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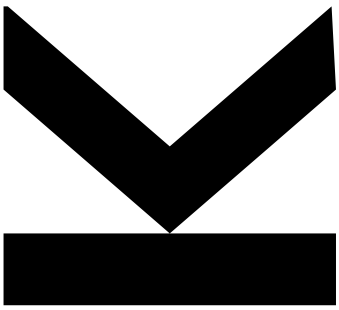
CURRICULUM GUIDE
MASTER IN
COMPUTER SCIENCE.



valid as of WS 2021/22

JOHANNES KEPLER
UNIVERSITÄT LINZ

1 Qualification profile

The Master's program in Computer Science at Johannes Kepler University (JKU) Linz offers six areas of specialization: *Computational Engineering*, *Data Science*, *Intelligent Information Systems*, *Networks and Security*, *Pervasive Computing*, and *Software Engineering*. Graduates of the program have acquired in-depth knowledge of the selected area of specialization in addition to a broad skill set for problem solving.

General profile

Computer Science encompasses concepts, methods, and tools for systematic and automated information processing. Its roots lie in mathematics and electrical engineering. Today, computer science is an established scientific discipline in its own right, and permeates numerous aspects of business and technology as well as our daily life.

The Master's program in Computer Science aims at fostering problem solving skills. Based on the foundations of computing, covered by the Bachelor's program in Computer Science at JKU, the Master's program provides students with a research-oriented education in contemporary areas of computer science. Graduates are experts in their area of specialization. They are equipped with a solid background in information technology and are capable of solving complex IT problems using scientific methods.

Computer Science at JKU distinguishes itself as an application-oriented engineering discipline with a balanced emphasis on theory and practice. Besides cultivating technical skills, the curriculum fosters proficiency in scientific methods, creativity, multidisciplinarity, team spirit, social skills as well as leadership skills, and prepares for life-long learning.

Computational Engineering

Computer Science is shaping our lives by enabling new technologies well beyond the traditional engineering of technical and physical systems. The specialization in Computational Engineering provides students with a solid command of discrete methods of modeling and computation in informatics and mathematics, and enables them to apply these methods to innovative engineering disciplines from computer systems to system verification and machine learning. The Master's program emphasizes the value of new computational methods as a driver for entirely new areas of engineering and prepares graduates with foundational knowledge to solve problems within the broad arena of systems engineering.

Data Science

Data science is an interdisciplinary field at the interface of computer science and statistics. Rapidly growing amounts of data require completely new solutions, for example in language and speech processing (e.g., machine translation) or image recognition (e.g., in self-driving cars). The specialization in Data Science empowers students to solve hard real-world problems in a data-driven manner. It provides them with profound skills in data analysis technologies such as machine learning, pattern recognition, probabilistic models, data mining, and data visualization, accompanied with a solid background in database and software technologies. Data scientists are highly demanded in industry across various domains such as medicine, smart production, finance and marketing.

Intelligent Information Systems

The large amounts of structured, unstructured, or multimedia data generated in almost all domains require intelligent strategies for their analysis and processing. The specialization in Intelligent Information Systems provides students with concepts, methods, and tools for the analysis, semantic modeling, processing, retrieval, extraction, and integration of information. Students acquire profound skills in (web) information systems, non-standard storage, (web) search strategies, data and web mining, social/semantic web intelligence, pattern recognition, artificial intelligence, recommendation systems, personalized and context-aware systems, cooperative situation awareness, and assistive technologies. Comprehensive skills in these fields enable graduates to work both in research and development.

Networks and Security

The protection of IT systems against internal and external attacks is a strategically important task for planning and operating IT infrastructures. The specialization in Networks and Security qualifies students for the systematic planning, configuration and monitoring of (networked) IT systems. Graduates acquire solid capabilities in the design, implementation, and administration of security strategies, the administration of systems, networks, and security policies, the application of cryptography as well as the understanding and implementation of legal requirements in the security domain. The profound technical education in this area allows for a career both in research and development.

