Curriculum for the

Master's Degree Programme Information and Computer Engineering

Curriculum 2015 in the version of 2020

This version of the curriculum was approved by the Curricular Committee of Graz University of Technology in the meeting dated March 2, 2020.

On the basis of the Federal Act on the Organisation of Universities and their Studies (UG), Austrian Federal Law Gazette (BGBl.) No. 120/2002 as amended, the Senate of Graz University of Technology issues the following curriculum for the master's degree programme in Information and Computer Engineering.

Table of contents

§ 1 General provisions

(1) The Master's Degree Programme Information and Computer Engineering is comprised of four semesters. The total scope of the programme is 120 ECTS credit points.

(2) The Master's Degree Programme Information and Computer Engineering is taught as a degree programme in a foreign language in English, according to § 64 (6) of the Universities Act (UG).

(3) Graduates of this degree programme are awarded the university degree of "Diplom-Ingenieurin"/"Diplom-Ingenieur", abbreviated: "Dipl.-Ing." or "DI". The international equivalent of this university degree is "Master of Science", abbreviated: "MSc".

(4) Admission to the Master's Degree Programme Information and Computer Engineering requires a subject-related bachelor's degree or another equivalent degree according to § 64 (5) of the Universities Act (UG). The Master's Degree Programme Information and Computer Engineering builds upon the content of the Bachelor's Degree Programme Information and Computer Engineering of Graz University of Technology. Graduates of this degree programme and also of the previous Bachelor's Degree Programme Telematics are admitted to this master's degree programme of Graz University of Technology without any prerequisites being imposed.

(5) Depending on the previous education of the applicant to the programme, up to 25 ECTS credit points from the courses of the above-mentioned Bachelor's Degree Programme Information and Computer Engineering may be prescribed as part of the admission to the curriculum presented here for graduates of other bachelor's degree programmes. The specified courses reduce the workload stipulated in the curriculum for achievements in the elective or minor subject area to a comparable extent. The details are specified in Part 5 of the Annex. The admission rules for selected bachelor's degree programmes are also summarised in Part 5 of the Annex. However, a bachelor's degree programme that entitles the student to be admitted must be comprised of a minimum of 180 ECTS credit points. In order to obtain an overall scope of 300 ECTS credit points for the graduate and postgraduate degree programmes, the assignment of one and the same course in both the bachelor's degree programme entitling to admission and the master's degree programme in question is not permitted.

(6) The degree programme is to be completed with a master's thesis and a final master's examination before a committee in accordance with § 7a.

§ 2 Object of degree programme and the qualification profile

(1) Object of degree programme

Throughout the history of human activity, there has never been such a rapid growth in knowledge and the associated changes in knowledge as is the case with information technologies. Graduates of the Master's Degree Programme Information and Computer Engineering learn to deal with this phenomenon and to adjust to the need for independent and constant renewal of their knowledge. For this reason, the curriculum is designed to allow a great deal of freedom in the choice of teaching content and prepares students to think, decide and act independently and proactively.

A particular objective of this programme is therefore to develop the ability to think, decide and act in an interdisciplinary manner, and to develop an integrative approach to systems and therefore environmental and social issues, which are gaining in significance, especially with regard to increasing economic and social globalisation.

Information technologies are the carriers and motors of globalisation and the expansion of the English language as the lingua franca of our world. This is why the use of English is a natural element of the Master's Degree Programme Information and Computer Engineering. International doctoral candidates are integrated into the field of studies, and visiting professors from the international community enrich the degree programme considerably and contribute to the development of social competence. Projects, lecture activities, written work and teamwork further the development of the corresponding key competencies. Strategic thinking is developed as an integral element of the degree programme.

(2) Qualification profile and skills

Graduates of the Master's Degree Programme Information and Computer Engineering are prepared for a wide range of challenges and are able to adapt more effectively to all areas of information and communication technology in a shorter period of time than people with master's degrees from other, less interdisciplinary education and training programmes. Students of the Master's Degree Programme Information and Computer Engineering have achieved the following goals by successfully completing the programme:

Knowledge and understanding

Graduates

- have developed an understanding of the relevant basics,
- are familiar with the key theories, principles and methods of information processing and information technology, and have deepened their knowledge considerably in two scientific fields of information processing and information technology,
- are familiar with the working methods of these areas and are able to apply these and the scientific principles in practice and

- are familiar with the most important strategies for solving problems.

Knowledge-based application and assessment

Graduates

- are able to apply theoretical knowledge of a technical and scientific nature in a practical way,
- have developed the capacity for interdisciplinary analysis and assessment and the ability to justify and advocate solutions and
- recognise the ethical, social, societal and economic connections and necessities.

Communicative, organisational and social competencies

Graduates

- are able to acquire new skills and work independently on research and development projects,
- have developed an awareness of the need for lifelong learning,
- are able to present the results in written and oral form and contribute to decision-making processes,
- have basic knowledge in the handling of projects,
- are able to integrate themselves into a team and independently take on subtasks and management functions and
- are capable of cross-border and interdisciplinary cooperation.

(3) Need and relevance of the degree programme for science and for the labour market

Information and telecommunications networks and systems have gained significant and rapid importance in recent decades and are an integral part of new technologies in virtually all aspects of science, economy and society. Consequently, the scope of activities of individuals with an education in Information and Computer Engineering is correspondingly broad.

Graduates of the Master's Degree Programme Information and Computer Engineering will be able to independently model, design, implement, operate and evaluate complex hardware and software systems in the field of information technology and telecommunications. Graduates have a broad, detailed and critical understanding of the state of the art in several specialist areas.

Due to the broad field of activities covered in the Master's Degree Programme Information and Computer Engineering, the career opportunities are highly diverse: in industry, as a service provider, in public administration and in teaching and research, predominantly in management positions.

§ 3 ECTS credit points

In accordance with the European Credit Transfer and Accumulation System, the individual courses are assigned ECTS credit points that determine the relative share of the workload. The Universities Act (UG) determines the workload for one ECTS credit point to be an average of 25 full hours, 60 minutes each.

§ 4 Structure of the degree programme

The Master's Degree Programme Information and Computer Engineering consists of

1. a major with a minimum of 40 ECTS credit points,
2. a minor with a minimum of 20 ECTS credit points,
3. an elective subject that includes courses totalling up to 14 ECTS credit points; The choice must be made from the courses listed in § 5a in such a way that the sum of the major, minor and elective subjects results in at least 74 ECTS credit points. A larger number of study achievements from items 1 and 2 therefore reduces the required number of achievements from the elective subject.
4. a seminar/project with 10 ECTS credit points, allocated to the major or the minor.
5. a free-choice subject that encompasses free-choice courses with a workload of 6 ECTS credit points, and
6. a master's thesis. The master's thesis corresponds to 30 ECTS credit points und is allocated to a technical subject area in accordance with § 4.5.

Master's Degree Programme Information and Computer Engineering	
Major:	min. 40 ECTS credit points
Minor	min. 20 ECTS credit points
Elective subject (to be assessed together with the minor)	max. 14 ECTS credit points
Seminar/Project (allocated to the major and minor)	10 ECTS credit points
Free-choice subject	6 ECTS credit points
Total workload without master's thesis	90 ECTS credit points
Master's thesis	30 ECTS credit points
Total Master's Degree Programme Information and Computer Engineering	120 ECTS credit points

§ 5a below includes a list of the individual courses of this master's degree programme and their allocation to the subject areas. The semester allocation is a recommendation and ensures that the sequence of courses builds optimally on acquired previous knowledge and that the workload of an academic year does not exceed 60 ECTS credit points.

Courses that were taken to complete the bachelor's degree programme to grant admission to this programme are not part of this master's degree programme. If compulsory courses that are provided for in this curriculum were already completed as part of the bachelor's degree programme described above, they are to be replaced by additional elective courses comprising the same work load.

§ 4.1 Mentoring

All students must choose a mentor competent in the relevant subject area. He or she should support and advise the student in the creation and design of the degree programme, in particular in the sensible selection of courses.

The list of mentors is compiled by the Curricular Committee Working Group for Information and Computer Engineering and published on the website of the responsible Dean's Office. Mentors have the option of refusing to supervise a student in the event of an excessive workload, but in any case one of the mentors responsible for the proposed subject area must take over the supervision. Students can request a change of

mentor from the officers responsible for study matters without giving reasons. If possible, such requests should be granted in consultation with the newly selected mentor.

In cases of conflict, the officers responsible for study matters decides.

§ 4.2 Choice of major, minor und elective subject

The Master's Degree Programme Information and Computer Engineering focuses on the design and analysis of information and communication technology systems. Major and minor subject areas represent meaningful specialisations in Information and Computer Engineering.

In the course of the first semester of the master's degree programme, the catalogues of electives belonging to the major and minor must be specified. These are either catalogues of electives from the list in § 5a or a new subject composition must be made for one or both of these subject areas. The major is to be chosen from the technical catalogues of electives, the minor may be selected from all catalogues of electives defined in § 5a; the courses for the elective subject may be selected from the entire range of courses according to § 5a including the supplementary catalogue.

If a new composition is made, it must be confirmed by a mentor who is responsible for the subject area and must be forwarded to the officers responsible for study law matters via the relevant Dean's Office. The compulsory courses and/or selected combinations of compulsory elective courses defined in the catalogues of electives under § 5a are in any case part of the corresponding subject area.

In the case of an individual subject combination, the mentor, in consultation with the officers responsible for study matters, decides on the proposal and defines a name for this subject area. In case of a deviation of less than 10 ECTS credit points from a catalogue of electives contained in § 5a, the name may be the same. All courses selected for an individual subject combination must be completed.

The choice of a catalogue of electives contained in § 5a can be changed by providing an explanation. In the case of an individual subject combination, the changes must only apply to a catalogue of electives contained in § 5a. A change within an individual subject combination is only possible in order to guarantee the ability to study, e.g. if a course belonging to the individual subject combination is unexpectedly discontinued.

§ 4.3 Lecture and exercise-oriented performances

The major, minor and elective subject combined have to comprise at least 33 ECTS credit points in lectures and portions of lectures with integrated exercises as well as at least 18 ECTS credit points in exercise-oriented achievements. The following are used for the calculation of these exercise-oriented services: the exercise portions of lectures with integrated exercises[1], exercises, design exercises, laboratory course, projects, and seminars, as well as a maximum of one seminar/project completed in addition to the prescribed seminar/project. The prescribed seminar/project is not included in the percentage of exercise-oriented achievements.

In individual cases, this restriction may be waived on request.

[1]The lecture and exercise percentage is to be found in § 7.

