, Fourier methods, and numerics.
- Problem solving skills
- Training in abstract reasoning and symbolic manipulation
- Ability to turn real-world problems into a concise mathematical question
- Ability to interpret mathematical statements back into the problem domain

Courses

120101 ESM 1A – Single Variable Calculus

120112 ESM 2B – Linear Algebra, Fourier, Probability

120201 ESM 3A – Advanced Linear Algebra, Stochastic Processes

120202 ESM 4A – Numerical Methods

Elective – Natural Science Modules

Short Name: ModGenSES
Semester: 1 – 2
Credit Points: 10 ECTS

General Information These are two first year natural science courses which offer a student to get introduced in other areas as well. Especially for students that feel unsure about their major choice, this offers the possibility to more easily change major.
Students may prefer language courses (see language module below), instead, each counted 2.5 credits to replace general courses from other majors. This possibility is limited to 4 language courses, in total.

Learning goals

- This should offer the student an introduction into other sciences offered within the School of Engineering and Science (SES).

Courses

2 General Engineering and Science lectures (5 ECTS credits each)

2.2 ECE Major

300100 – General Electrical Engineering

Short Name: ModGEEee
Semester: 1-2
Credit Points: 15 ECTS

General Information The emphasis of the first year is to familiarize the student with the general concepts of Electrical Engineering. Two lectures and two accompanying labs are provided.

Learning goals

- Get an overview over Electrical Engineering as a whole, its theoretical and practical aspects to an extend that would also be interesting for other sciences. This overview contains Ohm's law, electric, magnetic fields, analysis of simple circuits, signal processing, communications, control, and energy systems.
- By means of the accompanying lab course, theoretical concepts are deepened and hands-on experiences are obtained.
- The lecture/lab combination allows students to develop a self-directed working style in groups after having received the theoretical basis.
- First experiences in reporting of own lab experiments are an additional educational aspect.

Courses

300101 General Electrical Engineering I (lecture)

300102 General Electrical Engineering II (lecture)

300111 Natural Science Lab Unit Electrical Engineering I

300112 Natural Science Lab Unit Electrical Engineering II

320100 – General Computer Science

Short Name: ModGCSee
Semester: 1 – 2
Credit Points: 5 ECTS

General Information This lab module familiarizes students with general concepts of Computer Science. The two units are mainly oriented towards the practical side of computer science and provide an introduction to procedural programming.

Learning goals

- Introduction to procedural programming concepts
- Enabling students to solve simple programming problems

Courses

320111 Natural Science Lab Unit Programming in C I

320112 Natural Science Lab Unit Programming in C II

300200 – Signals and Systems

Short Name: ModSSee
Semester: 3
Credit Points: 15 ECTS

General Information This module contains standard and essential electrical engineering topics. It serves as *the* basis for signal processing, communications, control, and to some extent also for energy distribution systems (not directly part of the ECE curriculum).

Learning goals

- Understanding of continuous and discrete time signals and their descriptions in time and frequency domain. Deterministic and random signals are both treated in this module.
- A lab course allows students to deepen theoretical concepts while obtaining hands-on experience.
- Students develop a self-directed working style in groups after having received the theoretical basis.
- Students practice the documentation of lab results in reports.

Courses

300201 Signals and Systems (lecture)

300221 Signals and Systems Lab

300321 Probability and Random Signal Processing

300210 – ELECTROMAGNETICS

Short Name: ModEMee
Semester: 3
Credit Points: 5 ECTS

General Information Electromagnetics is one of the pillars of electrical engineering education. It introduces students to basic concepts of field theory, wave propagation, and antennas. Although the topic is not the major focus of ECE, the basic concepts should be taught. This lecture provides these basics.

Learning goals

- Understanding electric and magnetic fields, Maxwell's equations relating them, and wave propagation on transmission lines.

Courses

300211 Electromagnetics (lecture)

300220 – ELECTRONICS

Short Name: ModELee
Semester: 4
Credit Points: 10 ECTS

General Information Another pillar of traditional EE education is electronics. This course offers the principal understanding of the building blocks of analog and digital circuitry, but also offers the basis for a VLSI orientation in the 3rd year.

Learning goals

- Understanding analog passive and active components and basic circuits.
- Knowledge of the building blocks of digital circuits and descriptions of such logic circuits.
- Practical experiences with components and small circuits and in simulating circuit behavior.
- The combination of a lecture with a lab course allows students to deepen theoretical concepts while obtaining hands-on experience.
- Students develop a self-directed working style in groups after having received the theoretical basis.
- Students practice the documentation of lab results in reports.