Pervasive Computing

The design of miniaturized systems, which are invisibly integrated in their environment and are connected in a spontaneous and wireless way require special computer science methods. The specialization in Pervasive Computing therefore educates students in a combination of technologies (e.g., sensors, actuators, wireless communication), paradigms (e.g., context-aware and adaptive systems, autonomous and self-organizing systems) and methods (e.g., for interaction, coordination, computational perception, reasoning and learning, virtual reality, reliability, security and user friendliness). It provides decision and evaluation skills as well as skills for designing and developing pervasive computing systems such as information appliances, wearable systems or ambient intelligence systems.

Software Engineering

Business and industry have a great need for well-trained software engineers. The specialization in Software Engineering enables students to plan and manage large software projects, to apply cutting-edge software development techniques, to understand and apply advanced formal concepts in software development, and to apply state-of-the art processes and tools in software engineering. The focus is on scientific methods and their application in building high-quality software in an economic way. Since most Computer Science graduates work in software development, a specialization in Software Engineering is an excellent preparation for their professional career.

The programme is—with certain restrictions—suitable for students with professional duties or supervision obligations (up to 30 hours/week and flexible time management). Some lectures and combined courses are also offered in digital form (streaming or download). In general, there is no obligation to attend lectures, although attendance is recommended. In labs, attendance is often mandatory; however, lecturers will try to offer at least one of the lab groups in digital form at the end of the day. For exams, it cannot be guaranteed that they will be offered in digital form or at the end of the day. Working students must expect an extended period of study.

Further Information

- Home page of CS @ JKU — cs.jku.at
- Announcements of the curriculum committee — cs.jku.at/teaching/stuko/news/
- Study handbook with course descriptions — studienhandbuch.jku.at
- Official curriculum — cs.jku.at/teaching/
- Admission — cs.jku.at/teaching/master/admissionFAQs.html

This guide serves as the major source of information for students. The full legal provisions for this Master's program can be found in the official curriculum.

2 Overview

2.1 General structure

The Master's program in Computer Science is a two years' full-time program comprising 120 ECTS points. It is delivered in English. Table 1 shows its overall structure.

Table 1: *Master's program in Computer Science*

	hours/week	ECTS
Major Subject	25	37.5
Complementary Subject	18	27.0
Free Electives	8	12.0
Master's Thesis Seminars	6	16.0
Master's Thesis		25.0
Master's Examination		2.5
Total	*57*	*120.0*

The *Major Subject* is the core of the curriculum. It can be selected from five areas of specialization:

- Computational Engineering
- Data Science
- Intelligent Information Systems
- Networks and Security
- Pervasive Computing
- Software Engineering

All courses of the selected Major Subject have to be passed.

The *Complementary Subject* allows students to extend their Computer Science skills beyond the Major Subject. Students can freely select courses from other areas of specialization or from a catalogue of elective courses.

The *Free Electives* are courses that can be chosen from all degree programs at any university. They give students the opportunity to educate their personality and to acquire skills beyond Computer Science.

The *Master's Thesis* is the final project in this program. It is a scientific thesis, in which the knowledge and skills obtained during the study should be demonstrated. The *Master's Thesis Seminars* serve to prepare and guide the composition of the Master's Thesis. These seminars are compulsory courses.

2.2 Admissions

Graduates of the JKU Bachelor's program *Informatik* are admitted without restrictions. For bachelors of the JKU studies *Wirtschaftsinformatik* and *Elektronik und Informationstechnik* there is a list of courses from the Bachelor's program in Informatik that have to be attended as part of the Complementary Subject (see the web).

Graduates of Computer Science or related programs at other universities, universities of applied sciences, and other post-secondary educational institutions can be admitted if their degree programs are equivalent to the Bachelor's program in Informatik at JKU. Differences between programs can be compensated by replacing one or more courses from the Complementary Subject with courses specified in the notification of admission. If equivalence cannot be fully established the notification of admission can require additional courses with up to 20 ECTS points.