§ 4.4 Balance

Within the framework of the Master's Degree Programme Information and Computer Engineering, at least 18 ECTS credit points must be earned in the field of electrical engineering and information technology (Faculty of Electrical and Information Engineering) and at least 18 ECTS credit points in the field of information processing (Faculty of Computer Science and Biomedical Engineering and Faculty of Mathematics, Physics and Geodesy). This allocation can be found in the course number and is supplemented in Part 6 of the Annex.

§ 4.5 Master's thesis

As part of the Master's Degree Programme Information and Computer Engineering, a master's thesis is to be written. It must be assigned to one of the catalogues of electives listed in § 5a; the only exception is the catalogue of electives defined as non-technical in § 5a. In the case of individual subject combinations, the student, together with the mentor and the supervisor of the master's thesis, must make a meaningful allocation of the master's thesis to a subject area at the beginning of the master's thesis.

If the master's thesis is assigned to a subject area other than the major or minor subject area, it implicitly results in a broad education. In this case, students must earn at least 10 ECTS credit points from the catalogue of electives of the master's thesis.

§ 5 Course content and semester plan

Master's Degree Programme Information and Computer Engineering							
				Semesters with ECTS credit points			
Subject	**Course**	**SSt**	**Course Type**	**ECTS**	**I**	**II**	**III**	**IV**
	Seminar/Project	6	SP	10			10	
Total of major, minor und elective subject acc. to § 5a				74	30	30	14	0
Master's thesis				30				30
Free-choice subject according to § 5b				6	0	0	6	0
Total				**120**	**30**	**30**	**30**	**30**

§ 5a Catalogues of electives

The following table includes the proposed catalogues of electives of the Master's Degree Programme Computer Engineering. The table has the following structure:
1st row: Number, name of course
further rows:
1st column: Institute offering the course (the information is only to be regarded as a reference)
2nd column: Name of the course
3rd column: Semester course hours (SSt)
4th column: Type of course
5th column: ECTS credit points for the Master's Degree Programme Computer Engineering
6th column: Compulsory course (course must be completed when choosing the subject area)
Compulsory elective course (it is possible to choose from at least 2 alternatives when choosing the subject area)

The table contains the seminars/projects that are automatically allocated to the course. Seminars/projects from other institutes can be allocated in consultation with the mentor.
The list of the responsible university teachers and the mentors is compiled by the Curricular Committee Working Group for Information and Computer Engineering and is available on the website of the Dean's Office for Computer Science and Biomedical Engineering (csbme.tugraz.at) and at the TU4U at any time.

c01 Information Security					
	The elective subject “Information Security” deals with the challenge of ensuring the security of information and communication technology. The focus lies on understanding practical aspects of implementing and using security mechanisms as well as on the thorough knowledge of the principles of these mechanisms.				
705	Cloud Operating Systems	3	VU	5.0	
501	Coding and Cryptography	3	VO	4.5	
501	Coding and Cryptography	1	UE	1.5	
716	Compiler Construction	2	VO	3.0	
716	Compiler Construction	1	KU	2.0	
705	Cryptanalysis	2	VO	3.0	
705	Cryptanalysis	1	KU	2.0	
705	Cryptography	2	VO	3.0	Compulsory course
705	Cryptography	1	KU	2.0	Compulsory course
705	Digital System Design	2	VO	3.0	
705	Digital System Design	1	KU	2.0	
705	Digital System Integration and Programming	3	VU	5.0	
503	Discrete Stochastics and Information Theory	1	UE	1.0	
503	Discrete Stochastics and Information Theory (Computer Science)	3	VO	4.5	
U232	Introduction into ICT-Law[KFU, DE]	2	VO	3.0	
448	Fault-Tolerant Distributed Algorithms	2	VU	3.0	
716	Formal Specification and Design of Software	3	VU	5.0	
706	Knowledge Discovery & Data Mining 1	2	VO	3.0	
706	Knowledge Discovery & Data Mining 1	1	KU	1.5	
705	Logic and Computability	2	VO	3.0	
705	Logic and Computability	1	KU	1.5	
705	Mobile Security	2	VO	3.0	
705	Mobile Security	1	KU	2.0	
705	Model Checking	2	VO	3.0	
705	Model Checking	1	UE	2.0	
716	Model-Based Testing	3	VU	5.0	
705	Privacy Enhancing Technologies	2	VO	3.0	
705	Privacy Enhancing Technologies	1	KU	2.0	
716	Problem Analysis and Complexity Theory	3	VU	4.5	
705	Secure Application Design	2	VO	3.0	Compulsory elective course
705	Secure Application Design	1	KU	2.0	Compulsory elective course
705	Secure Product Lifecycle	2	VO	3.0	
705	Secure Product Lifecycle	1	KU	2.0	
705	Secure Software Development	2	VO	3.0	Compulsory course
705	Secure Software Development	1	KU	2.0	Compulsory course
705	Seminar Cryptology and Privacy	2	SE	3.5	
705	Seminar Formal Methods	2	SE	3.5	
705	Side-Channel Security	3	VU	5.0	
705	Verification and Testing	2	VO	3.0	Compulsory elective course
705	Verification and Testing	1	UE	2.0	Compulsory elective course
	Total ECTS				**118.0**

Options for the selection of compulsory elective courses:
All compulsory and compulsory elective courses must be completed for the major. All compulsory courses must be completed for the minor.

705	Seminar/Project Information Security	4	SP	10	

Mentors: Bloem, Eichelseder, Gruß, Mangard, Rechberger

c01a Software Technology

The elective subject “Software Technology” provides advanced techniques relevant to the development of complex and critical software. This includes the fields of analysis, design, validation and verification. Another issue is the application of artificial intelligence techniques in software engineering. Programming languages and compiler construction are also covered.

716	Advanced Topics in Artificial Intelligence	2	VO	3.0	
716	Advanced Topics in Artificial Intelligence	1	UE	2.0	
716	Agile Software Development	3	VU	5.0	
716	Architecture of Database Systems	3	VU	5.0	
716	Architecture of Machine Learning Systems	3	VU	5.0	
716	Compiler Construction	2	VO	3.0	Compulsory course
716	Compiler Construction	1	KU	2.0	Compulsory course
716	Configuration Systems	2	VU	3.0	
448	Design Patterns	2	VO	3.0	Compulsory elective course
448	Design Patterns	1	UE	1.5	Compulsory elective course
716	Design Thinking and Rapid Prototyping	3	LU	3.0	
706	Designing Interactive Systems	2	VU	3.0	
716	Formal Specification and Design of Software	3	VU	5.0	
448	Industrial Software Development and Quality Management	2	VO	3.0	
448	Industrial Software Development and Quality Management	1	UE	1.5	
716	Intelligent Systems	2	VO	3.0	
716	Intelligent Systems	1	KU	2.0	
716	Mobile Applications	3	VU	5.0	
705	Model Checking	2	VO	3.0	
705	Model Checking	1	UE	2.0	
716	Model-Based Testing	3	VU	5.0	
716	Modelling Technical Systems	2	VO	3.0	
716	Modelling Technical Systems	1	KU	2.0	
716	Object-oriented Analysis and Design[DE]	2	VU	3.0	
716	Problem Analysis and Complexity Theory	3	VU	4.5	
716	Quality Ensurance in Software Development[DE]	2	VU	2.5	
716	Recommender Systems	2	VU	3.0	
716	Secure Software Development	2	VO	3.0	
716	Secure Software Development	1	UE	2.0	
716	Software Engineering for Autonomous Robots	2	VU	3.0	
716	Software Technology	3	VU	5.0	Compulsory course
716	Software Testing for Safety-Critical Systems	2	VO	3.0	
716	Software Testing for Safety-Critical Systems	1	KU	2.0	
716	Software Maintenance	3	VU	4.5	
705	Verification and Testing	2	VO	3.0	Compulsory elective course
705	Verification and Testing	1	UE	2.0	Compulsory elective course
716	Web Technology	3	VU	5.0	
	Total ECTS				**118.5**

Options for the selection of compulsory elective courses:
Out of the 4 blocks (VU or VO+KU/UE), 4 blocks must be selected for the major and the two mandatory blocks must be selected for the minor.

716	Seminar/Project Software Technology	4	SP	10	
	Mentors: Aichernig, Bloem, Felfernig, Macher, Slany, Wotawa				

c02 Visual Computing

The elective subject “Visual Computing” provides students with a deeper knowledge of computer graphics, image processing, geometric modelling, virtual and augmented reality and information visualisation. In addition to mastering the theoretical basics of the subject area, particular emphasis is placed on practical application. The application areas range from medicine to industrial automation.

711	3D Computer Graphics and Realism	3	VU	5.0	
711	3D Object Retrieval	3	VU	5.0	
710	Augmented Reality	3	VU	5.0	Compulsory elective course
710	Camera Drones	3	VU	5.0	
710	Computer Vision 2[DE]	1.5	VU	2.5	Compulsory course
711	Computer-Aided Geometric Design	3	VU	5.0	
710	Computer Graphics 2[DE]	1.5	VU	2.5	Compulsory course
710	Convex Optimisation	3	VU	5.0	
507	Discrete Differential Geometry	2	VO	3.0	
711	Fundamentals of geometry processing	3	VU	4.5	
711	Geometric 3D-Modelling in Computer Graphics	3	VU	5.0	
710	GPU Programming	3	VU	5.0	
710	Image and Video Understanding	2	VO	3.0	
710	Image and Video Understanding	1	KU	2.0	
438	Image Based Measurement	2	VO	3.0	
438	Image Based Measurement, Laboratory	1	LU	1.5	
710	Image Processing and Pattern Recognition	2	VO	3.0	Compulsory elective course
710	Image Processing and Pattern Recognition	1	KU	2.0	Compulsory elective course
706	Information Visualisation	3	VU	5.0	
710	Mathematical Principles in Visual Computing	3	VU	5.0	
710	Medical Image Analysis	2	VO	3.0	
710	Medical Image Analysis	1	KU	2.0	
710	Numerical Optimisation	3	VO	4.5	
710	Numerical Optimisation	2	UE	2.5	
710	Real-Time Graphics	2	VO	3.0	Compulsory elective course
710	Real-Time Graphics	1	KU	2.0	Compulsory elective course
710	Robot Vision	2	VO	3.0	Compulsory elective course
710	Robot Vision	1	KU	2.0	Compulsory elective course
710	Seminar Pattern Recognition	3	SE	5.0	
711	Simulation and Animation	3	VU	5.0	
710	Virtual Reality	4	VU	7.0	
	Total ECTS				**116.0**

Options for the selection of compulsory elective courses:
The compulsory courses apply to major and minor. Out of the 4 compulsory elective blocks (VU or VO+KU/UE), 3 blocks for the major and 1 block for the minor must be completed.

