# Study plan

## Name of study plan: Master specialization Computer Security, 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: 98

Elective courses credits: 22 Sum of credits in the plan: 120

Note on the plan: The study plan is intended for those students who have been accepted to study since the academic year 2021/2022. Guarantor: prof. Ing. Róbert Lórencz, CSc., email: robert.lorencz@fit.cvut.cz

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 Project Robert Pergl <b>Zden k Muziká</b>	Z	30		L,Z	PP
NIE-MPR	Master Project Zden k Muziká Zden k Muziká (Gar.)	Z	7		Z,L	PP
NIE-MPI	Mathematics for Informatics Francesco Dolce Št pán Starosta Št pán Starosta (Gar.)	Z,ZK	7	3P+2C	Z	PP
NIE-PDP	Parallel and Distributed Programming 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 I	mowledge 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 evalu	ate heuristics for practical problems.		
NIE-DIP	Diploma Project	Z	30
NIF-MPR	Master Project	7	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.

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.

#### Parallel and Distributed Programming

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

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: Povinné p edm ty specializace

Minimal number of credits of the block: 35

The role of the block: PS

Code of the group: NIE-PS-PB.21

Name of the group: Compulsory Courses of Master Specialization Computer Security, Version 2021

Requirement credits in the group: In this group you have to gain 35 credits

Requirement courses in the group: In this group you have to complete 7 courses

Credits in the group: 35

Note on the group.

Note on the g	roup.					
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-KRY	Advanced Cryptology Ji í Bu ek, Róbert Lórencz Ji í Bu ek Róbert Lórencz (Gar.)	Z,ZK	5	2P+2C	Z	PS
NIE-AIB	Algorithms of Information Security  Martin Jure ek, Róbert Lórencz Róbert Lórencz Martin Jure ek (Gar.)	Z,ZK	5	2P+1C	Z	PS
NIE-HWB	Hardware Security Ji í Bu ek <b>Ji í Bu ek</b> Ji í Bu ek (Gar.)	Z,ZK	5	2P+2C	L	PS
NIE-MKY	Mathematics for Cryptology Martin Jure ek, Róbert Lórencz, Olha Jure ková Róbert Lórencz Róbert Lórencz (Gar.)	Z,ZK	5	3P+1C	L	PS
NIE-SIB	Network Security Simona Forn sek Simona Forn sek (Gar.)	Z,ZK	5	2P+1C	L	PS
NIE-REV	Reverse Engineering Josef Kokeš, Ji í Dostál Ji í Dostál Róbert Lórencz (Gar.)	Z,ZK	5	1P+2C	Z	PS
NIE-SBF	System Security and Forensics Simona Forn sek Simona Forn sek (Gar.)	Z,ZK	5	2P+1C	Z	PS

### Characteristics of the courses of this group of Study Plan: Code=NIE-PS-PB.21 Name=Compulsory Courses of Master Specialization Computer Security, Version 2021

**NIE-KRY** Advanced Cryptology Z.ZK

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-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-HWB** Hardware Security

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

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.

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-REV Reverse Engineering Z.ZK

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-SBF System Security and Forensics

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).

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-PB-VS.21

Name of the group: Elective Vocational Courses for Master Specialization Computer security

Requirement credits in the group: Requirement courses in the group:

Credits in the group: 0

Note on the group. Compulsory courses of all specializations with the exception of this specialization.

