

# Recommended pass through the study plan

## Name of the pass: Master program, unspecified branch, in Czech, 2020

Faculty/Institute/Others:

Department:

Pass through the study plan: Mgr. programme, for the phase of study without specialisation, ver. for 2020 and higher

Branch of study guaranteed by the department: Welcome page

Guarantor of the study branch:

Program of study: Informatika

Type of study: Follow-up master full-time

Note on the pass: Společný magisterský plán předpízením do oboru, verze 2020.

Coding of roles of courses and groups of courses:

P - compulsory courses of the program, PO - compulsory courses of the branch, Z - compulsory courses, S - compulsory elective courses, PV - compulsory elective courses, F - elective specialized courses, V - elective courses, T - physical training courses

Coding of ways of completion of courses (KZ/Z/ZK) and coding of semesters (Z/L):

KZ - graded assessment, Z - assessment, ZK - examination, L - summer semester, Z - winter semester

Number of semester: 1

Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members) <i>Tutors, authors and guarantors (gar.)</i>	Completion	Credits	Scope	Semester	Role
NI-KOP	<b>Combinatorial Optimization</b> <i>Jan Schmidt, Petr Fišer Jan Schmidt Jan Schmidt (Gar.)</i>	Z,ZK	6	2P+2C	Z	PP
NI-MPI	<b>Mathematics for Informatics</b> <i>Št pán Starosta, Jan Sp vák Št pán Starosta Št pán Starosta (Gar.)</i>	Z,ZK	7	3P+2C	Z	PP
NI-PRO.20	<b>Vyberte si (zatím jako volitelné) profilující p edm ty pro n kterou specializaci, verze 2020</b> <i>NI-ADM,NI-ADP,..... (see the list of groups below)</i>	Min. cours. 7 Max. cours. 7	Min/Max 35/35			VO
NI-V.2021	<b>ist volitelné magisterské p edm ty, verze 2021</b> <i>NI-ATH,BI-AG2.21,..... (see the list of groups below)</i>	Min. cours. 0 Max. cours. 68	Min/Max 0/333			V

Number of semester: 2

Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members) <i>Tutors, authors and guarantors (gar.)</i>	Completion	Credits	Scope	Semester	Role
NI-PDP	<b>Parallel and Distributed Programming</b> <i>Pavel Tvr dík Pavel Tvr dík Pavel Tvr dík (Gar.)</i>	Z,ZK	6	2P+2C	L	PP
NI-VSM	<b>Selected statistical Methods</b> <i>Daniel Vašata, Pavel Hrabák, Jana Vacková, Petr Novák, Jitka Hrabáková, Ivo Petr Pavel Hrabák Pavel Hrabák (Gar.)</i>	Z,ZK	7	4P+2C	L	PP
NI-PRO.20	<b>Vyberte si (zatím jako volitelné) profilující p edm ty pro n kterou specializaci, verze 2020</b> <i>NI-ADM,NI-ADP,..... (see the list of groups below)</i>	Min. cours. 7 Max. cours. 7	Min/Max 35/35			VO
NI-V.2021	<b>ist volitelné magisterské p edm ty, verze 2021</b> <i>NI-ATH,BI-AG2.21,..... (see the list of groups below)</i>	Min. cours. 0 Max. cours. 68	Min/Max 0/333			V

Number of semester: 3

Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members) <i>Tutors, authors and guarantors (gar.)</i>	Completion	Credits	Scope	Semester	Role
NI-MPR	<b>Master Project</b> <i>Zden k Muziká</i>	Z	7		Z,L	PP
NI-PRO.20	<b>Vyberte si (zatím jako volitelné) profilující p edm ty pro n kterou specializací, verze 2020</b> <i>NI-ADM,NI-ADP,..... (see the list of groups below)</i>	Min. cours. 7 Max. cours. 7	Min/Max 35/35			VO
NI-V.2021	<b>ist volitelné magisterské p edm ty, verze 2021</b> <i>NI-ATH,BI-AG2.21,..... (see the list of groups below)</i>	Min. cours. 0 Max. cours. 68	Min/Max 0/333			V

Number of semester: 4

Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members) <i>Tutors, authors and guarantors (gar.)</i>	Completion	Credits	Scope	Semester	Role
NI-DIP	<b>Diploma Project</b> <i>Zden k Muziká Zden k Muziká Zden k Muziká (Gar.)</i>	Z	30		L,Z	PP

## List of groups of courses of this pass with the complete content of members of individual groups

Kód		Name of the group of courses and codes of members of this group (for specification see here or below the list of courses)		Completion	Credits	Scope	Semester	Role
NI-PRO.20		Vyberte si (zatím jako volitelné) profilující p edm ty pro n kterou specializaci, verze 2020		Min. cours. 7 Max. cours. 7	Min/Max 35/35			vo
NI-ADM	Data Mining Algorithms	NI-ADP	Architecture and Design patterns	NI-AM1	Middleware Architectures 1			
NI-AM2	Middleware Architectures 2	NI-BML	Bayesian Methods for Machine Lea ...	NI-BVS	Embedded Security			
NI-BKO	Error Control Codes	NI-DSV	Distributed Systems and Computin ...	NI-DDW	Web Data Mining			
NI-EPC	Effective C++ programming	NI-EVY	Efficient Text Pattern Matching	NI-FME	Formal Methods and Specification ...			
NI-GEN	Code Generators	NI-GAK	Graph theory and combinatorics	NI-KOD	Data Compression			
NI-MVI	Computational Intelligence Metho ...	NI-MEP	Modelling of Enterprise Processe ...	NI-MPJ	Modelling of Programming Languag ...			
NI-MTI	Modern Internet Technologies	NI-NUR	User Interface Design	NI-NON	Nonlinear Continuous Optimizatio ...			
NI-NSS	Normalized Software Systems	NI-OSY	Operating Systems and Systems Pr ...	NI-BUI	Business Informatics			
NI-PIS	Enterprise Information Systems	NI-PAS	Advanced Aspects of Business	NI-PDB	Advanced Database Systems			
NI-GPU	GPU Architectures and Programmin ...	NI-PDD	Data Preprocessing	NI-RUN	Runtime Systems			
NI-SWE	Semantic Web and Knowledge Graph ...	NI-SIM	Digital Circuit Simulation and V ...	NI-SIB	Network Security			
NI-SCR	Statistical Analysis of Time Ser ...	NI-SYP	Parsing and Compilers	NI-DSS	Decision Support Systems			
NI-TES	Systems Theory	NI-TSP	Testing and Reliability	NI-TSW	Software Product Development			
NI-UMI	Artificial intelligence	NI-EHW	Embedded Hardware	NI-ESW	Embedded Software			
NI-VCC	Virtualization and Cloud Computi ...	NI-APR	Selected Methods for Program Ana ...	NI-PON	Selected Topics in Optimization ...			
NI-VMM	Retrieval from Multimedia	NI-MCC	Multicore CPU Computing					
NI-V.2021		ist volitelné magisterské p edm ty, verze 2021		Min. cours. 0 Max. cours. 68	Min/Max 0/333			v
NI-ATH	AlgorithmicTheories of Games	BI-AG2.21	Algorithms and Graphs 2	NI-AFP	Applied Functional Programming			
NI-APH	Architecture of computer games	BI-APS.21	Architectures of Computer System ...	NI-BPS	Wireless Computer Networks			
BI-BEK.21	Secure Code	BI-BLE	Blender	NI-E-BLO	Blockchain			
NI-CTF	Capture The Flag	NI-DPH	Game Design	NI-DSW	Design Sprint			
NI-PSD	Public Services Design	NI-DID	Digital drawing	NI-DZO	Digital Image Processing			
NI-DDM	Distributed Data Mining	NI-PAM	Efficient Preprocessing and Para ...	BI-EHA.21	Ethical Hacking			
NI-ESC	Experimental Project Course	BI-FMU	Financial and Management Account ...	BI-FTR.1	Financial Markets			
NI-GLR	Games and reinforcement learning	NI-GNN	Graph Neural Networks	NI-GRI	Grid Computing			
NI-HCM	Mind Hacking	NI-HSC	Side-Channel Analysis in Hardwar ...	NI-HMI2	History of Mathematics and Infor ...			
NI-IBE	Information Security	NI-IVS	Intelligent embedded systems	NI-IKM	Internet and Classification Meth ...			
NI-IAM	Internet and Multimedia	NI-IOT	Internet of Things	BI-JPO.21	Computer Units			
NI-KTH	Combinatorial Theories of Games	NI-FMT	Finite model theory	NI-CCC	Creative Coding and Computations ...			

