University *of Ljubljana*
Faculty *of Computer and Information Science*

SECOND CYCLE MASTER'S STUDY PROGRAMME
COMPUTER AND INFORMATION SCIENCE

HANDBOOK

for students enrolled for the first time in the first year in the 2021/2022 academic year

Ljubljana, January 2021

INFORMATION ABOUT THE STUDY PROGRAMME COMPUTER AND INFORMATION SCIENCE

Main objectives of the programme

The master's study programme in Computer and Information Science is intended to extend, broaden and enhance knowledge and skills acquired in the first cycle, and for the mastery of advanced practical and theoretical knowledge in the field of computer and information science. The programme keeps abreast of rapid technological progress and offers a foundation for lifelong learning and career success in both the local and international environment. The programme also provides a basis for research and development work and for a career in academia. Holders of the master's degree are capable of assuming senior and leading positions in industry, management, science and research. The programme is divided into thematic sets, which enables students to select subjects with aligned content. On their own initiative students can involve themselves in projects being pursued in individual Faculty research laboratories.

General competences

Masters of computer and information science build upon the competences acquired in the first cycle. Those that completed some other course in the first cycle will also flesh out their basic competence in computer and information science. Holders of the master's degree acquire the skills necessary to continue on to doctoral studies. The general competences acquired include:

- the ability to define, understand and deal with creative professional challenges in the field of computer and information science,
- a knowledge of linear algebra, of types, integral and discrete transformation, the functions of multiple variables and vector analysis,
- knowledge and use of functional programming,
- knowledge and application of analysis of algorithms, spatial data structures, parallel algorithms, hash codes, algorithms with assumptions, heuristic programming,
- knowledge and practical use of advanced procedures for data analysis,
- knowledge of input-output and peripheral devices, buses, network interfaces and drivers.

Subject-specific competences

By selecting subjects in specific thematic sets, holders of the master's degree in **both courses** acquire the following competences (depending on the selected course modules):

Intelligent Analysis of Data

- a knowledge of planning and conclusions, various methods of study, qualitative modelling, visualisation of models, combining algorithms, and interpreting predictions, connector rules and learning bots,
- practical use of advanced methods for data mining and data analysis,
- applying the theoretical basis of network science and applying network analysis,
- the ability to use approaches in selected technical fields and in the area of biology and genomes.

Media Technologies

● providing information and creating interactivity with emphasis on the development of user and data-focused multimedia software solutions,

● a knowledge of approaches for searching, extraction, capture and analysis of data from the web, taking account of the functioning and time analysis of algorithms,

● an understanding of the functioning and capacities of implementing methods of advanced computer graphics based on scientific literature,

● acquisition of knowledge in the field of computer audio production for technical and creative application in production environments.

Computer Systems and Computing

● interpreting the basic principles of operation of peripheral devices, planning and administration of computer systems,

● current processing methods and platforms as possible alternatives to classical electric transistor bivalent logic structures,

● a knowledge of the infrastructure for the operation of private, hybrid and personal clouds,

● acquisition of knowledge in the fields of parallel and distributed systems, parallel programming and processing.

Networks and Security

● a knowledge of the basics of cryptography and computer security,

● skills in protecting networks and privacy in modern information systems,

● a knowledge of sensor networks with limited processor capacity and limited power supply,

● a knowledge of the use of computers and information technology in forensic procedures.

Algorithms and Software

● transparent knowledge of the field of interaction between humans and computers,

● the ability to solve practical problems through theoretical computer science and creative technical tasks in the area of computer and information science, an understanding of basic topological concepts and constructions,

● an understanding of the field of approximation and random solving of computation problems,

● the ability to evaluate and implement programming languages and various programmer paradigms.

Computing Methods

● an understanding of basic topological concepts and constructions and the basics of numeric mathematics to solve practical problems,

● solving creative technical tasks in the area of computer and information science,

● the ability to use mathematical approaches in selected technical fields,

● a knowledge of alternative methods of processing and natural algorithms.