710 711	Seminar/Project Visual Computing	4	SP	10	

Mentors: Augsdörfer, Bischof, Fellner, Fraundorfer, Kalkofen, Lepetit, Schmalstieg, Pinz, Pock, Schreck, Steinberger

c03 Robotics and Intelligent Systems

The elective subject “Robotics and Intelligent Systems” provides in-depth knowledge of the key methods for developing intelligent robots and systems. In addition to teaching the theoretical principles of current methods such as navigation, computer vision, machine learning, knowledge representation, decision making or language comprehension, the focus lies on the ability to design, implement and validate intelligent systems.

716	Advanced Robotics	2	VO	3.0	Compulsory course
716	Advanced Robotics	1	LU	2.0	Compulsory course
716	Advanced Topics in Artificial Intelligence	2	VO	3.0	
716	Advanced Topics in Artificial Intelligence	1	UE	2.0	
442	Automatic Speech Recognition	2	VO	3.0	
710	Camera Drones	3	VU	5.0	
716	Construction of Mobile Robots	2	PT	5.0	Compulsory elective course
448	Context-Aware Computing	2	VO	3.0	
448	Context-Aware Computing	1	UE	1.5	
431	Control of Electric Drives and Machines	2	VO	3.0	
431	Control of Electric Drives and Machines, Laboratory	2	LU	3.0	
708	Deep Learning	2	VO	3.0	
708	Deep Learning	1	KU	2.0	
706	Designing Interactive Systems	2	VU	3.0	
716	Basics in Artificial Intelligence and Logic[DE]	2	VU	3.0	
438	Image Based Measurement	2	VO	3.0	
438	Image Based Measurement, Laboratory	1	LU	1.5	
301	Industrial Robotics[DE]	2	VO	3.0	
301	Robotics Lab[DE]	3	LU	3.0	
522	Inertial Navigation	2	VO	3.0	
522	Inertial Navigation	1	UE	1.5	
716	Intelligent Systems	2	VO	3.0	Compulsory elective course
716	Intelligent Systems	1	KU	2.0	Compulsory elective course
507	Kinematics and Robotics	2	VO	3.0	
507	Kinematics and Robotics	1	KU	2.0	
706	Knowledge Discovery & Data Mining 1	2	VO	3.0	
706	Knowledge Discovery & Data Mining 1	1	KU	1.5	
442	Computational Intelligence	2	VO	3.0	Compulsory elective course
442	Computational Intelligence	1	UE	1.5	Compulsory elective course
507	Mobile Robots	2	VO	3.0	Compulsory elective course
716	Mobile Robots	1	UE	2.0	Compulsory elective course
716	Modelling Technical Systems	2	VO	3.0	
716	Modelling Technical Systems	1	KU	2.0	
522	Navigation Systems	2	VU	3.0	
710	Numerical Optimisation	3	VO	4.5	
710	Numerical Optimisation	2	UE	2.5	
443	Optimisation and Control	2	VO	3.0	
443	Optimisation and Control, Laboratory	1	LU	1.5	
442	Nonlinear Signal Processing	2	VO	3.0	
442	Nonlinear Signal Processing	1	UE	1.5	
710	Robot Vision	2	VO	3.0	Compulsory course
710	Robot Vision	1	KU	2.0	Compulsory course
716	Software Engineering for Autonomous Robots	2	VU	3.0	
443	State Estimation and Filtering	2	VO	3.0	

443	State Estimation and Filtering	1	UE	1.5	
	Total ECTS				**120.0**

Options for the selection of compulsory elective courses:
In the major, the compulsory subjects and 2 blocks (each VO+UE/KU) from the compulsory elective subjects must be completed. In the minor, a total of 2 blocks from the compulsory and compulsory elective subjects must be completed.

708	Seminar/Project Machine Learning and Neuroinformatics	4	SP	10	
716	Seminar/Project Robotics	4	SP	10	
442	Seminar/Project Signal Processing	4	SP	10	

Mentors: Fraundorfer, Kubin, Legenstein, Pernkopf, Slany, Steinbauer, Wotawa

c04 Signal Processing and Human Communication

We can hear, see, speak, feel, think and regulate all processes of life with signals and have trained our communication and information devices, cars, machines, etc. to make use of them. The elective subject “Digital Signal Processing” focuses on the algorithms of signal processing which will lead future highly integrated systems of information technology to peak performance.

442	Adaptive Systems	2	VO	3.0	Compulsory course
442	Adaptive Systems	1	UE	1.5	Compulsory course
K17	Algorithms in acoustics and computer music 01[DE]	2	VO	3.0	
K17	Algorithms in acoustics and computer music 01[DE]	1	UE	1.5	
442	Audio Signal Processing Applications	2	VO	3.0	
442	Audio Signal Processors Laboratory	2	LU	3.0	
442	Automatic Speech Recognition	2	VO	3.0	
717	Biosignal Processing	2	VO	3.0	
717	Biosignal Processing	2	UE	3.0	
709	Cognitive Neuroscience	2	VO	3.0	
442	Digital Signal Processing, Laboratory	2	LU	3.0	
442	Digital Audio Engineering[DE]	2	VO	3.0	
442	Human Speech Production, Perception, and Pathologies	2	VU	3.0	
709	Introduction to Brain-Computer Interfaces	1	VO	1.5	
442	Linguistic Foundations of Speech and Language Technology	2	VO	3.0	
709	Methods of Functional Brain Research	2	VO	3.0	
442	Mixed-Signal Processing Systems Design	2	VU	3.0	
438	Multi-Sensor Data Fusion, Laboratory	2	LU	3.0	
709	Neurocomputing, Seminar	2	SE	3.5	
709	Neuroprosthetics	2	VO	3.0	
709	Non-Invasive Brain-Computer Interfaces	2	VO	3.0	Compulsory elective course
709	Non-Invasive Brain-Computer Interfaces	2	KU	3.0	Compulsory elective course
709	Non-Invasive Brain-Computer Interfaces 2	2	KU	3.0	
442	Nonlinear Signal Processing	2	VO	3.0	
442	Nonlinear Signal Processing	1	UE	1.5	
708	Principles of Brain Computation	2	VO	3.0	
708	Principles of Brain Computation	1	KU	2.0	
448	Processor Architecture	2	VO	3.0	
448	Processor Architecture, Laboratory	1	LU	1.5	
K17	Psychoacoustics 01[DE]	2	VO	3.0	
K17	Psychoacoustics 02[DE]	2	VO	3.0	
709	Rehabilitation Engineering	2	VO	3.0	
438	Signal Analysis	2	VO	3.0	Compulsory course
438	Signal Analysis	1	UE	1.5	Compulsory course
442	Signal Processing and Machine Learning 1, Seminar	2	SE	3.0	
442	Signal Processing and Machine Learning 2, Seminar	2	SE	3.0	

442	Speech Communication Laboratory	2	LU	4.0	Compulsory elective course
442	Speech Signal Processing	2	VO	3.0	Compulsory elective course
442	Speech Signal Processing	1	UE	1.5	
442	Speech Synthesis	2	VO	3.0	
442	Spoken Language in Human and Human-Computer Dialogue	2	VU	3.5	
438	Statistical Signal Processing	2	VO	3.0	Compulsory elective course
438	Statistical Signal Processing	1	UE	1.5	Compulsory elective course
	Total ECTS				**118.0**

Options for the selection of compulsory elective courses:
The compulsory courses apply to major and minor. For the major, it is necessary to additionally choose (Non-Invasive Brain-Computer Interfaces VO + KU) or (Statistical Signal Processing VO+UE) or (Speech Signal Processing VO and Speech Communication, Laboratory).

709	Seminar/Project Brain Computer Interface	4	SP	10	
442	Seminar/Project Signal Processing	4	SP	10	
442	Seminar/Project Speech Communication	4	SP	10	

Mentors: Hagmüller, Kubin, Müller-Putz, Pernkopf, Schuppler, Witrisal, Wriessnegger

c05 Communications and Mobile Computing

Everyday objects and environments are increasingly equipped with wirelessly networked computer systems that use sensors to detect conditions and automatically adapt to them. This development is reflected in concepts such as the Internet of Things or cyber-physical systems. The elective subject “Communications and Mobile Computing” deals with the basics and applications of such systems, from radio-based communication technologies, self-organising sensor networks and their integration into the Internet, to the development of smart services and machine learning methods for resource-limited mobile systems.

442	Adaptive Systems	2	VO	3.0	
442	Adaptive Systems	1	UE	1.5	
451	Antennas and Wave Propagation	2	VO	3.0	
451	Antennas and Wave Propagation	1	UE	1.5	
451	Applied Microwave Systems	2	VO	3.0	
440	Communication Networks	2	VO	3.0	
440	Communication Systems, Laboratory	2	LU	3.0	
437	Computational Electromagnetics	2	VO	3.0	
448	Context-Aware Computing	2	VO	3.0	Compulsory elective course
448	Context-Aware Computing	1	UE	1.5	Compulsory elective course
440	Design of Digital Modems	2	VO	3.0	
437	Electrodynamics ICE	2	VO	3.0	Compulsory elective course
437	Electrodynamics ICE	1	UE	1.5	Compulsory elective course
448	Embedded Internet	2	VU	3.0	
448	Embedded Internet, Laboratory	2	LU	3.0	
448	Fault-Tolerant Distributed Algorithms	2	VU	3.0	
442	Fundamentals of Digital Communications	2	VO	3.0	Compulsory elective course
442	Fundamentals of Digital Communications	1	UE	1.5	Compulsory elective course
451	HF-Engineering[DE]	2	VO	3.0	
451	HF-Engineering[DE]	1	UE	1.5	
451	HF-Engineering, Laboratory[DE]	1	LU	1.0	
440	Information Theory and Coding	2	VO	3.0	Compulsory elective course
440	Information Theory and Coding	1	UE	1.0	Compulsory elective course
451	Introduction to Radar Systems	2	VO	3.0	

448	Mobile Computing, Laboratory	2	LU	3.0	
448	Mobile Computing, Seminar	3	SE	5.0	Compulsory course
442	Mobile Radio Systems	2	VO	3.0	
440	Modelling of Wireless Propagation Channels	2	VO	3.0	
437	Numerical Optimisation	2	VO	3.0	
437	Numerical Optimisation	1	UE	1.5	
451	Optoelectronical Communication Engineering	3	VO	4.5	
451	Optoelectronical Communication Engineering	1	UE	2.0	
448	Power-Aware Computing	2	VU	3.0	
448	Power-Aware Computing, Laboratory	1	LU	1.5	
451	Radar, Seminar	1.5	SE	2.0	
440	Satellite Communications	2	VO	3.0	
440	Satellite Communications	1	UE	1.5	
451	Selected Topics of RFID Sensor Systems	2	VO	3.0	
448	Sensor Networks	2	VU	3.0	
448	Sensor Networks, Laboratory	2	LU	3.0	
437	Simulation of Time-Dependent Fields	2	VO	3.0	
437	Simulation of Time-Dependent Fields	1	UE	1.5	
451	Smart Antennas	2	VU	3.0	
448	Smart Service Development	2	VO	3.0	
448	Smart Service Development	1	UE	1.5	
	Total ECTS				**116.0**

Options for the selection of compulsory elective courses:
For the major, Mobile Computing, SE and 2 of the 4 compulsory elective blocks (VO+UE) must be completed; for the minor, Mobile Computing, SE and one of compulsory elective blocks (VO+UE) must be completed.

