Study plan

Name of study plan: Master Programme Informatics, unspecified Specialization, in English, 2021

Faculty/Institute/Others:
Department:
Branch of study guaranteed by the department: Welcome page
Garantor of the study branch:
Program of study: Informatics
Type of study: Follow-up master full-time
Required credits: 63
Elective courses credits: 57
Sum of credits in the plan: 120
Note on the plan: This version of the study plan is intended for students who have been admitted to study from the academic year 2024/2025 to the full-time form of the Master's degree programme, when applicants are admitted to study in the degree programme and choose a specialisation later. In addition to credits for compulsory courses of the programme, the student must obtain all credits for the compulsory courses of spacialisation in which he or she intends to profile during the study. In total, he or she must obtain a minimum of 120 credits.

Name of the block: Compulsory courses in the program
Minimal number of credits of the block: 63
The role of the block: PP

Code of the group: NIE-PP.21
Name of the group: Compulsory Courses of Master Study Program, Version 2021
Requirement credits in the group: In this group you have to gain 63 credits
Requirement courses in the group: In this group you have to complete 6 courses
Credits in the group: 63
Note on the group:

Code	Name of the course / Name of the group of courses *(in case of groups of courses the list of codes of their members)* *Tutors, **authors** and guarantors (gar.)*	Completion	Credits	Scope	Semester	Role
NIE-KOP	**Combinatorial Optimization** *Petr Fišer, Jan Schmidt **Petr Fišer** Petr Fišer (Gar.)*	Z,ZK	6	3P+1C	Z	PP
NIE-DIP	**Diploma Thesis** *Zdeněk Muzikář **Zdeněk Muzikář** Zdeněk Muzikář (Gar.)*	Z	30	270ZP	L,Z	PP
NIE-MPR	**Master Project** ***Zdeněk Muzikář*** *Zdeněk Muzikář (Gar.)*	Z	7		Z,L	PP
NIE-MPI	**Mathematics for Informatics** *Francesco Dolce **Štěpán Starosta** Štěpán Starosta (Gar.)*	Z,ZK	7	3P+2C	Z	PP
NIE-PDP	**Parallel and Distributed Programming** *Pavel Tvrdík **Pavel Tvrdík** Pavel Tvrdík (Gar.)*	Z,ZK	6	2P+2C	L	PP
NIE-VSM	**Selected statistical Methods** *Petr Novák **Pavel Hrabák** Pavel Hrabák (Gar.)*	Z,ZK	7	4P+2C	L	PP

Characteristics of the courses of this group of Study Plan: Code=NIE-PP.21 Name=Compulsory Courses of Master Study Program, Version 2021

NIE-KOP	Combinatorial Optimization	Z,ZK	6
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.			
NIE-DIP	Diploma Thesis	Z	30
NIE-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. The external supervisor enters the information on granting the credit using the form "Granting credit from the external supervisor of the final thesis" (http://fit.cvut.cz/student/studijni/formulare). The completed and signed form must be delivered in person or by email to the SZZ coordinator, who will arrange for the credit to be granted. 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.			

NIE-MPI	Mathematics for Informatics	Z,ZK	7
The course focuses on selected topics from general algebra with emphasis 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 the demonstration of applications in computer science. The course focuses on clear presentation and argumentation.			
NIE-PDP	Parallel and Distributed Programming	Z,ZK	6
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 acquianted 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.			
NIE-VSM	Selected statistical Methods	Z,ZK	7
Summary of probability theory; Multivariate normal distribution; Entropy and its application to coding; Statistical tests: T-tests, goodness of fit tests, independence test; Random processes - stacionarity; Markov chains and limiting properties; Queuing theory			

Name of the block: Elective vocational courses in the branch/specialization
Minimal number of credits of the block: 0
The role of the block: VO

Code of the group: NIE-PS-ALL.24
Name of the group: Profiling courses of all masters specializations of the Informatics program together
Requirement credits in the group:
Requirement courses in the group:
Credits in the group: 0
Note on the group: Enroll courses that will later be compulsory for the specialization in which you intend to profile.