Machine Perception Methods

● a knowledge of advanced methods of analysing complex signals such as video recordings,

● the basics of processing biomedical signals and images,

● an overview of the field of biometrics and the fundamentals of biometric systems in the area of computer vision,

● mastery of the theory and use of basic algorithms and approaches in the area of processing natural language.

In addition to the above competences, students in the **Data Skills course** also acquire the following competences:

● applying mathematical knowledge to understand classical and modern approaches to machine learning and statistics,

● applying methods of machine learning to solve tasks of progression, classification into groups and drawing conclusions from data,

● applying programme tools in solving problems in the area of data skills,

● applying critical thinking in dealing with the social aspects of data skills (security, privacy, ethics),

● the ability to transfer fundamental knowledge of data skills to solving practical problems in specific fields, such as network analysis, bioinformatics, biometry, processing natural language, computer vision and artificial intelligence.

Admission requirements

Enrolment in the master's programme is open to candidates who have:

Completed 1st cycle study programmes in computer and information science or natural sciences or technical courses (mathematics, physics, electrical engineering, chemistry and chemical technology, mechanical engineering, civil engineering).

Completed 1st cycle study programmes in fields other than those indicated above who have passed the following 1st cycle FRI exams prior to enrolment: Programming 1, Discrete Structures, Introduction to Digital Circuits, Computer Systems Architecture, Introduction to Information Systems, or who covered the subject matter of these courses in their undergraduate studies.

Selection criteria for limited enrolment

In the event of a decision limiting enrolment, candidates will be selected depending on:

- GPA in first-cycle studies (40% of points),
- selection exam results (60%).

The selection exam will cover the fields of mathematics, programming, algorithms and computer systems. Demonstrating exceptional achievements that are evaluated on the basis of a structured CV and potential interview will form a constituent part of the overall assessment. The scope of exceptional achievements will be assessed by the FRI Committee for Study Affairs.

The selection exam will be held in accordance with the rules and criteria for evaluation in place at the Faculty.

Criteria for recognising knowledge and skills acquired prior to enrolment

The study programme enables the recognition of relevant knowledge acquired through formal, non-formal and experiential learning. This knowledge can be recognised as part of the completed study requirements, at up to 6 ECTS for one set (the approximate study programme for a course) of knowledge acquired outside of the Faculty. In the recognition process certificates and other documents are taken

into account. Requests for recognition of acquired knowledge will be considered by the FRI Committee for Study Affairs and on its recommendation approved by the Faculty Senate.

Assessment methods

The methods of assessment comply with the UL Statutes and are set out in the curriculums.

Requirements for progression through the course

Students who have completed course units consisting of 54 credit points may enrol in the second year. For repeat enrolment in the same year students must have completed at least half the programme requirements of that year (i.e. 30 credits).

Requirements for transferring between programmes

In accordance with the Criteria for Transferring between Programmes, transferring is possible from study programmes:

1. which upon completion guarantee similar competences and,
2. which enable the recognition of at least half of the obligations based on the European Credit Transfer System (ECTS) from the first study programme relating to compulsory subjects of the second study programme.

Requirements for transferring to the master's programme of Computer and Information Science from other (master's) programmes are:

- fulfilled requirements for enrolment in the master's programme in Computer and Information Science,
- fulfilled conditions for enrolment in the second year of the study specialisation in which the student is currently enrolled, with the added condition that they have completed the requirements in all courses that are essential for continuing or equivalent courses at other higher education institutions whose appropriateness is assessed by the Committee for Study Affairs.

Requirements for completing the study programme

The requirements for completing the proposed programme are the following for all students: fulfilled study obligations in enrolled courses, equivalent to at least 96 ECTS; a master's thesis prepared and submitted in accordance with the relevant rules, equivalent to 24 ECTS; and a successful public defence of the master's thesis.

Requirements for completing individual parts of the programme if the programme contains them

The study programme contains no parts that can be completed individually. The programme is integral.