437	Seminar/Project Computational Electrodynamics	4	SP	10	
448	Seminar/Project Technical Informatics	4	SP	10	
440	Seminar/Project Telecommunications	4	SP	10	

Mentors: Boano, Bösch, Brenner, Gappmair, Grosinger, Koudelka, Leitgeb, Magele, Renhart, Römer, Saukh, Steger, Witrisal

c06 Embedded and Automotive Systems

The elective subject “Embedded and Automotive Systems” provide and deepen theoretical and practical knowledge about design, implementation and analysis of embedded systems. Hardware, software and their co-design are treated as well as their application in electronic and mechanical contexts, for example in vehicles, cyber-physical systems, sensors, actuators or the Internet of Things.

452	Automotive Electronics	2	VO	3.0	
452	Automotive Electronics, Laboratory	2	LU	3.0	
331	Automotive Engineering for Electrical, Information and Computer Engineering	2	VO	3.0	Compulsory elective course
438	Automotive Measurement	2	VO	3.0	
438	Automotive Measurement, Laboratory	1	LU	1.5	
438	Automotive Sensors and Actuators	2	VO	3.0	
438	Automotive Sensors and Actuators, Laboratory	2	LU	3.0	
448	Design of Real-Time Systems, Laboratory	2	LU	3.0	
448	Design Patterns	2	VO	3.0	
448	Design Patterns	1	UE	1.5	
448	Distributed Embedded Systems, Seminar	3	SE	5.0	Compulsory elective course
261	Dynamical Systems[DE]	3	VU	5.0	Compulsory elective course
313	Piston Engines, Introduction[DE]	2	VO	3.0	
313	Thermodynamics Introduction[DE]	2	VO	3.0	
439	Electromagnetic Compatibility of Electronic Systems	2	VO	3.0	
439	Electromagnetic Compatibility of Electronic Systems, Laboratory	1	LU	1.5	

448	Embedded Automotive Software	2	VU	3.0	Compulsory elective course
448	Embedded Systems	2	VO	3.0	Compulsory course
448	Embedded Systems, Laboratory	1	LU	1.5	Compulsory course
448	Fault-Tolerant Computing Systems	2	VO	3.0	
448	Fault-Tolerant Computing Systems	1	UE	1.5	
431	Introduction to Electric Machines[DE]	1.5	VO	2.0	
448	Industrial Software Development and Quality Management	2	VO	3.0	
448	Industrial Software Development and Quality Management	1	UE	1.5	
331	Automotive Power Transmissions[DE]	2	VO	3.0	
448	Microcontroller	1.5	VO	2.0	
448	Microcontroller	2	UE	3.0	
448	Microcontroller Design, Laboratory	4	LU	6.0	
438	On Board Diagnosis	2	VO	3.0	
448	Processor Architecture	2	VO	3.0	
448	Processor Architecture, Laboratory	1	LU	1.5	
443	Process Automation	2	VO	3.0	
443	Process Automation, Laboratory	2	LU	2.5	
438	Process Instrumentation[DE]	2	VO	3.0	
438	Process Instrumentation, Laboratory[DE]	2	LU	3.0	
448	Real-Time Bus Systems	1	VO	1.5	Compulsory elective course
448	Real-Time Bus Systems, Laboratory	1	LU	1.5	Compulsory elective course
448	Real-Time Operating Systems	2	VO	3.0	Compulsory course
448	Real-Time Operating Systems	1	LU	1.5	Compulsory course
448	Smart Service Development	2	VO	3.0	
448	Smart Service Development	1	UE	1.5	
438	Testing and Verification Methods for Distributed Software Systems	2	VO	3.0	
438	Vibrational Measurements	2	VO	3.0	
438	Vibrational Measurements, Laboratory	1	LU	1.5	
	Total ECTS				**118.5**

Options for the selection of compulsory elective courses:
For the major, the compulsory courses must be completed as well as at least another 5 ECTS credit points from the compulsory elective courses (VO+LU if available); for the minor, Embedded Systems (VO+LU) as well as at least another 4.5 ECTS credit points from the compulsory and compulsory elective courses (VO+LU if available) must be completed.

439	Seminar/Project Electronics	4	SP	10
438	Seminar/Project Measurement Techniques	4	SP	10
448	Seminar/Project Technical Informatics	4	SP	10

Mentors: Baunach, Bergmann, Boano, Brenner, Bretterklieber, Macher, Steger, Watzenig, Wegleiter

c07 Measurement and Control Systems

Educational objectives of the elective subject “Measurement and Control Systems”:
.) Proficiency in methods for creating mathematical models for technical systems,
.) Solid knowledge of algorithms for digital simulation and their use in practice relevant tasks,
.) Proficiency in procedures for the systematic design of regulations and their practical implementation

442	Adaptive Systems	2	VO	3.0
442	Adaptive Systems	1	UE	1.5
443	Advanced Control Concepts	2	VO	3.0
443	Advanced Control Concepts	1	UE	1.5
443	Computer Aided Control System Design	2	VO	3.0
443	Computer Aided Control System Design	1	UE	1.5
443	Computer Aided System Modelling and Simulation[DE]	2	VO	3.0
443	Computer Aided System Modelling and Simulation[DE]	1	UE	1.5

443	Control Systems 2	2	VO	3.0	Compulsory elective course
443	Control Systems 2	1	UE	1.5	Compulsory elective course
438	Electrical Measuring Instruments, Laboratory	1	LU	1.5	
438	Energy Harvesting Systems	2	VO	3.0	
452	Environmental Sensing	2	VO	3.0	
443	Nonlinear Control Systems, Basics	2	VO	3.0	Compulsory elective course
443	Nonlinear Control Systems, Basics	1	UE	1.5	Compulsory elective course
438	Image Based Measurement	2	VO	3.0	
438	Image Based Measurement, Laboratory	1	LU	1.5	
438	Measurement Signal Processing	2	VO	3.0	
443	Mechatronic Systems Modelling	2	VO	3.0	
443	Mechatronic Systems Modelling	1	UE	1.5	
438	Measurement 2[DE]	2	VO	3.0	
431	Modelling and Simulation of Electric Drive Systems and Machines	2	VO	3.0	
431	Modelling and Simulation of Electric Drive Systems and Machines, Laboratory	2	LU	3.0	
438	Multi-Sensor Data Fusion, Laboratory	2	LU	3.0	
443	Multivariable Systems	2	VO	3.0	
443	Multivariable Systems	1	UE	1.5	
443	Nonlinear Control Systems	2	VO	3.0	Compulsory course
443	Nonlinear Control Systems	2	UE	3.0	Compulsory course
442	Nonlinear Signal Processing	2	VO	3.0	
442	Nonlinear Signal Processing	1	UE	1.5	
437	Numerical Optimisation	2	VO	3.0	
437	Numerical Optimisation	1	UE	1.5	
443	Optimal Feedback Design	2	VO	3.0	
443	Optimal Feedback Design	1	UE	1.5	
443	Optimisation and Control	2	VO	3.0	
443	Optimisation and Control, Laboratory	1	LU	1.5	
438	Photonic Sensors	2	VO	3.0	
438	Photonic Sensors, Laboratory	1	LU	1.5	
438	Physical Effects for Sensors	2	VO	3.0	
443	Process Automation	2	VO	3.0	
443	Process Automation, Laboratory	2	LU	2.5	
438	Process Instrumentation[DE]	2	VO	3.0	
438	Process Instrumentation, Laboratory[DE]	2	LU	3.0	
443	Selected Topics of Control & Dynamic Systems	2	SE	3.0	
438	Signal Analysis	2	VO	3.0	Compulsory course
438	Signal Analysis	1	UE	1.5	Compulsory course
443	State Estimation and Filtering	2	VO	3.0	
443	State Estimation and Filtering	1	UE	1.5	
	Total ECTS				**118.0**

Options for the selection of compulsory elective courses:
For the minor, all compulsory courses must be completed; for the major, an additional compulsory elective block (VO+UE) must be completed.

438	Seminar/Project Measurement Techniques	4	SP	10
443	Seminar/Project Modelling, Simulation and Control	4	SP	10
442	Seminar/Project Signal Processing	4	SP	10

Mentors: Bergmann, Bretterklieber, Horn, Reichhartinger, Wegleiter

c08 Microelectronics and IC Design

The elective subject “Microelectronics and IC Design” provides students with the essential knowledge and skills of semiconductor physics and integrated circuit technology for the design of analogue and digital integrated circuits, for which a good physical understanding of the devices is necessary. Lectures and exercises in this subject area enable students to develop electronic devices and systems independently all the way from the formulation of specifications to commissioning. Contemporary concepts (e.g. simulation techniques) as well as the interaction with other systems and the environment (EMC) are of particular importance.

