JACOBS UNIVERSITY

Electrical Engineering and Computer Science

Bachelor's Degree Program (BSc)

Contents

Preamble

As of September 1, 2014 the School of Engineering and Science and the School of Humanities and Social Sciences have been replaced by the Focus Areas Health, Mobility and Diversity. Handbooks and policies might still refer to the old structure of Schools.

If this is the case, references to the School of Engineering and Science include courses offered within the following disciplines:

- Electrical Engineering and Computer Science
- Life Sciences
- Logistics
- Mathematical Sciences
- Natural and Environmental Sciences

References to the School of Humanities and Social Sciences include courses offered within the following disciplines:

- Economics and Management
- History
- Humanities
- Law
- Psychology
- Social Sciences
- Statistics and Methods

1 Electrical Engineering and Computer Science

1.1 Concept

One of the particular strengths of Jacobs University undergraduate education is its pronounced interdisciplinary approach. It is our objective to put this into practice for the engineering major and to connect electrical engineering and computer science seamlessly in one undergraduate major.

Therefore, the major in Electrical Engineering and Computer Science (EECS) is a combination of the more conventional Electrical Engineering (EE) and Computer Science (CS) Majors. The rationale behind this combination is the fact that

- on the one hand, through digital electronics EE has become to a large degree, a software / mathematically driven engineering discipline, and that
- on the other hand, CS is intimately tied up with EE as the major enabling technology for CS.

The program endeavors to give students a thorough training in both disciplines without sacrificing the academic quality and without putting an unduly high workload on the students.

1.2 Cooperation with Other Universities

The EECS curriculum is developed in close cooperation with Rice University faculty members (or ex-members), in particular with A. C. Antoulas and Raymond O. Wells. In addition, numerous informal communication channels are used with members from other universities strong in either of the major or in a combined major.

Furthermore, the School of Engineering and Science at Jacobs University has an exchange program for second-year EECS undergraduate students specializing in CS with the School of Computer Science at Carnegie Mellon University.

1.3 Job Market and Number of Applicants

The starting point of the idea to combine EE and CS in one joint major has been the observation that there is a strong demand for interdisciplinary engineers and scientists in the IT, electronics and general industry, and that very often competencies from both fields are needed at the same time. It is expected that graduates from this major will have a competitive advantage compared to students from traditional EE or CS majors, provided there is no loss in quality, i.e., no shortcomings in what students must know, in substance and methods, in order to qualify as an electrical or computer science engineer.

Two key factors, excellent job opportunities world wide and highly challenging research, make the EECS major very attractive to students. Therefore, it is not surprising that this major enjoys the largest number of students in the School of Engineering and Science at Jacobs University.

1.4 Integration of Industry Relevant Aspects

Due to the industrial relevance, care has been taken that practical aspects and requirements are integrated into the development of the curriculum in addition to the academic aspects.

About half of the EE faculty members have an industrial background. All the other EECS faculty members have been recruited from academic or research institutions that have a significant record of bi- or multilateral cooperation with industrial organizations.

1.5 Curriculum Development Process

At the outset of developing the curriculum, many information sources were explored to obtain a comprehensive picture of the expectations of future employers. This comprise an Internet survey on the rationale of EE and CS curricula at other universities, publications of engineering associations (e.g., IEEE, VDI), personal contacts of EE faculty to industrial executives, inputs in connection with the development of the utility management master curriculum (Jacobs School), and personal experience of the ex-industrial faculty members.

The greatest challenge for a combined EE-CS curriculum is to integrate a sound academic training with the practical aspects and the cross- and transdisciplinary aspects into a 3 year course program. The main ideas to make this possible are:

- Focus on the sub-disciplines that combine a "mainstream" breadth with a high relevance for future innovations. In EE, Information Technology and Telecommunication Technology are seen as the two most important fields. In CS, the program focuses on Artificial Intelligence (including robotics and machine learning), databases and networking technologies. Some of the more traditional fields (like power generation and power distribution in EE or compiler design in CS) will either not be covered or limited to short overviews.
- In-depth treatment of carefully selected topics and a first specialization with respect to either EE or CS in the second year.
- Further specialization in the third year including a thesis paper on a guided research project, getting the student into contact with current research topics and methods.
- Laboratory courses with high relevance for practical aspects and allows for early participation in cutting edge research in areas like robotics, artificial intelligence, system modeling, communications, wireless communications, micro-electronics and electronic devices.
- Since mathematical tools are at the core of understanding EE and CS concepts and the application to practical problems, an early systematic training in the relevant mathematical disciplines is ensured.
- In spite of the challenge that EECS is essentially a double major, all requirements concerning interdisciplinary and transdisciplinary courses are included in the curriculum to develop social competencies and the ability to analyze with a wide perspective (both of which are pointed out by employers as skill gaps of most graduates).

- The practical aspects of the training are highlighted in the mandatory 2-3 months industry internship. It is strongly encouraged (and practical help is given) that students find a host organization that has EE or CS as its core competencies.

More detailed information can be found in the individual course descriptions.

1.6 Career Options

There are two principal career options for a student graduating in EECS:

The first option is entering a professional career directly. In line with the expectations and demands of a majority of potential employers, EECS graduates will be able to start a career in industry / business / the public sector after studying for three years. Our future engineers will start their career at a young age of 21-22, so that there is ample time for job specific training at the future employer.

The second option is, of course, to study for a Master degree (as the next step in an academic or industrial career). The EECS major will prepare students for graduate studies, in particular for

- the two graduate programs in Electrical Engineering and Computer Science at Jacobs University,
- the Master Courses in Utility Management and in Physics at Jacobs University,
- the same subjects at other institutions of higher education,
- more business oriented fields for those seeking a management career in high-tech enterprises.

The majority of Jacobs University students who graduated with B.Sc. degrees in EECS went on to study for a Master's degree. The best among them could enlist in the world's leading institutions in their specialization areas (EPF Lausanne, ETH Zürich, Urbana-Champaign, Cornell), witnessing the high quality of the training they received at Jacobs University.