Professional or academic title (male)

- magister inženir računalništva in podatkovnih ved
- magister inženir računalništva in informatike

Professional or academic title (female)

- magistrica inženirka računalništva in podatkovnih ved
- magistrica inženirka računalništva in informatike

Professional or academic title (abbreviated)

- mag. inž. rač. in pod. ved
- mag. inž. rač. in inf.

CURRICULUM OF THE STUDY PROGRAMME WITH EXPECTED SUBJECT LECTURERS

Data Science (Computer and Information Science programme track)

YEAR 1

				Contact hours									
No.	**Course code**	**Study unit**	**Lecturer**	**Lectures**	**Seminar**	**Tutorial**	**Laboratory work**	**Field work**	**Individ. work**	**Total**	**ECTS**	**Semester**	**Elective**
1.	63506	Mathematics 1	Polona Oblak	45		30			105	180	6	Fall	No
2.	63564	Principles of uncertainty	Erik Štrumbelj	45		30			105	180	6	Fall	No
3.	63565	Introduction to data science	Tomaž Curk	45		30			105	180	6	Fall	No
4.	M1-P1	Module 1 - course 1		45		30			105	180	6	Fall	Yes
5.	M1-P2	Module 1 - course 2		45		30			105	180	6	Fall	Yes
6.	63566	Machine learning for data science 1	Blaž Zupan	45		30			105	180	6	Spring	No
7.	63567	Mathematics 2	Gašper Fijavž, Polona Oblak, Žiga Virk	45		30			105	180	6	Spring	No
8.	M1-P3	Module 1 - course 3		45		30			105	180	6	Spring	Yes

9.	M1-P4	Module 1 - course 4		45		30			105	180	6	Spring	Yes
10.	63568	Project	Tomaž Curk		30				150	180	6	Spring	No
		Total		405	30	270	0	0	1095	1800	60		

YEAR 2

				Contact hours									
No.	**Course code**	**Study unit**	**Lecturer**	**Lectures**	**Seminar**	**Tutorial**	**Laboratory work**	**Field work**	**Individ. work**	**Total**	**ECTS**	**Semester**	**Elective**
1.	A1	Specialist elective course from list A 1/2		45		30			105	180	6	Fall	Yes
2.	B1	Specialist elective course from list B 1/3		45		30			105	180	6	Fall	Yes
3.	B2	Specialist elective course from list B 2/3		45		30			105	180	6	Fall	Yes
4.	0008	General elective course		45		30			105	180	6	Fall	Yes
5.	63548	Master's thesis			60				660	720	24	Fall, Spring	No

6.	A2	Specialist elective course from list A 2/2		45		30			105	180	6	Spring	Yes
7.	B3	Specialist elective course from list B 3/3		45		30			105	180	6	Spring	Yes
		Total		270	60	180	0	0	1290	1800	60		

Electives: Students select 1 module (of 4 subjects each) – selection from modules in the Computer and Information Science course. Students also select 2 subjects from list A and 3 subjects from list B. External electives are envisaged for all general elective subjects.

Year 2, Specialist elective courses from list A: In-depth subjects Data Science

				Contact hours									
No.	**Course code**	**Study unit**	**Lecturer**	**Lectures**	**Seminar**	**Tutorial**	**Laboratory work**	**Field work**	**Individ. work**	**Total**	**ECTS**	**Semester**	**Elective**
1.	63562	Machine learning for data science 2	Blaž Zupan, Erik Štrumbelj	45		30			105	180	6	Fall	Yes
2.	63563	Bayesian statistics	Erik Štrumbelj	45		30			105	180	6	Fall	Yes
3.	63561	Deep learning	Danijel Skočaj	45		30			105	180	6	Spring	Yes
4.	63560	Big data	Matjaž Kukar	45		30			105	180	6	Spring	Yes
		Total		180	0	120	0	0	420	720	24		