439	Advanced Analog IC Design 1	3	VU	4.5	
439	Advanced Analog IC Design 2	3	VU	4.5	
439	Advanced Layout Techniques	1	VU	1.5	
439	Analog Circuit, Laboratory	3	LU	3.0	
439	Analog IC Design 1	2	VO	3.0	Compulsory course
439	Analog IC Design 1	2	UE	3.0	Compulsory course
439	Analog IC Design 2	2	VO	3.0	Compulsory elective course
439	Analog IC Design 2	2	UE	3.0	Compulsory elective course
439	Analog IC Layout 1	2	UE	3.0	
439	Compact Modelling and Robust IC Design	1	VU	1.5	
439	Development of Electronic Systems	4	VO	6.0	
439	Digital Circuit, Laboratory	3	LU	4.0	
705	Digital System Design	2	VO	3.0	Compulsory course
705	Digital System Design	1	KU	2.0	Compulsory course
705	Digital System Integration and Programming	3	VU	5.0	Compulsory elective course
439	Dimensioning of Electronic Circuits	2	UE	3.0	
439	Dimensioning of Electronic Circuits, Laboratory	1	LU	2.0	
439	Electromagnetic Compatibility of Electronic Systems	2	VO	3.0	
439	Electromagnetic Compatibility of Electronic Systems, Laboratory	1	LU	1.5	
439	Electromagnetic Compatibility of ICs	1	VO	1.5	
439	Electromagnetic Compatibility of ICs, Laboratory	1	LU	1.5	
439	Evaluation of ICs, Laboratory	3	LU	4.5	
451	Introduction to MW Engineering	2	VO	3.0	Compulsory elective course
451	Introduction to MW Engineering	1	UE	2.0	Compulsory elective course
439	Microelectronics - Introduction	2	VO	3.0	
448	Hardware Description Languages	2	VO	3.0	
448	Hardware Description Languages	1	UE	1.5	
448	Hardware-Software Codesign	2	VO	3.0	
448	Hardware-Software Codesign	1	UE	1.5	
439	IC Design Fundamentals	2	VO	3.0	Compulsory elective course
439	IC Design Fundamentals	2	UE	3.0	Compulsory elective course
439	IC Design Project Management and Quality	1	VO	1.5	
439	Methods for IC Evaluation and Failure Analysis	2	VU	3.0	
438	Micro-Electromechanical Systems	2	VO	3.0	
451	Microwave Measurement Techniques	2	VU	3.0	
439	Noise and Crosstalk in ICs	2	VU	3.0	
513	Physics of Semiconductor Devices	2	VO	3.0	
439	Production Test and Design for Test	2	VO	3.0	
439	Reliable Integrated Circuits in Design and Application	1	VO	1.5	
451	RF and Microwave Component Design	2	VU	3.0	
439	Selected Topics of Advanced Analog IC Design	2	VU	3.0	
451	Selected Topics of RFID Sensor Systems	2	VO	3.0	
	Total ECTS				**120.0**

Options for the selection of compulsory elective courses:
For the major, all compulsory courses as well as one of the compulsory elective course blocks (each VU/VO+UE) must be completed; for the minor, Analog IC Design 1 VO, IC Design Fundamentals VO and Digital System Design VO must be completed.

439	Seminar/Project Electronics	4	SP	10	
438	Seminar/Project Measurement Techniques	4	SP	10	
448	Seminar/Project Technical Informatics	4	SP	10	
	Mentors: Auer, Deutschmann, Eichberger, Söser, Steger, Winkler				

s01 Supplementary Catalogue

505	Advanced and Algorithmic Graph Theory	3	VO	4.5	
505	Advanced and Algorithmic Graph Theory	1	UE	1.5	
437	Basic Experiments in Electrodynamics[DE]	2	LU	2.0	
708	Computational Geometry[DE]	2.5	VO	3.0	
502	Combinatorial Optimisation 1[DE]	4	VO	6.0	
502	Combinatorial Optimisation 1[DE]	1	UE	1.5	
431	Power Electronics 2	2	VO	3.0	
440	RFID Systems	2	VO	3.0	
437	Simulation of Static Fields	2	VO	3.0	
437	Simulation of Static Fields	1	UE	1.5	
711	Object-Oriented Programming 2[DE]	1	VO	1.5	
711	Object-Oriented Programming 2[DE]	2	KU	2.5	
	Total ECTS			**33.0**	

w01 Business, Law, and Management

The elective subject “Business, Law and Management” is designed to give students a basic education in the field of management. Students with little economic background who want to learn the basic principles are welcome.

373	Business Sociology[DE]	2	VO	3.0	
374	Business Informatics	1	VO	1.5	
374	Business Informatics	2	UE	3.0	
373	Controlling (engl.)	2	VO	3.0	
373	Controlling (engl.)	1	UE	1.5	
371	Creativity Techniques	2	VU	2.0	
373	Encyclopaedia Business Economics	3	VO	4.5	Compulsory course
373	Encyclopaedia Business Economics	2	UE	3.0	Compulsory course
372	Entrepreneurship	2	VO	3.0	
372	Entrepreneurship	1	UE	1.5	
372	General Management and Organisation	2	VO	3.0	
372	General Management and Organisation	2	UE	3.0	
372	General Management, Case Studies	3	SE	3.0	
710	Start-Ups and Small Business Management[DE]	3	VU	3.0	
372	Start-up Garage[DE]	2	SE	2.0	
371	Industrial Management and Innovation	2	VO	3.0	
371	Industrial Management and Innovation	1	UE	1.0	
371	Industrial Management[DE]	3	VO	4.5	
371	Industrial Management[DE]	3	UE	3.0	
372	Information Management	3	VU	4.0	
371	Modelling and Optimisation in Production and Logistic Systems	2	VU	2.0	
373	Marketing Management	3	SE	3.0	
374	Practice of Digital Transformation[DE]	1	VO	1.5	
374	Practice of Digital Transformation[DE]	1	UE	1.5	
371	Product Innovation Project	3	PR	5.0	
374	Production Planning & Control	2	VO	3.0	
374	Production Planning & Control	2	UE	3.0	
372	Process Management[DE]	4	SE	4.0	
374	Quantitative Methods for Business	2	VO	3.0	

374	Quantitative Methods for Business	3	UE	4.5
374	Selected Topics of Business Informatics	2	VO	2.0
374	Selected Topics of Business Informatics	1	UE	1.0
371	Value Engineering	3	VU	3.0
940	Diversity Management	2	SE	2.0
940	Intercultural Social Competence for Work and Life	2	SE	2.0
940	English for Engineers: Perfection level - Oral Skills (C1/1)	2	SE	2.0
940	English for Engineers: Perfection level - Professional Meetings (C1/1)	2	SE	2.0
373	Industrial Law (Labour Law)[DE]	2	VO	3.0
373	Civil Law and Law of Business Enterprises[DE]	3	VO	4.5
373	Patent Law[DE]	2	VO	3.0
373	Law of Taxation[DE]	2	VO	3.0
434	Energy and Environment	2	VO	3.0
638	Financial Management	2	VO	3.0
432	Design of Nuclear Powerplants[DE]	2	VO	3.0
706	Sustainable Innovation	2	VU	4.0
433	Complexity and Dynamics in the Information- and Knowledge-Society[DE]	2	SE	2.0
706	Science, Technology and Society: Interdisciplinary Approaches	2	SE	4.0
706	Technology – Ethics – Politics[DE]	2	VU	4.0
706	Gender & Technology 1[DE]	2	SE	4.0
706	Gender & Technology 2[DE]	2	SE	4.0
706	Technology Assessment[DE]	2	SE	4.0
442	The ICE Age: The History of Information and Communications Engineering as an Art, Science, and Pervasive Culture	2	VU	3.0
	Total ECTS			**147.5**

Options for the selection of compulsory elective courses:
All compulsory courses must be completed for the minor.

[DE]: This course is offered in German only.

First column begins with U: This course is offered by the University of Graz, co-registration at this university is required.

First column begins with K: This course is offered by the University of Music and Performing Arts Graz, co-registration at this university is required.

Please note: Possible additions to the catalogues of electives will be announced in the University Gazette of Graz University of Technology.

Instead of the two courses “English for Engineers: Perfection level - Oral Skills (C1/1)” and “English for Engineers: Perfection level - Professional Meetings (C1/1)” other courses for the consolidation of a foreign language (English or German) can also be taken within the framework of the elective subject, up to a total of 3 ECTS credit points.

Courses with the title “Selected Topics of [catalogue name] (subtitle)” are assigned to the respective catalogue of electives, whereby one semester course hour usually corresponds to 1.5 ECTS credit points. These courses have descriptive subtitles and are offered with a total scope of 1-3 semester course hours. VO, VU or SE and/or 1-2 semester course hours UE. Courses with different subtitles must be classified as different courses.

§ 5b Free-choice subject

The courses to be completed as part of the free-choice subject are designed to provide individual emphasis and further development of the students. They may be freely

chosen from the courses offered at any recognised national and international universities and also at universities of applied sciences and universities of teacher education.

Students are recommended to spread free-choice courses over the entire length of the programme.

If a course is assigned the same number of ECTS credit points in all curricula in which it is a compulsory or an elective course, it must be allocated the same number of ECTS credit points when taken as a free-choice subject. If a course has been allocated varying numbers of ECTS credit points, the minimum number of assigned ECTS credit points is to be allocated to the course when taken as a free-choice subject.

Courses that are neither compulsory nor electives are assigned 1 ECTS credit point per semester course hour (SSt). However, if such courses are lecture-type courses (VO), they are assigned 1.5 ECTS credit points for each semester course hour.

§ 5c Stays abroad and practical training

1) Recommended stays abroad
   Students of the degree programme are recommended to study abroad for a semester. In this master's degree programme, the 2nd or 3rd semesters are particularly suitable for this purpose. Equivalent modules or courses completed during the stay abroad must be recognised by the officers responsible for study matters. For the recognition of examinations taken during stays abroad, please refer to § 78 (6) of the Universities Act (UG) (pre-notification of recognition).
   Furthermore, upon application to the officers responsible for study matters, achievements from shorter study stays abroad, such as active participation in international summer or winter schools, may also be recognised with up to 3 ECTS credit points within the framework of free-choice courses.

2) Internship
   Students are encouraged to complete a job-related internship within the framework of the free-choice courses.
   Each week of full employment corresponds to 1.5 ECTS credit points. Active participation in an academic event may also count as an internship. This internship must be approved by the officers responsible for study matters and is considered a useful addition to the degree programme. A maximum of half of the free-choice courses can be replaced by this internship.

§ 6 Admission to examinations

Admission to examinations is not subject to any prerequisites.

In order to assist students in completing their degrees in a timely manner, courses with continuous assessment must allow students to submit, supplement or repeat partial course requirements no later than two weeks after the start of the semester following the course.

§ 6a Guidelines for the allocation of places on courses

(1) If the number of students registered for a course exceeds the number of available places, parallel courses are to be provided. If necessary, these parallel courses may also be provided during the holidays and semester breaks.

(2) If it is not possible to offer a sufficient number of parallel courses (groups), the students are to be admitted to the course according to the following priority ranking:
   a) Students who are required to complete the course according to their curriculum have priority.
   b) Further students are to be ranked according to the sum of the successfully completed courses of the respective degree programme (total ECTS credit points).
   c) Students who have met the participation requirement at an earlier date are ranked by date.
   d) Students who have already been deferred once or who have to repeat the course are to be given preferential admission to the next course to be held.
   e) The further ranking is made according to the grade of the examination or the average grade of the examinations (weighted on the basis of the ECTS credit points) of the respective course(s) that are specified as the participation requirement.
   f) Students who do not need to complete such courses in order to fulfil their curriculum are only considered based on the number of free places. It is possible to be included on a separate waiting list. The abovementioned provisions apply mutatis mutandis.

