FACULTY
OF MATHEMATICS
AND PHYSICS
Charles University

Degree Plans - General Computer Science

Coordinating Department: Computer Science Institute and Department of Applied Mathematics **Specialization Coordinator:** doc. Mgr. Robert Šámal, Ph.D.

The specialization General Computer Science is suitable mainly for students interested in obtaining a solid foundation in computer science and mathematics, and who aim to follow their bachelor studies with a master's programme of study. Students are also well prepared for the job market, too. Taking General Computer Science allows the student to pursue algorithms, optimization, and their guiding principles, and also discrete mathematics.

Common obligatory courses in Computer Science

Common obligatory courses for all specializations are listed above in the section giving general information.

2.1 Obligatory Courses

Code	Subject		Credits	Winter	Summer
NPRX005	**Non-procedural Programming**		5	—	2/2 C+Ex
NOPX048	**Linear programming and combinatorial optimization**		5	—	2/2 C+Ex
NMAX055	**Mathematical Analysis 2**	[1]	5	2/2 C+Ex	—

[1] In 2019/20 the course Mathematical Analysis 2 is taught in the summer semester for students who started their studies in previous years. Students studying according to the current degree plan will take this course in the winter semester of 2020/21.

2.2 Elective Courses

Elective courses – group 1

A prerequisite for taking either part of the State Final Exam is to have obtained at least 30 credits from courses in this group.

Code	Subject	Credits	Winter	Summer
NDMI084	Introduction to approximation and randomized algorithms	5	2/1 C+Ex	—
NDMI098	Algorithmic Game Theory	5	2/2 C+Ex	—
NDMI010	Graph Algorithms	3	2/0 Ex	—
NDMX012	Combinatorics and Graph Theory 2	5	—	2/2 C+Ex
NDMX009	Introduction to Combinatorial and Computational Geometry	6	2/2 C+Ex	—
NOPX046	Discrete and Continuous Optimization	5	—	2/2 C+Ex
NMAX062	Algebra 1	5	2/2 C+Ex	—
NMAI063	Algebra II	3	—	2/0 Ex
NMAX056	Mathematical Analysis 3	5	—	2/2 C+Ex
NMAX042	Numerical Mathematics	5	—	2/2 C+Ex
NMAI059	Probability and Statistics	6	2/2 C+Ex	—
NAIL063	Set Theory	3	—	2/0 Ex

Elective courses – group 2

A prerequisite for taking either part of the State Final Exam is to have obtained at least 5 credits from courses in this group.

Code	Subject	Credits	Winter	Summer
NPRX041	Programming in C++	5	2/2 C+Ex	—
NPRX013	Java	5	2/2 C+Ex	—
NPRX035	C# Language and .NET Framework	5	2/2 C+Ex	—

Elective courses – group 3

A prerequisite for taking either part of the State Final Exam is to have obtained at least 45 credits from elective courses overall. There is no specific limit for this third group.

Code	Subject	Credits	Winter	Summer
NPFL054	Introduction to Machine Learning	5	2/2 C+Ex	—
NPGR035	Machine learning in computer vision	5	2/2 C+Ex	—
NAIL120	Introduction to Artificial Intelligence	5	—	2/2 C+Ex
NPGR003	Introduction to Computer Graphics	5	2/2 C+Ex	—
NPGR002	Digital Image Processing	4	3/0 Ex	—
NPGR038	Introduction to computer game development	5	—	2/2 C+Ex
NPFL124	Natural Language Processing	4	—	2/1 C+Ex
NPFL012	Introduction to Computer Linguistics	3	2/0 Ex	—
NSWX004	Operating Systems	4	2/1 MC	—
NPRX036	Data Formats	5	—	2/2 C+Ex
NSWI090	Computer Networks	3	—	2/0 Ex
NSWI143	Computer Architecture	3	—	2/0 Ex
NDBI007	Data Organisation and Processing I	4	2/1 C+Ex	—
NDBI040	Modern Database Concepts	5	2/2 C+Ex	—
NSWI098	Compiler Principles	6	2/2 C+Ex	—
NPRG042	Programming in Parallel Environment	6	—	2/2 C+Ex
NSWX142	Web Applications Programming	5	2/2 C+Ex	—
NPRG054	High Performance Software Development	6	—	2/2 C+Ex
NPRX051	Advanced C++ Programming	5	—	2/2 C+Ex
NPRX021	Advanced Programming in Java	5	—	2/2 C+Ex
NPRX038	Advanced C# Programming	5	—	2/2 C+Ex

2.3 Recommended Course of Study

The recommended course of study gives all the obligatory courses, while only some elective courses and optional courses are listed. Students need to choose other such courses themselves. Obligatory courses are printed in boldface, elective courses in roman, and optional courses in italics.