Year 2, Specialist elective courses from list B Data Science

				Contact hours									
No.	**Course code**	**Study unit**	**Lecturer**	**Lectures**	**Seminar**	**Tutorial**	**Laboratory work**	**Field work**	**Individ. work**	**Total**	**ECTS**	**Semester**	**Elective**
1.	63519	Machine Learning	Igor Kononenko	45	6	24			105	180	6	Fall	Yes
2.	63520	Introduction to bioinformatics	Blaž Zupan	45	20	10			105	180	6	Fall	Yes
3.	63514	Biomedical signal and image processing	Franc Jager	45		30			105	180	6	Fall	Yes
4.	63555	Natural language processing	Marko Robnik Šikonja	45	10	20			105	180	6	Spring	Yes
5.	63554	Image based biometry	Peter Peer	45	10	20			105	180	6	Fall	Yes
6.	63562	Machine learning for data science 2	Blaž Zupan, Erik Štrumbelj	45		30			105	180	6	Fall	Yes
7.	63563	Bayesian statistics	Erik Štrumbelj	45		30			105	180	6	Fall	Yes
8.	63552	Advanced topics in computer vision	Matej Kristan	45	10	20			105	180	6	Spring	Yes

9.	63551	Web information extraction and retrieval	Marko Bajec	45	10	20			105	180	6	Fall, Spring	Yes
10.	63543	High performance computing	Uroš Lotrič	45	10	20			105	180	6	Spring	Yes
11.	63561	Deep learning	Danijel Skočaj	45		30			105	180	6	Spring	Yes
12.	63560	Big data	Matjaž Kukar	45		30			105	180	6	Spring	Yes
13.	63510	Artificial intelligence	Ivan Bratko	45	10	20			105	180	6	Spring	Yes
14.	63545B	Network analysis	Lovro Šubelj	45	20	10			105	180	6	Spring	Yes
		Total		630	106	314	0	0	1470	2520	84		

Computer and Information Science (Computer and Information Science programme track)

YEAR 1

				Contact hours									
No.	**Course code**	**Study unit**	**Lecturer**	**Lectures**	**Seminar**	**Tutorial**	**Laboratory work**	**Field work**	**Individ. work**	**Total**	**ECTS**	**Semester**	**Elective**
1.	63506	Mathematics 1	Polona Oblak	45		30			105	180	6	Fall	No
2.	M1-P1	Module 1 - course 1		45		30			105	180	6	Fall	Yes

3.	M1-P2	Module 1 - course 2		45		30			105	180	6	Fall	Yes
4.	M2-P1	Module 2 - course 1		45		30			105	180	6	Fall	Yes
5.	M2-P2	Module 2 - course 2		45		30			105	180	6	Fall	Yes
6.	M1-P3	Module 1 - course 3		45		30			105	180	6	Spring	Yes
7.	M1-P4	Module 1 - course 4		45		30			105	180	6	Spring	Yes
8.	M2-P3	Module 2 - course 3		45		30			105	180	6	Spring	Yes
9.	M2-P4	Module 2 - course 4		45		30			105	180	6	Spring	Yes
10.	0002	General elective course		45		30			105	180	6	Spring	Yes
		Total		450	0	300	0	0	1050	1800	60		

YEAR 2

				Contact hours									
No.	**Course code**	**Study unit**	**Lecturer**	**Lectures**	**Seminar**	**Tutorial**	**Laboratory work**	**Field work**	**Individ. work**	**Total**	**ECTS**	**Semester**	**Elective**
1.	M3-P1	Module 3 - course 1		45		30			105	180	6	Fall	Yes
2.	M3-P2	Module 3 - course 2		45		30			105	180	6	Fall	Yes

3.	0008	General elective course		45		30			105	180	6	Fall	Yes
4.	0012	Specialist elective course (any module/other)		45		30			105	180	6	Fall, Spring	Yes
5.	63548	Master's thesis			60				660	720	24	Fall, Spring	No
6.	M3-P3	Module 3 - course 3		45		30			105	180	6	Spring	Yes
7.	M3-P4	Module 3 - course 4		45		30			105	180	6	Spring	Yes
		Total		270	60	180	0	0	1290	1800	60		

Electives: Students select 3 modules (of 4 subjects each), and can also select 1 professional elective (from any model or list of other offered subjects). External electives are envisaged for all general elective subjects.