(3) Students who complete a part of their studies at Graz University of Technology in the context of mobility programmes are given priority for up to 10% of the available places.

§ 7 Examination regulations

Courses are evaluated individually.

1. Examinations for courses held as lectures (VO) cover the complete content of the course.
2. For courses held as lectures with integrated exercises (VU), exercise-based courses (PR, UE), design exercises (KU), laboratory courses (LU), seminar-type courses (SE, SP), and excursions (EX), a student's performance is continually assessed on the basis of that student's contributions and/or through accompanying tests. The assessment must always consist of at least two examinations.
3. The positive result of examinations is to be assessed as "excellent" (1), "good" (2), "satisfactory" (3) or "sufficient" (4) and the negative result as "unsatisfactory" (5). Specially indicated courses and excursion-type courses are assessed as "successful completed" or as "not completed".
4. If a subject area includes separate examinations for the relevant courses, the overall subject grade is to be determined by:
   a) multiplying the grade of each examination result in connection with the subject area with the ECTS credit points of the corresponding course,
   b) adding the values calculated according to lit. a.,
   c) dividing the result of the addition by the sum of the ECTS credit points of the courses, and

d) rounding the result of the division to a whole-numbered grade if required. The grade is rounded up if the decimal place exceeds 0.5. Otherwise, the grade is rounded down.

The types of courses are explained in Part 4 of the Annex.

In addition to the types of courses, the following maximum group sizes are set forth:

1. The maximum group size for exercise-based courses (UE), exercise components of lectures with integrated exercises (VU) and for design exercises (KU) is 25 students.
2. The maximum group size for projects (PR), seminars (SE) and excursions (EX) is 15 students.
3. The maximum group size for laboratory courses (LU) is 6 students.
4. The maximum group size for projects (PR) and seminar/projects (SP) is 8 students. Alternatively, the officers responsible for study matters can assign the seminar/project with individual mentoring. In this case, the seminar/project is equivalent to an assignment of 0.5 project hours.

Lectures with integrated exercises (VU) are divided into lecture and exercise components, with 2/3 of the semester course hours (SSt) being allocated to lecture components and 1/3 being allocated to exercise components. The following courses are excluded and divided as follows:

Course	SSt	Type	ECTS	SSt VO	SSt UE
Advanced Analog IC Design 1	3.0	VU	4.5	1.5	1.5
Advanced Analog IC Design 2	3.0	VU	4.5	1.5	1.5
Compact Modelling and Robust IC Design	1.0	VU	1.5	0.5	0.5
Dynamical Systems	3.0	VU	5.0	1.5	1.5
Embedded Automotive Software	2.0	VU	3.5	1.5	0.5
Embedded Internet	2.0	VU	3.0	1.5	0.5
Methods for IC Evaluation and Failure Analysis	2.0	VU	3.0	1.0	1.0
Microwave Measurement Techniques	2.0	VU	3.0	1.0	1.0
Mixed-Signal Processing Systems Design	2.0	VU	3.5	1.0	1.0
Navigation Systems	2.0	VU	3.0	1.0	1.0
Noise and Crosstalk in ICs	2.0	VU	3.0	1.0	1.0
Power-Aware Computing	2.0	VU	3.0	1.5	0.5
Camera Drones	3.0	VO	5.0	1.0	2.0
Recommender Systems	2.0	VU	3.0	1.0	1.0
RF and Microwave Component Design	2.0	VU	3.0	1.0	1.0
Sensor Networks	2.0	VU	3.0	1.5	0.5
Smart Antennas	2.0	VU	3.5	1.0	1.0
Spoken Language in Human and Human-Computer Dialogue	2.0	VU	3.5	1.0	1.0
Virtual Reality	4.0	VU	7.0	2.0	2.0

§ 7a Final examination before a committee

Admission to the final master's degree examination before a committee requires proof of positive assessment of all examination results according to § 4 and § 5 above as well as proof of positive assessment of the master's thesis.

The final examination before a committee takes place before an board of examiners composed of three persons who are appointed by the officers responsible for study matters. The supervisor of the master's thesis must be part of the board of examiners. In the event of the supervisor's incapacity, he/she can suggest a substitute.

During the final master's degree examination before a committee, students must present their master's thesis written in accordance with the regulations, and must defend the thesis before the members of the board of examiners in the subsequent oral examination. The total duration of the final examination before a committee must not exceed one hour.

§ 7b Degree certificate

The master's degree certificate is comprised of:

a) the major according to § 5 and its assessment,
b) the minor including elective subject according to § 5 and its assessment,
c) the title and the assessment of the master's thesis,
d) the assessment of the final examination before a committee,
e) the entirety of the ECTS credit points for successfully completed free-choice courses from the free-choice subject, as defined in § 5b above, and
f) the overall assessment according to § 73 (3) of the Universities Act (UG).

§ 8 Transitional provisions

As of October 1, 2020, regular students of the Master's Degree Programme Information and Computer Engineering will be subject to the curriculum in the present 2020 version.

The ECTS credit points are calculated according to the current status when issuing the certificate or at the time of recognition of courses for the Master's Degree Programme Information and Computer Engineering.

All courses completed at the time when they were included in the curriculum of the Master's Degree Programme Information and Computer Engineering in the version 2015 or in the curriculum of the Master's Degree Programme Telematics can be recognised for the curriculum 2015 in the current 2020 version. The officers responsible for study matters determine the catalogue of electives to which the courses is assigned in each case, based on a proposal by the student and with the consent of the mentor.

§ 9 Legal validity

This 2015 curriculum in its 2020 version (TUGRAZonline abbreviation 20U) obtains legal validity on October 1, 2020.

Annex to the curriculum of the Master's Degree Programme Information and Computer Engineering

Part 1 of the Annex:

Descriptions of the elective subject

Elective subject: c01 Information Security

Content of elective subject: The elective subject “Information Security” deals with the challenge of ensuring the security of information and communication technology. The focus lies on understanding practical aspects of implementing and using security mechanisms as well as on the thorough knowledge of the principles of these mechanisms.

Learning outcomes: Upon completion of the elective subject, students are familiar with the various aspects of information security and are able to apply them in theory and practice.

Prerequisites for participation: No formal prerequisites; basic knowledge in Information Security is an advantage.

Elective subject: c01a Software Technology

Content: The elective subject “Software Technology” provides advanced techniques relevant to the development of complex and critical software. This includes the fields of analysis, design, validation and verification. Another issue is the application of artificial intelligence techniques in software engineering. Programming languages and compiler construction are also covered.

Learning outcomes: Upon completion of the elective subject, students are familiar with the various aspects of software technology and are able to apply them in theory and practice.

Prerequisites for participation: No formal prerequisites; basic knowledge in Information Security is an advantage.

Elective subject: c02 Visual Computing

Content: The elective subject “Visual Computing” provides students with a deeper knowledge of computer graphics, image processing, geometric modelling, virtual and augmented reality and information visualisation. In addition to mastering the theoretical basics of the subject area, particular emphasis is placed on practical application. The application areas range from medicine to industrial automation.

Learning outcomes: Upon completion of the elective subject, students are able to independently develop imaging and image processing procedures in various fields of application, as well as to propose and implement solutions.

Prerequisites for participation: No formal prerequisites; basic knowledge in Computer Graphics and Computer Vision is an advantage.

Elective subject: c03 Robotics and Computational Intelligence

Content: The elective subject “Robotics and Computational Intelligence” provides students with access to the most important currently known methods of making machines “intelligent”, as well as practical experience with state-of-the-art software from the fields of machine learning, neural networks, simulation and modelling of technical systems, navigation and robot vision. Due to the interdisciplinary nature of the subject area, the elective subject includes courses from the fields of mechanical engineering, electrical engineering and computer science. The focus of the elective subject lies on the practical implementation of the contents learned.

Learning outcomes: Upon completion of the elective subject, students are familiar with the most important algorithms and techniques as well as the construction of "intelligent" machines. They know the advantages and disadvantages of the various (learning) algorithms and are able to solve practical and theoretical problems independently and to design a robot for an assigned task and program it accordingly.

Prerequisites for participation: No formal prerequisites; basic knowledge in knowledge processing, computational intelligence, modelling and simulation is an advantage.

Elective subject: c04 Signal Processing and Human Communication

Content: The elective subject “Signal Processing and Human Communication” focuses on hearing, seeing, speaking, and thinking as essential aspects of life. The acquisition and processing of the associated signals requires knowledge of the physics of sound wave propagation, the analysis, synthesis and coding of signals, automatic pattern recognition including models of human perception, and the understanding and generation of spoken or written language in automatic dialogue.

Learning outcomes: Upon completion of the elective subject, students are familiar with the essential algorithms and techniques for the acquisition of speech and biosignals as well as the algorithms to process them and are able to develop highly integrated systems in the field of information and communication technology.

Prerequisites for participation: No formal prerequisites; basic knowledge in Signal Processing is an advantage.

Elective subject: c05 Communications and Mobile Computing

Content: Everyday objects and environments are increasingly equipped with wirelessly networked computer systems that use sensors to detect conditions and automatically adapt to them. This development is reflected in concepts such as the Internet of Things or cyber-physical systems. The elective subject “Communications and Mobile Computing” deals with the basics and applications of such systems, from radio-based communication technologies, self-organising sensor networks and their integration into the Internet, to the development of smart services and machine learning methods for resource-limited mobile systems.

Learning outcomes: Upon completion of the elective subject, students are familiar with physics, simulation and the implementation of wireless communication as well as with the concepts of context- and location-based applications. They are able to create

and implement mobile wireless communication concepts optimised for the respective application.

Prerequisites for participation: No formal prerequisites; basic knowledge in electrodynamics and software development is an advantage.

Elective subject: c06 Embedded and Automotive Systems

Content: The courses in this catalogue provide and deepen theoretical and practical knowledge about design, implementation and analysis of embedded systems. Hardware, software and their co-design are treated as well as their application in electronic and mechanical contexts, for example in vehicles, cyber-physical systems, sensors, actuators or the Internet of Things.

Learning outcomes: Upon completion of the elective subject, students are able to understand embedded systems with their complex interaction possibilities and to independently develop solutions with context-, location-, and performance-based methods according to the specific requirements.

Prerequisites for participation: No formal prerequisites; basic knowledge of hardware and software systems and interprocess communication is an advantage.

Elective subject: c07 Measurement and Control Systems

Content: The elective subject “Measurement and Control Systems” provides students with a theoretical and practical basic framework not only for the acquisition of physical measured variables, taking into account electronics with regard to increased measurement accuracy, self-diagnosis capability and reduced susceptibility to faults, but also for the analysis, creation of models and simulation of technical systems, right through to the design and optimisation of linear and non-linear controls.