Candidates have to apply at the JKU Admissions Office. Further information can be obtained from www.jku.at/en/studying/studies-from-a-z/admission-procedures/admission-to-a-masters-degree-program/ and from cs.jku.at/teaching/master/admissionFAQs.html.

2.3 Academic degree

Graduates are awarded the academic degree "Diplom-Ingenieurin" or "Diplom-Ingenieur", abbreviated "Dipl.-Ing.", "Dipl.-Ing. (JKU)", "DI", or "DI (JKU)". This corresponds to the international degree "Master of Science" (MSc), although the MSc degree is not conferred.

2.4 Course types

Lectures ("Vorlesungen", VO) are courses that introduce students to certain areas and methods of their study.

Labs ("Übungen", UE) are courses which reinforce topics from the corresponding lecture by carrying out practical and concrete exercises. Marking is based on continuous assessment of the students' work.

Combined courses ("Kombinierte Veranstaltungen", KV) are courses consisting of lectures and labs, which are intertwined according to didactic aspects.

Practicals (PR) have similar goals as labs and are continuously assessed. In contrast to labs they can be independent from lectures and usually promote project-oriented work in a team.

Seminars (SE) are courses involving collaboration between students. Marking of seminars is based on continuous assessment of the students' work, on their preparation of talks (including seminar papers) and on their participation in discussions.

2.5 ECTS points

In line with the *European Credit Transfer System* (ECTS) 1 ECTS point corresponds to 25 full hours of work. This includes the attendance of courses as well as the time for preparation, exercises, and practical work at home. The total effort of this Master's program is 120 ECTS points, or 30 ECTS points per semester. With a few exceptions, 1 weekly hour of teaching is worth 1.5 ECTS points.

Lecturers have to adjust the effort of every course such that it matches the ECTS points of the course, where corresponding lectures and labs are considered as a unit.

2.6 Number of students per course

In courses of the Major Subject 35 students are admitted to labs, 15 students are admitted to practicals, and 20 students are admitted to seminars. Combined courses as well as electives do not have parallel groups.

3 Major Subject

For the Major Subject students have to select one of six areas of specialization listed in Table 2 and have to take all courses listed in the selected area.

Table 2: *Mandatory courses and areas of specialization (WS = winter semester, SS = summer semester)*

Areas of specialization		Lecturer	ECTS	WS/SS
Computational Engineering				
Model Checking	2VO+1UE	Seidl	4.5	WS
Machine Learning: Supervised Techniques	2VO+1UE	Kofler et al.	4.5	WS
Probabilistic Models	2VO(+1UE)	Widmer	3.0	WS
System Software	2KV	Mössenböck	3.0	WS
Parallel Computing	3KV	Schreiner, Zoitl	4.5	SS
Hardware Design	3KV	Wille et al.	4.5	SS
Computer Algebra for Concrete Mathematics	2VO(+1UE)	Paule	3.0	SS
Project in Computational Engineering	5PR		7.5	WS/SS
Seminar in Computational Engineering: ...	2SE		3.0	WS/SS