1.7 Future Prospects

Students with a degree in EECS will find themselves at the very heart of modern developments in industry and commerce. There is hardly a field which has not been affected by the revolutionary development of IT and micro-electronics, which has for example resulted in the ubiquitous use of computers, the omnipresence of telecommunication devices and the rapidly expanding use of the numerous network-based services offered. Novel products (mobile phones, PDAs, GPS) have gained rapid acceptance, traditional products either have been made better and cheaper (from digital answering machines, printers, copiers, to car electronics, motor management,..). The pace of change will not slow down. It is to be predicted that the share of the electronics and IT industries in the gross national product will further significantly increase. Hence there is, from a national economics perspective, an urgent need for excellent

EECS graduates, and it appears certain job prospects will remain excellent for at least more than a decade.

In addition, the EECS major aims at an early involvement of undergraduate students in research which is highly relevant to industry and academia alike. This is accomplished by project work, which is an integral part of the education at Jacobs University.

The overall mission of the EECS major is to enable students to select from a great variety of career options when they graduate from Jacobs University.

1.8 Keeping the Curriculum Up-to-Date

In the next years, the curriculum will be continuously scrutinized as to whether it both 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 time span of less than e.g., six months).

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

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

2 Modules: Electrical Engineering and Computer Science

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. But 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 modularisation. The freely choosable Home School Electives and transdisciplinary courses fall outside this structure.

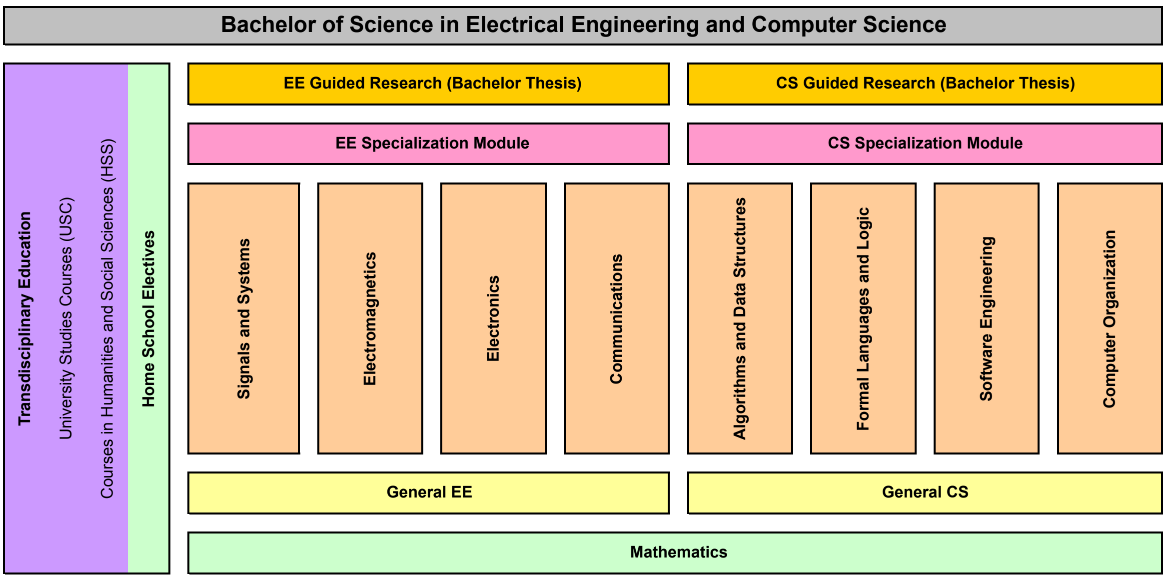

Figure 1: EECS Module Structure

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. In the second year, home school (Engineering and Science, ECs) courses are required which is shown 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 EE and CS specialization modules.

120130 – ESM for Electrical Engineering and Computer Science

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

General Information Students of Electrical Engineering and Computer Science are required to take four semesters of Engineering and Science Mathematics; the courses listed below are mandatory for the EECS major. Students with an interest in theory, particularly those thinking of specializing in Electrical Engineering, 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

2.2 EECS Major

300100 – General Electrical Engineering

Short Name: ModGEEeecs
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, it's 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: ModGCSeecs
Semester: 1 – 2
Credit Points: 15 ECTS

General Information This module familiarizes students with general concepts of Computer Science. Two lecture and two accompanying lab units are provided. The lectures, based on a clear mathematical foundation, introduce abstract and concrete notions of computing machines, information, and algorithms. They also introduce basic concepts of logic, boolean circuits up to very elementary computer architectures. The lab units are more oriented towards the practical side of computer science and provide an introduction to procedural and object-oriented programming.

Learning goals

- Understanding of the mathematical foundation of computer science and core concepts such as computation or complexity
- Introduction to procedural, object-oriented and functional programming concepts
- Enabling students to solve simple programming problems

Courses

320101 General Computer Science I (lecture)

320102 General Computer Science II (lecture)

320111 Natural Science Lab Unit Programming in C I

320112 Natural Science Lab Unit Programming in C II

300200 – Signals and Systems

Short Name: ModSSeecs
Semester: 3
Credit Points: 10 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 EECS curriculum). It also offers basic knowledge for students with computer science orientation. One may just think of error-correcting codes and robotics, where signal from sensors need to be analyzed and processed.

Learning goals

- Understanding of continuous and discrete time signals and their descriptions in time and frequency domain.
- 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

300201 Signals and Systems (lecture)

300221 Signals and Systems Lab

300210 – ELECTROMAGNETICS

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

General Information In a pure electrical engineering education, one of the pillars of the curriculum would be electromagnetics, field theory, wave propagation, and antennas. A mixed EECS curriculum will not strongly focus on this topic, but still, 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: ModELeecs
Semester: 4
Credit Points: 10 ECTS

General Information Another pillar of traditional EE education is electronics. In our combined EECS major 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: ModCOMeecs
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 EECS 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)

320200 – Algorithms and Data Structures

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

General Information Understanding of basic algorithms and data structures and their properties is essential in every computer science program. This module introduces these concepts from the theoretical as well as the practical point of view.

Learning goals

- Understanding of core algorithms and data structures.
- Ability to analyze algorithms or data structures in terms of their complexity.
- Ability to apply data structures and algorithms to problems based on a sound understanding of their properties.

Courses

320201 Algorithms and Data Structures (lecture)

320210 – Formal Languages and Logic

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

General Information This module deepens the theoretical foundation of computer science by introducing the theory of formal languages, their relationships to automata in more depth. The module also covers first-order logic which is the mathematical basis of many areas in computer science.