Code	Name of the course / Name of the group of courses *(in case of groups of courses the list of codes of their members)* *Tutors, **authors** and guarantors (gar.)*	Completion	Credits	Scope	Semester	Role
DA-DRS	**Digital Risk And Security (DA-DRS)** ***Michal Valenta***	Z,ZK	6	30KP+30KC	Z	VO
NIE-KRY	**Advanced Cryptology** *Jiří Buček, Róbert Lórencz **Jiří Buček** Róbert Lórencz (Gar.)*	Z,ZK	5	2P+2C	Z	VO
NIE-PDB	**Advanced Database Systems** *Martin Svoboda **Martin Svoboda** Martin Svoboda (Gar.)*	Z,ZK	5	2P+1C	Z	VO
NIE-PIS	**Advanced Information Systems** *Petr Kroha, Petra Pavlíčková **Petra Pavlíčková** Petr Kroha (Gar.)*	Z,ZK	5	2P+1C	L	VO
NIE-AIB	**Algorithms of Information Security** *Martin Jureček, Róbert Lórencz **Martin Jureček** Róbert Lórencz (Gar.)*	Z,ZK	5	2P+1C	Z	VO
NIE-ADP	**Architecture and Design patterns** *Jiří Borský **Jiří Borský** Filip Křikava (Gar.)*	Z,ZK	5	2P+1C	Z	VO
DA-DMI	**Data Mining** ***Michal Valenta***	Z,ZK	6	30KP+30KC	Z,L	VO
NIE-SIM	**Digital Circuit Simulation and Verification** *Martin Kohlík **Martin Kohlík** Martin Kohlík (Gar.)*	Z,ZK	5	2P+1C	L	VO
DD-DIN	**Digital innovation** ***Michal Valenta***	ZK	6		Z	VO
DD-DSG	**Digital strategy and governance** ***Michal Valenta***	ZK	6	2P+2C	Z	VO
NIE-DSV	**Distributed Systems and Computing** *Pavel Tvrdík, Peter Macejko **Peter Macejko** Pavel Tvrdík (Gar.)*	Z,ZK	5	2P+1C	Z	VO
NIE-EPC	**Effective C++ programming** *Daniel Langr **Daniel Langr** Daniel Langr (Gar.)*	Z,ZK	5	2P+1C	Z	VO
NIE-EHW	**Embedded Hardware** *Jan Schmidt **Jan Schmidt** Jan Schmidt (Gar.)*	Z,ZK	5	2P+1C	Z	VO
NIE-BVS	**Embedded Security** *Jiří Buček, Martin Novotný **Martin Novotný** Martin Novotný (Gar.)*	Z,ZK	5	2P+2C	L	VO
NIE-ESW	**Embedded Software** *Hana Kubátová, Miroslav Skrbek **Miroslav Skrbek** Hana Kubátová (Gar.)*	Z,ZK	5	2P+1C	Z	VO
NIE-BKO	**Error Control Codes** *Pavel Kubalík **Pavel Kubalík** Pavel Kubalík (Gar.)*	Z,ZK	5	2P+1C	L	VO
NIE-FME	**Formal Methods and Specifications** *Stefan Ratschan **Stefan Ratschan** Stefan Ratschan (Gar.)*	Z,ZK	5	2P+1C	L	VO
NIE-GPU	**GPU Architectures and Programming** *Ivan Šimeček **Ivan Šimeček** Ivan Šimeček (Gar.)*	Z,ZK	5	2P+1C	L	VO
NIE-HWB	**Hardware Security** *Jiří Buček **Jiří Buček** Jiří Buček (Gar.)*	Z,ZK	5	2P+2C	L	VO

NIE-MKY	**Mathematics for Cryptology** *Martin Jureček, Róbert Lórencz, Olha Jurečková* ***Róbert Lórencz*** *Róbert Lórencz (Gar.)*	Z,ZK	5	3P+1C	L	VO
NIE-AM1	**Middleware Architectures 1** *Tomáš Vitvar, Milan Dojčinovski, Jaroslav Kuchař* ***Jaroslav Kuchař*** *Tomáš Vitvar (Gar.)*	Z,ZK	5	2P+1C	Z	VO
NIE-MTI	**Modern Internet Technologies** *Viktor Černý, Alexandru Moucha* ***Alexandru Moucha*** *Alexandru Moucha (Gar.)*	Z,ZK	5	2P+1C	Z	VO
NIE-MCC	**Multicore CPU Computing** *Daniel Langr, Ivan Šimeček* ***Ivan Šimeček*** *Ivan Šimeček (Gar.)*	Z,ZK	5	2P+1C	Z	VO
NIE-SIB	**Network Security** *Tomáš Zahradnický, Jiří Dostál, Simona Fornůsek, Gramoz Cubreli* ***Simona Fornůsek*** *Simona Fornůsek (Gar.)*	Z,ZK	5	2P+1C	L	VO
NIE-NSS	**Normalized Software Systems** *Jan Verelst, Robert Pergl, Marek Suchánek* ***Robert Pergl*** *Robert Pergl (Gar.)*	ZK	5	2P	L	VO
NIE-REV	**Reverse Engineering** *Josef Kokeš* ***Josef Kokeš*** *Josef Kokeš (Gar.)*	Z,ZK	5	1P+2C	Z	VO
DD-SMN	**Strategic management** ***Michal Valenta***	ZK	6	4P+0C	Z	VO
NIE-SBF	**System Security and Forensics** *Tomáš Zahradnický, Jiří Buček, Simona Fornůsek, Marián Svetlík* ***Simona Fornůsek*** *Simona Fornůsek (Gar.)*	Z,ZK	5	2P+1C	Z	VO
NIE-TES	**Systems Theory** *Tomáš Kolárik, Stefan Ratschan, Jiří Vyskočil* ***Stefan Ratschan*** *Stefan Ratschan (Gar.)*	Z,ZK	5	2P+1C	Z	VO
NIE-TSP	**Testing and Reliability** *Petr Fišer* ***Petr Fišer*** *Petr Fišer (Gar.)*	Z,ZK	5	2P+2C	Z	VO
NIE-NUR	**User Interface Design** *Josef Pavlíček* ***Josef Pavlíček*** *Josef Pavlíček (Gar.)*	Z,ZK	5	2P+1C	Z	VO
NIE-VCC	**Virtualization and Cloud Computing** *Tomáš Vondra, Jan Fesl* ***Tomáš Vondra*** *Tomáš Vondra (Gar.)*	Z,ZK	5	2P+1C	L	VO

Characteristics of the courses of this group of Study Plan: Code=NIE-PS-ALL.24 Name=Profiling courses of all masters specializations of the Informatics program together

DA-DRS	Digital Risk And Security (DA-DRS)	Z,ZK	6

Information technology has become crucial in the growth, sustainability and support of enterprises. However, the pervasive use of technologies also incurs many business risks, anging from abuse, cybercrime, fraud, errors and ommissions. The objective of this course is to understand and analyse IT related business risks and and how these risks can be translated into an appropiate information risk management and security strategy and action plan. In the course, will first discuss the basics of IT Risk, Information Security, and some of the general and specific standards and frameworks to address them. Next, we will elaborate on the IT risk management and IT security functions in an organisation. Specific attention will be given to risk assessment methods, both qualitative and quantitative. The theoretical knowledge will be applied in a group project, where students will conduct a risk assessment in a real organisation, and present the results to the responsible managers. Guarantor and teacher: MSc. Steven De Haes, Ph.D.