Data Science				
Machine Learning: Supervised Techniques	2VO(+1UE)	Kofler et al.	3.0	WS
Probabilistic Models	2VO(+1UE)	Widmer	3.0	WS
Visual Analytics	2VO(+1UE)	Streit	3.0	WS
Statistical Principles of Data Science	3KV	Futschik	6.0	WS
Data Warehousing	2VO+2UE	Schütz	6.0	WS
Big Data Management and Processing	2KV	Pröll et al.	3.0	SS
Computational Data Analytics	2KV	Fürnkranz	3.0	SS
Project in Data Science	5PR		7.5	WS/SS
Seminar in Data Science: ...	2SE		3.0	WS/SS
Intelligent Information Systems				
Knowledge Based Systems	2KV	Küng	3.0	WS
Information Retrieval and Extraction	2KV	Pröll	3.0	WS
Basic Methods of Data Analysis	2KV	Nessler et al.	3.0	WS
Multimedia Search and Retrieval	3KV	Schedl	4.5	WS
Integrated Information Systems	2KV	Wöß	3.0	SS
Learning from User-generated Data	2VO+1UE	Schedl	4.5	SS
Web Information Systems	3KV	Retschitz., Kaps.	4.5	SS
Accessible Software and Web Design	1KV	Miesenberger	1.5	SS
Project in Intelligent Information Systems	5PR		7.5	WS/SS
Seminar in Intelligent Information Systems: ...	2SE		3.0	WS/SS
Networks and Security				
Introduction to IT Security	2VO	Mayrhofer	3.0	WS
Information Security Management	2KV	Beham	3.0	WS
Computer Forensics and IT Law	2VO	Sonntag	3.0	WS
System Administration	2KV	Hörmanseder	3.0	WS
Systems Security	2KV	INS	3.0	SS
Secure Code	1KV	INS	1.5	SS
Network Management	2KV	Hörmanseder	3.0	SS
Network Security	1KV	Hörmanseder	1.5	SS
Cryptography	2KV	Scharinger	3.0	SS
Security Models in Information Systems	2KV	Küng	3.0	SS
Project in Networks and Security	5PR		7.5	WS/SS
Seminar in Networks and Security: ...	2SE		3.0	WS/SS
Pervasive Computing				
Pervasive Comp.: Systems and Environments	2VO+1UE	Ferscha	4.5	WS
Pervasive Comp.: Design and Development	2VO+1UE	Ferscha	4.5	WS
Computer Vision	2VO+1UE	Bimber	4.5	WS
Principles of Interaction	3KV	Kotsis et al.	4.5	SS
Principles of Cooperation	3KV	Khalil	4.5	SS
Machine Learning and Pattern Classification	2VO+1UE	Widmer	4.5	SS
Project in Pervasive Computing	5PR		7.5	WS/SS
Seminar in Pervasive Computing: ...	2SE		3.0	WS/SS
Software Engineering				
Formal Methods in Software Development	3KV	Schreiner	4.5	WS
Requirements Engineering	2KV	Grünbacher	3.0	WS
Principles of Programming Languages	2KV	Prähofer	3.0	WS
System Software	2KV	Mössenböck	3.0	WS
Software Architectures	3KV	Weinreich	4.5	SS
Model-driven Engineering	2KV	Egyed	3.0	SS
Software Testing	2KV	Plösch, Ramler	3.0	SS
Software Processes and Tools	2KV	Grünbacher	3.0	SS
Project in Software Engineering	5PR		7.5	WS/SS
Seminar in Software Engineering: ...	2SE		3.0	WS/SS

Practical and Seminar

Each area of specialization has a practical (5 hours) and a seminar (2 hours). The practical serves as a consolidation and an application of the skills acquired in the respective area. It is usually organised as a team work. The seminar should rehearse scientific working principles. Its name is "Seminar in *A*" (where *A* is the name of the area of specialization) with an appropriate subtitle denoting the topic of the seminar. The seminar is also part of the seminar catalogue in Table 4.

4 Complementary Subject

The Complementary Subject allows students to deepen and/or broaden their computing skills according to their special interests. Students have to select courses with a total of 18 hours (27 ECTS) from the following categories (they are strongly expected to select 3 ECTS points from Gender Studies):

- Areas of specialization that were not selected as the Major Subject (projects excluded)
- General Electives as described in Section 4.1
- Special Topics as described in Section 4.2
- Seminars as described in Section 4.3
- Gender Studies as described in Section 4.4

4.1 General Electives

The General Electives comprise the courses listed in Table 3. Courses that have already been taken in the Bachelor's program cannot be selected in the Master's program. The General Electives are regularly offered at least every two years.