Courses

300212 Electronics (lecture)

300222 Electronics Lab

300230 – COMMUNICATIONS

Short Name: ModCOMee
Semester: 4
Credit Points: 5 ECTS

General Information This is an introductory communications module. It serves two purposes by providing an overview of basic communication principles for all ECE students while at the same time serving as the foundation for students who want to specialize in communications.

Learning goals

- Understanding and being able to describe deterministic and probabilistic signals and to apply them to analog and digital communications.
- Being aware of the filtering requirements at the transmitter and receiver of a communication system when changing between time-continuous and time-discrete signal representations in digital communications.

- Understanding and being able to apply the basic trade-offs, requirements and limitations of signal transmission.
- Being able to demonstrate basic knowledge on information transmission and detection methods, building blocks of a transmission link, channel properties and its influence on the choice of a particular transmission and detection method.

Courses

300202 Communications (lecture)

300xxx – Digital Signal Processing and its Architectures

Short Name: ModDSPee
Semester: 4
Credit Points: 15 ECTS

General Information This module provided the theoretical foundations of digital signal processing and guides the student all the way to practical implementations. It covers hardware (processor architecture), algorithmic aspects, and software realization.

Learning goals

- Understanding the principles of digital signal processing.
- Understanding the design principles and structures of current processing hardware.
- Being able to sucessfully develop and implement real-time algorithms.
- The combination of a lecture with a lab course allows students to deepen theoretical concepts while obtaining hands-on experience.
- Students develop a self-directed working style in groups after having received the theoretical basis.
- Students practice the documentation of lab results in reports.

Courses

300302 Digital Signal Processing (lecture)

300231 Digital Signal Processing and Communications Lab

320241 Computer Architecture

300300 – ECE Specialization Module

Short Name: ModEESPee
Semester: 5 – 6
Credit Points: 30 ECTS

General Information During the third year, students can specialize in the areas of their specific interests. This module gathers all ECE specialization courses offered in the third year. Students are required to take five courses and a lab covering different aspects of advanced ECE.

Learning goals

- The student should specialize, typically into, e.g., communications, control, or microelectronics. However, also other combinations are possible for a broader orientation.
- Courses familiarize students with the basic knowledge and skills needed to understand and reflect state-of-the-art research and development in the choosen areas.
- An advanced lab exposes the students to up-to-date technology used in Jacobs University's ECE research. This lab combines experiments from different areas.
- Students are prepared to either enter graduate research and development programs and acquire the knowledge necessary to successfully enter the job marked in the choosen focus areas.

Courses

300322 Advanced Random Processes

300301 Dynamical Systems and Control

300341 Information Theory

300362 Coding Theory

300311 Wireless Communications

300371 Wavelets and their Applications

320301 Networks and Protocols

300331 Electronic Devices

300332 Microelectronics

300351 Advanced Digital Design

320311 Robotics

300392 Specialization Areas Lab

300310 – GUIDED RESEARCH MODULE

Short Name: ModGRee
Semester: 6
Credit Points: 7.5 ECTS

General Information Guided Research represents the final project in the ECE bachelor's program and is finalized by a B.Sc. thesis and presentation. The accompanying course is in the form of a seminar directed by the professor who has proposed a certain topic.

Learning goals

- The student should be guided into own research and development. They finally have to show ability to further work outside of the university making use of their collected knowledge, i.e., they show to be ready for a job or prepared for further graduate studies.
- Students should learn how to write a scientific thesis, get used to structural and content rules.
- They learn how to give scientific presentations, especially how to structure, handle time constraints, and show the ability to speak freely in front of an audience.

Courses

300361 Guided Research in Electrical Engineering

300342 Guided Research in Electrical Engineering + Thesis

3 Requirements for a B.Sc. in Electrical and Computer Engineering

3.1 General Requirements

To obtain a B.Sc. degree at Jacobs University, a minimum of 180 ECTS credit points must be earned over a period of 6 semesters.

- A minimum of 140 ECTS credits must be earned in the School of Engineering and Science.
- 30 ECTS credits must be earned through transdisciplinary courses, comprised of courses in the School of Humanities and Social Sciences (SHSS) and University Study Courses (USC). Students can choose how many USCs or S HSS courses they take.
- 10 ECTS credits (4 courses) are accredited either for language courses or additional Home School electives. Students can decide whether they take language courses or not.