NIE-KRY	Advanced Cryptology	Z,ZK	5

Students will learn the essentials of cryptanalysis and the mathematical principles of constructing symmetric and asymmetric ciphers. They will know the mathematical principles of random number generators. They will have an overview of cryptanalysis methods, elliptic curve cryptography and quantum cryptography, which they can apply to the integration of their own systems or to the creation of their own software solutions.

NIE-PDB	Advanced Database Systems	Z,ZK	5

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. This course is equivalent to the course MIE-PDB.

NIE-PIS	Advanced Information Systems	Z,ZK	5

Students learn the notion of business process logic and its formalization, with business process roles, business rules, and data processing, with the notion of service oriented company, enterprise services and service solution of business logic. They get acquainted with these notions also for the other types of ISs. They learn about agility and adaptivity and using of artificial intelligence methods for implementation of these ideas in ISs. They understand modern object-oriented methodologies for modelling of business processes, business rules, processed data, and enterprise ISs. They will get the rules and technologies for successful implementation of IS.

NIE-AIB	Algorithms of Information Security	Z,ZK	5

Students will get acquainted with the algorithms of secure key generation and cryptographic error (not only biometric) data processing. Furthermore, students will learn the mathematical principles of cryptographic protocols (identification, authentication, and signature schemes). Another part of the course is dedicated to malware detection and the use of machine learning in detection systems. The last topic includes practical steganographic methods and attacks on steganographic systems.

NIE-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.

DA-DMI	Data Mining	Z,ZK	6

In the past decade, weve witnessed a huge increase in the amount of data being captured and stored. In these large datasets very useful knowledge is present, though often concealed in the vastness of the data. With data mining techniques patterns are automatically revealed from such large datasets. First, data mining techniques and applications are discussed. Next, we will go into popular predictive and descriptive data mining techniques, with applications in marketing and risk management. Also, analyses such as social network analysis, text mining, process mining, and Big Data will be looked at. Basic programming skills in Python will be learnt. The learned concepts, techniques and programming language will be applied and evaluated with a real-life case. Teaching takes place at University of Antwerpen. See the web page
https://www.uantwerpen.be/en/study/programmes/all-programmes/digital-business-engineering/about-the-programme/study-programme/

NIE-SIM	Digital Circuit Simulation and Verification	Z,ZK	5

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 today recent verification methods, too.

DD-DIN	Digital innovation	ZK	6
This course focuses on innovation in the context of the digital, software-intensive economy. Starting from a broader perspective on innovation, both mainstream theories and thinking on innovation, as well as alternative views from challengers, are discussed. This includes omnipresent innovation models in which IT-related innovations are adopted by startups and scaleups (eg. blockchains or drones) and making them available in certain business domains, which requires agility and speed of development at the software level. Also, disruptive innovation, where existing value chains are challenged, is discussed with its requirement for new levels of productivity in software development. Leading theories are discussed and illustrated with local and international cases using guest lectures. Students of a master double degree specialisation Digital Business Engineering will attend this course during their stay at the partner university Antwerp.			
DD-DSG	Digital strategy and governance	ZK	6
The course provides a complete and comprehensive overview of what digital governance entails and how it can be applied in practice. The course is organized around the following three main themes: concepts and practices of digital governance, the impact of digital governance on business/IT strategic and operational alignment, and the notion of digital value and risk. The course is based on the teacher's knowledge obtained in applied research projects on the relationship between digital governance practices and digital value. To support the student in understanding and absorbing the material provided, the course uses short assignments and case studies. Students of a master double degree specialisation Digital Business Engineering will attend this course during their stay at the partner university Antwerp			
NIE-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.			
NIE-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 effectivity and efficiency in the form of writing maintainable and portable source code and creating correct programs with low memory and processor time requirements.			
NIE-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.			
NIE-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.			
NIE-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.			
NIE-BKO	Error Control Codes	Z,ZK	5
The course expands the basic knowledge of security codes used in current systems for error detection and correction. It provides the necessary mathematical theory and principles of linear, cyclic codes and codes for the correction of multiple errors, clusters of errors and whole syllables (bytes). Students will also learn how to implement these detections and corrections for different types of transmissions (parallel, serial) when storing data in memory and when transmitting over telecommunication channels.			
NIE-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.			
NIE-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.			
NIE-HWB	Hardware Security	Z,ZK	5
The course provides the knowledge needed for the analysis and design of computer systems security solutions. Students get an overview of safeguards against abuse of the system using hardware means. They will be able to safely use and integrate hardware components into systems and test them for resistance to attacks. Students will gain knowledge about the cryptographic accelerators, PUF, random number generators, smart cards, biometric devices, and devices for internal security functions of the computer.			
NIE-MKY	Mathematics for Cryptology	Z,ZK	5
Students will gain deeper knowledge of algebraic procedures solving the most important mathematical problems concerning the security of ciphers. In particular, the course focuses on the problem of solving a system of polynomial equations over a finite field, the problem of factorization of large numbers and the problem of discrete logarithm. The problem of factorization will also be solved on elliptic curves. Students will further become familiar with modern encryption systems based on lattices.			
NIE-AM1	Middleware Architectures 1	Z,ZK	5
Students will study new trends, concepts, and technologies in the area of service-oriented architectures. The will gain an overview of information system architecture, web service architecture and aplication servers. The will also study principles and technologies for middleware focused on application integrations, asynchronous communications and high availability of applications. This course replaces the course MIE-MDW.			
NIE-MTI	Modern Internet Technologies	Z,ZK	5
Students learn advanced networking technologies and protocols for both local area networks and wide area networks. They get acquainted with routing techniques and transfer technologies of modern internet, including multimedia data transfer, with various types of network virtualization, and with last-mile security.			
NIE-MCC	Multicore CPU Computing	Z,ZK	5
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 memory, which are today the most common computing nodes of powerful computer systems. Students will gain knowledge of architecturally specific optimization techniques used to reduce the decrease in computing power due to the widening performance 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.			
NIE-SIB	Network Security	Z,ZK	5
The students will gain theoretical and practical knowledge and experience in the area of current security threats in computer networks, specifically about detection and defense. The course explains basic pricipals of security monitoring, packet-based and flow-based analysis, in order to detect anomalies and suspicious network traffic. The course focuses on explanation and practical examples of various mechanisms of securing network infrastructure and detection in real time. The course covers general principals of handling detected security events (i.e. incident handling and incident response).			