Note on the group	Compulsory courses of all special	lizations with	the exc	eption o	f this speci	alizatio
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-PDB	Advanced Database Systems Martin Svoboda Martin Svoboda (Gar.)	Z,ZK	5	2P+1C	Z	V
NIE-PIS	Advanced Information Systems Petr Kroha, Petra Pavlí ková Petra Pavlí ková (Gar.)	Z,ZK	5	2P+1C	L	V
NIE-ADP	Architecture and Design patterns Ji í Borský Ji í Borský Filip K ikava (Gar.)	Z,ZK	5	2P+1C	Z	V
NIE-MVI	Computational Intelligence Methods Miroslav epek, Pavel Kordík Pavel Kordík Pavel Kordík (Gar.)	Z,ZK	5	2P+1C	Z	V
NIE-KOD	Data Compression Jan Holub Jan Holub (Gar.)	Z,ZK	5	2P+1C	L	V
NIE-ADM	Data Mining Algorithms Pavel Kordík, Rodrigo Augusto Da Silva Alves Daniel Vašata Pavel Kordík (Gar.)	Z,ZK	5	2P+1C	L	V
NIE-SIM	Digital Circuit Simulation and Verification  Martin Kohlik Martin Kohlik Martin Kohlik (Gar.)	Z,ZK	5	2P+1C	L	V
NIE-DSV	Distributed Systems and Computing Jan Jane ek, Pavel Tvrdík, Peter Macejko Peter Macejko Jan Jane ek (Gar.)	Z,ZK	5	2P+1C	Z	V
NIE-EPC	Effective C++ programming Daniel Langr Daniel Langr (Gar.)	Z,ZK	5	2P+1C	Z	V
NIE-EVY	Efficient Text Pattern Matching Jan Holub Jan Holub (Gar.)	Z,ZK	5	2P+1C	Z	V
NIE-EHW	Embedded Hardware Jan Schmidt Jan Schmidt Jan Schmidt (Gar.)	Z,ZK	5	2P+1C	Z	V
NIE-BVS	Embedded Security Martin Novotný Martin Novotný (Gar.)	Z,ZK	5	2P+2C	L	V
NIE-ESW	Embedded Software Hana Kubátová, Miroslav Skrbek Hana Kubátová (Gar.)	Z,ZK	5	2P+1C	Z	V
NIE-BKO	Error Control Codes Pavel Kubalík Pavel Kubalík Pavel Kubalík (Gar.)	Z,ZK	5	2P+1C	L	V
NIE-FME	Formal Methods and Specifications Stefan Ratschan Stefan Ratschan (Gar.)	Z,ZK	5	2P+1C	L	V
NIE-GPU	GPU Architectures and Programming Ivan Šime ek Ivan Šime ek Ivan Šime ek (Gar.)	Z,ZK	5	2P+1C	L	V
NIE-GAK	Graph theory and combinatorics Tomáš Valla Tomáš Valla Tomáš Valla (Gar.)	Z,ZK	5	2P+2C	L	V
NIE-AM1	Middleware Architectures 1 Milan Doj inovski, Jaroslav Kucha , Tomáš Vitvar Jaroslav Kucha Tomáš Vitvar (Gar.)	Z,ZK	5	2P+1C	Z	V
NIE-MTI	Modern Internet Technologies Viktor erný, Alexandru Moucha Alexandru Moucha Alexandru Moucha (Gar.)	Z,ZK	5	2P+1C	Z	V
NIE-MCC	Multicore CPU Computing  Daniel Langr, Ivan Šime ek Ivan Šime ek (Gar.)	Z,ZK	5	2P+1C	Z	V
NIE-SIB	Network Security Simona Forn sek Simona Forn sek (Gar.)	Z,ZK	5	2P+1C	L	V
NIE-NON	Nonlinear Continuous Optimization and Numerical Methods Jaroslav Kruis Jaroslav Kruis (Gar.)	Z,ZK	5	2P+1C	Z	V
NIE-NSS	Normalized Software Systems Robert Pergl, Marek Suchánek Robert Pergl Robert Pergl (Gar.)	ZK	5	2P	L	V
NIE-SYP	Parsing and Compilers Jan Janoušek Jan Janoušek (Gar.)	Z,ZK	5	2P+1C	Z	V