Learning goals

- Understanding of the theoretical foundations of computer science.
- Abstract thinking skills.
- Introduction and training of prove techniques.

- Developing an understanding of the fundamental limitations of computational models.

Courses

320211 Formal Languages and Logic (lecture)

320220 – Software Engineering

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

General Information The development of large software systems requires to know a set of techniques to support the various stages of a software development project. This module introduces key software engineering topics such as process models, data modeling techniques, object-oriented design techniques and tools relevant for implementation, testing, and verification.

Learning goals

- Familiarity with fundamental software engineering techniques.
- Application of these techniques in a concrete software development project.
- Experience with software development, documentation, and testing tools.
- 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

320212 Software Engineering (lecture)

320222 Software Engineering Lab

320230 – Computer Organization

Short Name: ModCORGeecs
Semester: 1, 4
Credit Points: 5 ECTS

General Information This module introduces fundamental knowledge about the organization of digital computers. It covers hardware concepts such as instruction sets and processor designs and fundamental principles of memory systems and system busses. The module also covers operating systems, which are complex software systems with non-sequential flows of control implementing several resource management algorithms to make effective use of the hardware components. Operating systems form a good basis to study concurrency and synchronization problems, scheduling algorithms, and resource allocation algorithms in general. The module also introduces core network programming interfaces provided by operating systems.

Learning goals

- Familiarity with computer architectures and fundamentals of basic components of digital computing systems.
- Understanding of core concepts underlying operating systems and data networks.
- Familiarity with the programming abstractions provided by operating systems.
- Ability to write simple concurrent and communicating programs.

Courses

320241 Computer Architecture (lecture)

320202 Operating Systems (lecture)

300300 – EE Specialization Module

Short Name: ModEESPee
Semester: 5 – 6
Credit Points: 20/10 ECTS

General Information During the third year, students can specialize in the areas of their specific interests. This module gathers all EE specialization courses offered in the third year. Students specializing in EE are required to take four courses while students specializing in CS are encouraged to take two courses from the courses offered in this module.

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.

- Students are prepared to either enter graduate research and development programs or to be acquire the knowledge necessarity to successfully enter the job marked in the choosen focus areas.

Courses

300301 Dynamical Systems and Control

300311 Wireless Communications

300321 Probability and Random Signal Processing

300331 Electronic Devices

300302 Digital Signal Processing

300371 Wavelets and their Applications

300341 Information Theory

300362 Coding Theory

300322 Advanced Random Processes

300332 Microelectronics

300351 Advanced Digital Design

320300 – CS Specialization Module

Short Name: ModCSSPcs
Semester: 5 – 6
Credit Points: 20/10 ECTS

General Information During the third year, students can specialize in the areas of their specific interests. This module gathers all CS specialization courses offered in the third year. Students specializing in CS are required to take four courses while students specializing in EE are encouraged to take two courses from the courses offered in this module.

Learning goals

- Students specialize in their chosen fields of interest.
- 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.
- Students are prepared to either enter graduate research and development programs or to be acquire the knowledge necessarity to successfully enter the job marked in the choosen focus areas.

Courses

320301 Computer Networks

320302 Databases and Web Applications

320331 Artificial Intelligence

320341 Programming in Java

320312 Distributed Systems

320322 Graphics and Visualization

320311 Robotics

320352 Computability and Complexity

320321 Image Processing

320351 Medical Image Analysis

320521 Autonomous Systems

320441 Computational Logic

320372 Machine Learning

300310 – EE Guided Research Module

Short Name: ModGRee
Semester: 6
Credit Points: 10 ECTS

General Information Guided Research represents the final project in the EECS 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

320310 – CS Guided Research Module

Short Name: ModGRcs
Semester: 5 – 6
Credit Points: 10 ECTS

General Information Guided research projects are designed to get students involved into research activities. The topics are posted by faculty members and usually related to their specific research activities. The deliverables produced by the students are a research proposal, an oral presentation of the topic and the achieved results, and the final guided research report (B.Sc. thesis).

Learning goals

- Students get involved in ongoing research activities.
- Ability to independently work on a given problem.
- Students learn to organize their work and time.
- Training of writing and presentation skills.

Courses

320371 Guided Research in Computer Science

320342 Guided Research in Computer Science + Thesis

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

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 SHSS 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

The EECS program is a combined major and thus is more regulated than other majors and requires a slightly higher overall workload. Instead of 140 ECTS credits, students choosing EECS have to earn 145 ECTS credits in Engineering and Sciences out of the following courses:

Year 1 Level Courses	Course Numbers	ECTS Credits
Engineering and Science Mathematics I A / II B	120101, 120112	10
General Computer Science I/II	320101, 320102	10
NatSciLab Units Programming in C I/II	320111, 320112	5
Programming in C++	320142	5
Computer Architecture	320241	5
General Electrical Engineering I/II	300101, 300102	10
NatSciLab Units Electrical Engineering I/II	300111, 300112	5

Year 2 Level Courses (EE specialization)	Course Numbers	ECTS Credits
Engineering and Science Mathematics III A / IV A	120201, 120202	10
Signals and Systems / Signals and Systems Lab	300201, 300221	10
Electromagnetics	300211	5
Communications	300202	5
Algorithms and Data Structures	320201	5
Electronics / Electronics Lab	300212, 300222	10
Software Engineering / Software Engineering Lab	320212, 320222	10

Year 2 Level Courses (CS specialization)	Course Numbers	ECTS Credits
Engineering and Science Mathematics III A / IV A	120201, 120202	10
Signals and Systems / Signals and Systems Lab	300201, 300221	10
Algorithms and Data Structures	320201	5
Formal Languages and Logic	320211	5
Communications	300202	5
Electronics	300212	5
Software Engineering / Software Engineering Lab	320212, 320222	10
Operating Systems	320202	5

Year 3 Level Courses (EE specialization)	Course Numbers	ECTS Credits
EE Specialization Area Courses	n/a	20
EECS Specialization Area Courses	n/a	10
EE Guided Research and BSc Thesis	300361, 300342	10

Year 3 Level Courses (CS specialization)	Course Numbers	ECTS Credits
CS Specialization Area Courses	n/a	20
EECS Specialization Area Courses	n/a	10
CS Guided Research and BSc Project	320371, 320342	10

Additional Courses	Course Numbers	ECTS Credits
Language Courses or Home School Electives	n/a	10

Students following the CS specialization may count the course 300211 as a 3rd year EECS specialization area course. Similarily, students following the EE specialization may count the course 320211 as a 3rd year EECS specialization area course.