University requirements outside of the school of the major are type-coded "u" in the recommended course plan below.

3.2 Requirements of the Major

Students are required to take 140 ECTS credits in Engineering and Sciences which will be marked by m (mandatory) or e (elective) in the respective course plan. Especially the electives in the 3rd year offer the possibilty to further specialize in the major or to add courses also from other majors that allow for more specialization in a certain direction. Those other major course will typically come from CS, math, physics, or chemistry, depending on the student's orientation. Students are adviced to select courses according to a certain orientation, e.g., communications, control, microelectronics to cover one area sufficiently, unless, they clearly prefer a broader overview education. In order to ensure a suitable course selection, consulting a professor belonging to the special field of interest or the academic advisor is recommended.

Students with special interests in certain subject areas can, with the approval of the instructor of record, choose courses offered as part of the EE graduate program as specialization area courses.

The electives in the first year offer the possibility to add another general lecture from another major. For ECE, typical choices would be CS or physics. Adding the CS general lecture would offer the possibility to easily change to EECS or CS after the first year. Note that, although the general CS lab courses are mandatory for ECE students, the corresponding lectures is not. Generally, physics is a typical choice for all EE-oriented programs. The elective can also be used for students that are unsure about their major choice to keep the door halfways open for moving to another one, usually another natural or engineering science. Some courses may, however, be missing (especially lab courses). Such a gap can then be filled in the second year.

3.3 Recommendations

Although already mentioned in the previous section, we would like to highlight again the following:

- Students who like to be able to change easily to the programsElectrical Engineering and Computer Science (EECS) or Computer Science (CS) at the end of the first year should consider to select the General Computer Science I/II lectures in the first two semesters.

4 Recommended Course Plan

This course plan has been compiled based on the assumption of no previous knowledge when entering Jacobs University. Although not binding, it is highly recommended since it ensures an even workload, optimum efficiency and maximum congruence with the objectives of the curriculum.

Year 1 Courses	**Fall**	**C**	**T**	**Spring**	**C**	**T**
ESc Mathematics I A / II B	120101	*5*	m	120112	*5*	m
General Electrical Engineering I/II	300101	*5*	m	300102	*5*	m
NatSciLab EE I/II	300111	*2.5*	m	300112	*2.5*	m
NatSciLab Computer Science I/II	320111	*2.5*	m	320112	*2.5*	m
Computer Architecture	320241	*5*	m			
First year lecture in a ESc subject or language courses		*5*	e		*5*	e
Transdisciplinary Courses		*5*	u/e		*10*	u/e
Running Total / *Semester Total*	30	*30*		60	*30*	

Year 2 Courses	**Fall**	**C**	**T**	**Spring**	**C**	**T**
ESc Mathematics III A / IV A	120201	*5*	m	120202	*5*	m
Signals and Systems	300201	*5*	m			
Signals and Systems Lab	300221	*5*	m			
Electromagnetics	300211	*5*	m			
Probability and Random Signal Processing	300321	*5*	m			
Communications				300202	*5*	m
Electronics				300212	*5*	m
Electronics Lab				300222	*5*	m
Digital Signal Processing				300302	*5*	m
Digital Signal Processing and Communications Lab				300231	*5*	m
Transdisciplinary Courses		*5*	u/e			
Running Total / *Semester Total*	90	*30*		120	*30*	

Year 3 Courses	**Fall**	**C**	**T**	**Spring**	**C**	**T**
ECE Specialization Area Courses		*3*5*	m		*2*5*	m
ECE Specialization Areas Lab	300392	*5*	m			
Home School Electives or Language Courses		*5*	e		*5*	e
Guided Research and BSc Thesis EE	300361	2.5	m	300342	*7.5*	m
Transdisciplinary Courses		*5*	u/e		*5*	u/e
Running Total / *Semester Total*	152.5	*32.5*		180.0	*27.5*	

C = ECTS credit points, T=type (m=mandatory, e=elective, u=university)
Transdisciplinary courses are School of Humanities and Social Sciences and University Studies Courses.
Up to 4 language courses (2.5 credits each) can be taken in the first or third year replacing other general courses or home school electives. However, this reduces flexibility in choosing another major after the first year or may conflict with other typical 1st-year choices like physics or the General Computer Science lecture.

4.1 Professional Skills

The SES highly recommends attending the Professional Skills seminars offered by the Career Services Center. Those seminars include soft skills development seminars and application training which will help you to cope with your studies and master your internship and job search.