	Systems Theory Tomáš Kolárik, Stefan Ratschan Stefan Ratschan (Gar.)	Z,ZK	5	2P+1C	Z	V
	Testing and Reliability Petr Fišer <b>Petr Fišer</b> Petr Fišer (Gar.)	Z,ZK	5	2P+2C	Z	V
	User Interface Design Josef Pavlí ek Josef Pavlí ek Josef Pavlí ek (Gar.)	Z,ZK	5	2P+1C	Z	V
	Virtualization and Cloud Computing Jan Fesl, Tomáš Vondra Tom <b>áš Vondra</b> Tomáš Vondra (Gar.)	Z,ZK	5	2P+1C	L	V
<u>'</u>		<b>-</b> 1 4' \				
Characteristics of the c Specialization Compute	ourses of this group of Study Plan: Code=NIE-PB-VS.21 Namer security	ne=Elective V	ocationa	al Course	s for Ma	aster
	vork Security			Z	Z,ZK	5
The state of the s	cal and practical knowledge and experience in the area of current security threats in	computer networ	ks, specifica	1		d defense. The
	of security monitoring, packet-based and flow-based analysis, in order to detect and	-				
security events (i.e. incident ha	nples of various mechanisms of securing network infrastructure and detection in real and incident response)	time. The course	covers ger	erai principa	als of nand	ling detected
	anced Database Systems			7	Z,ZK	5
	problems of evaluation and optimization of SQL queries. The next part of the course	deals with new c	oncepts of o	1	′ '	_
databases), with the related ne	ew data models (XML, graph databases, column databases) and languages for worki	ing with them (XC	Query, XPat	n, CYPHER,	Gremlin).	The last part of
<u>_</u>	ance evaluation of database machines. This course is equivalent to the course MIE-P	DB.				
	anced Information Systems				Z,ZK	5
	siness process logic and its formalization, with business process roles, business rules e solution of business logic. They get acquainted with these notions also for the othe	-	-			
-	or implementation of these ideas in ISs. They understand modern object-oriented me		-		-	-
<del>-</del>	e ISs. They will get the rules and technologies for successful implementation of IS.	J	Ü	·	,	•
NIE-ADP Arch	itecture and Design patterns			Z	Z,ZK	5
	to provide students with both work knowledge about the underlying foundations of ob-	-	-	-		-
	deoffs of advanced software design. In the first part of the course, the students will re	-		-	-	
=	only used object-oriented design patterns that represent the best practices for solving les of software architecture design and analysis. This includes the classical architectu				-	
architectures used in large-sca		rai otyloo, oompo	nont bacca	oyotomo, am	a como aa	varioud continui c
	putational Intelligence Methods			Z	Z,ZK	5
· ·	asic methods and techniques of computational intelligence, which are based on tradi	itional artificial int	telligence, a	re parallel in	nature an	d are applicable
	ems. The subject is also devoted to modern neural networks and the ways in which the	-	roevolution.	Students wi	ll learn hov	these methods
	problems related to data extraction, management, intelligence in games and optimis	sation, etc.			7.714	
	Compression basic principles of data compression. They will learn the necessary theoretical back.	around and got a	n overview		Z,ZK	5
	covers principles of integer coding and of statistical, dictionary, and context data cor					_
•	ds used in image, audio, and video compression.		ao aaa	on, oraconto		
NIE-ADM Data	Mining Algorithms			Z	Z,ZK	5
•	ims used in the fields of machine learning and data mining. However, this is not an in	•				
	advanced algorithms (e.g., gradient boosting) and non-basic kinds of machine learn	ning tasks (e.g., re	ecommenda	tion system	s) and mod	lels (e.g., kernel
methods).	al Circuit Cimulation and Varification			1 7	7 71/	
	al Circuit Simulation and Verification It the students with principles of digital circuit simulation at RTL (Register Transfer Le	evel) and TLM (Tr	ansaction I		Z,ZK	5 nd with the
·	course covers today recent verification methods, too.				.g, .στσ.σ α	
NIE-DSV Distr	ibuted Systems and Computing			Z	Z,ZK	5
	nods for coordination of processes in distributed environment characterised by nondete	rministic time resp	oonses of co	mputing pro	cesses and	communication
,	orithms that assure correctness of computations realized by a group of loosely coupling	ed processes and	d mechanis	ns that supp	ort high av	ailability of both
data and services, and safety in						
	ctive C++ programming modern features of contemporary versions of the C++ programming language for sol	ftware developme	ont The cou		Z,ZK	5 nmina offactivity
	iting maintainable and portable source code and creating correct programs with low					illilling ellectivity
	ient Text Pattern Matching				Z,ZK	5
= =	cient algorithms for text pattern matching. They learn to use so called succinct data stru	uctures that are ef	ficient in bo		, I	_
They will be able to use the known	owledge in design of applications that utilize pattern matching.					
l .	edded Hardware				Z,ZK	5
	hat govern digital design and basic techniques to use them. It deals with both large a					
	specialized structure for effective computation and acceleration. Design of fast custor	n computing mad	chines is dis	cussed, incl	uding stan	dardized means
	allelism extraction and utilization in special structures and system architectures.  edded Security				Z,ZK	5
· ·	edded Security · in selected topics of cryptography and cryptanalysis. The course focuses particularly	on efficient imple	mentations	1		_
-	stems). Students gain a good overview of functionality of (hardware) cryptographic acc	-				
of computer systems.						
NIE-ESW Emb	edded Software			Z	Z,ZK	5
	quainted students with the specifics of software development for embedded systems. The				-	
	zations, through typical areas as the reliable software development, embedded oper	ating systems, si	gnal proces	sing, up to s	ophisticate	ed techniques
combined with artificial intellige	CHICE.					