NI-KYB	Cybernality	NI-LSM2	Statistical Modelling Lab	NI-LOM	Linear Optimization and Methods
NI-MPL	Managerial Psychology	NI-MSI	Mathematical Structures in Compu ...	NI-MZI	Mathematics for data science
BI-MPP.21	Methods of interfacing periphera ...	NI-MOP	Modern Object-Oriented Programmi ...	NI-NMU	New media in art and design
NI-OLI	Linux Drivers	NIE-PML	Personalized Machine Learning	NI-ARI	Computer arithmetic
NI-PG1	Computer Grafics 1	NI-EDW	Enterprise Data Warehouse System ...	NI-PVR	Advanced Virtual Reality
NI-AML	Advanced machine learning	NI-IOS	Advanced techniques in iOS appli ...	NI-APT	Advanced Program Testing
NI-PVS	Advanced embedded systems	NI-DNP	Advanced .NET	NI-PYT	Advanced Python
NIE-PDL	Practical Deep Learning	BI-PJP.21	Programming Languages and Compil ...	NI-PSL	Programming in Scala
BI-PMA	Programming in Mathematica	NI-RUB	Programming in Ruby	NI-ROZ	Pattern Recognition
NI-SCE1	Computer Engineering Seminar Mas ...	NI-SCE2	Computer Engineering Seminar Mas ...	NI-SZ1	Knowledge Engineering Seminar Ma ...
NI-SZ2	Knowledge Engineering Seminar Ma ...	PI-SCN	Seminars on Digital Design	BI-SOJ	Machine Oriented Languages
NI-MLP	Machine Learning in Practice	BI-SVZ.21	Machine vision and image process ...	NI-SEP	World Economy and Business
BI-SRC.21	Real-time systems	NI-TVH	Virtual Reality Technology	NI-TS1	Theoretical Seminar Master I
NI-TS2	Theoretical Seminar Master II	NI-TS3	Theoretical Seminar Master III	NI-TS4	Theoretical Seminar Master IV
NI-TKA	Category Theory	NI-TNN	Theory of Neural Networks	NI-CPX	Complexity Theory
BI-CCN	Compiler Construction	NI-DVG	Introduction to Discrete and Com ...	BI-VHS.21	Virtual game worlds
NI-VOL	Elections	BI-VMM	Selected Mathematical Methods	NI-VYC	Computability
NI-VRP	Research Project	NI-ZS10	Master internship abroad for 10 ...	NI-ZS20	Master internship abroad for 20 ...
NI-ZS30	Master internship abroad for 30 ...				

## List of courses of this pass:

Code	Name of the course	Completion	Credits
BI-AG2.21	Algorithms and Graphs 2	Z,ZK	5
This course, presented in Czech, introduces basic algorithms and concepts of graph theory as a follow-up on the introduction given in the compulsory course BI-AG1.21. It further delves into advances data structures and amortized complexity analysis. It also includes a very light introduction to approximation algorithms. For English version of the course see BIE-AG2.21.			
BI-APS.21	Architectures of Computer Systems	Z,ZK	5
Students will learn the construction principles of internal architecture of computers with universal processors at the level of machine instructions. Special emphasis is given on the pipelined instruction processing and on the memory hierarchy. Students will understand the basic concepts of RISC and CISC architectures and the principles of instruction processing not only in scalar processors, but also in superscalar processors that can execute multiple instructions in one cycle, while ensuring the correctness of the sequential model of the program. The course further elaborates the principles and architectures of shared memory multiprocessor and multicore systems and the memory coherence and consistency in such systems.			
BI-BEK.21	Secure Code	Z,ZK	5
The students will learn how to assess security risks and how to take them into account in the design phase of their own code and solutions. After getting familiar with the threat modeling theory, students gain practical experience with running programs with reduced privileges and methods of specifying these privileges, since not every program needs to run with administrator privileges. Dangers inherent in buffer overflows will be practically demonstrated. Students will be introduced to the principles of securing data and the relationships of security and database systems, web, remote procedure calls, and sockets in general. The module concludes with Denial of Service attacks and the defense against them.			
BI-BLE	Blender	Z,ZK	4
The course extends knowledge of opensource program Blender from BI-MGA (Multimedia and Graphics Applications) course. It is intended for those interested in 3D graphics and animation. It offers a complete and practically oriented introduction to Blender environment. Students may continue to BI-PGA (Programming graphics applications) course.			
BI-CCN	Compiler Construction	Z,ZK	5
This is an introductory class on compiler construction for bachelor students in computer science. The goal of the class is to introduce basic principles of compilers for students to understand the design and implementation of programming languages. Seeing and actually understanding self-compilation is the overarching theme of the class.			
BI-EHA.21	Ethical Hacking	Z,ZK	5
The goal of the course is to introduce students to the field of penetration testing and ethical hacking. The course deals with cybersecurity threats, vulnerabilities, and their possible exploitation in computer networks, web applications, wireless networks, operating systems, and others like the Internet of Things or cloud. The focus is on hands-on experience with vulnerabilities testing and the following process of penetration test documentation.			
BI-FMU	Financial and Management Accounting	Z,ZK	5
The aim of the course is explanation of basic terms in the theory of accounting, the principles of balancing the property amounts and liabilities in the particular accounting operations, operations in accounts and accounting statements including opening and closing of bookkeeping. The course provides students with a legal modification of bookkeeping, description of economic operations based on current methods of double-entry bookkeeping for enterprising subjects in the Czech Republic. Principles of management accounting are base of Business Intelligence moduls in Business information systems.			
BI-FTR.1	Financial Markets	Z,ZK	5
This course is presented in Czech. However, there is an English variant in the program Informatics (B1801 / 4753).			
BI-JPO.21	Computer Units	Z,ZK	5
Students deepen their basic knowledge of digital computer units acquired in the obligatory course of the program (BIE-SAP), get acquainted in detail with the internal structure and organization of computer units and processors and their interactions with the environment, including accelerating arithmetic-logic units and using appropriate codes for implementation of multiplication. The organization of main memory and other internal memories (addressable, LIFO, FIFO and CAM) will be discussed in detail, including codes for error detection and correction for parallel and serial data transmissions. They will also get acquainted with the methodology of controller design, with the principles of communication of the processor with the environment and the architecture of the bus system. The problems will be practically evaluated in the labs and with the help of the educational microprogrammed processor simulator and programmable hardware design kits (FPGA).			
BI-MPP.21	Methods of interfacing peripheral devices	Z,ZK	5
The course is focused on methods for interfacing of peripheral devices. Interfacing of real peripheral devices is focused on techniques based on Universal serial bus (USB). The course includes both PC side and peripheral devices side. Labs are practically oriented. Students gain experience with implementation of relevant parts of USB devices, Linux and Windows drivers, simple application development, and APIs of selected devices.			