All undergraduate students are required to complete an internship, normally to be accomplished between the second and third year of study. Information about the internship will be listed on the transcript. The internship must last at least two consecutive months. No credits are connected to the internship requirement. For more information on internships see:

http://www.jacobs-university.de/career-services/internship

5 Courses: Electrical Engineering

5.1 1^{st} Year Courses and Labs

After the first year, the students should be conversant in the general principles of Electrical Engineering and programming, and, since ECE makes use of advanced mathematical tools, with the most important mathematical concepts needed. All courses listed here are mandatory for ECE students. For the inter- and transdisciplinary education, the students are furthermore required to take four transdisciplinary courses from the School of Humanities and Social Sciences or University Studies courses.
Elective general courses from other majors or languages as alternatives are, of course, not listed in this section.

300101 – General Electrical Engineering I

Short Name: GenEE I
Type: Lecture
Semester: 1
Credit Points: 5 ECTS
Prerequisites: None
Corequisites: 300111
Tutorial: None

Course contents The emphasis of the first year is to familiarize the student with the general concepts of Electrical Engineering, such as e.g. Ohm's law, electric and magnetic fields (including an overview on electromagnetic theory) and the analysis of simple circuits and its applications. Furthermore, the principal properties and applications of simple components (resistors, capacitors, inductances, diodes, Bipolar and FET transistors, Integrated circuits) will be covered. The theoretical concepts are deepened by "hands on experience" in the NatSciLab Electrical Engineering I, which is mandatory. The course is planned in such a manner that students should, as a rule, also take Electrical Engineering II in the Spring term. However, the course can also serve as a "stand alone" course within the shell model. The choice of what is taught (and to which depth) in General EE I and General EE II and their associated Lab Courses concentrates on those areas with high relevance for main stream and future EE developments.

300111 – Natural Science Lab Unit Electrical Engineering I

Short Name: NatSciLabEE I
Type: Lab
Semester: 1
Credit Points: 2.5 ECTS
Prerequisites: None
Corequisites: 300101
Tutorial: None

Course contents The objective of the lab is to give the student "hands-on experience" in the basic concepts of Electrical Engineering, as worked out in the lecture General Electrical Engineering I (mandatory for the lab course). Moreover, the students will be familiarized with the standard measurement tools of the electrical engineer, multimeters and the oscilloscope.

300102 – General Electrical Engineering II

Short Name: GenEE II
Type: Lecture
Semester: 2
Credit Points: 5 ECTS
Prerequisites: 300101
Corequisites: 300112
Tutorial: None

Course contents The course will deepen selected fields of electrical engineering which were introduced in the course General Electrical Engineering I (300101), namely, introduction to circuit analysis techniques, signal processing and communication Systems. In addition, there will be brief introductions to control systems and energy systems. While providing some of the theoretical groundwork for the second year courses in electrical engineering, the practical aspects of the subjects will be kept in focus, too.

300112 – Natural Science Lab Unit Electrical Engineering II

Short Name: NatSciLabEE II
Type: Lab
Semester: 2
Credit Points: 2.5 ECTS
Prerequisites: None
Corequisites: 300102
Tutorial: None

Course contents The lab course accompanies the General Electrical Engineering II (300102) lecture. The key concepts treated in the lecture will be highlighted by experiments (such as Fourier analysis, amplitude and frequency modulation, signal processing,...).

320111 – Natural Science Lab Unit Programming in C I

Short Name: NatSciLabCS I
Type: Lab
Semester: 1
Credit Points: 2.5 ECTS
Prerequisites: None
Corequisites: None
Tutorial: None

Course contents This lab unit is a first introduction to programming using the programming language C. The course covers fundamental procedural programming constructs and simple algorithms in a hands-on manner.

320112 – Natural Science Lab Unit Programming in C II

Short Name: NatSciLabCS II
Type: Lab
Semester: 2
Credit Points: 2.5 ECTS
Prerequisites: 320111
Corequisites: None
Tutorial: None

Course contents This lab unit is a continuation of the first year CS lab unit and deepens the basic programming skills from the first lab. It covers advanced topics of C programming such as data structures, file handling, libraries, and debugging techniques.

320241 – Computer Architecture

Short Name: CSCA
Type: Lecture
Semester: 1
Credit Points: 5 ECTS
Prerequisites: None
Corequisites: None
Tutorial: None

Course contents Starting from essential logical circuits, this course introduces core components (processors, memory systems, buses) and architectures of modern computing systems.