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.

Z,ZK

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NIE-BKO

Error Control Codes

NIE-FME Formal Methods and Specifications 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 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-GAK** Z,ZK Graph theory and combinatorics 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 undestanding 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. 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. Z,ZK NIE-MTI Modern Internet Technologies 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 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-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. **NIE-NSS** Normalized Software Systems ZK 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-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. Z,ZK NIE-TES Systems Theory 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. Testing and Reliability 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 User Interface Design 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

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).

Code of the group: NIE-V.21

Name of the group: Purely Elective Master Courses, Version 2021

Requirement credits in the group: Requirement courses in the group:

Credits in the group: 0

Note on the group:

In addition to courses from this group, students can enroll in courses from the group "Elective vocational courses for this specialization". Courses of this group that a student has completed in the bachelor study at CTU cannot be re-completed.

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 R ži ka, Marek Bielik Josef Gattermayer Róbert Lórencz (Gar.)	Z,ZK	5	1P+2C	Z	V
BIE-CCN	Compiler Construction Christoph Kirsch Christoph Kirsch (Gar.)	Z,ZK	5	3P	L	V
NIE-CPX	Complexity Theory Dušan Knop	Z,ZK	5	3P+1C	z	V
NIE-VYC	Computability Jan Starý Jan Starý (Gar.)	Z,ZK	4	2P+2C	L	V
NIE-MVI	Computational Intelligence Methods Miroslav epek, Pavel Kordík Pavel Kordík (Gar.)	Z,ZK	5	2P+1C	Z	V
NIE-ARI	Computer arithmetic Pavel Kubalík Pavel Kubalík Alois Pluhá ek (Gar.)	Z,ZK	4	2P+1C	Z,L	V
NIE-SCE1	Computer Engineering Seminar Master I Hana Kubátová Hana Kubátová (Gar.)	Z	4	2C	Z	V
NIE-SCE2	Computer Engineering Seminar Master II Hana Kubátová Hana Kubátová (Gar.)	Z	4	2C	L	V
NIE-KOD	Data Compression Jan Holub Jan Holub (Gar.)	Z,ZK	5	2P+1C	L	V
NI-DSW	Design Sprint Ond ej Brém, Michal Manda Michal Manda David Pešek (Gar.)	Z	2	30B	Z	V
NI-DID	Digital drawing Denisa S vová, Eliška Novotná Denisa S vová Denisa S vová (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 (Gar.)	Z,ZK	3	2P+1C	Z	V
NIE-DVG	Introduction to Discrete and Computational Geometry Maria Saumell Mendiola Maria Saumell Mendiola (Gar.)	Z,ZK	5	2P+1C	L	V
MIE-MZI	Mathematics for data science Št pán Starosta	Z,ZK	4	2P+1C	L	V
NIE-AM2	Middleware Architectures 2  Milan Doj inovski Milan Doj inovski (Gar.)	Z,ZK	5	2P+1C	L	V
NIE-PAM	Parameterized Algorithms Ond ej Suchý	Z,ZK	4	2P+1C	L	V
NIE-SYP	Parsing and Compilers  Jan Janoušek Jan Janoušek (Gar.)	Z,ZK	5	2P+1C	Z	V
NIE-ROZ	Pattern Recognition Michal Haindl	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 Zden k Buk, Miroslav epek, Petr Šimánek, Rodrigo Augusto Da Silva Alves, Vojt ch Rybá Miroslav epek Miroslav epek (Gar.)	Z,ZK	5	2P + 1C	L	V
NIE-PDL	Practical Deep Learning Martin Barus, Yauhen Babakhin Karel Klouda Martin Barus (Gar.)	KZ	5	2P+1C	Z	٧
NIE-VPR	Research Project Št pán Starosta Št pán Starosta Št pán Starosta (Gar.)	Z	5		Z,L	V
NIE-SWE	Semantic Web and Knowledge Graphs Milan Doj inovski Milan Doj inovski (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 Vojt ch Miškovský, Petr Socha Vojt ch Miškovský Vojt ch Miškovský (Gar.)	Z,ZK	4	2P+2C	Z	V
NIE-DDW	Web Data Mining Milan Doj inovski Milan Doj inovski (Gar.)	Z,ZK	5	2P+1C	L	V
NIE-BPS	Wireless Computer Networks Alexandru Moucha Alexandru Moucha (Gar.)	Z,ZK	4	2P+1C	L	V
MIE-SEP	World Economy and Business Tomáš Evan Tomáš Evan (Gar.)	Z,ZK	4	2P+1C	Z	V