Table 3: *General Electives (* = offered every second year)*

Inst.	Courses		Lecturer	ECTS	WS/SS
CG	Explainable AI	1VO+1UE	Streit	3.0	WS
	Information Displays	2VO	Bimber	3.0	SS*
	Information Visualization	3KV	Streit	4.5	SS*
	Visual Analytics	1UE	Streit	1.5	WS
CP	Biometrische Identifikation	2VO	Scharinger	3.0	WS
	Digitale Bildverarbeitung	2KV	Scharinger	3.0	SS
	Probabilistic Models	1UE	Widmer	1.5	WS
	Reinforcement Learning	2VO+1UE	Widmer	4.5	WS
FAW	Application Oriented Knowledge Processing	2KV	Küng	3.0	SS
	Computational Data Analytics	1PR	Fürnkranz	1.5	SS
	Conceptual Data Modeling	2KV	Wöß	3.0	SS
	Semantic Data Modeling and Applications	2KV	Wöß	3.0	SS
	Web Search and Mining	2KV	Pröll	3.0	SS
	Web Engineering	2KV	Pröll	3.0	WS
ICS	Debugging	2KV	Große	3.0	SS
	Statistik 2	2KV	Forstner	3.0	WS/SS
IIC	Emerging Computer Technologies	3KV	Wille	4.5	WS
	VLSI Design	2KV	IIC	3.0	WS
IIS	Assistive Technologies and Accessibility	2KV	Miesenberger	3.0	WS
	Web Usability	1KV	Miesenberger	1.5	WS
INS	Advanced Operating Systems	2KV	Mayrhofer	3.0	SS
	Cloud Security	2KV	Mayrhofer	3.0	WS
	Hardwareorientiertes Arbeiten an PCs	2PR	Bauer	3.0	WS*
	Introduction to Linux	1KV	INS	1.5	SS
	Web Security	2KV	Sonntag	3.0	SS
	Wireless LANs	1KV	INS	1.5	SS
ISSE	Engineering of Software-intensive Systems	2KV	Mashkoor	3.0	SS
	Product Line Engineering	2KV	Rabiser	3.0	SS

ML	Deep Learning and Neural Nets I	2VO+1UE	Klambauer et al.	4.5	WS
	Machine Learning: Supervised Techniques	1UE	Kofler et al.	1.5	WS
	Machine Learning: Unsupervised Techniques	2VO+1UE	Hochreiter et al.	4.5	SS
	Natural Language Processing	1VO+1UE	Rekabsaz	3.0	WS
	Sequence Analysis and Phylogenetics	2VO+2UE	Regl et al.	6.0	WS
	Theoretical Concepts of Machine Learning	2VO+1UE	Nessler	4.5	SS
AG	Computational Geometry	2VO+1UE	Jüttler	4.5	SS*
RISC	Computer Algebra	2VO+1UE	Winkler	4.5	WS
	Computer Algebra for Concrete Mathematics	1UE	Paule	1.5	SS
	Formal Semantics of Programming Languages	2VO	Schreiner	3.0	SS*
	Rewriting in Computer Science and Logic	2VO	Kutsia	3.0	SS*
SAI	Planning and Reasoning in Artificial Intelligence	2VO+1UE	Seidl	4.5	WS
	SAT Solving	2KV	Seidl	3.0	SS
SSW	Advanced Compiler Construction	2KV	Mössenböck	3.0	SS*
	Modeling and Computer Simulation	2KV	Prähofer	3.0	WS*
STAT	Advanced Regression Analysis	2SE	Waldl	4.0	WS
	Multivariate Verfahren	2KV	Waldl	4.0	WS
	Verallgemeinerte Lineare Modelle	2KV	Wagner	4.0	SS
TK	Human/Computer Interaction	2KV	Kotsis	3.0	WS
	Mobile Computing	2KV	Hummel	3.0	WS
	Web Performance	2KV	Kotsis	3.0	WS
TK	Advanced Model Engineering	2KV	Retschitz., Kaps.	3.0	WS
CIS	Big Data Engineering	2KV	Kaps., Retschitz.	3.0	SS
	Modeling Internet Applications	2KV	Schwinger	3.0	SS

4.2 Special Topics

Special Topics allow institutes to take up current trends in their fields and to use the teaching offer of guest lecturers. Courses from this category can be announced without being listed in the curriculum, and there is no obligation to hold them regularly.