BI-PJP.21	Programming Languages and Compilers	Z,ZK	5
Students learn basic compiling methods of programming languages. They are introduced to intermediate representations used in current compilers GNU and LLVM. They learn to create a specification of a translation of a text that conforms a given syntax, to a target code and also to create a compiler based on the specification. The compiler can translate not only a programming language but any text in a language generated by a given LL input grammar.			
BI-PMA	Programming in Mathematica	Z,ZK	4
Students will be working with modern technical and scientific software. Students will learn how to use different programming styles (functional programming, rule-based programming, etc.), how to create dynamic interactive applications and visualisations, data processing and presentations.			
BI-SOJ	Machine Oriented Languages	Z,ZK	4
Students of the course will gain an ability to create their own programs in the assembly language of the most common PC platform focusing on optimal use of microprocessor's features and efficient cooperation of software with hardware. Next, there will be discussed x86 specifics of the majority of OSES from the application point of view linked to higher level languages. This knowledge will be used during reverse engineering, optimization, and evaluation of code security.			
BI-SRC.21	Real-time systems	Z,ZK	5
Students obtain the basic knowledge in the real-time (RT) system theory and in the design methods for RT systems including the dependability issues. Theoretical knowledge from lectures will be experimentally verified in computer labs. The course is mainly focused on embedded RT systems, therefore the design kits in the lab are the same as in the BIE-VES course.			
BI-SVZ.21	Machine vision and image processing	Z,ZK	5
Camera systems are becoming a common part of life by being universally available. Related to this phenomenon is the need to process and evaluate image information. The course introduces students to different types of camera systems and a variety of methods for image and video processing. The course is focused on practical use of camera systems for solving problems of practice that the graduates may encounter.			
BI-VHS.21	Virtual game worlds	Z,ZK	5
In the course students learn methods to create a complex virtual world. It is a follow-up course of basic courses of the PG specialization (BIE-MGA, BIE-PGR). Students gain knowledge of the theory of game design, of principles of writing dialogues and characters in order to create a functional virtual world. Within the labs they get practical skills within team development work on the semester project.			
BI-VMM	Selected Mathematical Methods	Z,ZK	4
We start reviewing geometric properties of linear spaces with inner product. Next, we introduce and analyze the discrete Fourier transform (DFT) and its fast implementation (FFT). Further we deal with differential calculus of functions involving multiple variables. We present methods for the localization of extreme values of functions. For this purposes, we study normed linear spaces and quadratic forms. In addition, we introduce the least square method. The last part of the course is devoted to optimization and duality. The linear programming and the Simplex method is analyzed in more detail.			
NI-ADM	Data Mining Algorithms	Z,ZK	5
The course focuses on algorithms used in the fields of machine learning and data mining. However, this is not an introductory course, and the students should know machine learning basics. The emphasis is put on advanced algorithms (e.g., gradient boosting) and non-basic kinds of machine learning tasks (e.g., recommendation systems) and models (e.g., kernel methods).			
NI-ADP	Architecture and Design patterns	Z,ZK	5
The objective of this course is to provide students with both work knowledge about the underlying foundations of object-oriented design and analysis as well as with understanding of the challenges, issues, and tradeoffs of advanced software design. In the first part of the course, the students will refresh and deepen their knowledge of object-oriented programming and get familiar with the commonly used object-oriented design patterns that represent the best practices for solving common software design problems. In the second part the students will be introduced to the principles of software architecture design and analysis. This includes the classical architectural styles, component based systems, and some advanced software architectures used in large-scale distributed systems.			
NI-AFP	Applied Functional Programming	KZ	5
This course is presented in Czech. Functional programming represents one of the traditional programming paradigms. Traditional and novel functional programming languages are on the rise nowadays and the functional paradigm becomes an important construct of traditionally imperative languages (C++, C#, Java). As such, mastering this paradigm becomes a necessary competence of a software engineer: the theory and especially the practice.			
NI-AM1	Middleware Architectures 1	Z,ZK	5
Students will study new trends, concepts, and technologies in the area of service-oriented architectures. They will gain an overview of information system architecture, web service architecture and application servers. They will also study principles and technologies for middleware focused on application integrations, asynchronous communications and high availability of applications.			
NI-AM2	Middleware Architectures 2	Z,ZK	5
Students will learn new trends and technologies on the Web including theoretical foundations. They will gain an overview of Web application architectures, concepts and technologies for microservices, distributed cache and databases, smart contracts, realtime communication and web security.			
NI-AML	Advanced machine learning	Z,ZK	5
The course introduces students to selected advanced topics of machine learning and artificial intelligence. The topics present techniques in the field of recommendation systems, image processing, control and interconnection of physical laws with the field of machine learning. The aim of the exercise is to familiarize students with the methods discussed.			
NI-APH	Architecture of computer games	Z,ZK	4
Students will gain a basic understanding of the various issues in the field of computer games development, especially from a technical point of view, but also from design and philosophical perspective. They will get a grasp of component-oriented and functional-oriented architecture, game mechanics, decision-making processes and base components that form an integral part of most games. They will also understand the basics of pathfinding, networking and scripting and apply them in practical exercises (labs). An important part of the course is an implementation of a simple game, with a strong focus on nontrivial game mechanics.			
NI-APR	Selected Methods for Program Analysis	Z,ZK	5
Program analysis studies program behavior with the aim of code optimization and error detection. Students will learn static program analysis, which approximates program behavior without the need to actually run the program, as well as dynamic program analysis which analyse programs at runtime. Students will be introduced to the common techniques and algorithms and use them on some classical problems.			
NI-APT	Advanced Program Testing	Z,ZK	5
Testing a program is essential to ensure that a program respects its specification, that changes do not introduce regressions or security issues. The goal of the course is to present advanced program testing techniques, beyond writing unit tests, especially fuzzing and symbolic execution.			
NI-ARI	Computer arithmetic	Z,ZK	4
Students will learn various data representations used in digital devices and will be able to design arithmetic operations implementation units.			
NI-ATH	Algorithmic Theories of Games	Z,ZK	4
Traditional game theory is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory studies the behaviour of agents (players) of a certain competitive process by designing a mathematical model and investigating the strategies. The traditional task of classical game theory is to find the equilibria, which are the states of the game where no player wants to deviate from his strategy. Due to the recent development of computers, internet, social networks, online auctions, advertising, multiagent systems and other concepts the algorithmic point of view is gaining attention. In addition to existential questions we study the problems of efficient computation of various solution concepts. In this course we introduce the basics of game theory of many players, solution concept (usually equilibria) and methods of their computation.			

NI-BKO	Error Control Codes	Z,ZK	5
The goal of the course is to present various ways to detect or correct individual errors and burst errors in data stored into memories or transmitted via channels.			
NI-BML	Bayesian Methods for Machine Learning	KZ	5
The subject is focused on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it studies the construction of appropriate models providing description of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the hidden variables (true object position from noisy observations etc.). The emphasis is put on understanding of explained principles and methods and their practical adoption. For this purpose, a number of real world examples and applications will be presented to students, for instance, 2D/3D object tracking, radiation source term estimation, or separation in medical imaging. The students will try to solve some of them.			
NI-BPS	Wireless Computer Networks	Z,ZK	4
Students will learn about the modern technologies, protocols, and standards for wireless networks. They will understand the routing mechanisms in ad-hoc networks, multicast and broadcast mechanisms, and data flow control mechanisms. They will also learn about principles of communication in sensor networks. They get knowledge of security mechanisms for wireless networks and get skills of configuration of wireless network elements and simulation of wireless networks using suitable tools.			
NI-BUI	Business Informatics	Z,ZK	5
The aim of the course is to focus on operational, tactical and strategic management of business informatics. Students will gain knowledge in the areas of business process management, ICT services and architectures in enterprise informatics. They will also learn about the principles, models and standards (ITIL, COBIT) in IT management, and lifecycle management of ICT services and resource management (sourcing). Students will learn the process of creating and implementing information strategy, IT Governance, the importance of ICT for business and the context of information strategy with global business strategy. They will also gain knowledge in the areas of economic IT management, revenue and investment management, IT investment evaluation and human resources management in IT (roles CIO, CEO, CFO).			
NI-BVS	Embedded Security	Z,ZK	5
Students gain basic knowledge in selected topics of cryptography and cryptanalysis. The course focuses particularly on efficient implementations of cryptographic primitives in hardware and software (in embedded systems). Students gain a good overview of functionality of (hardware) cryptographic accelerators, smart cards, and resources for securing internal functions of computer systems.			
NI-CCC	Creative Coding and Computational Art	KZ	4
Students work on practical tasks, get acquainted with creative and yet proven methods of visualizing various types of data. The course freely follows the basic graphics courses (MGA, BLE,...) and introduces students to suitable visualization methods for traditional as well as for open data. It combines well-known visualization techniques with artistic methods using modern technologies. The aim is to create an interesting visualization project. It is planned to work closely with IPR CAMP (Center of Architecture and Metropolitan Planning) and IIM (Institute of Intermedia FEL).			
NI-CPX	Complexity Theory	Z,ZK	5
Students will learn about the fundamental classes of problems in the complexity theory and different models of algorithms and about implications of the theory concerning practical (in)tractability of difficult problems.			
NI-CTF	Capture The Flag	KZ	4
The course is designed to introduce students to CTF competitions and let them gain practical experience in the field of cyber security.			
NI-DDM	Distributed Data Mining	KZ	4
Course focuses on state-of-the-art approaches for distributed data mining and parallelization of machine learning algorithms. Students will gain hands on experience with large scale data processing framework Apache Spark and with existing distributed DM / ML algorithms. They will learn principles of their parallel implementations and will be capable to propose approaches to parallelize other algorithms. The course is presented in czech language.			
NI-DDW	Web Data Mining	Z,ZK	5
Students will learn latest methods and technologies for web data acquisition, analysis and utilization of the discovered knowledge. Students will gain an overview of Web mining techniques for Web crawling, Web structure analysis, Web usage analysis, Web content mining and information extraction. Students will also gain an overview of most recent developments in the field of social web and recommendation systems.			
NI-DID	Digital drawing	Z	2
The course will introduce students to the basic principals of digital drawing and graphical design. Students will gain understanding of composition, perspective and color theory, which they will practically apply in their own design works. Students will also gain experience in drawing and painting with digital and analog tools. The course is fit for anyone who wants to practice or learn drawing and painting. The course is organized as a thematic practices covering parts of theory and practical exercise to practice gained knowledge.			
NI-DIP	Diploma Project	Z	30
NI-DNP	Advanced .NET	Z,ZK	4
Students will acquire an overview of platform .NET and will gain knowledge about technologies ASP.NET, Entity Framework, WPF, .NET MAUI and also will get notions of Azure DevOps and GIT. Students will get practical experience in semestral work where they will create a client-server application utilizing technologies ASP.NET, Entity Framework and (Blazor, .NET MAUI or WPF) and also Azure DevOps and GIT.			
NI-DPH	Game Design	Z,ZK	5
The course complements the NI-APH (Architecture of Computer Games) and BI-VHS (Virtual gaming worlds) course, while focusing primarily on game design. It is intended for people interested in deeper knowledge of the principles used for games design, such as: level design, gameplay design, character design, game mechanics design, storytelling, and game development cycle. The students will get an overview of game development from the designer's perspective, from theoretical concepts to practical implementation applied to semestral projects.			
NI-DSS	Decision Support Systems	Z,ZK	5
The aim of the course is to provide students with knowledge and skills in decision support systems, their classification (Powerova), selected principles of data-oriented, model-oriented and knowledge-oriented decision support systems. Students will also gain knowledge of multicriterial decision-making methods and game theory. They will also learn about the principles of conceptually and ontologically oriented decision support systems and the basics of distribution, optimization and evolution methods and algorithms.			
NI-DSV	Distributed Systems and Computing	Z,ZK	5
Students are introduced to methods for coordination of processes in distributed environment characterised by nondeterministic time responses of computing processes and communication channels. They learn basic algorithms that assure correctness of computations realized by a group of loosely coupled processes and mechanisms that support high availability of both data and services, and safety in case of failures.			
NI-DSW	Design Sprint	Z	2
Students will work on projects using the Design Sprint method, developed by Google. Thanks to this method the teams are able to go from idea to validated prototype in 5 days. During the course the students will get familiar with the method as participants. Through practical challenges they will try the whole 5 day process starting with research and finishing with testing the prototypes (plus final presentation).			
NI-DVG	Introduction to Discrete and Computational Geometry	Z,ZK	5
The course intends to introduce the students to the discipline of Discrete and Computational Geometry. The main goal of the course is to get familiar with the most fundamental notions of this discipline, and to be able to solve simple algorithmic problems with a geometric component.			
NI-DZO	Digital Image Processing	Z,ZK	4
This course presents a comprehensive overview of modern methods for interactive editing of digital images and video. It mainly deals with practical algorithms that are both easy to implement and have an interesting theoretical basis. Visually attractive applications provide better understanding of basic theoretical background that is also valuable outside the domain			