NIE-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.

NIE-REV	Reverse Engineering	Z,ZK	5

Students will learn fundamentals of reverse engineering of computer software (methods of executing and initializing programs, organization of executable files, work with third-party libraries). Special attention will be paid to C ++. Students will also become familiar with the principles of debugging tools, disassemblers and obfuscation methods. Finally, the course will focus on code compression and decompression and executable file reconstruction.

DD-SMN	Strategic management	ZK	6

In the first part of the course, the different concepts and perspectives of strategic management are analyzed. The basic characteristics of strategic thinking are being analyzed. Then the importance of mission/vision, as the starting point in strategic thinking, is being discussed. This is being linked to the broader concept of sustainability / corporate social responsibility. The remaining parts focus on the three basic dimensions of strategy: (1) the strategy content: business level strategy, corporate level strategy, and network level strategy (2) the strategy process: strategic formation, strategic change, and strategic innovation, (3) the strategy context: the industry context, the organizational context, and the international context. In each of the different chapters, the fundamental strategic management paradoxes are situated and evaluated in the strategic management theory. Attention is also given to some strategic management tools which can be used to manage the strategy process. Students of a master double degree specialisation Digital Business Engineering will attend this course during their stay at the partner university Antwerp

NIE-SBF	System Security and Forensics	Z,ZK	5

Students will be introduced to various aspects of system security (principles of endpoint security, principles of security policies, security models, authentication concepts). Students will also learn about forensic analysis as a tool for investigating security incidents (techniques used by malicious software or attackers, forensic analysis techniques, and the importance of memory or file system artifacts for attack analysis and detection).

NIE-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.

NIE-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.

NIE-NUR	User Interface Design	Z,ZK	5

Students will understand the theorical background of human-computer interaction and user interface (UI) design, will learn formal description of UIs, formal user models, the fundamental notions and procesures. They get acquainted with graphical, speech, and multimodal UIs. Thanks to the gained knowledge, the students will be able to design advanced UIs.

NIE-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).

Name of the block: Elective courses
Minimal number of credits of the block: 0
The role of the block: V

Code of the group: NIE-V.21
Name of the group: Purely elective master's courses
Requirement credits in the group:
Requirement courses in the group:
Credits in the group: 0
Note on the group:

Code	**Name of the course / Name of the group of courses** ***(in case of groups of courses the list of codes of their members)*** *Tutors,* ***authors*** *and guarantors (gar.)*	Completion	Credits	Scope	Semester	Role
NIE-BLO	**Blockchain** *Josef Gattermayer, Róbert Lórencz, Jakub Růžička, Marek Bielik* ***Josef Gattermayer*** *Róbert Lórencz (Gar.)*	Z,ZK	5	1P+2C	Z	V
NIE-CPX	**Complexity Theory** *Dušan Knop, Ondřej Suchý* ***Dušan Knop*** *Dušan Knop (Gar.)*	Z,ZK	5	3P+1C	Z	V
NIE-VYC	**Computability** *Jan Starý* ***Jan Starý*** *Jan Starý (Gar.)*	Z,ZK	4	2P+2C	L	V
NIE-MVI	**Computational Intelligence Methods** *Miroslav Čepek, Pavel Kordík* ***Pavel Kordík*** *Pavel Kordík (Gar.)*	Z,ZK	5	2P+1C	Z	V
NIE-ARI	**Computer arithmetic** *Pavel Kubalík* ***Pavel Kubalík*** *Pavel Kubalík (Gar.)*	Z,ZK	4	2P+1C	Z,L	V
NIE-SCE1	**Computer Engineering Seminar Master I** *Hana Kubátová* ***Hana Kubátová*** *Hana Kubátová (Gar.)*	Z	4	2C	Z	V
NIE-SCE2	**Computer Engineering Seminar Master II** *Hana Kubátová* ***Hana Kubátová*** *Hana Kubátová (Gar.)*	Z	4	2C	L	V