Topics Computer architectures, processors, instruction sets, memory systems, system buses, parallel processing.

5.2 2^{nd} Year Courses and Labs

In the second year, we introduce transform domain descriptions of signals and further digital signal processing concepts. These provide the fundaments for signal processing, communications, and control. Furthermore basic electronic components and circuits are introduced. These two basic orientations are also offered for further specialization in the 3^{rd} year.

The mathematical training is mandatory for all students and the transdisciplinary education is continued with one transdisciplinary course.

300201 – Signals and Systems

Short Name: FundEE I
Type: Lecture
Semester: 3
Credit Points: 5 ECTS
Prerequisites: 300102
Corequisites: 300221
Tutorial: None

Course contents This course 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. 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.

300221 – Signals and Systems Lab

Short Name: AdvLabEE I
Type: Lab
Semester: 3
Credit Points: 5 ECTS
Prerequisites: 300102
Corequisites: 300201
Tutorial: None

Course contents The concepts of signal and systems will be applied throughout the lab course by experimental and simulation means. The lab course is offered in conjunction with the course on Signals and Systems (300201). The concepts of signals and systems are generic and applications can be found in several areas like communications, speech and image processing, or process control. The goal of the lab is to apply these concepts by a combined approach of experiments and simulations. The experiments will provide the students with practical experience and allow the students to relate the experiments to signals and systems theory.

Topics Step response of RLC circuits, filters (RLC circuits), Fourier transform and Fourier series, sampling, digital filters, modulation, control experiment.

300302 – Digital Signal Processing

Short Name: EEDSP
Type: Lecture
Semester: 4
Credit Points: 5 ECTS
Prerequisites: 300201
Corequisites: None
Tutorial: None

Course contents Basic concepts of discrete linear shift-invariant systems are emphasized, including sampling, quantization, and reconstruction of analog signals. Extensive coverage of the Z-transform, discrete Fourier transform, and fast Fourier transform is given. Discussion of digital filter design includes impulse invariance, bilinear transform, and window functions. Practical filter implementations are discussed, including finite length register effects, round-off noise, and limit cycles. Attention is given to the use of digital filters for analysis and prediction of stochastic time series. Filter banks, two-dimensional transforms, and wavelets are discussed together with their application in video coding. Further applications are studied in communications, like adaptive equalization and multi-carrier transmission.

300231 – Digital Signal Processing and Communications Lab

Short Name: EEDSPL
Type: Lab
Semester: 4
Credit Points: 5 ECTS
Prerequisites: 300201 and 300221
Corequisites: 300302
Tutorial: None

Course contents This lab is on the one hand intended to directly accompany the corresponding DSP lecture in performing C and Matlab realizations of, e.g., transforms and digital filters. On the other hand it tries to give an insight into a system realization on a signal processor and FPGA platform. For signal-processor implementations, first tools are used to generate the DSP code followed by optimization of time-critical code segments. This means, learning DSP assembler programming will be part of the course. In the case of FPGA, tools will also generate the VHDL code, but essential VDHL properties will be taught, as well.
Some of the experiments will be devoted to the communications field. The lab will thus as well serve as a counterpart for the communications lecture.

300321 – Probability and Random Signal Processing

Short Name: EEPRSP
Type: Lecture
Semester: 3
Credit Points: 5 ECTS
Prerequisites: 120112
Corequisites: None
Tutorial: None

Course contents This course provides a foundation in the theory and applications of probability and stochastic processes and an understanding of the mathematical techniques relating to random processes in the areas of signal processing, detection, estimation, and communication. Topics include the axioms of probability, random variables, and distribution functions, functions and sequences of random variables; stochastic processes; and representations of random processes.

300211 – Electromagnetics

Short Name: AdvEE I
Type: Lecture
Semester: 3
Credit Points: 5 ECTS
Prerequisites: 300101
Corequisites: 300102
Tutorial: None

Course contents This course gives an introduction to electric and magnetic field theory, leading to Maxwell's equations. In addition, 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 traveling through lines and electronic devices.

Topics Electric charge, charge distributions, Coulomb's law, electric field, dipoles, electric flux, Gauss' law, potential, capacitance, current density, conductance, superconductors, semiconductors, magnetic field, magnetic force, magnetic flux, Ampere's law, inductance, Faraday's law, Lenz' law, displacement current, boundary conditions, Maxwell's equations, electromagnetic waves, waves on transmission lines, wave reflection, standing waves, line parameters, Smith chart, cascaded two-port networks.