of digital image processing. This course will introduce algorithms solving the following practical applications: edge-aware editing, tone mapping, HDR compression, de-blurring in frequency domain, abstraction, hybrid images, gradient domain editing, seamless image stitching and cloning, digital photo-montage, color-to-gray conversion, context enhancement, interactive as-rigid-as-possible image deformation, free-form image registration, texture synthesis, interactive segmentation, colorization, painting, adding depth, alpha matting.					
NI-EDW	Enterprise Data Warehouse Systems			Z,ZK	5
The Enterprise Data Warehouses course focuses on the area of business intelligence. Students will be introduced to business intelligence methods and will gain practical knowledge not only in designing warehouses and various architectures, but also their deployment and maintenance. This course also includes an introduction to the area of reporting and data visualization.					
NI-EHW	Embedded Hardware			Z,ZK	5
The course brings basic laws that govern digital design and basic techniques to use them. It deals with both large and small scale systems. This is the base of advanced embedded systems, that profit from their specialized structure for effective computation and acceleration. Design of fast custom computing machines is discussed, including standardized means of internal communication, parallelism extraction and utilization in special structures and system architectures.					
NI-EPC	Effective C++ programming			Z,ZK	5
Students learn how to use the modern features of contemporary versions of the C++ programming language for software development. The course focuses on programming effectiveness and efficiency in the form of writing maintainable and portable source code and creating correct programs with low memory and processor time requirements.					
NI-ESC	Experimental Project Course			KZ	8
"The Design Project course offers a holistic exploration of the design process, providing students with a well-rounded understanding of the principles, methodologies, and tools used in designing technology-driven solutions that are user-centric and industry-relevant. Throughout the semester, students will work on real-world design projects, collaborate with industry experts, and learn to integrate theory with practical application. Through a hands-on, project-based learning approach, students will develop their skills in user-centered design and user experience evaluation, as well as gain experience working in a team to design and prototype a functional solution."					
NI-ESW	Embedded Software			Z,ZK	5
Embedded software course acquainted students with the specifics of software development for embedded systems. The course covers the areas from the basic techniques of programming in C language and code optimizations, through typical areas as the reliable software development, embedded operating systems, signal processing, up to sophisticated techniques combined with artificial intelligence.					
NI-EVY	Efficient Text Pattern Matching			Z,ZK	5
Students get knowledge of efficient algorithms for text pattern matching. They learn to use so called succinct data structures that are efficient in both access time and memory complexity. They will be able to use the knowledge in design of applications that utilize pattern matching.					
NI-FME	Formal Methods and Specifications			Z,ZK	5
Students are able to describe semantics of software formally and to use sound reasoning for construction of correct software. They learn to use some software tools that allow to prove basic properties of software.					
NI-FMT	Finite model theory			Z,ZK	4
The aim of the course is to introduce students to the basics of finite model theory. The original motivation is the questions expressibility and verifiability of logical properties of database systems. Since its inception in the 1970s, the course has evolved rapidly and touched on many other areas of theoretical computer science, such as descriptive complexity theory, the Constraint Satisfaction Problem (CSP), the theory of algorithmic meta-theorems and combinatorics.					
NI-GAK	Graph theory and combinatorics			Z,ZK	5
The goal of the class is to introduce the most important topics in graph theory, combinatorics, combinatorial structures, discrete models and algorithms. The emphasis will be not only on understanding the basic principles but also on applications in problem solving and algorithm design. The topics include: generating functions, selected topics from graph and hypergraph coloring, Ramsey theory, introduction to probabilistic method, properties of various special classes of graphs and combinatorial structures. The theory will be also applied in the fields of combinatorics on words, formal languages and bioinformatics.					
NI-GEN	Code Generators			Z,ZK	5
NI-GLR	Games and reinforcement learning			Z,ZK	4
The field of reinforcement learning is very hot recently, because of advances in deep learning, recurrent neural networks and general artificial intelligence. This course is intended to give you both theoretical and practical background so you can participate in related research activities. Presented in English.					
NI-GNN	Graph Neural Networks			Z,ZK	4
The course introduces students to advanced artificial intelligence techniques for working with graphs. Lectures will focus on the latest graph neural networks for creating vector representations of nodes, edges and entire graphs. The techniques discussed cover various types of graphs, including time-varying graphs. The last part of the course also covers graph generation and interpretability of graph neural networks. In the exercises, students will try out selected techniques and problems.					
NI-GPU	GPU Architectures and Programming			Z,ZK	5
Students will gain knowledge of the internal architecture of modern massively parallel GPU processors. They will learn to program them mainly in the CUDA programming environment, which is already a widespread programming technology of GPU processors. As an integral part of the effective computational use of these hierarchical computational structures, students will also learn optimization programming techniques and methods of programming multiprocessor GPU systems.					
NI-GRI	Grid Computing			Z,ZK	5
Grid computing and gain knowledge about the world-wide network and computing infrastructure.					
NI-HCM	Mind Hacking			ZK	5
Cognitive security is an emerging discipline that is closely related to cyber security. While the domain of cyber security is the protection of networks, information systems and assets, the domain of cognitive security is the protection of the human mind from intentional and unintentional digital manipulation. The topic of cognitive security is growing in importance in the context of information warfare, increasing digital dependence and the development of artificial intelligence, where these phenomena from the Internet environment have real societal impacts such as disruption of social cohesion, threats to democracy or war.					
NI-HMI2	History of Mathematics and Informatics			ZK	3
This course is presented in Czech. Selected topics (Infinitesimal calculus, probability, number theory, general algebra, different examples of algorithms, transformations, recursive functions, elliptic curves, etc.) note on possibilities of applications of some mathematical methods in informatics and its development.					
NI-HSC	Side-Channel Analysis in Hardware			Z,ZK	4
This course is dedicated to so-called side-channel information leakage in hardware devices. It focuses on both theoretical analysis and practical attacks. Students get familiar with various kinds of side channels and they get deeper insight in power attacks. Students learn to implement various profiled and non-profiled attacks and get familiar with higher-order attacks. They also get practice in both designing the SCA countermeasures and analyzing the amount and characteristics of the side-channel information leakage.					
NI-IAM	Internet and Multimedia			Z,ZK	4
The NI-IAM course is focused on principles and modern technologies for network transmissions of audiovisual (AV) signals. The syllabus includes acquisition of AV signals (input), presentation of AV signals (output), network communication protocols, device interfaces, codecs, data formats and stereoscopy. We will look at practical use case scenarios of real-time audiovisual transmissions. Within the labs, students will practically assemble AV transmission chains using HW and SW technologies and verify the effect of various components on the quality and latency of AV transmissions. Students will learn how to build Internet infrastructure for end-to-end AV transmissions from the recording the scene up to the presentation for audience.					