NI-DSW	**Design Sprint** *Ondřej Brém, Michal Manda **Michal Manda** David Pešek (Gar.)*	Z	2	30B	Z	v
NI-DID	**Digital drawing** *Denisa Nováčková, Eliška Novotná **Denisa Nováčková** Denisa Nováčková (Gar.)*	Z	2	4C	Z,L	v
NIE-EVY	**Efficient Text Pattern Matching** *Jan Holub **Jan Holub** Jan Holub (Gar.)*	Z,ZK	5	2P+1C	Z	v
NI-GLR	**Games and reinforcement learning** ***Juan Pablo Maldonado Lopez***	Z,ZK	4	2P+2C	L	v
NI-GRI	**Grid Computing** *André Sopczak, Petr Fiedler **Pavel Tvrdík** André Sopczak (Gar.)*	Z,ZK	5	2P+1C	Z	v
NIE-HMI	**History of Mathematics and Informatics** *Alena Šolcová **Alena Šolcová** Alena Šolcová (Gar.)*	Z,ZK	3	2P+1C	Z	v
NIE-DVG	**Introduction to Discrete and Computational Geometry** *Maria Saumell Mendiola **Maria Saumell Mendiola** Maria Saumell Mendiola (Gar.)*	Z,ZK	5	2P+1C	L	v
FITE-EHD	**Introduction to European Economic History** ***Tomáš Evan***	Z,ZK	3	2P+1C	L	v
MIE-MZI	**Mathematics for data science** ***Štěpán Starosta***	Z,ZK	4	2P+1C	L	v
NIE-AM2	**Middleware Architectures 2** *Milan Dojčinovski **Milan Dojčinovski** Milan Dojčinovski (Gar.)*	Z,ZK	5	2P+1C	L	v
NIE-OSY	**Operating Systems and Systems Programming** *Petr Zemánek **Petr Zemánek** Petr Zemánek (Gar.)*	Z,ZK	5	2P+1C	Z	v
NIE-PAM	**Parameterized Algorithms** *Ondřej Suchý **Ondřej Suchý** Ondřej Suchý (Gar.)*	Z,ZK	4	2P+1C	L	v
NIE-SYP	**Parsing and Compilers** *Jan Janoušek **Jan Janoušek** Jan Janoušek (Gar.)*	Z,ZK	5	2P+1C	Z	v
NIE-ROZ	**Pattern Recognition** *Michal Haindl **Michal Haindl** Michal Haindl (Gar.)*	Z,ZK	5	2P+1C	Z	v
NIE-PML	**Personalized Machine Learning** *Rodrigo Augusto Da Silva Alves **Karel Klouda** Rodrigo Augusto Da Silva Alves (Gar.)*	Z,ZK	5	2P+1C	Z	v
NI-AML	**Advanced machine learning** *Zdeněk Buk, Miroslav Čepek, Petr Šimánek, Rodrigo Augusto Da Silva Alves, Vojtěch Rybář **Miroslav Čepek** Miroslav Čepek (Gar.)*	Z,ZK	5	2P + 1C	L	v
NIE-PDL	**Practical Deep Learning** *Martin Barus, Yauhen Babakhin **Karel Klouda** Karel Klouda (Gar.)*	KZ	5	2P+1C	Z	v
NIE-VPR	**Research Project** *Štěpán Starosta **Štěpán Starosta** Štěpán Starosta (Gar.)*	Z	5		Z,L	v
NIE-SWE	**Semantic Web and Knowledge Graphs** *Milan Dojčinovski **Milan Dojčinovski** Milan Dojčinovski (Gar.)*	Z,ZK	5	2P+1C	Z	v
MI-SCE1	**Computer Engineering Seminar Master I** ***Hana Kubátová***	Z	4	2C	L,Z	v
NIE-HSC	**Side-Channel Analysis in Hardware** *Vojtěch Miškovský, Petr Socha **Vojtěch Miškovský** Vojtěch Miškovský (Gar.)*	Z,ZK	4	2P+2C	Z	v
NIE-DDW	**Web Data Mining** *Milan Dojčinovski **Milan Dojčinovski** Milan Dojčinovski (Gar.)*	Z,ZK	5	2P+1C	L	v
NIE-BPS	**Wireless Computer Networks** *Alexandru Moucha **Alexandru Moucha** Alexandru Moucha (Gar.)*	Z,ZK	4	2P+1C	L	v
NIE-SEP	**World Economy and Business** ***Tomáš Evan***	Z,ZK	4	2P+1C	Z	v
FITE-SEP	**World Economy and Business** ***Tomáš Evan***	Z,ZK	4	2P+2C	Z	v

Characteristics of the courses of this group of Study Plan: Code=NIE-V.21 Name=Purely elective master's courses

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-CPX	Complexity Theory	Z,ZK	5

Students will learn about the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of the theory concerning practical (in)tractability of difficult problems.

NIE-VYC	Computability	Z,ZK	4

Classical theory of recursive functions and effective computability.

NIE-MVI	Computational Intelligence Methods	Z,ZK	5

Students will understand the basic methods and techniques of computational intelligence, which are based on traditional artificial intelligence, are parallel in nature and are applicable to solving a wide range of problems. The subject is also devoted to modern neural networks and the ways in which they learn and neuroevolution. Students will learn how these methods work and how to apply them to problems related to data extraction, management, intelligence in games and optimisation, etc.

NIE-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.