300202 – Communications

Short Name: FundEE II
Type: Lecture
Semester: 4
Credit Points: 5 ECTS
Prerequisites: 300201
Corequisites: None
Tutorial: None

Course contents This course serves as an introduction to the fundamentals of communications. The key building blocks for the transmission of information across a certain medium are discussed. This includes a discussion on how the transmission medium influences the choice of a particular technique. This course builds upon the basic methods such as Fourier transformation that have been taught in the course Signals and Systems. In addition, due to their significance, a review of relevant statistical methods is provided.

Topics (1) Review of periodic and transient signals, (2) Random signals and noise, (3) Sampling, (4) Multiplexing and PCM (pulse code modulation), (5) Optimum filtering for transmission and reception, (6) Modulation.

300212 – Electronics

Short Name: AdvEE II
Type: Lecture
Semester: 4
Credit Points: 5 ECTS
Prerequisites: 300101
Corequisites: 300222
Tutorial: None

Course contents The course gives an introduction to electronics and electronic circuits. Throughout the first part the operation principle and the application of diodes, bipolar junction transistors (BJT's), and field-effect transistors (FET's) will be discussed. Different electronic circuits will be analyzed and designed like operational amplifiers. In the second part the terminology and the concepts of digital electronics are introduced, including number systems and

logic. The operation principles of logic gates, flip-flops, counters, shift registers and adders will be described. The student will be able to analyze and design simple logic circuits using tools such as Boolean Algebra and Karnaugh Mapping.

Topics Diode, BJT, FET, Inverter, Logic Gates, Shift Register, Flip Flops.

300222 – Electronics Lab

Short Name: AdvLabEE II
Type: Lab
Semester: 4
Credit Points: 5 ECTS
Prerequisites: 300101
Corequisites: 300212
Tutorial: None

Course contents The goal of the lab course is to establish a basic understanding of electrical circuits and electronic components. The knowledge and understanding of Kirchhoff's laws, mesh and nodal analysis, and basic circuit theorems taught throughout the courses on general electrical engineering I and II is assumed. The goal will be accomplished by a combined approach of experimental and simulation experiments. The experiments will provide the students with practical experience and allow the students to relate the experiments to device and circuit models. Spice and OrCad will be used for the simulation of the basic components and circuits.

Topics 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 inverter circuits and elementary logical circuits.

5.3 3^{rd} Year Courses and Labs

In the third year, ECE students will further specialize. Specialization lectures will bring the student "up to speed" to the frontiers of research and technology in their chosen orientation and provide the theoretical groundwork for the guided research work (see section 5.4) which has to be completed in the third year.
A mandatory lab course offers insights into research labs and gives access to more advanced equipment.

The mathematics training has been completed in the first two years. The transdisciplinary education is completed with one course.

300322 – Advanced Random Processes

Short Name: EEARP
Type: Lecture
Semester: 6
Credit Points: 5 ECTS
Prerequisites: 300321
Corequisites: None
Tutorial: None

Course contents The course covers advanced topics in the field of random processes and introduces the students to a number of applications of statistical signal processing such as Wiener Filtering, Kalman Filtering, and Hidden Markov Models.

This course is also a valid choice in the CSE graduate program.

300301 – Dynamical Systems and Control

Short Name: EEDSC
Type: Lecture
Semester: 5
Credit Points: 5 ECTS
Prerequisites: 300201
Corequisites: None
Tutorial: None

Course contents The course will be devoted to the understanding of dynamical systems both from a continuous and a discrete point of view (keywords: ordinary differential equations, difference equations, Laplace transform, z-transform). Although the focus is on linear systems, the scope is wider and also includes an introduction to nonlinear dynamics (bifurcations). With this background, students will be prepared to study control issues in dynamical systems, the concept of transfer functions, and control design.

300311 – Wireless Communications

Short Name: EEWC
Type: Lecture
Semester: 6
Credit Points: 5 ECTS
Prerequisites: 300201 and 300202
Corequisites: None
Tutorial: None

Course contents Today no well-defined body of knowledge exists which a student must learn to become proficient in wireless communications and mobile information systems. This shows that this is an emerging field. It builds on radio engineering, digital communications, computer networks and protocols, distributed systems, information management, and applications. Most of these topics are taught in other specialization courses mainly within this major, but also within other majors. This course will equip students with the basic knowledge in wireless communications and radio system engineering. It will make the physical limitations of communications technologies understandable to the computer scientist, while making the system architecture and technology accessible to the electrical engineer.