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 and CS graduate programs as specialization area courses.

Jacobs University Bremen reserves the right to substitute courses by replacements and/or reduce the number of mandatory/mandatory elective courses offered.

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.

4.1 Recommended Course Plan – Specialization Area EE

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
General Computer Science I/II	320101	*5*	m	320102	*5*	m
Programming in C (NatSciLab CS I/II)	320111	*2.5*	m	320112	*2.5*	m
Computer Architecture	320241	*5*	m			
Programming in C++				320142	*5*	m
Transdisciplinary Courses		*5*	u/e		*5*	u/e
Running Total / *Semester Total*	30.0	*30.0*		60.0	*30.0*	
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			
Communications				300202	*5*	m
Electronics				300212	*5*	m
Electronics Lab				300222	*5*	m
Algorithms and Data Structures	320201	*5*	m			
Software Engineering				320212	*5*	m
Software Engineering Lab				320222	*5*	m
Transdisciplinary Courses		*5*	u/e		*5*	u/e
Running Total / *Semester Total*	90.0	*30.0*		125.0	*35.0*	
Year 3 Courses	**Fall**	**C**	**T**	**Spring**	**C**	**T**
EE Specialization Area Courses		*3*5*	me		*5*	me
EECS Specialization Area Courses		*5*	me		*5*	me
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*	157.5	*32.5*		185.0	*27.5*	

C = ECTS credit points
T = type (m=mandatory, e=elective, u=university, me=mandatory elective)

Transdisciplinary Courses are School of Humanities and Social Sciences courses or University Studies Courses

4.2 Recommended Course Plan – Specialization Area CS

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
General Computer Science I/II	320101	*5*	m	320102	*5*	m
Programming in C (NatSciLab CS I/II)	320111	*2.5*	m	320112	*2.5*	m
Computer Architecture	320241	*5*	m			
Programming in C++				320142	*5*	m
Transdisciplinary Courses		*5*	u/e		*5*	u/e
Running Total / *Semester Total*	30.0	*30.0*		60.0	*30.0*	
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			
Communications				300202	*5*	m
Electronics				300212	*5*	m
Algorithms and Data Structures	320201	*5*	m			
Formal Languages and Logic	320211	*5*	m			
Operating Systems				320202	*5*	m
Software Engineering				320212	*5*	m
Software Engineering Lab				320222	*5*	m
Transdisciplinary Courses		*5*	u/e		*5*	u/e
Running Total / *Semester Total*	90.0	*30.0*		125.0	*35.0*	
Year 3 Courses	**Fall**	**C**	**T**	**Spring**	**C**	**T**
CS Specialization Area Courses		*4*5*	me			
EECS Specialization Area Courses		*5*	me		*5*	me
Home School Electives or Language Courses					*2*5*	e
Guided Research and BSc Thesis CS	320371	2.5	m	320342	*7.5*	m
Transdisciplinary Courses		*5*	u/e		*5*	u/e
Running Total / *Semester Total*	157.5	*32.5*		185.0	*27.5*	

C = ECTS credit points
T = type (m=mandatory, e=elective, u=university, me=mandatory elective)

Transdisciplinary Courses are School of Humanities and Social Sciences courses or University Studies Courses

For the CS orientation, in the last semester, (almost) only graduate-level courses will be offered as CS specialization courses. Please take this into consideration when planning your studies.

4.3 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 and Computer Science

5.1 1^{st} Year Courses and Labs

After the first year, the students should be conversant in the general principles of Electrical Engineering, Computer Science and, since both EE and CS make use of advanced mathematical tools, with the most important mathematical concepts needed. All courses listed here are mandatory for EECS students. For the inter- and transdisciplinary education, the students are furthermore required to take two electives from each of the schools and one University Studies course.

300101 – General Electrical Engineering I

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

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.

320101 – General Computer Science I

Short Name: GenCS I
Type: Lecture
Semester: 1
Credit Points: 5 ECTS
Prerequisites: None
Corequisites: None

Course contents The course covers the 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 vs. meaning in Computer Science.

To have a theoretical notion of computation, we introduce inductively defined structures, term representations, abstract interpretation via equational substitution. This is contrasted with a first concrete model of computation: Standard ML, which will also act as the primary programming language for the course. We cover a basic subset of ML that includes types, recursion, termination, lists, strings, higher-order programming, effects, and exceptions. Back on the theoretical side, we cover string codes, formal languages, Boolean expressions (syntax) and Boolean Algebras (semantics). The course introduces elementary complexity theory (big-O), applying it to analyzing the gate-complexity of Boolean Expressions (prime implicants and Quine McCluskey's algorithm).

Topics Discrete mathematics, terms, substitution, abstract interpretation, computation, recursion, termination, complexity, Standard ML, types, formal languages, boolean expressions.

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

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.

320241 – Computer Architecture

Short Name: CSCA
Type: Lecture
Semester: 1
Credit Points: 5 ECTS
Prerequisites: None
Corequisites: 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 busses, parallel processing.

300102 – General Electrical Engineering II

Short Name: GenEE II
Type: Lecture
Semester: 2
Credit Points: 5 ECTS
Prerequisites: 300101
Corequisites: 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

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, . . .).

320102 – General Computer Science II

Short Name: GenCS II
Type: Lecture
Semester: 2
Credit Points: 5 ECTS
Prerequisites: 320101
Corequisites: None

Course contents The course continues the introduction of the fundamental concepts and techniques of Computer Science. Building on Boolean Algebra, it introduces Propositional Logic as a model for general logical systems (syntax, semantics, calculi). Based on elementary graph theory, combinatory circuits are introduced as basic logic computational devices. Interpreting sequences of Boolean values as representations of numbers (in positional number systems, twos-complement system), Boolean circuits are extended to numerical computational machines (presenting adders, subtracters, multipliers) and extended to basic ALUs. The course introduces very elementary computer architectures and assembly language concrete computational devices, and compares them to Turing machines to fathom the reach of computability.

In a final part of the course, two topics of general Computer Science are covered in depth, for instance "search algorithms" and "programming as search" to complement the rather horizontal (i.e. methods-oriented) organization of the course with vertically (i.e. goal-oriented) organized topics.