The name of special topics courses consists of a main title ("Special Topics:") and a subtitle denoting the actual contents of the course. The type of such courses (VO, UE, KV, PR, SE) as well as their length in hours can be freely chosen by the lecturers. The ECTS points are calculated as hours × 1.5.

4.3 Seminars

Seminars are courses in which scientific methods are taught and practiced. Students have to write a seminar thesis about a research-related topic and present it in a seminar talk. The name of a seminar consists of a main title as shown in Table 4 and a subtitle denoting the topic of the seminar.

Table 4: *Seminars*

Seminars		ECTS	WS/SS
Seminar in Computational Engineering: ...	2SE	3.0	WS/SS
Seminar in Data Science: ...	2SE	3.0	WS/SS
Seminar in Intelligent Information Systems: ...	2SE	3.0	WS/SS
Seminar in Networks and Security: ...	2SE	3.0	WS/SS
Seminar in Pervasive Computing: ...	2SE	3.0	WS/SS
Seminar in Software Engineering: ...	2SE	3.0	WS/SS

4.4 Gender Studies

Courses from Gender Studies help students to understand gender-specific aspects of computing and technology. Students are strongly expected to select 3 ECTS points from Table 5.

Table 5: *Gender Studies*

Courses		ECTS	WS/SS
Ethics and Gender Studies	2VO	3.0	WS/SS
Gender Studies Managing Equality TN	2KV	3.0	WS/SS
Soziale und geschlechterspezifische Aspekte der IT	2KS	3.0	SS

5 Free Electives

Students have to take free elective courses with a total of 8 hours (12 ECTS). These courses can be selected from any degree program at any university and can be taken throughout the whole Master's program. Their goal is to provide students with additional skills beyond the area of Computer Science. Courses in social skills, foreign languages, and gender studies are particularly recommended, but it is also possible to select more Computer Science courses here.

6 Master's thesis and Master's thesis seminars

As a final project students have to write a Master's thesis. The Master's thesis can be written at any Computer Science institute, but its topic should be chosen from the selected Major Subject. The goal of the Master's thesis is to demonstrate that students are able to solve a non-trivial problem in their area of specialization using scientific methods and latest technology.

As a preparation and a guidance for the Master's thesis, students have to take the two master seminars from Table 6.

Table 6: *Master's thesis seminars*

Courses		ECTS	WS/SS
Master's Thesis Seminar WS	3SE	8.0	WS
Master's Thesis Seminar SS	3SE	8.0	SS

7 Examinations

The degree program is completed if all examinations for the courses described in Sections 3 to 6, as well as the Master's examination have been passed and the Master's thesis has been accepted.

Course examinations. The examination mode (written or oral) for lectures (VO) and for combined courses (KV) can be defined by the lecturer. Labs (UE) and practicals (PR) are assessed by continuous and final evaluations. Seminars (SE) are assessed on the basis of the seminar paper, the seminar presentation and the cooperation of the student in the seminar.

Master's examination. The Master's examination is the final examination of the degree program. It is assessed by a committee of three professors and consists of the following three parts:

- *Master's thesis defence* (20 minutes), assessed by the head of the examination committee (not the advisor of the thesis).
- *Examination about the Major Subject* (20 minutes), assessed by an examiner representing the Major Subject (usually the advisor of the thesis).
- *Examination about one or several courses of the Complementary Subject* (20 minutes), assessed by an examiner representing these courses.

The effort of the Master's examination is calculated with 2.5 ECTS points.

8 Recommended course of study

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<tr><td>Major Subject</td><td>13.5</td><td>Major Subject</td><td>13.5</td><td>Master's Thesis</td><td>8.5</td><td rowspan="2">Master's Thesis</td><td rowspan="2">16.5</td></tr>
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<tr><td>Master's Examination</td><td>2.5</td></tr>
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