I. Intelligent Analysis of Data (module specialist elective courses)

				Contact hours									
No.	**Course code**	**Study unit**	**Lecturer**	**Lectures**	**Seminar**	**Tutorial**	**Laboratory work**	**Field work**	**Individ. work**	**Total**	**ECTS**	**Semester**	**Elective**
1.	63519	Machine Learning	Igor Kononenko	45	6	24			105	180	6	Fall	Yes
2.	63520	Introduction to bioinformatics	Blaž Zupan	45	20	10			105	180	6	Fall	Yes
3.	63510	Artificial intelligence	Ivan Bratko	45	10	20			105	180	6	Spring	Yes

4.	63545B	Network analysis	Lovro Šubelj	45	20	10			105	180	6	Spring	Yes
		Total		180	56	64	0	0	420	720	24		

II. Media technologies (module specialist elective courses)

				Contact hours									
No.	**Course code**	**Study unit**	**Lecturer**	**Lectures**	**Seminar**	**Tutorial**	**Laboratory work**	**Field work**	**Individ. work**	**Total**	**ECTS**	**Semester**	**Elective**
1.	63527	Interaction and Information Design	Franc Solina	45	20	10			105	180	6	Fall	da
2.	63523	Computer based sound production	Denis Trček	45		30			105	180	6	Fall	da
3.	63551	Web information extraction and retrieval	Marko Bajec	45	10	20			105	180	6	Spring, Fall	da
4.	63553	Advanced Computer Graphics	Matija Marolt	45		30			105	180	6	Spring	da
		Total		180	30	90	0	0	420	720	24		

III. Computer Systems and Computing (module specialist elective courses)

				Contact hours									
No.	**Course code**	**Study unit**	**Lecturer**	**Lectures**	**Seminar**	**Tutorial**	**Laboratory work**	**Field work**	**Individ. work**	**Total**	**ECTS**	**Semester**	**Elective**

1.	63512	Unconventional computing	Miha Mraz	45	20	10			105	180	6	Fall	Yes
2.	63541	Cloud Computing	Branko Matjaž Jurič	45	20	10			105	180	6	Fall	Yes
3.	63543	High performance computing	Uroš Lotrič	45	10	20			105	180	6	Spring	Yes
4.	63509	Computer Systems	Branko Šter	45		30			105	180	6	Spring	Yes
		Total		180	50	70	0	0	420	720	24		

IV. Computer Networks and Security (module specialist elective courses)

				Contact hours									
No.	**Course code**	**Study unit**	**Lecturer**	**Lectures**	**Seminar**	**Tutorial**	**Laboratory work**	**Field work**	**Individ. work**	**Total**	**ECTS**	**Semester**	**Elective**
1.	63528	Cryptography and Computer Security	Aleksandar Jurišić	45	10	20			105	180	6	Fall, Spring	Yes
2.	63521	Information Security and Privacy	Denis Trček	45		30			105	180	6	Fall	Yes
3.	63530	Digital forensic	Andrej Brodnik	45		30			105	180	6	Spring	Yes
4.	63511	Wireless Sensor networks	Nikolaj Zimic	45	10	20			105	180	6	Spring	Yes

	Total	180	20	100	0	0	420	720	24		

V. Algorithmics and Software (module specialist elective courses)

				Contact hours									
No.	**Course code**	**Study unit**	**Lecturer**	**Lectures**	**Seminar**	**Tutorial**	**Laboratory work**	**Field work**	**Individ. work**	**Total**	**ECTS**	**Semester**	**Elective**
1.	63550	Human-Computer Interaction	Franc Jager	45		30			105	180	6	Fall	Yes
2.	63507	Functional programming	Zoran Bosnić	45	10	20			105	180	6	Fall	Yes
3.	63557	Approximation and randomized algorithms	Borut Robič	45		30			105	180	6	Spring	Yes
4.	63508	Algorithms	Tomaž Dobravec	45	20	10			105	180	6	Spring	Yes
		Total		180	30	90	0	0	420	720	24		