Topics Propositional logic, calculi, soundness, completeness, automated theorem proving, combinatory circuits, assembler turing machines, search, logic programming.

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

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.

320142 – Programming in C++

Short Name: CSPCPP
Type: Lecture / Lab
Semester: 2
Credit Points: 5 ECTS
Prerequisites: 320111
Corequisites: None

Course contents The course is an introduction into object-oriented programming using the programming language C++. The unit covers the object-oriented programming constructs in C++ in a hands-on manner.

Topics C++ programming language, practical implementation of algorithms.

5.2 2^{nd} Year Courses and Labs

In the second year the student has to make a first choice whether s/he will emphasize EE or CS. It is, of course, also possible to take all the EE and CS second year lectures. In this case, some lectures are counted as home school electives.

In EE, the focus is on the main stream areas of the field, digital signal processing, systems and communication, which will be taught in the Fundamental EE courses. In CS, the focus areas are data structure and algorithms, computer architectures and operating systems, formal languages, discrete automata, first-order logic, and software engineering.

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

300201 – Signals and Systems

Short Name: FundEE I
Type: Lecture
Semester: 3
Credit Points: 5 ECTS
Prerequisites: 300102
Corequisites: 300221

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

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.

300211 – Electromagnetics

Short Name: AdvEE I
Type: Lecture
Semester: 3
Credit Points: 5 ECTS
Prerequisites: 300101
Corequisites: 300102

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

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

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

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.

320201 – Algorithms and Data Structures

Short Name:	CSAD
Type:	Lecture
Semester:	3
Credit Points:	5 ECTS
Prerequisites:	(320112 or 350112) and 120112
Corequisites:	None

Course contents This course introduces a basic set of data structures and algorithms that form the basis of almost all computer programs. The data structures and algorithms are analyzed in respect to their computational complexity with techniques such as worst case and amortized analysis.

Topics Fundamental data structures (lists, stacks, trees, hash tables), fundamental algorithms (sorting, searching, graph traversal).

320211 – Formal Languages and Logic

Short Name: CSFLL
Type: Lecture
Semester: 3
Credit Points: 5 ECTS
Prerequisites: 320102
Corequisites: None

Course contents This course gives an introduction to the most basic themes of theoretical computer science. Formal languages and discrete automata are the foundations of programming languages and their parsing and compiling. First-order logic is the basis of artificial intelligence, program verification and advanced data base systems.

Topics Formal languages, discrete automata, first-order logic.

320202 – Operating Systems

Short Name: CSOS
Type: Lecture
Semester: 4
Credit Points: 5 ECTS
Prerequisites: 320201 and 320112 and 320241
Corequisites: None

Course contents This course provides an introduction to the concepts underlying operating systems. Students will develop an understanding how operating systems realize a virtual machine that can be used to execute multiple concurrent application programs. The course discusses resource allocation algorithms and how concurrency problems can be solved.

Topics Operating system architectures, system calls and interrupts, concurrent processes and threads, scheduling, synchronization, deadlocks, virtual memory, file systems, inter-process communication, socket programming interface.

320212 – Software Engineering

Short Name: CSSE
Type: Lecture
Semester: 4
Credit Points: 5 ECTS
Prerequisites: (320201 and 320142) or (320201 and 350112)
Corequisites: None

Course contents This course is an introduction to software engineering (SE) and object-oriented software design. At the core of the lecture is the notion of software quality and the methods to achieve and maintain it. Based on their pre-existing knowledge of an object-oriented programming language, students are familiarized with software architectures, design patterns and frameworks, software components and middleware, UML-based modelling, and validation by code analysis and testing. Both classical development and modern variants, in particular: Web Engineering, are covered.

Further, the course addresses the more organizational topics of project management and version control.

Topics Software quality, process models, design patterns and frameworks, components and middleware, UML, testing, tools, project management, version control.

320222 – Software Engineering Lab

Short Name:	CSSELAB
Type:	Lab
Semester:	4
Credit Points:	5 ECTS
Prerequisites:	320142
Corequisites:	320212

Course contents The Software Engineering Lab course ends the series of courses on software development basics, placing particular emphasis on programming-in-the-large, i.e., "multi-person construction of multi-version software". Project work encompasses team-oriented specification, implementation, documentation, and compliance tests of some non-trivial software system.

Topics Team-oriented software development project.

5.3 3^{rd} Year Courses and Labs

In the third year, each EECS student will specialize in either EE or CS. The purpose of the specialization lectures is to bring the student "up to speed" to the frontiers of research and technology in their chosen fields and to provide the theoretical groundwork for the guided research work (see section 5.5) which has to be completed in the third year.

The mathematics training has been completed in the first two years. The transdisciplinary education is completed by two University Studies courses and two courses from the School of Humanities and Social Sciences (HSS).

300301 – Dynamical Systems and Control

Short Name:	EEDSC
Type:	Lecture
Semester:	5
Credit Points:	5 ECTS
Prerequisites:	300201
Corequisites:	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

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.

300321 – Probability and Random Signal Processing

Short Name: EEPRSP
Type: Lecture
Semester: 3
Credit Points: 5 ECTS
Prerequisites: 120112
Corequisites: 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.

300331 – Electronic Devices

Short Name: EEED
Type: Lecture
Semester: 5
Credit Points: 5 ECTS
Prerequisites: 300221 and 300222
Corequisites: 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.

300302 – Digital Signal Processing

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

Course contents The course is actually a combination of standard 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,...).

Overall, the course provides a complete coverage of digital signal processing and the essential basics of digital communications. The course is hence mandatory for ECE and a must for other students with a focus towards signal processing, video and audio, and communications.

300371 – Wavelets and their Applications

Short Name: EEWAVE
Type: Lecture
Semester: 5
Credit Points: 5 ECTS
Prerequisites: 300201
Corequisites: 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.

300341 – Information Theory

Short Name: EEIT
Type: Lecture
Semester: 5
Credit Points: 5 ECTS
Prerequisites: 120112 and 120201
Corequisites: 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.

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 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.
Aside from source and channel aspects, an introduction to security is given, including public-key cryptography.
Information theory is 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

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.

300322 – Advanced Random Processes

Short Name: EEARP
Type: Lecture
Semester: 6
Credit Points: 5 ECTS
Prerequisites: 300321
Corequisites: 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.