Learning outcomes: Upon completion of the elective subject, students are able to analyse and model processes, select or develop suitable sensors and design controllers using modern mathematical methods.

Prerequisites for participation: No formal prerequisites; basic knowledge of linear algebra and signal analysis is an advantage.

Elective subject: c08 Microelectronics and IC Design

Content: The elective subject “Microelectronics and IC Design” provides students with the essential knowledge and skills of semiconductor physics and integrated circuit technology for the design of analogue and digital integrated circuits, whereby a good physical understanding of the devices is necessary. Lectures and exercises in this subject area enable students to develop electronic devices and systems independently all the way from the formulation of specifications to commissioning. Contemporary concepts (e.g. simulation techniques) as well as the interaction with other systems and the environment (EMC) are of particular importance.

Learning outcomes: Upon completion of the elective subject, students have acquired the necessary knowledge to be able to develop integrated analogue and/or digital circuits independently.

Prerequisites for participation: No formal prerequisites; basic knowledge of semiconductor physics and electronics is an advantage.

Supplementary Catalogue: s01 Supplementary Catalogue

Content: The supplementary catalogue offers on the one hand courses for the deepening of mathematical basics, on the other hand supplementary topics which are relevant for several other subject areas and can be completed within the scope of the elective.

Prerequisites for participation: No formal prerequisites.

Non-technical elective subject: b01 Business, Law, and Management

Content: The elective subject “Business, Law, and Management” cannot be chosen as a major. When chosen as a minor, the focus lies on the basics of setting up and running a business. In addition, management tools, aspects of ethics, the environment and sustainability, legal issues and finally a deepening of language training are offered to complement the options.

Learning outcomes: Upon completion of the minor elective subject, students have acquired the necessary basics to successfully assume management functions in companies.

Prerequisites for participation: No formal prerequisites.

Part 2 of the Annex:

Recognition and equivalence list

Courses for which the equivalence or recognition is defined in this part of the Annex to the curriculum do not require separate recognition by the officers responsible for study matters. Reference is made to the possibility of individual recognition according to § 78 of the Universities Act (UG) by decisions from the officers responsible for study matters.

An equivalence list defines the equal value of successfully completed courses of this curriculum and the previous curriculum. This equivalence applies in both directions, that is, successfully completed courses of the previous curriculum may be credited in this curriculum and successfully completed courses of this curriculum may be credited in the previous curriculum.

Courses of Graz University of Technology that are the same with regard to name and type, the number of ECTS credit points and the number of semester course hours are considered to be equivalent, and are thus not explicitly listed in the equivalence list.

Equivalence list

Present curriculum for 2015 Version 20				Previous curriculum for 2015			
New course	**SSt**	**Type**	**ECTS**	**Previous course**	**SSt**	**Type**	**ECTS**
Mobile Security	2	VO	3.0	Advanced Computer Networks	2	VO	3.0

Mobile Security	1	KU	2.0	Advanced Computer Networks	1	KU	2.0
Advanced Layout Techniques	1	VU	1.5	Analog IC Layout 2	1	VU	1.5
Cryptography	2	VO	3.0	Applied Cryptography	2	VO	3.0
Cryptography	1	KU	2.0	Applied Cryptography	1	KU	2.0
Cryptanalysis	2	VO	3.0	Applied Cryptography 2	2	VO	3.0
Cryptanalysis	1	KU	2.0	Applied Cryptography 2	1	KU	2.0
Advanced Topics in Artificial Intelligence	2	VO	3.0	Autonomously Learning Systems	2	VO	3.0
Advanced Topics in Artificial Intelligence	1	UE	2.0	Autonomously Learning Systems	1	KU	2.0
Computational Geometry	2.5	VO	3.0	Computational Geometry	2	VO	3.0
				Computational Geometry	1	UE	1.5
Computer Vision 2	1.5	VU	2.5	Computer Vision 2	1.5	VU	2.5
Computer Graphics 2	1.5	VU	2.5	Computer Graphics 2	1.5	VU	2.5
Construction of Mobile Robots	2	PT	5.0	Construction of Mobile Robots	2	PR	5.0
Creativity Techniques	2	VU	2.0	Creativity Techniques	1	VO	1.5
				Creativity Techniques	1	UE	1.5
Optimal Feedback Design	2	VO	3.0	Design of Optimal Systems	2	VO	3.0
Optimal Feedback Design	1	UE	1.5	Design of Optimal Systems	1	UE	1.5
Audio Signal Processing Applications	2	VO	3.0	Digital Audio Engineering 2	2	VO	3.0
Audio Signal Processors Laboratory	2	LU	3.0	Digital Audio Engineering, Laboratory	2	LU	3.0
Electromagnetic Compatibility of Electronic Systems	2	VO	3.0	Electromagnetic Compatibility of Electronic Systems	2	VO	3.0
Entrepreneurship	2	VO	3.0	Entrepreneurship and Start-Up of Corporation	2	VO	3.0
Entrepreneurship	1	UE	1.5	Entrepreneurship and Start-Up of Corporation	1	UE	1.5
Intelligent Systems	2	VO	3.0	Expert Systems	2	VO	3.0
Intelligent Systems	1	KU	2.0	Expert Systems	1	KU	2.0
Automotive Engineering for Electrical, Information and Computer Engineering	2	VO	3.0	Automotive Engineering for Electrical Engineering and Telematics	2	VO	3.0
General Management, Case Studies	3	SE	3.0	General Management, Case Studies	1	VO	1.5
				General Management, Case Studies	2	UE	3.0
Advanced and Algorithmic Graph Theory	3	VO	4.5	Graph Theoretic Algorithms	3	VO	4.5
Advanced and Algorithmic Graph Theory	1	UE	1.5	Graph Theoretic Algorithms	1	UE	1.5
Image and Video Understanding	2	VO	3.0	Image Understanding	2	VO	3.0
Image and Video Understanding	1	KU	2.0	Image Understanding	1	KU	2.0
Practice of Digital Transformation	1	VO	1.5	Information and Communication Management	1	VO	1.5
Practice of Digital Transformation	1	UE	1.5	Information and Communication Management	1	UE	1.5
Information Management	3	VU	4.0	Information Management	1	VO	1.5
				Information Management	2	UE	3.0
Privacy Enhancing Technologies	2	VO	3.0	IT Security	2	VO	3.0
Privacy Enhancing Technologies	1	KU	2.0	IT Security	1	KU	2.0
Modelling and Optimisation in Production and Logistic Systems	2	VU	2.0	Logistics	1	VO	1.5
				Logistics	1	UE	1.5
Marketing Management	3	SE	3.0	Marketing Management	2	VO	3.0
				Marketing Management	1	UE	1.5
Deep Learning	2	VO	3.0	Neural Networks	2	VO	3.0

Deep Learning	1	KU	2.0	Neural Networks	1	KU	2.0
Photonic Sensors	2	VO	3.0	Optical Measurement Principles	2	VO	3.0
Numerical Optimisation	3	VO	4.5	Optimisation for Computer Science	2	VO	3.0
Numerical Optimisation	2	UE	2.5	Optimisation for Computer Science	1	UE	2.0
Seminar Pattern Recognition	3	SE	5.0	Pattern Recognition, Seminar	3	SE	5.0
Dimensioning of Electronic Circuits	2	UE	3.0	Practical Analog Circuit Design	2	UE	3.0
Dimensioning of Electronic Circuits, Laboratory	1	LU	2.0	Practical Analog Circuit Design, Laboratory	2	LU	2.0
Process Management	4	SE	4.0	Process Management	2	VO	3.0
				Process Management	2	UE	3.0
GPU Programming	3	VU	5.0	Real-Time Graphics 2	1	VO	1.5
				Real-Time Graphics 2	2	KU	4.0
Secure Software Development	2	VO	3.0	Security Aspects in Software Development	2	VO	3.0
Secure Software Development	1	KU	2.0	Security Aspects in Software Development	1	KU	2.0
Secure Application Design	2	VO	3.0	Selected Topics IT Security 1	2	VO	3.0
Secure Application Design	1	KU	2.0	Selected Topics IT Security 1	1	KU	2.0
Selected Topics of RFID Sensor Systems	2	VO	3.0	Selected Topics RFID	2	VO	3.0
Seminar/Project Information Security	4	SP	10	Seminar/Project Applied Information Processing	6	SP	10
Seminar/Project Brain Computer Interface	4	SP	10	Seminar/Project Brain-Computer Interface	6	SP	10
Seminar/Project Computational Electrodynamics	4	SP	10	Seminar/Project Computational Electrodynamics	6	SP	10
Seminar/Project Visual Computing	4	SP	10	Seminar/Project Computer Graphics	6	SP	10
Seminar/Project Electronics	4	SP	10	Seminar/Project Electronics	6	SP	10
Seminar/Project Machine Learning and Neuroinformatics	4	SP	10	Seminar/Project Machine Learning and Neuroinformatics	6	SP	10
Seminar/Project Measurement Techniques	4	SP	10	Seminar/Project Measurement Techniques	6	SP	10
Seminar/Project Modelling, Simulation and Control	4	SP	10	Seminar/Project Modelling, Simulation, and Control	6	SP	10
Seminar/Project Robotics	4	SP	10	Seminar/Project Robotics	6	SP	10
Seminar/Project Signal Processing	4	SP	10	Seminar/Project Signal Processing	6	SP	10
Seminar/Project Software Technology	4	SP	10	Seminar/Project Software Technology	6	SP	10
Seminar/Project Speech Communication	4	SP	10	Seminar/Project Speech Communication	6	SP	10
Seminar/Project Technical Informatics	4	SP	10	Seminar/Project Technical Informatics	6	SP	10
Seminar/Project Telecommunications	4	SP	10	Seminar/Project Telecommunications	6	SP	10
Speech Signal Processing	2	VO	3.0	Speech Communication 1	2	VO	3.0
Start-Up Garage	2	SE	2.0	Start-Ups and Small Business Management	3	VU	3.0
Digital System Integration and Programming	3	VU	5.0	System-on-Chip Architectures and Modelling	3	VU	5.0
Value Engineering	3	VU	3.0	Value Management I	1	VO	1.5
				Value Management I	1	UE	1.5
Gender & Technology 2	2	SE	4.0	Gender & Technology 2	2	SE	5.0

In contrast, a recognition list defines when successfully completed courses of the previous curriculum are recognised as successfully completed courses of this curriculum, with no automatic crediting being provided in the opposite direction.