<b>NI-IBE</b>	<b>Information Security</b>	<b>ZK</b>	<b>2</b>
Students learn information and IS/ICT security management systems (ISMS), methods for information access control, and basic norms and international standards in this area. They understand methods for management of internal and external security threats, for IS/IT security audits, and for application security testing (e.g., penetration testing).			
<b>NI-IKM</b>	<b>Internet and Classification Methods</b>	<b>Z,ZK</b>	<b>4</b>
In this course, the students get acquainted with classification methods used in four important internet, or generally network applications: in spam filtering, in recommendation systems, in malware detection systems and in intrusion detection systems. However, they will learn more than only how classification is performed when solving these four kinds of problems. On the background of these applications, they get an overview of the fundamentals of classification methods. The course is taught in a 2-weeks cycle with 2-hour lectures and 2-hour exercises. During the exercises, the students on the one hand implement simple examples to topics from the lectures, on the other hand consult their semester tasks.			
<b>NI-IOS</b>	<b>Advanced techniques in iOS applications</b>	<b>KZ</b>	<b>4</b>
Students will learn the latest trends in mobile development technologies for iOS platform. Class covers advanced topics, students need to know all the basics from the beginners class BI-IOS.			
<b>NI-IOT</b>	<b>Internet of Things</b>	<b>Z,ZK</b>	<b>4</b>
The subject is focused on the area of hardware and software technologies for the strongly growing computer support of various devices. Its goal is familiarization with available development elements (Raspberry Pi, Arduino Due) and with the language for efficient application development and modification (GNU Forth).			
<b>NI-IVS</b>	<b>Intelligent embedded systems</b>	<b>KZ</b>	<b>4</b>
Intelligent embedded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The course is an advance version of the Intelligent embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot programming and advance application development. Lectures provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, students develop advanced applications combining knowledge of various courses like nature inspired algorithms, data mining algorithms, image recognition and web technologies			
<b>NI-KOD</b>	<b>Data Compression</b>	<b>Z,ZK</b>	<b>5</b>
Students are introduced to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data compression methods being used in practice. The overview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, students learn the fundamentals of lossy data compression methods used in image, audio, and video compression.			
<b>NI-KOP</b>	<b>Combinatorial Optimization</b>	<b>Z,ZK</b>	<b>6</b>
The students will gain knowledge and understanding necessary deployment of combinatorial heuristics at a professional level. They will be able not only to select and implement but also to apply and evaluate heuristics for practical problems.			
<b>NI-KTH</b>	<b>Combinatorial Theories of Games</b>	<b>Z,ZK</b>	<b>4</b>
Traditional game theory is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory studies the behaviour of agents (players) of a certain competitive process by designing a mathematical model and investigating the strategies. The traditional task of classical game theory is to find the equilibria, which are the states of the game where no player wants to deviate from his strategy. Historically, the second big development in game theory of two-player full-information combinatorial games, was by Conway, Berlekamp and Guy. They developed a theory, originally used for solving end-games in Go, into a full fledged field. The idea is to evaluate games such that otherwise incompatible games can be added, that is, played simultaneously. This led to the algebraic approach to study combinatorial games. The third most important step is the work of Beck, who established the theory of positional games (like tic-tac-toe and hex). In analysis of these game, one cannot escape the brute-force traversal of the game tree, which is no efficient. Beck introduced the "false probabilistic method", which aims to tackle this problem. In this course we build the foundation of the theory of combinatorial and positional games. We focus on theoretical analysis of games and building the theory, not on the programming aspects of game solving algorithms. The course requires independent work, ability to mathematically analyse, think and proof. The course is also suitable for bachelors student in the third year, who attended introduction to graph theory, as well as for PhD students looking for research topics.			
<b>NI-KYB</b>	<b>Cybernality</b>	<b>ZK</b>	<b>5</b>
Students get acquainted with the fundamentals of legislation and international activities in the area of fighting cybercrime. Students will understand the classification of attacks and have an overview of systems for computer surveillance and traffic monitoring in the cyberspace. Students will also familiarize themselves with hacker activities and behavior. The course will also discuss the cooperation of the state agencies and subjects dealing with defence of the cyberspace (especially CSIRT and CERT teams).			
<b>NI-LOM</b>	<b>Linear Optimization and Methods</b>	<b>Z,ZK</b>	<b>5</b>
Students learn the applications of optimization methods in computer science, economics, and industry. They are aware of practical importance of linear and integer programming. They are able to work with optimization software and are familiar with languages used in programming of that software. They get skills in formalization of optimization problems in computer science (such as scheduling of tasks to processors, analysis of network flows), distribution and allocation of resources (transportation problems, travelling salesman problems, etc.), issues from economics, and modelling of conflicts via the game theory. They get an overview of computational complexity of optimization problems. They get orientation in algorithms in linear programming.			
<b>NI-LSM2</b>	<b>Statistical Modelling Lab</b>	<b>KZ</b>	<b>5</b>
The topic of LSM2 is advanced multiple target tracking (MTT). This domain covers simultaneous tracking of multiple targets using radar under the presence of clutter, or video tracking. We aim at the state-of-the-art filters, in particular the PHD (Probability Hypothesis Density) and PMBM (Poisson Multi-Bernoulli) filters.			
<b>NI-MCC</b>	<b>Multicore CPU Computing</b>	<b>Z,ZK</b>	<b>5</b>
Students will get acquainted in detail with hardware support and programming technologies for the creation of parallel multithreaded computations on multicore processors with shared and virtually shared memories, which are today the most common computing nodes of powerful (super)computer systems. Students will gain knowledge of architecturally specific optimization techniques used to reduce the performance drop due to the widening gap between the computational requirements of multi-core CPUs and memory interface throughput. On specific non-trivial multithreaded programs, students will also learn the basics of the art of creating these applications.			
<b>NI-MEP</b>	<b>Modelling of Enterprise Processes</b>	<b>Z,ZK</b>	<b>5</b>
The subject is focused on introduction to the discipline of Enterprise Engineering. Students learn the importance of a proper methodological approach for (re)engineering and implementation of processes, organisation structures and information support in big enterprises and institutions.			
<b>NI-MLP</b>	<b>Machine Learning in Practice</b>	<b>Z,ZK</b>	<b>5</b>
Applying machine learning methods to real projects in practice involves many other necessary tasks - from understanding the intentions of the client to, ideally, technical implementation. The course guides students through all phases of a project according to the standard CRISP-DM methodology, not only theoretically but also practically. The aim is to experience real data processing and learn how to describe the whole process from exploration to evaluation of the model performance in the form of a clear and understandable report.			
<b>NI-MOP</b>	<b>Modern Object-Oriented Programming in Pharo</b>	<b>KZ</b>	<b>4</b>
Object-oriented programming is currently one of the most widespread paradigms of software creation, especially enterprise information systems, where its ability to natural abstraction is used to build complex modern applications. In this course, we build on the knowledge acquired in the course BI-OOP and aim to further deepen the skills of design and implementation of object systems in modern pure object system Pharo ( <a href="https://pharo.org">https://pharo.org</a> ). The course focuses on individual approach to students, their development needs and areas of interest. In addition to deepening object programming skills, which are generally applicable in other OO languages, students will also gain the opportunity to work on interesting projects and OO technologies in terms of semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involvement in the Pharo Consortium.			
<b>NI-MPI</b>	<b>Mathematics for Informatics</b>	<b>Z,ZK</b>	<b>7</b>
The course comprises topics from general algebra with focus on finite structures used in computer science. It includes topics from multi-variate analysis, smooth optimization and multi-variate integration. The third large topic is computer arithmetics and number representation in a computer along with error manipulation. The last topic includes selected numerical algorithm and their stability analysis. The topics are completed with demonstration of applications in computer science. The course focuses on clear presentation and argumentation.			