300332 – Microelectronics

Short Name: EEME
Type: Lecture
Semester: 6
Credit Points: 5 ECTS
Prerequisites: 300212 and 300222
Corequisites: 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.

300351 – Advanced Digital Design

Short Name: ADD
Type: Lecture
Semester: 6
Credit Points: 5 ECTS
Prerequisites: 300212 and 300222
Corequisites: 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.”

320301 – Computer Networks

Short Name:	CSCN
Type:	Lecture
Semester:	5
Credit Points:	5 ECTS
Prerequisites:	320202
Corequisites:	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. Fundamental algorithms and principles are explained in the context of existing IEEE / Internet protocols in order to demonstrate how they are applied in real-world scenarios. This course is recommended for all students with a strong interest in communication networks and distributed systems.

The course covers topics such as 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.

320302 – Databases and Web Applications

Short Name:	CSDBWA
Type:	Lecture
Semester:	5
Credit Points:	5 ECTS
Prerequisites:	320201
Corequisites:	None

Course contents This course introduces (relational) database systems in theory and practice, with special emphasis on Web-based information services. Topics addressed include database design (ER, UML), SQL, relational design theory, transaction management, security, web applications, 3-tier architectures, XML, XPath/XQuery, and an outlook on novel paradigms like NewSQL.

In the homeworks, the core of a database-enabled Web service is implemented. Students arrange themselves into small teams. Each team picks some individual application it finds exciting and agrees it with the instructor. In a guided process over the semester, the team then designs, documents, implements, and validates its chosen service based on a LAMP platform provided.

The course requires basic knowledge about algebraic expressions and laws, basic data structures like trees, object-oriented concepts, as well as basics of HTML and – for the homeworks – Linux.

Learning goals are (i) knowledge about databases and Web-based information systems and (ii) skills in designing and building database and Web services for science, engineering, and business domains.

320331 – Artificial Intelligence

Short Name:	CSAI
Type:	Lecture
Semester:	5
Credit Points:	5 ECTS
Prerequisites:	320201 and 320211
Corequisites:	None

Course contents Among the disciplines of CS, Artificial Intelligence is one of the most interdisciplinary, with connections to robotics, pattern recognition, machine learning, high-level programming, databases, software engineering and many more. To provide a modern treatment of the subject, the course focuses on approaches and techniques which enable an intelligent agent to plan, learn, and make decisions in stochastic environments.

Topics Dynamic programming and search, probabilistic reasoning, inference in Bayesian networks, Hidden Markov Models, Kalman filter, dynamic Bayesian networks, decision-theoretic expert systems, Markov decision processes, intelligent control, information entropy and decision trees, classification and regression, reinforcement learning, various applications in robotics and machine perception.

320341 – Programming in Java

Short Name:	CSPJ
Type:	Lecture / Lab
Semester:	3
Credit Points:	5 ECTS
Prerequisites:	(320102 and 320112) or (350102 and 350112)
Corequisites:	None

Course contents Java is an object-oriented programming language which is very widely used for the development of applications running on the Internet, and in particular electronic commerce applications. Java has some unique features such as platform independence and a very rich set of reusable class libraries. This course introduces the core language and the most important core Java packages.

Topics Java Virtual Machine, object-oriented programming in Java (types, objects, interfaces, abstract classes, etc.), Java threads, core packages (java.net, java.io, java.sql), Java web programming (servlets, JSP, beans, enterprise beans).

320322 – Graphics and Visualization

Short Name:	CSGV
Type:	Lecture
Semester:	5
Credit Points:	5 ECTS
Prerequisites:	320202 and 320222
Corequisites:	None

Course contents This is an introductory class into the concepts and techniques of 3D interactive computer graphics and visualization. Mathematical foundations, basic algorithms and principles, and advanced methods of real-time rendering and visualization are being taught. This course is recommended for all EECS students with an interest in data visualization and computer graphics.

Topics Geometric foundations, object representation, raster graphics, color models, shading and lighting, textures, animation and modelling, scientific visualization.

320311 – Robotics

Short Name: CSR
Type: Lecture
Semester: 5
Credit Points: 5 ECTS
Prerequisites: 320201 and 320222
Corequisites: 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.

The course is offered biannually (alternating with "Autonomous Systems").

320521 – Autonomous Systems

Short Name: CSAS
Type: Lecture
Semester: 5
Credit Points: 5 ECTS
Prerequisites: 320201 and 320222
Corequisites: None

Course contents There is an increasing interest and need to generate artificial systems that can carry out complex missions in unstructured environments without permanent human supervision. Intelligent mobile robots are often used as prototype or even defining example of according autonomous systems. The investigation of autonomous systems is driven from two different perspectives. First, it is motivated by the engineering aspects of generating application oriented devices. Second, artificial autonomous systems offer new ways to investigate and constructively understand natural cognition.

The course is offered biannually (alternating with "Robotics").

320321 – Image Processing

Short Name: CSImgProc
Type: Lecture
Semester: 5
Credit Points: 5 ECTS
Prerequisites: 320222 or 300221
Corequisites: None

Course contents The course provides a foundation in the theory and applications of digital image processing. The first part will concentrate on morphological image processing, which is one of the most powerful tool sets in dealing with digital images and it is the backbone of many of today's high-performance image analysis systems. We will start on basic concepts of dilation, erosion, geodesic transformations, morphological filtering, and watershed transform, and will develop into advanced strategies for image segmentation and texture analysis. The second part of the course will concentrate on solving problems from biomedical, environmental, and industrial imaging, and will provide an overview of the broader field of image processing.

The course is offered biannually (alternating with "Medical Image Analysis").

Topics Morphological image processing, distance transformations, geodesic transformations, reconstruction based operators, image segmentation, watershed transformation, automated threshold selection, advanced image processing, motion analysis, image registration, pattern recognition, texture analysis, selected applications

320351 – Medical Image Analysis

Short Name:	CSMedIA
Type:	Lecture
Semester:	5
Credit Points:	5 ECTS
Prerequisites:	320222 or 300221
Corequisites:	None

Course contents The course provides a foundation in the theory and methods of digital image processing with applications in medical imaging. We start with morphological image processing, which is one of the most powerful tool sets in dealing with digital images and it is the backbone of many of today's high-performance image analysis systems. After basic concepts of image-to-image transformations, morphological and Fourier filtering, and the watershed transform, we develop into advanced strategies for image segmentation, image registration, and pattern recognition. Not least, we concentrate on solving problems from diagnostic and therapeutic medical imaging, and will provide an overview of the broader field of medical image analysis. The course also addresses practical implementation aspects of specific image processing tasks. To this end, knowledge in C or C++ will be required.