Topics Cellular network planning and management, channel models, transmission and multiple access techniques, receiver architectures, radio resource management, system support for mobility.

300371 – Wavelets and their Applications

Short Name: EEWAVE
Type: Lecture
Semester: 5
Credit Points: 5 ECTS
Prerequisites: 300201
Corequisites: None
Tutorial: None

Course contents In signal processing, the first step is the analysis of a signal, usually in terms of frequency components or various combinations of time and frequency components. The second step is to modify some of the components of the original signal by eliminating undesirable features, or, to compress the signal for more efficient transmission and storage. Examples are audio compression, video compression, denoising, etc.. Finally, the signal is reconstituted from its (altered) components.

In this course, we will examine the following methods for signal processing:

1. Fourier series and the Fourier transform (review).
2. Windowed Fourier transforms.
3. Continuous wavelet transforms.
4. Filter banks.
5. Discrete wavelet transforms (Haar and Daubechies wavelets).

Mathematically, all of these methods are based on the decomposition of square integrable (summable) functions into orthogonal components.

This course is also a valid choice in the CSE graduate program.

300341 – Information Theory

Short Name: EEIT
Type: Lecture
Semester: 5
Credit Points: 5 ECTS
Prerequisites: 120112 and 120201
Corequisites: None
Tutorial: None

Course contents Information theory serves as the most important foundation for communication systems. The course provides an analytical framework for modeling and evaluating point-to-point and multi-point communication.

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 course 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. Information theory is a standard in every communications-oriented Bachelor's program.

300362 – Coding Theory

Short Name: EECT
Type: Lecture
Semester: 6
Credit Points: 5 ECTS
Prerequisites: 120112 and 120201
Corequisites: None
Tutorial: None

Course contents 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 and storage/recording device, like your CD player, your DSL home Internet access, and your mobile phone, to name just a few. This course 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.

This course is also a valid choice in the CSE graduate program.

320301 – Networks and Protocols

Short Name: CSNP
Type: Lecture
Semester: 5
Credit Points: 5 ECTS
Prerequisites: 320202
Corequisites: None
Tutorial: None

Course contents The course discusses network protocols in some depth in order to enable students to understand the core issues involved in network protocol design. The fundamental algorithms and principles are explained in the context of existing IEEE / Internet protocols in order to demonstrate how fundamental principles are applied in real-world protocols. This course is recommended for all students with a strong interest in communication networks.

Topics Local area networks (IEEE 802), Internet protocols, routing algorithms and protocols, flow and congestion control mechanisms, data representation, application layer protocols, remote procedure calls, network security.

300331 – Electronic Devices

Short Name: EEED
Type: Lecture
Semester: 5
Credit Points: 5 ECTS
Prerequisites: 300221 and 300222
Corequisites: None
Tutorial: None

Course contents The course covers the fundamentals of electronic devices, which are the foundation of the electronics industry. The concept of a band structure in semiconductors will be introduced. The basics of carrier generation, carrier recombination and electronic transport in semiconductors will be described. The operation principle of pn-diodes, bipolar junction transistors and field effect transistors will be introduced and discussed. First order device models that reflect physical principles will be introduced for integrated circuit analysis and design.

300351 – Advanced Digital Design

Short Name: ADD
Type: Lecture
Semester: 6
Credit Points: 5 ECTS
Prerequisites: 300212 and 300222
Corequisites: None
Tutorial: None

Course contents As the feature size of semiconductor devices continues to shrink at a staggering rate, the increasing degree of integration allows very complex digital systems to be realized on a single chip. Such systems can either be fabricated in application specific integrated circuits (ASICs) using very high scale integration (VLSI) techniques or implemented in programmable devices, such as field programmable gate arrays (FPGAs). In both cases, very large designs are partitioned into a hierarchy of logical blocks, and by adhering to a set of standard design rules, the difficulty of integrating these blocks is dramatically reduced. The most popular approach is synchronous design with register transfer level (RTL) logic, but asynchronous designs are also possible.