VI. Computational Methods (module specialist elective courses)

				Contact hours									
No.	**Course code**	**Study unit**	**Lecturer**	**Lectures**	**Seminar**	**Tutorial**	**Laboratory work**	**Field work**	**Individ. work**	**Total**	**ECTS**	**Semester**	**Elective**
1.	63558	Collective behaviour	Iztok Lebar Bajec	45		30			105	180	6	Fall	Yes
2.	63542	Topological data analysis	Žiga Virk	45	10	20			105	180	6	Fall	Yes

3.	63522	Numerical Mathematics	Polona Oblak	45		30			105	180	6	Fall, Spring	Yes
4.	63532	Discrete Mathematics	Gašper Fijavž	45		30			105	180	6	Spring	Yes
		Total		180	10	110	0	0	420	720	24		

VII. Machine Perception Methods (module specialist elective courses)

				Contact hours									
No.	**Course code**	**Study unit**	**Lecturer**	**Lectures**	**Seminar**	**Tutorial**	**Laboratory work**	**Field work**	**Individ. work**	**Total**	**ECTS**	**Semester**	**Elective**
1.	63514	Biomedical signal and image processing	Franc Jager	45		30			105	180	6	Fall	Yes
2.	63554	Image based biometry	Peter Peer	45	10	20			105	180	6	Fall	Yes
3.	63555	Natural language processing	Marko Robnik Šikonja	45	10	20			105	180	6	Spring	Yes
4.	63552	Advanced topics in computer vision	Matej Kristan	45	10	20			105	180	6	Spring	Yes
		Total		180	30	90	0	0	420	720	24		

Specialist elective courses

				Contact hours									

No.	Course code	Study unit	Lecturer	Lectures	Seminar	Tutorial	Laboratory work	Field work	Individ. work	Total	ECTS	Semester	Elective
1.	63513	Perception in cognitive systems	Aleš Leonardis	45		30			105	180	6	Fall	Yes
2.	63533	Management of production and service processes	Branko Matjaž Jurič	45	10	20			105	180	6	Fall	Yes
3.	63547	Teaching algorithmic thinking	Janez Demšar	45	20	10			105	180	6	Fall	Yes
4.	63515	Advanced Software Development Methods	Damjan Vavpotič	45	10	20			105	180	6	Spring	Yes
5.	63560	Big data	Matjaž Kukar	45		30			105	180	6	Spring	Yes
6.	63561	Deep learning	Danijel Skočaj	45		30			105	180	6	Spring	Yes
7.	63545	Topical research themes 1	Matej Kristan	45	10	20			105	180	6	Fall	Yes
8.	63546	Topical research themes 2	Matej Kristan	45	10	20			105	180	6	Spring	Yes

9.	63536	Topics in Computer and Information Science	Gašper Fijavž	45		30			105	180	6	Spring	Yes
10.	63544	Research seminar	Gašper Fijavž	15	45				300	360	12	Fall	Yes
		Total		420	105	210	0	0	1245	1980	66		

General elective courses

				Contact hours									
No.	**Course code**	**Study unit**	**Lecturer**	**Lectures**	**Seminar**	**Tutorial**	**Laboratory work**	**Field work**	**Individ. work**	**Total**	**ECTS**	**Semester**	**Elective**
1.	63534	Computer science and society 1	Gašper Fijavž	5				40	45	90	3	Fall, Spring	Yes
2.	63535	Computer science and society 2	Gašper Fijavž	5				40	45	90	3	Fall, Spring	Yes
3.	63549	Data mining and visualization	Marko Robnik Šikonja	45		30			105	180	6	Fall, Spring	Yes
		Total		55	0	30	0	80	195	360	12		