NI-MPJ	Modelling of Programming Languages	Z,ZK	5
The analysis, transformation, and code generation processes depend on the semantics of the language; in particular, they are correct if they preserve the semantics of the language. This course explores the semantics of programming languages. The students will learn the language models with emphasis on functional languages, students are expected to understand the basics of the lambda calculus and here get acquainted with the advanced lambda calculus. The students also get hands-on-experience with semantic modeling and execution tools.			
NI-MPL	Managerial Psychology	ZK	2
NI-MPR	Master Project	Z	7
1. At the beginning of the semester, a student reserves her/his final thesis topic and gets together with its supervisor. Together they decide on partial tasks that should be carried out during the semester. If the requirements they agreed upon are met, the supervisor awards the student an assessment for the course MI-MPR at the end of the semester. 2. External Master these (MT) supervisor fills his/her assessment into the paper "Form to award assessment by an external Final theses (FT) supervisor" (for the courses BIE-BAP, MIE-MPR, MIE-DIP). Students, then, ensure that the assessment is registered into the information system (IS) by asking their internal FT opponent to award the assessment to the IS based on the confirmation of the external MT supervisor. In the case the FT opponent is external as well, the assessment will be registered to the IS by the head of the department responsible for the topic of the MT. 3. If the FT topic that the student has reserved is rather general, the immediate tasks the supervisor assigns to the student for the upcoming semester should aim at fine-tuning the FT topic so that the FTT will be complete and approvable at the end of the semester.			
NI-MSI	Mathematical Structures in Computer Science	Z,ZK	4
Mathematical semantics of programming languages. Data types as continuous lattices, Scott topology. Procedures as continuous mappings. The Scott model of lambda calculus. Introduction to category theory.			
NI-MTI	Modern Internet Technologies	Z,ZK	5
SYNOPSIS The subject "Modern Internet Technologies" is designed on four major pillars of networking: 1. Unified Communication and Collaboration - A single network, oriented on TCP/IP is able to carry whatever types of protocols for whatever purposes. This architecture is able to be protocol independent and carries voice, video and data to achieve seamless integrated services. 2. Design of Extremely Scalable Networks - This provides the insights of network architectures which can accommodate hundreds of millions of users and billions of devices. Thus, there is a paradigm switch from LANs (Local Area Networks) to SPs (Service Providers). 3. Traffic Segregation, Traffic Matching and Traffic Prioritisation - These technologies allow service providers to create private channels of communication between customers, with guaranteed parameters (bandwidth, delay, jitter, type of protocol). 4. Acceleration Technologies - They allow traffic to be carried at the optimal speed and allow for graceful degradation of service parameters in case of failures.			
NI-MVI	Computational Intelligence Methods	Z,ZK	5
Students will understand methods and techniques of computational intelligence that are mostly nature-inspired, parallel by nature, and applicable to many problems. They will learn how these methods work and how to apply them to problems related to data mining, control, intelligent games, optimizations, etc.			
NI-MZI	Mathematics for data science	Z,ZK	4
In this course, students are introduced to those fields of mathematics that are necessary for understanding standard methods and algorithms used in data science. The studied topics include mainly: linear algebra (matrix factorisations, eigenvalues, diagonalization), continuous optimisation (optimisation with constraints, duality principle, gradient methods) and selected notions from probability theory and statistics.			
NI-NMU	New media in art and design	ZK	3
The course introduces students to the issue of using new media in artistic and design work. Key topics are moving image, internet, computer game and sound. The main goal is to familiarize the student with the largest possible range of creative approaches in new media. The subject emphasizes dialogue with students, especially in lectures devoted to specific art projects.			
NI-NON	Nonlinear Continuous Optimization and Numerical Methods	Z,ZK	5
Students will be introduced to nonlinear continuous optimization, principles of the most popular methods of optimization and applications of such methods to real-world problems. They will also learn the finite element method and the finite difference method used for solving ordinary and partial differential equations in engineering. They will learn to solve systems of linear algebraic equations that arise from discretization of the continuous problems by direct and iterative algorithms. They will also learn to implement these algorithms sequentially as well as in parallel.			
NI-NSS	Normalized Software Systems	ZK	5
Students will learn the foundations of normalized systems theory that studies the evolvability of modular structures based on concepts from engineering, such as stability from system theory and entropy from thermodynamics. Students will understand a set of principles that indicate where violations of stability and entropy-related issues occur in any given software architecture. In the second part of the course, students learn how to construct software architectures using a set of 5 design patterns called elements. These elements provide the core functionality of information systems in terms of storing data, executing actions, workflows, connectors, and triggers, while handling violations of the stability and entropy-related principles. This knowledge allows students to realize new levels of evolvability in software architectures.			
NI-NUR	User Interface Design	Z,ZK	5
Students will understand the theoretical background of human-computer interaction and user interface (UI) design, will learn formal description of UIs, formal user models, the fundamental notions and procedures. They get acquainted with graphical, speech, and multimodal UIs. Thanks to the gained knowledge, the students will be able to design advanced UIs.			
NI-OLI	Linux Drivers	Z,ZK	4
The Linux operating system is an important operating system for personal computer and also for embedded systems. Systems on chip and combining powerful processors and FPGAs increase the variability of peripheral subsystems requiring specific software drivers. This course is an advanced course in the Linux driver development for master's students. The course provides knowledge of Linux operating system architecture, principles of development of various types drivers, including practical experience.			
NI-OSY	Operating Systems and Systems Programming	Z,ZK	5
The course covers system programming in UNIX environment. Emphasis is given on kernel development with focus on kernel architecture and kernel data structures. Key topics are: process management, memory management, file operations and architecture of modern file systems, device drivers and network programming. The course also addresses kernel development process, upgrades of existing kernels, kernel booting, debugging using dynamic instrumentation, and techniques to guarantee portability. Specifics of kernel architecture in embedded and real-time operating systems are also discussed. Theoretical and general principles are demonstrated on the LINUX kernel. Within labs, students will work on projects focused on development of LINUX kernel modules.			
NI-PAM	Efficient Preprocessing and Parameterized Algorithms	Z,ZK	4
There are many optimization problems for which no polynomial time algorithms are known (e.g. NP-complete problems). Despite that it is often necessary to solve these problems exactly in practice. We will demonstrate that many problems can be solved much more effectively than by naively trying all possible solutions. Often one can find a common property (parameter) of the inputs from practice-e.g., all solutions are relatively small. Parameterized algorithms exploit that by limiting the time complexity exponentially in this (small) parameter and polynomially in the input size (which can be huge). Parameterized algorithms also represent a way to formalize the notion of effective polynomial time preprocessing of the input, which is not possible in the classical complexity. Such a polynomial time preprocessing is then a suitable first step, whatever is the subsequent solution method. We will present a plethora of parameterized algorithm design methods and we will also show how to prove that for some problem (and parameter) such an algorithm (presumably) does not exist. We will also not miss out the relations to other approaches to hard problems such as moderately exponential algorithms or approximation schemes.			
NI-PAS	Advanced Aspects of Business	Z,ZK	4
The aim of the course is to provide students with advanced (compared to the bachelor's degree) knowledge and skills needed to establish and run their own business or business management, especially in law, administration (necessary steps and documents), business economics, foreign trade and related aspects.			