The course is offered biannually (alternating with "Image Processing")

320441 – Computational Logic

Short Name:	CSCL
Type:	Lecture
Semester:	5
Credit Points:	5 ECTS
Prerequisites:	320211
Corequisites:	None

Course contents In this course we will cover the basics of computational logic. We will introduce the syntax and semantics of first-order logic, and discuss calculi, soundness, completeness on this system. We will cover machine-oriented inference calculi like analytic tableaux, and resolution and apply them to theorem proving and logic programming applications.

We will discuss the non-deductive reasoning modes of abduction and induction and briefly introduce computational methods for mechanizing them. Finally, we will give an introduction to knowledge representation and description logics, leading to an introduction of "semantic web" techniques.

320372 – Machine Learning

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

Course contents Machine learning (ML) is all about algorithms which are fed with (large quantities of) real-world data, and which return a compressed "model" of the data. An example is the "world model" of a robot: the input data are sensor data streams, from which the robot learns a model of its environment – needed, for instance, for navigation. Another example is a spoken language model: the input data are speech recordings, from which ML methods build a model of spoken English – useful, for instance, in automated speech recognition systems. There is a large number of formalisms in which such models can be cast, and an equally large diversity of learning algorithms. However, there is a relatively small number of fundamental challenges which are common to all of these formalisms and algorithms: most notably, the "curse of dimensionality" and the almost deadly-dangerous problem of under- vs. overfitting. This lecture introduces such fundamental concepts and illustrates them with a choice of elementary model formalisms (linear classifiers and regressors, radial basis function networks, clustering, mixtures of Gaussians, Parzen windows). Furthermore, the course also provides an intense refresher of the requisite concepts from probability theory, statistics, and linear algebra.

320352 – Computability and Complexity

Short Name: CSCC
Type: Lecture
Semester: 4
Credit Points: 5 ECTS
Prerequisites: 320211
Corequisites: None

Course contents This lecture presents one half of the core material of theoretical computer science (the other half is covered in the lecture "Formal Languages and Logic"). The question: "What problems can a computer possibly solve?", is fully answered (by characterizing those solvable problems, equivalently, through Turing machines, random access machines, recursive functions and lambda calculus). A full answer to the related question, "how much computational resources are needed for solving a given problem" is not known today. However, the basic outlines of today's theory of computational complexity will be presented up to the most famous open problem in computer science, namely the famous "P = NP" question: if a computer can guess the answer to a problem (and only needs to check its correctness), does that really help to speed up computation?

Topics Computable functions and complexity, lambda calculus, functional programming.

320312 – Distributed Systems

Short Name: CSDS
Type: Lecture
Semester: 6
Credit Points: 5 ECTS
Prerequisites: 320301
Corequisites: None

Course contents The first part of the course focusses on distributed file systems and generic middleware systems such as CORBA or Web Services. The second part of the course focusses on distributed algorithms that are the foundation for complex and fault-tolerant distributed systems. The material covered has been selected to provide a solid overview over the key algorithms and to develop an understanding of the issues that influence solutions for a certain problem in a distributed system.

Topics Middleware systems, distributed file systems, clock synchronization, logical and vector clocks, reliable, causal and atomic multicasts, virtual synchrony, election algorithms, voting algorithms, consistent snapshots, security.

5.4 Graduate Courses in Computer Science

In the last semester, academically strong undergraduate students specializing in Computer Science may participate in the following courses offered as part of the Computer Science graduate program. Enrollment in these courses requires the consent of the Instructor of Record. The credits count either as 3rd year CS or EECS specialization course credits or they may alternatively count towards a future CS graduate degree in case the student is able to fulfill the graduation requirements without the credits earned in these courses.

320523 – Advanced Autonomous Systems

Short Name: AdvAutSys
Type: Lecture
Semester: 2nd
Credit Points: 5 ECTS
Prerequisites: 320521
Corequisites: None

Course contents The Advanced Autonomous Systems course builds upon the Autonomous Systems course offered in the previous semester of that academic year. The Advanced Autonomous Systems course covers selected areas in more profound depth. The content of the course is hence devoted to most recent state of the art research on Autonomy like Cooperation or Cognitive Models.

320581 – Advanced Visualization

Short Name: AdvViz
Type: Lecture
Semester: 2nd
Credit Points: 5 ECTS
Prerequisites: 320322
Corequisites: None

Course contents Scientific visualization deals with the visualization of data with a natural spatial interpretation such as computer-generated data from numerical simulations (physics, chemistry) or measured data using scanning or sensor techniques (medicine, life sciences, geosciences). Volume visualization methods such as segmentation, surface extraction, and direct volume rendering for structured and unstructured gridded as well as scattered data are being taught. These include techniques for scalar field, vector field, and tensor field visualization.

Information visualization deals with the visualization of abstract data with no spatial interpretation such as graph- or network-based data (life sciences, social sciences, computer networks) or multi-dimensional data (economics, databases). Methods that tackle these visualization problems are being taught.

The course deepens, broadens, and enhances the knowledge in visualization obtained from the undergraduate course on ”Graphics and Visualization” in terms of visualization methods.

320541 – Computational Semantics of Natural Language

Short Name:	CompSem
Type:	Lecture
Semester:	2nd
Credit Points:	5 ECTS
Prerequisites:	320441
Corequisites:	None

Course contents In this course we will cover the logical and linguistic foundation of syntactical and semantic modeling of natural language in computational linguistics (the study of natural languages from a computational perspective). We will proceed by the “method of fragments”, where fragments of natural language are studied on a syntactic level (grammar and lexicon), the semantic level (transforming syntactic structures into logical forms), and a pragmatic level (inferring material that is not explicitly realized linguistically).

We will build up a sequence of fragments of increasing coverage (covering selected salient features of language) and discuss the linguistic and logical phenomena involved in detail.

The course will be accompanied by a hands-on programming lab, where the topics of the course will be implemented in the programming language PROLOG.