NIE-SCE1	Computer Engineering Seminar Master I	Z	4
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 KČN laboratories. The capacity of the subject is limited by the possibilities of the seminar teachers. The topics are new for each semester.			
NIE-SCE2	Computer Engineering Seminar Master II	Z	4
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 KČN laboratories. The capacity of the subject is limited by the possibilities of the seminar teachers. The topics are new for each semester.			
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-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.			
NIE-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-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-GRI	Grid Computing	Z,ZK	5
Grid computing and gain knowledge about the world-wide network and computing infrastructure.			
NIE-HMI	History of Mathematics and Informatics	Z,ZK	3
The course focuses on selected topics from calculus, general algebra, number theory, numerical mathematics and logic - useful for today computer science The topics are selected for finding some relations between computer science and mathematical methods. Some examples of applications of mathematics to computer sciences will be showed.			
NIE-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.			
FITE-EHD	Introduction to European Economic History	Z,ZK	3
The course introduces a selection of themes from the European economic history. It gives the student basic knowledge about forming of the global economy through the description of the key periods in history. As European countries have been dominant actors in this process it focuses predominantly on their roles in the economic history. From large economic area of Roman Empire to fragmentation of the Middle Ages, from destruction of WWII to the current affairs, the development of modern financial institutions is deciphered. The course does not cover detailed economic history of particular European countries but rather the impact of trade and role of particular events, institutions and organizations in history. Class meetings will consist of a mixture of lecture and discussion.			
MIE-MZI	Mathematics for data science	Z,ZK	4
In this course, the students are introduced to the domains of mathematics necessary for understanding the 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.			
NIE-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, distrubuted cache and databases, smart contracts, realtime communication and web security.			
NIE-OSY	Operating Systems and Systems Programming	Z,ZK	5
This course is focused on the design and implementation of the basic components that make up modern operating systems. This includes threads, processes, switching context, virtual memory, system calls, interrupts and interactions of SW and HW using drivers. Students will learn the theory of the concept of operating system architecture with emphasis on the kernel architecture. Within the course, they will gain practical experience with the development of a small but fully functional operating system.			
NIE-PAM	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.			
NIE-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.			
NIE-ROZ	Pattern Recognition	Z,ZK	5
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.			
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.			
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.			

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-VPR	Research Project	Z	5
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.			
NIE-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.			
MI-SCE1	Computer Engineering Seminar Master I	Z	4
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 KČN laboratories. The capacity of the subject is limited by the possibilities of the seminar teachers. The topics are new for each semester.			
NIE-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.			
NIE-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.			
NIE-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.			
NIE-SEP	World Economy and Business	Z,ZK	4
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.			
FITE-SEP	World Economy and Business	Z,ZK	4
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.			

List of courses of this pass:

Code	Name of the course	Completion	Credits
DA-DMI	Data Mining	Z,ZK	6
In the past decade, weve witnessed a huge increase in the amount of data being captured and stored. In these large datasets very useful knowledge is present, though often concealed in the vastness of the data. With data mining techniques patterns are automatically revealed from such large datasets. First, data mining techniques and applications are discussed. Next, we will go into popular predictive and descriptive data mining techniques, with applications in marketing and risk management. Also, analyses such as social network analysis, text mining, process mining, and Big Data will be looked at. Basic programming skills in Python will be learnt. The learned concepts, techniques and programming language will be applied and evaluated with a real-life case. Teaching takes place at University of Antwerpen. See the web page https://www.uantwerpen.be/en/study/programmes/all-programmes/digital-business-engineering/about-the-programme/study-programme/			
DA-DRS	Digital Risk And Security (DA-DRS)	Z,ZK	6
Information technology has become crucial in the growth, sustainability and support of enterprises. However, the pervasive use of technologies also incurs many business risks, anging from abuse, cybercrime, fraud, errors and ommissions. The objective of this course is to understand and analyse IT related business risks and and how these risks can be translated into an appropiate information risk management and security strategy and action plan. In the course, will first discuss the basics of IT Risk, Information Security, and some of the general and specific standards and frameworks to address them. Next, we will elaborate on the IT risk management and IT security functions in an organisation. Specific attention will be given to risk assessment methods, both qualitative and quantitative. The theoretical knowledge will be applied in a group project, where students will conduct a risk assessment in a real organisation, and present the results to the responsible managers. Guarantor and teacher: MSc. Steven De Haes, Ph.D.			
DD-DIN	Digital innovation	ZK	6
This course focuses on innovation in the context of the digital, software-intensive economy. Starting from a broader perspective on innovation, both mainstream theories and thinking on innovation, as well as alternative views from challengers, are discussed. This includes omnipresent innovation models in which IT-related innovations are adopted by startups and scaleups (eg. blockchains or drones) and making them available in certain business domains, which requires agility and speed of development at the software level. Also, disruptive innovation, where existing value chains are challenged, is discussed with its requirement for new levels of productivity in software development. Leading theories are discussed and			