<b>NI-PDB</b>	<b>Advanced Database Systems</b>	<b>Z,ZK</b>	<b>5</b>
Students orient themselves in problems of evaluation and optimization of SQL queries. The next part of the course deals with new concepts of database machines (so called NoSQL databases), with the related new data models (XML, graph databases, column databases) and languages for working with them (XQuery, XPath, CYPHER, Gremlin). The last part of the course deals with performance evaluation of database machines.			
<b>NI-PDD</b>	<b>Data Preprocessing</b>	<b>Z,ZK</b>	<b>5</b>
Students learn to prepare raw data for further processing and analysis. They learn what algorithms can be used to extract information from various data sources, such as images, texts, time series, etc., and learn the skills to apply these theoretical concepts to solve specific problems in individual projects - e.g., extraction of characteristics from images or from web pages.			
<b>NI-PDP</b>	<b>Parallel and Distributed Programming</b>	<b>Z,ZK</b>	<b>6</b>
21st century in computer architectures is primarily influenced by the shift of the Moore's law into parallelization of CPUs at the level of computing cores. Parallel computing systems are becoming a ubiquitous commodity and parallel programming becomes the basic paradigm of development of efficient applications for these platforms. Students get acquainted with architectures of parallel and distributed computing systems, their models, theory of interconnection networks and collective communication operations, and languages and environments for parallel programming of shared and distributed memory computers. They get acquainted with fundamental parallel algorithms and on selected problems, they will learn the techniques of design of efficient and scalable parallel algorithms and methods of performance evaluation of their implementations. The course includes a semester project of practical programming in OpenMP and MPI for solving a particular nontrivial problem.			
<b>NI-PG1</b>	<b>Computer Graphics 1</b>	<b>ZK</b>	<b>4</b>
The course builds on graphic courses (mainly BI-PGA and BI-PGR) and the knowledge from these courses is deepened by state-of-the-art knowledge. The course is designed for those interested in advanced computer graphics. Students will gain practical knowledge with realistic texturing and raytracing methods. An integral part of the course is the study of scientific articles and their subsequent implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and topics of computer graphics.			
<b>NI-PIS</b>	<b>Enterprise Information Systems</b>	<b>Z,ZK</b>	<b>5</b>
The course is focused on the current IT requirements of large companies in the Czech Republic (Top 100). The basis is Data management, storage of big data (BigData) and their use in BI (Business Intelligence). The principles of solving the overall architecture of information systems in the banking, insurance and telecommunications sectors will be explained on real examples. Furthermore, students will get acquainted with the life cycle of information systems in the company / organization and its impact on the business strategy of the company. Students will be acquainted with technologies that have proven themselves in the elimination of basic risks in the planning, implementation and operation of information systems in the company / organization.			
<b>NI-PON</b>	<b>Selected Topics in Optimization and Numerical mathematics</b>	<b>Z,ZK</b>	<b>5</b>
The course focuses on optimization problems that appear in the field of machine learning and artificial intelligence. Students broaden their knowledge of continuous optimization obtained in the course Mathematics for informatics. The methods are explained and described along with the details on how they are implemented on computers. Hence, the relevant concepts of numerical mathematics, mainly numerical linear algebra, are explained too.			
<b>NI-PSD</b>	<b>Public Services Design</b>	<b>KZ</b>	<b>4</b>
The course will introduce students to specifics of UX, Service design and development for public sector. We will look into the design and development process from the perspective of suppliers (devs and designers) as well as clients. In small teams students will work on projects from partner organizations and will try out collaboration with client representatives. Course is aimed at students-designers as well as clients.			
<b>NI-PSL</b>	<b>Programming in Scala</b>	<b>Z,ZK</b>	<b>4</b>
The course introduces the modern programming language Scala which exploits object-functional paradigm. Scala comprises advance language features - e.g. pattern matching and advance standard library. Scala enables to use of applications functional patterns e.g. H-List, Monads, etc. Scala is used by many powerful frameworks and libraries e.g. Play, Cassandra, Scalaz, etc.			
<b>NI-PVR</b>	<b>Advanced Virtual Reality</b>	<b>KZ</b>	<b>4</b>
The course introduces advanced parts of the virtual reality. It is a continuation of the already running graphic objects, especially the creation of 3D models in Blender, and among other things, it introduces students to their application in virtual reality. Lectures will focus on virtual reality technology, its use in various applications and will also deal with creating applications in available 3D engines (mainly Unity3D). The course is freely connected with the subject VHS (virtual game worlds), students will be able to apply the knowledge gained in this subject in virtual reality, or directly create a complex game for VR.			
<b>NI-PVS</b>	<b>Advanced embedded systems</b>	<b>Z,ZK</b>	<b>4</b>
The course is focused on ARM processors and microcontrollers and their usage in wide range of applications. The course includes a series of advanced topics like security support, working with mass storage devices, motor control, system control and industrial communication. The students obtain both theoretical and also practical experiences with embedded systems.			
<b>NI-PYT</b>	<b>Advanced Python</b>	<b>KZ</b>	<b>4</b>
The goal of this course is to learn various advanced techniques and methods in Python. The course indirectly continues where Programming in Python (BI-PYT) left of. The course is very hands-on and it has only tutorials, everything is demonstrated on examples. Classification is based on work in class as well as semestral coursework. The course is lead by external teachers from Red Hat.			
<b>NI-ROZ</b>	<b>Pattern Recognition</b>	<b>Z,ZK</b>	<b>5</b>
The aim of the module is to give a systematic account of the major topics in pattern recognition with emphasis on problems and applications of the statistical approach to pattern recognition. Students will learn the fundamental concepts and methods of pattern recognition, including probability models, parameter estimation, and their numerical aspects.			
<b>NI-RUB</b>	<b>Programming in Ruby</b>	<b>KZ</b>	<b>4</b>
This course is presented in Czech.			
<b>NI-RUN</b>	<b>Runtime Systems</b>	<b>Z,ZK</b>	<b>5</b>
As the abstraction level of programming languages steadily rises, modern programs require greater and greater support during their runtime. This course introduces students to various aspects of the runtime support, such as runtime-effective program description, memory management support and garbage collection, just-in-time compilation, and interoperability with other languages and systems.			
<b>NI-SCE1</b>	<b>Computer Engineering Seminar Master I</b>	<b>Z</b>	<b>4</b>
The Seminar of Computer Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance to failures and attacks. Students are approached individually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the subject is work with scientific articles and other professional literature and/or work in K N laboratories. The capacity of the subject is limited by the possibilities of the seminar teachers. The topics are new for each semester.			
<b>NI-SCE2</b>	<b>Computer Engineering Seminar Master II</b>	<b>Z</b>	<b>4</b>
The Seminar of Computer Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance to failures and attacks. Students are approached individually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the subject is work with scientific articles and other professional literature and/or work in K N laboratories. The capacity of the subject is limited by the possibilities of the seminar teachers. The topics are new for each semester.			
<b>NI-SCR</b>	<b>Statistical Analysis of Time Series</b>	<b>Z,ZK</b>	<b>5</b>
The course deals with the practical use of the basic time series modelling theory in engineering tasks, ranging from economics (stock exchange prices, employment) and industrial problems (modelling of signals and processes) to computer networks (network components load, attacks detection). The students learn to select a convenient process model, estimate			

its parameters, analyze its properties and use it for forecasting of future or intermediate values. The stress is put on understanding and adoption of the main principles based on practical real-world examples. Both the lab classes and the lectures exploit freely available software packages in order to provide easy and straightforward transfer of students' knowledge from the academic to the real world.