320671 – Machine Vision

Short Name:	MachViz
Type:	Lecture
Semester:	2nd
Credit Points:	5 ECTS
Prerequisites:	120201 (ESM 3A)
Corequisites:	None

Course contents Machine vision algorithms are used in a variety of real-world applications, such as surveillance and object tracking, 3D model building (photogrammetry), and object recognition. Apart from their visual appeal, these algorithms also represent elegant applications of advanced linear algebra and optimization techniques. Topics covered in this course include image-formation and camera calibration, image homographies, segmentation, feature detection and matching, structure from motion, 3D point-cloud processing, and an introduction to object-recognition.

320402 – Advanced Computer Networks

Short Name: AdvCompNet
Type: Lecture
Semester: 2nd
Credit Points: 5 ECTS
Prerequisites: 320301
Corequisites: None

Course contents This course covers advanced computer networking concepts such as multimedia communication and content distribution. The course covers voice communication in packet switched IP networks, related signaling and transport protocols, quality of service approaches (integrated and differentiated services), and multicast group communications. Some attention will be given to reliability and security aspects. Finally, the course covers technologies popular in backbone networks such as MPLS and new technologies of the IEEE 802 family of standards used in modern optical access networks.

320643 – Applied Machine Learning

Short Name: AppML
Type: Lecture
Semester: 2nd
Credit Points: 5 ECTS
Prerequisites: 320372
Corequisites: None

Course contents This Spring course builds on the introductory Fall course “Machine Learning” and presents a number of machine learning techniques which are widely used in application practice: adaptive linear filters (employed virtually everywhere in signal processing and control), feedforward neural networks (employed when it comes to learn complex nonlinear input-output relationships, as e.g. in financial time series prediction or image recognition), hidden Markov models (the workhorse for speech recognition), and fuzzy logic (used by engineers to predict and control very nonlinear systems). From a math/methods side, the two main classes of supervised learning algorithms are studied: optimization by gradient descent, and by “expectation-maximization” algorithms.

320574 – Modeling Complex Systems

Short Name: ModCompSys
Type: Lecture
Semester: 2nd
Credit Points: 5 ECTS
Prerequisites: 320372
Corequisites: None

Course contents This Spring course builds on the introductory Fall course “Machine Learning” and presents a number of machine learning techniques which aspire to model extremely complex real-world datasets and systems. Examples: robots navigating in unknown stochastic environments, image and video collections, the space shuttle, VLSI circuits, the weather. Modeling of such systems is an inherently probabilistic task: there is never enough data available to completely know the real system’s state or laws – the gap must be filled by statistics. Therefore, the emphasis in this course lies on statistical modelling and other methods that allow one to cope with uncertainty. A choice from the following techniques will be covered: (i) sampling methods and representations of probability distributions, optimization by simulated annealing, (ii) Bayesian networks and graphical models, with exact, Monte Carlo, and/or variational inference techniques, (iii) input-output models used in agent modelling and control (POMDP’s, input-output-OOMs), (iv) recurrent neural networks.

320491 – Advanced Graphics

Short Name: AdvGrafx
Type: Lecture
Semester: 2nd
Credit Points: 5 ECTS
Prerequisites: 320322
Corequisites: None

Course contents Computer graphics deals with the digital synthesis and manipulation of visual content, typically embedded in a three-dimensional scene. Prominent tasks in computer graphics are geometry processing, rendering, and animation. Geometry processing is concerned with object representations such as surfaces and their modeling, rendering is concerned with simulating light transport to get physically-based photorealistic images of 3D scenes or applying a certain style to create non-photorealistic images, and animation is concerned with descriptions for objects that move or deform over time. Methods that tackle these three tasks are being taught.

The course deepens, broadens, and enhances the knowledge in 3D computer graphics obtained from the undergraduate course on ”Graphics and Visualization” in terms of graphics methods.

320421 – Advanced Robotics

Short Name: AdvRob
Type: Lecture
Semester: 2nd
Credit Points: 5 ECTS
Prerequisites: 320311
Corequisites: None

Course contents The Advanced Robotics course builds upon the Robotics course offered in the previous semester of that academic year. The Advanced Robotics course covers selected areas of robotics in more profound depth. The content of the course is hence devoted to most recent state of the art research in a field related to work of Jacobs Robotics like Underwater Robotics or 3D Perception and Mapping.

320411 – Information Architectures

Short Name: InfArch
Type: Lecture
Semester: 2nd
Credit Points: 5 ECTS
Prerequisites: 320302
Corequisites: None

Course contents The title of this course can, and should, be understood in a twofold way. On conceptual level, mastering the rapidly growing volume and complexity of information in industry, science, and society requires improved modelling and design methodologies. On implementation level, existing storage, retrieval, and delivery techniques have to be revisited and new ones have to be designed in order to meet the challenges formulated conceptually. While these issues largely fall into the fields of databases, information retrieval, and Internet technology, the questions arising clearly transcend these fields and call for interdisciplinary research on more efficient and effective methods.

The course, therefore, starts with an overview of existing knowledge in the core fields and then covers selected themes in more depth. Among the candidate themes are non-standard applications such as spatio-temporal databases, array databases, parallel and distributed databases, XML databases, and NoSQL / NewSQL databases.

The goal is to make students familiar with the state of the art in Web-enabled information systems so that they will be successful database / Internet professionals in the IT industry and also have a sound knowledge base to specialize towards a scientific career in the field.

5.5 Guided Research in EECS

300361 – Guided Research in Electrical Engineering

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

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.

320371 – Guided Research in Computer Science

Short Name: CSGRP
Type: Project
Semester: 5
Credit Points: 2.5 ECTS
Prerequisites: None
Corequisites: 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 with timetable. The course is offered by all professors of Computer Science jointly. Topics are offered by the individual faculty members.

320342 – Guided Research in Computer Science + Thesis

Short Name: CSGR
Type: Project
Semester: 6
Credit Points: 7.5 ECTS
Prerequisites: 320371
Corequisites: None

Course contents The course is offered by all professors of Computer Science jointly. The purpose of this course is to engage the students in a research project under the close supervision of a CS 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.

5.6 CSE Seminar

The CSE seminar is a graduate lecture series on Electrical Engineering topics also open to interested undergraduate students. It is be 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

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/

5.7 Course Dependencies