	illustrated with local and international cases using guest lectures. Students of a master double degree specialisation Digital Business Engineering will attend this course during their stay at the partner university Antwerp.		
DD-DSG	Digital strategy and governance	ZK	6
	The course provides a complete and comprehensive overview of what digital governance entails and how it can be applied in practice. The course is organized around the following three main themes: concepts and practices of digital governance, the impact of digital governance on business/IT strategic and operational alignment, and the notion of digital value and risk. The course is based on the teacher's knowledge obtained in applied research projects on the relationship between digital governance practices and digital value. To support the student in understanding and absorbing the material provided, the course uses short assignments and case studies. Students of a master double degree specialisation Digital Business Engineering will attend this course during their stay at the partner university Antwerp		
DD-SMN	Strategic management	ZK	6
	In the first part of the course, the different concepts and perspectives of strategic management are analyzed. The basic characteristics of strategic thinking are being analyzed. Then the importance of mission/vision, as the starting point in strategic thinking, is being discussed. This is being linked to the broader concept of sustainability / corporate social responsibility. The remaining parts focus on the three basic dimensions of strategy: (1) the strategy content: business level strategy, corporate level strategy, and network level strategy (2) the strategy process: strategic formation, strategic change, and strategic innovation, (3) the strategy context: the industry context, the organizational context, and the international context. In each of the different chapters, the fundamental strategic management paradoxes are situated and evaluated in the strategic management theory. Attention is also given to some strategic management tools which can be used to manage the strategy process. Students of a master double degree specialisation Digital Business Engineering will attend this course during their stay at the partner university Antwerp		
FITE-EHD	Introduction to European Economic History	Z,ZK	3
	The course introduces a selection of themes from the European economic history. It gives the student basic knowledge about forming of the global economy through the description of the key periods in history. As European countries have been dominant actors in this process it focuses predominantly on their roles in the economic history. From large economic area of Roman Empire to fragmentation of the Middle Ages, from destruction of WWII to the current affairs, the development of modern financial institutions is deciphered. The course does not cover detailed economic history of particular European countries but rather the impact of trade and role of particular events, institutions and organizations in history. Class meetings will consist of a mixture of lecture and discussion.		
FITE-SEP	World Economy and Business	Z,ZK	4
	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.		
MI-SCE1	Computer Engineering Seminar Master I	Z	4
	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 KČN laboratories. The capacity of the subject is limited by the possibilities of the seminar teachers. The topics are new for each semester.		
MIE-MZI	Mathematics for data science	Z,ZK	4
	In this course, the students are introduced to the domains of mathematics necessary for understanding the 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-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-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-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-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-GRI	Grid Computing	Z,ZK	5
	Grid computing and gain knowledge about the world-wide network and computing infrastructure.		
NIE-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.		
NIE-AIB	Algorithms of Information Security	Z,ZK	5
	Students will get acquainted with the algorithms of secure key generation and cryptographic error (not only biometric) data processing. Furthermore, students will learn the mathematical principles of cryptographic protocols (identification, authentication, and signature schemes). Another part of the course is dedicated to malware detection and the use of machine learning in detection systems. The last topic includes practical steganographic methods and attacks on steganographic systems.		
NIE-AM1	Middleware Architectures 1	Z,ZK	5
	Students will study new trends, concepts, and technologies in the area of service-oriented architectures. The will gain an overview of information system architecture, web service architecture and aplication servers. The will also study principles and technologies for middleware focused on application integrations, asynchronous communications and high availability of applications. This course replaces the course MIE-MDW.		
NIE-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, distrubuted cache and databases, smart contracts, realtime communication and web security.		
NIE-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.		

NIE-BKO	Error Control Codes	Z,ZK	5
The course expands the basic knowledge of security codes used in current systems for error detection and correction. It provides the necessary mathematical theory and principles of linear, cyclic codes and codes for the correction of multiple errors, clusters of errors and whole syllables (bytes). Students will also learn how to implement these detections and corrections for different types of transmissions (parallel, serial) when storing data in memory and when transmitting over telecommunication channels.			
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-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.			
NIE-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.			
NIE-CPX	Complexity Theory	Z,ZK	5
Students will learn about the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of the theory concerning practical (in)tractability of difficult problems.			
NIE-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.			
NIE-DIP	Diploma Thesis	Z	30
NIE-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.			
NIE-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.			
NIE-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.			
NIE-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 effectivity and efficiency in the form of writing maintainable and portable source code and creating correct programs with low memory and processor time requirements.			
NIE-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.			
NIE-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.			
NIE-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.			
NIE-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.			
NIE-HMI	History of Mathematics and Informatics	Z,ZK	3
The course focuses on selected topics from calculus, general algebra, number theory, numerical mathematics and logic - useful for today computer science The topics are selected for finding some relations between computer science and mathematical methods. Some examples of applications of mathematics to computer sciences will be showed.			
NIE-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.			
NIE-HWB	Hardware Security	Z,ZK	5
The course provides the knowledge needed for the analysis and design of computer systems security solutions. Students get an overview of safeguards against abuse of the system using hardware means. They will be able to safely use and integrate hardware components into systems and test them for resistance to attacks. Students will gain knowledge about the cryptographic accelerators, PUF, random number generators, smart cards, biometric devices, and devices for internal security functions of the computer.			
NIE-KOP	Combinatorial Optimization	Z,ZK	6
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.			
NIE-KRY	Advanced Cryptology	Z,ZK	5
Students will learn the essentials of cryptanalysis and the mathematical principles of constructing symmetric and asymmetric ciphers. They will know the mathematical principles of random number generators. They will have an overview of cryptanalysis methods, elliptic curve cryptography and quantum cryptography, which they can apply to the integration of their own systems or to the creation of their own software solutions.			