NI-SEP	World Economy and Business	Z,ZK	4
This course is presented in Czech. However, there is an English variant in the program Informatics (N1801 / 4793). The course introduces students of technical university to the international business. It does that predominantly by comparing individual countries and key regions of world economy. Students get to know about different religions and cultures, necessary for doing business in diverse societies as well as indexes of economic freedom, corruption and economic development, which are needed for the right investment decision. Seminars help to improve on the knowledge in the form of discussions based on individual readings. It is advised to take bachelor level of this course BIE-SEP as a prerequisite.			
NI-SIB	Network Security	Z,ZK	5
NI-SIM	Digital Circuit Simulation and Verification	Z,ZK	5
The aim of the course is to acquaint the students with principles of digital circuit simulation at RTL (Register Transfer Level) and TLM (Transaction Level Modeling) levels and with the properties of proper tools. The course covers recent verification methods, too.			
NI-SWE	Semantic Web and Knowledge Graphs	Z,ZK	5
The students will learn the most recent concepts and technologies of the Semantic Web. The course will provide an overview of the Semantic Web technologies, methods and best practices for modelling, integration, publishing, querying and consumption of semantic data. The students will also gain skills in creation of knowledge graphs and their systematic quality assurance.			
NI-SYP	Parsing and Compilers	Z,ZK	5
The module builds upon the knowledge of fundamentals of automata theory, formal language and formal translation theories. Students gain knowledge of various variants and applications of LR parsing and are introduced to special applications of parsers, such as incremental and parallel parsing.			
NI-SZ1	Knowledge Engineering Seminar Master I	Z	4
On this seminar you will present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top research labs around the world. Additionally, you will learn how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top machine learning and AI conferences and summer schools, as well as FIT's own Summer Research Program (VyLet).			
NI-SZ2	Knowledge Engineering Seminar Master II	Z	4
On this seminar you will present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top research labs around the world. Additionally, you will learn how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top machine learning and AI conferences and summer schools, as well as FIT's own Summer Research Program (VyLet).			
NI-TES	Systems Theory	Z,ZK	5
Today, humankind has the ability to develop systems of incredible complexity (e.g., trains, microprocessors, airplanes, nuclear power plants). However, the costs of managing this complexity and of ensuring the correct behavior of a given system have become critical. A key technique for mastering this complexity is the usage of models that describe only those aspects of the systems that are important for the task at hand, and automated tools for analyzing those models. This subject will present theory and algorithms that form the basis for the modeling and analysis of complex systems.			
NI-TKA	Category Theory	Z,ZK	4
NI-TNN	Theory of Neural Networks	Z,ZK	5
In this course, we study neural networks from the point of view of the theory of function approximation and from the point of view of probability theory. At first, we recall basic concepts pertaining to artificial neural Networks, such as neurons and connections between them, types of neurons from the point of view of signal transmission, network topology, somatic and synaptic mappings, network training, and the role of time in neural networks. In connection with network topology, we get acquainted with its transformation into a canonical topology, and in connection with somatic and synaptic mappings, with their composition into mappings computed by the Network. Finally in connection with training, we pay attention to the problem of overtraining and to the fact that training is actually a specific optimization task, recalling the most typical objective functions and the most important optimization methods employed for neural network training. We will see the meaning of all these concepts in the context of common kinds of forward neural networks. Within the topic approximation approach to neural networks, we first notice the connection of neural networks to expressing functions of many variables using functions of fewer variables (Kolmogorov theorem, Vituškin theorem). Afterwards, we will see how the universal approximation capacity of neural networks can be mathematically formalized as the sets of mappings computed by neural networks being dense in important Banach spaces of functions, in particular in the spaces of continuous functions, spaces of functions integrable with respect to a finite measure, spaces of functions with continuous derivatives, and Sobolev spaces. Within the topic probabilistic approach, we first get acquainted with training based on expectation and training based on a random sample, and with probabilistic assumptions about training data with which those two kinds of neural networks can be employed. We will see how it is possible to get an estimate of the conditional expectancy of network outputs conditioned by its inputs using the expectancy based learning. We recall the strong and the weak law of large numbers and get acquainted with an analogy of the strong law of large numbers for neural networks and with the assumptions for its validity. Finally, we recall the central limit theorem, get acquainted with its analogy for neural networks, with the assumptions for its validity and with the hypothesis tests based on it. We will see how those tests can be employed to search for the topology of the network.			
NI-TS1	Theoretical Seminar Master I	Z	4
Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar.			
NI-TS2	Theoretical Seminar Master II	Z	4
Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar.			
NI-TS3	Theoretical Seminar Master III	Z	4
Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar.			
NI-TS4	Theoretical Seminar Master IV	Z	4
Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar.			
NI-TSP	Testing and Reliability	Z,ZK	5
Students will gain knowledge about circuit testing and about methods for increasing reliability and security. They will get practical skills to be able to prepare a test set with the help of the intuitive path sensitization and to use an ATPG for automatic test generation. They will be able to design easily testable circuits and systems with built-in-self-test equipment. They will be able to compute, analyze, and control the reliability and availability of the designed circuits.			
NI-TSW	Software Product Development	KZ	4
The course is presented in Czech.			

NI-TVRR	Virtual Reality Technology	Z,ZK	3
Students will be introduced to the basic concepts of virtual reality. Techniques for displaying virtual worlds (CAVE, HMD, ...) and the possibilities of controlling virtual avatars (position tracking, hand tracking, eye tracking) will be discussed. Furthermore, the concepts of mixed and augmented reality will be introduced. Finally, ways of using virtual and augmented reality will be presented.			
NI-UMI	Artificial intelligence	Z,ZK	5
The course covers search and inference algorithms in major formal paradigms used in artificial intelligence such as logic theories, constraint programming and automated planning. The main principles and practical applications of discussed techniques will be illustrated.			
NI-VCC	Virtualization and Cloud Computing	Z,ZK	5
Students will gain knowledge of architectures of large computer systems that are used in data centers and computer infrastructure of companies and organizations. They will get acquainted with virtualization principles, tools and technologies that serve to facilitate and automate configuration, testing and monitoring, and to efficiently operate and optimize the performance parameters of modern computer systems. Theoretically and practically, they will get acquainted with containerization as the most effective technology today for the management of complex computer systems and with specific technologies of cloud systems. Finally, they will learn the principles and gain practical skills in the use of modern integration and development tools (Continuous integration and development).			
NI-VMM	Retrieval from Multimedia	Z,ZK	5
The student obtains general knowledge regarding interfaces of portals providing multimedia content, the principles of similarity search, the methods of feature extraction from multimedia objects, indexing, and structure of distributed search engines.			
NI-VOL	Elections	Z,ZK	5
We will cover the basics of (committee) elections and, in general, opinion aggregation.			
NI-VPR	Research Project	Z	5
Student obtains the credits for published scientific outputs. The details are at <a href="https://courses.fit.cvut.cz/NI-VPR/en">https://courses.fit.cvut.cz/NI-VPR/en</a> .			
NI-VSM	Selected statistical Methods	Z,ZK	7
The course leads the student through advanced probabilistic and statistical methods used in information technology praxis. Particularly it deals with multivariate normal distribution, application of entropy in coding theory, hypothesis testing (T-tests, goodness of fit tests, independence test). Second part of the course deals with random processes with focus on Markov chains. The high point of the course is the Queuing theory and its application in networks.			
NI-VYC	Computability	Z,ZK	4
Classical theory of recursive functions and effective computability.			
NI-ZS10	Master internship abroad for 10 credits	Z	10
Each student can once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institution. Before the internship the Dean of the FIT, or the vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and extent of the internship. Auxiliary courses MI-ZS10, MI-ZS20, MI-ZS30 are used for the evidence and evaluation of the internship in IS KOS. Every 10 credits correspond to 4 weeks of full-time employment with a foreign institution. The maximum number of credits a student can earn for one internship is 30 credits. This amount can be divided into two subjects if the internship exceeds the academic year's dead-line.			
NI-ZS20	Master internship abroad for 20 credits	Z	20
Each student can once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institution. Before the internship the Dean of the FIT, or the vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and extent of the internship. Auxiliary courses MI-ZS10, MI-ZS20, MI-ZS30 are used for the evidence and evaluation of the internship in IS KOS. Every 10 credits correspond to 4 weeks of full-time employment with a foreign institution. The maximum number of credits a student can earn for one internship is 30 credits. This amount can be divided into two subjects if the internship exceeds the academic year's dead-line.			
NI-ZS30	Master internship abroad for 30 credits	Z	30
The course is presented in chzech language. Each student can once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institution. Before the internship the Dean of the FIT, or the vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and extent of the internship. Auxiliary courses MI-ZS10, MI-ZS20, MI-ZS30 are used for the evidence and evaluation of the internship in IS KOS. Every 10 credits correspond to 4 weeks of full-time employment with a foreign institution. The maximum number of credits a student can earn for one internship is 30 credits. This amount can be divided into two subjects if the internship exceeds the academic year's dead-line.			
NIE-BLO	Blockchain	Z,ZK	5
Students will understand the foundations of blockchain technology, smart contract programming, and gain an overview of most notable blockchain platforms. They will be able to design, code and deploy a secure decentralized application, and assess whether integration of a blockchain is suitable for a given problem. The course places an increased emphasis on the relationship between blockchains and information security. It is concluded with a defense of a research or applied semester project, which prepares the students for implementing or supervising implementation of blockchain-based solutions in both academia and business.			
NIE-PDL	Practical Deep Learning	KZ	5
This course is designed to provide students with a comprehensive understanding of Deep Learning using PyTorch, a popular open-source machine learning framework. Throughout the course, students will develop practical skills in building and training deep neural networks, using PyTorch to solve real-world problems in fields such as computer vision and natural language processing.			
NIE-PML	Personalized Machine Learning	Z,ZK	5
Personalized machine learning (PML) is a sub-field of machine learning that aims to create models and predictions based on the unique characteristics and behaviors of individual entities. While PML is commonly used in applications such as recommender systems, which recommend items to users based on their personal interests, its principles can be applied to a wide range of other fields, including education, medicine, and chemical engineering. In this course, we will explore the latest PML methods from theoretical, algorithmic, and practical perspectives. Specifically, we will focus on cutting-edge models that are of interest to both the research and commercial communities.			
PI-SCN	Seminars on Digital Design	ZK	4
This subject deals with problems of realization and implementation of digital circuits - both combinational and sequential. Basic means of description of digital circuits and basic logic synthesis and optimization algorithms are described. Basics of EDA (Electronic Design Automation) systems are given, together with combinatorial problems emerging in EDA.			

For updated information see <http://bilakniha.cvut.cz/en/FF.html>

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