A complete overview of all equivalencies and recognitions is available on the website of the Dean's Office of Computer Science and Biomedical Engineering(csbme.tugraz.at and at TU4U at the latest version at any time.

Part 3 of the Annex:

Recommended free-choice courses

Free-choice courses may be freely chosen from the courses offered at any recognised national or international universities and also at universities of applied sciences and universities of teacher education, according to § 5b of this curriculum.
In order to broaden the basic knowledge students acquire in the subject areas of this degree programme, courses in foreign languages, social competence, technology assessment as well as women's and gender studies are recommended. In particular, we would like to refer students to the courses offered by the Graz University of Technology service department Languages, Key Competencies and In-House Training or "treffpunkt sprachen" and Centre for Social Competence of the University of Graz as well as the Science, Technology and Society Unit.

Part 4 of the Annex:

Types of courses offered by Graz University of Technology

The types of courses are defined in the relevant regulations of the standard curriculum (decision of the Senate of Graz University of Technology dated October 6, 2008, announced in the University Gazette No. 5 dated December 3, 2008), as follows:

1. Lectures: VO
   In lecture-type courses, students are given a didactically well-structured introduction to the sub-areas of the subject area and its methods. In lectures, the content and methods of a subject area are presented.
2. Exercise-based courses: UE, KU, PR, EX
   In exercises, abilities and skills are taught as part of a scientific pre-vocational education and training to deepen or broaden the subject matter of the respective lectures. These exercises may comprise practical, experimental, theoretical and/or design work. The curriculum may specify that the successful completion of the exercise is a requirement to register for the examination of the respective lecture.
   a) UE
      In exercises, students develop the ability to apply their subject knowledge to solve specific problems.
   b) KU
      In design exercises, abilities and skills are taught as part of a scientific pre-vocational education and training to deepen or broaden the subject matter of the respective lectures by means of design work. Special equipment or a specially equipped room is required.

c) PR
In projects, experimental, theoretical and/or design applied work is carried out, or small research papers are written, taking into account all necessary steps. Projects must be completed with a written paper that is part of the assessment. Projects can be carried out as teamwork or individual work; in the case of teamwork, it must still be possible to assess individual performance within the team.

d) EX
Excursion-type courses help to illustrate and consolidate the content of this type of course. Due to their practical relevance outside the place of study, excursions help to illustrate the content developed in other types of courses.

3. Lecture with integrated exercises VU

   In addition to the introduction in sub-areas of the subject area and its methods, lectures with integrated exercises (VU) also offer guidance on independent acquisition of knowledge or independent application using examples. The percentage of lectures and exercises is to be specified in the curriculum. These courses are courses with continuous assessment.

4. Laboratory courses: LU

   Laboratory courses (LU) deepen and/or broaden the subject matter of the respective lectures by means of practical, experimental or design work. Students are taught abilities and skills as part of a scientific pre-vocational education and training with particularly intensive tutoring. An essential component of the laboratory courses is the drawing up of short logs on the work carried out.

5. Seminar-type courses: SE, SP

   Seminar-type courses enhance scientific work and discussion, and are intended to introduce students to expert-level discourse and argumentation. In this context, students have to write papers or give an oral presentation and take part in critical discussions. Seminars are courses with continuous assessment.

   a) SE
   Seminars introduce students to scientific methods, to the development and critical assessment of their own work results, to special topics in scientific literature and provide them with exercises in technical discussions.

   b) SP
   In seminar projects, students apply scientific methods to work on experimental, theoretical and/or design applied problems; or they carry out short research assignments, taking into account all the necessary steps. Seminar projects are completed with a written paper and an oral presentation that are part of the assessment. Seminar projects can be carried out as teamwork or individual work; in the case of teamwork, it must still be possible to assess individual performance within the team.

The regulations referred to at the beginning also encompass provisions concerning the implementation and assessment of the different types of courses. In particular, they stipulate the following:

In lectures (type of course VO), the assessment takes place by way of a final examination that – at the discretion of the examiner – may be a written examination, an oral examination, a written and an oral examination, as well as a written or an oral examination. The examination procedure must be announced in the course description.

Courses of the type VU, SE, SP, UE, KU, PR, EX and LU are courses with continuous assessment.

Part 5 of the Annex:

5.1 Admission to the degree programme

According to § 1 of this curriculum, graduates of the Bachelor's Degree Programme Information and Computer Engineering are admitted without further restrictions.

Graduates of the following bachelor's degree programmes are admitted to the Master's Degree Programme Information and Computer Engineering, but have to complete a list of prescribed courses of the Bachelor's Degree Programme Information and Computer Engineering as part of the elective subject; these courses become compulsory subjects due to the admission to the master's degree programme. They replace a corresponding amount of achievements from the elective subject. If the scope of the courses exceeds the intended scope of the elective subject of 14 ECTS credit points, the officers responsible for study matters determine which percentage of these courses are assigned to the major or minor. The total number of major, compulsory subject and elective subject must in any case amount to at least 74 ECTS credit points.

If the prescribed courses were already completed as part of the bachelor's degree programme that grants admission to the master's degree programme, § 4 of this curriculum applies accordingly.

5.2 Admission of graduates of the Bachelor's Degree Programmes Computer Science and Software Engineering and Management

Graduates of the Bachelor's Degree Programmes **Computer Science** and **Software Engineering and Management** at Graz University of Technology (curriculum 2019) are admitted to this master's degree programme, with the following courses of the Bachelor's Degree Programme Information and Computer Engineering being stipulated as compulsory subjects according to § 1 above:

Course	SSt	Type	ECTS
Signal Processing	2	VO	3.0
Signal Processing	1	UE	1.5
Control Systems 1	3	VO	4.0
Control Systems 1	1	UE	1.5
Fundamentals of Electrical Engineering ICE	3	VO	4.5
Fundamentals of Electrical Engineering ICE	1	UE	1.0
Introduction to Electrical Engineering	2	LU	3.0
Communication Engineering	3	VO	4.5
Electronic Circuit Design 1	2	VO	3.0
Total compulsory subject			**26.0**

5.3 Admission of graduates of the Bachelor's Degree Programmes Electrical Engineering, Electrical Engineering and Audio Engineering as well as Biomedical Engineering

Graduates of the Bachelor's Degree Programmes **Electrical Engineering, Electrical Engineering and Audio Engineering** as well as **Biomedical Engineering** at Graz University of Technology (curriculum 2016 or 2017) are admitted to this master's degree programme, with the following courses of the Bachelor's Degree Programme Information and Computer Engineering being stipulated as compulsory subjects according to § 1 above:

Course	SSt	Type	ECTS
Data Structures and Algorithms 1	2	VO	3.0
Data Structures and Algorithms 1	1	UE	1.5
Databases	2	VU	3.0
Information Security	2.5	VO	4.0
Information Security	2.5	KU	3.0
Computer Graphics and -Vision	2	VU	2.5
Software Development Practical Exercises	1	VO	1.5
Software Development Practical Exercises	3	KU	4.0
Computer Organisation and Networks	2.5	VO	4.0
Total compulsory subject			**26.5**

If the prescribed courses have already been partially completed according to the 2015 curriculum, the following equivalence list applies:

Courses Curriculum 2019	SSt	Type	ECTS	Courses Curriculum 2015	SSt	Type	ECTS
Data Structures and Algorithms 1	2	VO	3.0	Data Structures and Algorithms	2	VO	3.0
Data Structures and Algorithms 1	1	UE	1.5	Data Structures and Algorithms	1	UE	1.5
Databases	2	VU	3.0	Databases	2	VU	3.0
Information Security	2.5	VO	4.0	Introduction to Information Security	2	VO	3.0
Information Security	2.5	KU	3.0	Introduction to Information Security	1	KU	1.5
Computer Graphics and Vision	2	VU	2.5	Computer Graphics 1	1.5	VU	2.5
User Interfaces	1.5	VU	2.5	Computer Vision 1	1.5	VU	2.0
Software Development Practical Exercises	1	VO	1.5	Software Development practical	3	VU	5.0
Software Development Practical Exercises	3	KU	4.0				
Computer Organisation and Networks	2.5	VO	4.0	Computer and Communication Networks	2	VO	3.0
				Computer and Communication Networks	1	KU	1.5
Total compulsory subject			**29.0**	**Total compulsory subject**			**26.0**

Part 6 of the Annex

Addition to § 4.4 Balance

Achievements from the subject area information processing include courses starting with the numbers 5 or 7. Achievements from the subject area electrical engineering and information technology include courses starting with the number 4. In addition, the courses from the table below are also included in this category.

Course	SSt	Type	ECTS
Algorithms in Acoustics and Computer Music 01	2	VO	3.0
Algorithms in Acoustics and Computer Music 01	1	UE	1.5
Dynamical Systems	3	VU	5.0
Automotive Power Transmissions	2	VU	3.0
Piston Engines, Introduction	2	VO	3.0
Thermodynamics Introduction	2	VO	3.0
Automotive Engineering for Electrical, Information and Computer Engineering	2	VO	3.0

Part 7 of the Annex

Definitions

Major: The major must comprise at least 40 ECTS credit points from one of the technical catalogues of electives (c01-c08)

Minor: The minor must comprise at least 20 ECTS credit points from one of the catalogues of electives (c01-c08, b01), the catalogue of the major subject area may not be selected for this purpose.

Elective subject: The elective is freely selectable from the courses offered in the Master's Degree Programme Information and Computer Engineering (c01-c08, s01, b01).

Compulsory subject: As part of the admission to the Master's Degree Programme Information and Computer Engineering, courses from the Bachelor's Degree Programme Computer Engineering can be prescribed as a compulsory subject for the Master's Degree Programme Information and Computer Engineering; the compulsory subject replaces the minor. If more than 14 ECTS credit points are required, the officers responsible for study matters determines which percentage of these credits are allocated to the major or minor subject area.

Free-choice subject: The free-choice course is comprised of the courses offered at any recognised national or international universities and also at universities of applied sciences and universities of teacher education.

Compulsory elective subject: A subject is a combination of coherent courses that are individually defined or selected from a catalogue of electives and then named after the corresponding catalogue of electives. Both the major and the minor can be replaced by a compulsory elective subject.

Catalogue of electives: Collection of related courses defined in the curriculum from which the courses can be selected.

Supplementary catalogue: Collection of supplementary courses defined in the curriculum, which can be chosen as elective subjects.

Compulsory course: A compulsory course represents a course defined in the catalogue of electives, which, if this catalogue of electives is chosen, must be completed.

Compulsory elective course: A catalogue of electives may lay down rules for compulsory elective courses, according to which, if this catalogue of electives is chosen, courses must be taken.

Mentor: A mentor supervises the studies of a student and has responsibilities and rights defined in the curriculum.