Although digital systems were traditionally designed at the schematic level, the current trend is toward hardware description languages (HDLs) that allow compact description of very complex hardware constructs. The appearance of sophisticated automatic hardware synthesis engines that implement logic directly from HDL have made HDLs the choice for new logic designs. Although the target language of this class is VHDL, other languages such as Verilog and SystemC apply the same design strategies. This course stresses the importance of viewing HDL as a way of describing real hardware, and not ”just another programming language.”

300332 – Microelectronics

Short Name: EEME
Type: Lecture
Semester: 6
Credit Points: 5 ECTS
Prerequisites: 300212 and 300222
Corequisites: None
Tutorial: None

Course contents Microelectronics is the key enabling technology for almost all IT and electronic products and services. It is estimated that about 10% of all EE engineers work in microelectronics industry and their suppliers, and a much larger percentage depends directly or indirectly on a basic knowledge of microelectronics technology and production methods. It is therefore the objective of the course to provide an overview of the field. Topics to be covered are: production and quality of semiconductor materials; IC manufacturing technology; unit processes (photolithography, dry and wet etching, hot processes, layer deposition, assembly,

testing) process integration, quality management, industrial engineering. In many of these topics, EE and CS competencies are applied. - A more thorough treatment of the subject on the key areas will be offered within the graduate program.

320311 – Robotics

Short Name: CSR
Type: Lecture
Semester: 6
Credit Points: 5 ECTS
Prerequisites: 320331 and 320222
Corequisites: None
Tutorial: None

Course contents Robotics is a field that spans the entire range from low-level mechatronics and signal processing to high-level cooperation protocols of intelligent agents, and thus touches large portions of both CS and EE. Correspondingly, the course aims at an integrative, practically oriented education that enables students to practically combine methods he/she has encountered in various more specialized courses before. An active robotics lab and participation in international robot contests give additional substance and motivation to this course.

Topics Embedded hardware and networking, mobile energy supply, sensors, motors, mechanics, mechatronics, manipulation, locomotion, control and modeling, cooperation of multiple systems.

300392 – Specialization Areas Lab

Short Name: EESAL
Type: Lab
Semester: 5
Credit Points: 5 ECTS
Prerequisites: None
Corequisites: None
Tutorial: None

Course contents This lab provides experiments from different specialization areas. It will thus contain experiments from fields such as communications, microelectronics, or control. A placement in the final year of studies allows students to address up-to-date systems and to obtain hands-on experiences with high-end measurement equipment.

5.4 Guided Research in Electrical and Computer Engineering

Although CS faculty is partly involved in the ECE program, guided research in ECE is handled by EE faculty. Therefore, course numbers have been chosen to be identical to the guided research in the EE specialization of the EECS program. Nevertheless, guided research can, of course, also be carried out in cooperation with CS faculty when a suitable topic has been determined.

300361 – Guided Research in Electrical Engineering

Short Name: EEGRP
Type: Project
Semester: 5
Credit Points: 2.5 ECTS
Prerequisites: None
Corequisites: None
Tutorial: None

Course contents The purpose of this course is to let students choose a topic for the bachelor thesis and to work out a proposal which introduces the field of study, states the research questions/hypotheses, surveys the expected results, and sets up a work plan. The course is offered by all professors of Electrical Engineering, jointly. Topics are offered by the individual faculty members.

300342 – Guided Research in Electrical Engineering + Thesis

Short Name: EEGR
Type: Project
Semester: 6
Credit Points: 7.5 ECTS
Prerequisites: 300361
Corequisites: None
Tutorial: None

Course contents The course is jointly offered by all professors of Electrical Engineering. The purpose of this course is to engage the students in a research project under the close supervision of an EE faculty member. Topics are offered by the individual faculty members. Upon completion of the research, the student will prepare a final report (20 pages) and present the project in a seminar during the last 2 weeks of the semester. Both the presentation and the final report will count towards the final grade.

5.5 CSE Seminar

The CSE seminar is a graduate lecture series on Electrical Engineering topics also open to interested undergraduate students. It is used by EE faculty and staff to present their research to each other and interested students, and to host talks from external speakers and research collaborators. The seminar gives a unique opportunity to gain an insight into EE / CSE research at Jacobs University and in the world.

300431 – CSE Seminar

Short Name: CSESEM
Type: Seminar
Semester: all
Credit Points: None
Prerequisites: None
Corequisites: None
Tutorial: None

Course contents The CSE seminar is a lecture series featuring topics from Electrical Engineering. It gives interested students an insight into current research topics in these areas. Details and a schedule can be found online:

http://www.eecs.jacobs-university.de/seminar/