First year

Common to all specializations – see under general information above.

Second year

Code	Subject	Credits	Winter	Summer
NTIX061	**Algorithms and Data Structures 2**	5	2/2 C+Ex	—
NAIX062	**Propositional and Predicate Logic**	5	2/2 C+Ex	—

NMAX055	**Mathematical Analysis 2**	[1]	5	2/2 C+Ex	—
NDMX011	**Combinatorics and Graph Theory 1**	[1]	5	2/2 C+Ex	—
NPRX...	Programming in Java/C#/C++		5	2/2 C+Ex	—
NTIX071	**Automata and Grammars**		5	—	2/2 C+Ex
NPRX005	**Non-procedural Programming**		5	—	2/2 C+Ex
NOPX048	**Linear programming and combinatorial optimization**		5	—	2/2 C+Ex
NMAX059	**Probability and Statistics**		5	2/2 C+Ex	—
NPRG045	**Individual Software Project**		4	—	0/1 C
	Elective course – group 1		5		2/2 C+Ex
	Elective courses				
	Optional courses				

[1] In 2019/20 the courses Mathematical Analysis 2 and Combinatorics and Graph Theory 1 are taught in the summer semester for students who started their studies in previous years. Students studying according to the current degree plan will take these courses in the winter semester of 2020/21.

Third year

Code	Subject	Credits	Winter	Summer
NDBX025	**Database Systems**	5	—	2/2 C+Ex
NSZZ031	**Bachelor Thesis**	6	—	0/4 C
	Elective courses	30		
	Optional courses	15		

Recommended elective courses

To prepare for the State Final Exam, as well as for the further study of computer science, we suggest the following courses in particular.

Code	Subject	Credits	Winter	Summer
NOPX046	Discrete and Continuous Optimization	5	—	2/2 C+Ex
NDMI084	Introduction to approximation and randomized algorithms	5	2/1 C+Ex	—
NDMI010	Graph Algorithms	3	2/0 Ex	—
NDMX009	Introduction to Combinatorial and Computational Geometry	6	2/2 C+Ex	—
NDMX012	Combinatorics and Graph Theory 2	5	—	2/2 C+Ex
NAIL063	Set Theory	3	—	2/0 Ex
NMAX062	Algebra 1	5	2/2 C+Ex	—

2.4 State Final Exam

The State Final Exam knowledge requirements common to all specializations are described in the first section of this chapter (General Information on Computer Science bachelor's degree plans). Students of the General Computer Science specialization will be further tested according to the list below from topics 1.-3. and from two selected topics among 4.-7. The choice of these two topics is to be declared by the student when signing up for the State Final Exam.

1. Networking Fundamentals
Taxonomy of computer networks. ISO/OSI reference architecture. Overview of the TCP/IP protocol model. Routing. Addresses, ports, sockets. Client-server architectures. Fundamentals of HTTP, FTP and SMTP protocols.

2. Multivariable Differential and Integral Calculus
Riemann integral. Extreme values of multivariable functions. Metric spaces, open and closed sets. Compactness.

3. Combinatorics
Generating functions. Estimates of factorials and binomial coefficients. Ramsey theorems. Error-correcting codes.

4. Optimization Methods

Polyhedra, Minkowski–Weyl theorem. Basics of linear programming, duality theorems, algorithms for LP. Edmonds' algorithm. Integer programming. Approximation algorithms for combinatorial problems (satisfiability, independent set, set cover, scheduling). Applications of linear programming to approximation algorithms. The use of probability in the design of algorithms.

5. Advanced Algorithms and Data Structures

Random-access machine (RAM). Dynamic programming. Strongly connected components of directed graphs. Maximal flows: Dinic and Goldberg algorithms. Application of flows: disjoint paths, matching in bipartite graphs. Flows and paths in graphs with integer weights. Text search algorithms: Knuth–Morris–Pratt, Aho–Corasick, and Rabin–Karp algorithms. DFT and its applications. Approximation algorithms and schemes. Parallel algorithms in Boolean circuits and comparator networks.

6. Geometry

Basic theorems about convex sets (Helly, Rado, separation). Minkowski's lattice theorem. Convex polytopes (basic properties, V-polytopes, H-polytopes, combinatorial complexity). Geometric duality. Voronoi diagrams, hyperplane arrangements, point-line incidences. Elementary computational geometry algorithms (construction of a line arrangement in the plane, construction of a convex hull in the plane).

7. Advanced Discrete Mathematics

Graph colouring (Brooks' and Vizing's theorem). Tutte's theorem. Extremal combinatorics (Turán's theorem, Erdös–Ko–Rado theorem). Drawing graphs on surfaces. Sets and mappings. Subvalence and equivalence of sets. Well-ordered sets. Axiom of choice (Zermelo's theorem, Zorn's lemma).