NIE-MCC	Multicore CPU Computing	Z,ZK	5
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 memory, which are today the most common computing nodes of powerful computer systems. Students will gain knowledge of architecturally specific optimization techniques used to reduce the decrease in computing power due to the widening performance 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.			
NIE-MKY	Mathematics for Cryptology	Z,ZK	5
Students will gain deeper knowledge of algebraic procedures solving the most important mathematical problems concerning the security of ciphers. In particular, the course focuses on the problem of solving a system of polynomial equations over a finite field, the problem of factorization of large numbers and the problem of discrete logarithm. The problem of factorization will also be solved on elliptic curves. Students will further become familiar with modern encryption systems based on lattices.			
NIE-MPI	Mathematics for Informatics	Z,ZK	7
The course focuses on selected topics from general algebra with emphasis 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 the demonstration of applications in computer science. The course focuses on clear presentation and argumentation.			
NIE-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. The external supervisor enters the information on granting the credit using the form "Granting credit from the external supervisor of the final thesis" (http://fit.cvut.cz/student/studijni/formulare). The completed and signed form must be delivered in person or by email to the SZZ coordinator, who will arrange for the credit to be granted. 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.			
NIE-MTI	Modern Internet Technologies	Z,ZK	5
Students learn advanced networking technologies and protocols for both local area networks and wide area networks. They get acquainted with routing techniques and transfer technologies of modern internet, including multimedia data transfer, with various types of network virtualization, and with last-mile security.			
NIE-MVI	Computational Intelligence Methods	Z,ZK	5
Students will understand the basic methods and techniques of computational intelligence, which are based on traditional artificial intelligence, are parallel in nature and are applicable to solving a wide range of problems. The subject is also devoted to modern neural networks and the ways in which they learn and neuroevolution. Students will learn how these methods work and how to apply them to problems related to data extraction, management, intelligence in games and optimisation, etc.			
NIE-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.			
NIE-NUR	User Interface Design	Z,ZK	5
Students will understand the theorical background of human-computer interaction and user interface (UI) design, will learn formal description of UIs, formal user models, the fundamental notions and procesures. They get acquainted with graphical, speech, and multimodal UIs. Thanks to the gained knowledge, the students will be able to design advanced UIs.			
NIE-OSY	Operating Systems and Systems Programming	Z,ZK	5
This course is focused on the design and implementation of the basic components that make up modern operating systems. This includes threads, processes, switching context, virtual memory, system calls, interrupts and interactions of SW and HW using drivers. Students will learn the theory of the concept of operating system architecture with emphasis on the kernel architecture. Within the course, they will gain practical experience with the development of a small but fully functional operating system.			
NIE-PAM	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.			
NIE-PDB	Advanced Database Systems	Z,ZK	5
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. This course is equivalent to the course MIE-PDB.			
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-PDP	Parallel and Distributed Programming	Z,ZK	6
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 acquianted 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.			
NIE-PIS	Advanced Information Systems	Z,ZK	5
Students learn the notion of business process logic and its formalization, with business process roles, business rules, and data processing, with the notion of service oriented company, enterprise services and service solution of business logic. They get acquainted with these notions also for the other types of ISs. They learn about agility and adaptivity and using of artificial intelligence methods for implementation of these ideas in ISs. They understand modern object-oriented methodologies for modelling of business processes, business rules, processed data, and enterprise ISs. They will get the rules and technologies for successful implementation of IS.			
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.		
NIE-REV	Reverse Engineering	Z,ZK	5
	Students will learn fundamentals of reverse engineering of computer software (methods of executing and initializing programs, organization of executable files, work with third-party libraries). Special attention will be paid to C ++. Students will also become familiar with the principles of debugging tools, disassemblers and obfuscation methods. Finally, the course will focus on code compression and decompression and executable file reconstruction.		
NIE-ROZ	Pattern Recognition	Z,ZK	5
	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.		
NIE-SBF	System Security and Forensics	Z,ZK	5
	Students will be introduced to various aspects of system security (principles of endpoint security, principles of security policies, security models, authentication concepts). Students will also learn about forensic analysis as a tool for investigating security incidents (techniques used by malicious software or attackers, forensic analysis techniques, and the importance of memory or file system artifacts for attack analysis and detection).		
NIE-SCE1	Computer Engineering Seminar Master I	Z	4
	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 KČN laboratories. The capacity of the subject is limited by the possibilities of the seminar teachers. The topics are new for each semester.		
NIE-SCE2	Computer Engineering Seminar Master II	Z	4
	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 KČN laboratories. The capacity of the subject is limited by the possibilities of the seminar teachers. The topics are new for each semester.		
NIE-SEP	World Economy and Business	Z,ZK	4
	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.		
NIE-SIB	Network Security	Z,ZK	5
	The students will gain theoretical and practical knowledge and experience in the area of current security threats in computer networks, specifically about detection and defense. The course explains basic pricipals of security monitoring, packet-based and flow-based analysis, in order to detect anomalies and suspicious network traffic. The course focuses on explanation and practical examples of various mechanisms of securing network infrastructure and detection in real time. The course covers general principals of handling detected security events (i.e. incident handling and incident response).		
NIE-SIM	Digital Circuit Simulation and Verification	Z,ZK	5
	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 today recent verification methods, too.		
NIE-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.		
NIE-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.		
NIE-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.		
NIE-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.		
NIE-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).		
NIE-VPR	Research Project	Z	5
	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.		
NIE-VSM	Selected statistical Methods	Z,ZK	7
	Summary of probability theory; Multivariate normal distribution; Entropy and its application to coding; Statistical tests: T-tests, goodness of fit tests, independence test; Random processes - stacionarity; Markov chains and limiting properties; Queuing theory		

NIE-VYC	Computability	Z,ZK	4
	Classical theory of recursive functions and effective computability.		

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