Characteristics of the courses of this group of Study Plan: Code=NIE-V.21 Name=Purely Elective Master Courses, Version 2021

NIE-MVI Computational Intelligence Methods

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-KOD	Data Compression	Z,ZK	5
	d to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data compression.		_
	verview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, s	tudents learn the	fundamentals of
NIE-EVY	n methods used in image, audio, and video compression.	7 74	F
	Efficient Text Pattern Matching of efficient algorithms for text pattern matching. They learn to use so called succinct data structures that are efficient in both ac	Z,ZK	5
	e the knowledge in design of applications that utilize pattern matching.	cess time and mer	nory complexity.
NIE-SYP		7.71/	5
_	Parsing and Compilers the knowledge of fundamentals of automata theory, formal language and formal translation theories. Students gain knowledge	Z,ZK	_
· ·	ntroduced to special applications of parsers, such as incremental and parallel parsing.	oi various variants	and applications
NIE-BLO	Blockchain	Z,ZK	5
	ן בוסטגנו זמוו d the foundations of blockchain technology, smart contract programming, and gain an overview of most notable blockchain pla		
	are decentralized application, and assess whether integration of a blockchain is suitable for a given problem. The course place	-	-
	ockchains and information security. It is concluded with a defense of a research or applied semester project, which prepares		•
-	ation of blockchain-based solutions in both academia and business.		
BIE-CCN	Compiler Construction	Z,ZK	5
	class on compiler construction for bachelor students in computer science. The goal of the class is to introduce basic principle	1 ' 1	_
· · · · · · · · · · · · · · · · · · ·	and implementation of programming languages. Seeing and actually understanding self-compilation is the overarching theme		
NIE-CPX	Complexity Theory	Z,ZK	5
	ut the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of t	1 ' 1	ing practical
(in)tractability of difficul	t problems.		
NIE-VYC	Computability	Z,ZK	4
Classical theory of recu	rrsive functions and effective computability.		
NIE-ARI	Computer arithmetic	Z,ZK	4
Students will learn vario	bus 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
	ter Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistan	. – .	ttacks. Students
=	ually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of		
articles and other profe	ssional literature and/or work in K N laboratories. The capacity of the subject is limited by the possibilities of the seminar tea	chers. The topics a	are new for each
semester.			
NIE-SCE2	Computer Engineering Seminar Master II	Z	4
The Seminar of Compu	ter Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistan	ce to failures and a	ttacks. Students
are approached individ	ually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of	the subject is worl	k with scientific
articles and other profe	ssional literature and/or work in K N laboratories. The capacity of the subject is limited by the possibilities of the seminar tea	chers. The topics a	are new for each
semester.		,	
NI-DSW			
	Design Sprint	Z	2
Students will work on p	rojects using the Design Sprint method, developed by Google. THanks to this method the teams are able to go from idea to var	llidated prototype i	n 5 days. During
Students will work on p the course the students	rojects using the Design Sprint method, developed by Google. THanks to this method the teams are able to go from idea to value will get familiar with the method as participants. Through practical challenges they will try the whole 5 day process starting with the method as participants.	llidated prototype i	n 5 days. During
Students will work on p the course the students testing the prototypes (	rojects using the Design Sprint method, developed by Google. THanks to this method the teams are able to go from idea to value will get familiar with the method as participants. Through practical challenges they will try the whole 5 day process starting values final presentation).	llidated prototype i	n 5 days. During finishing with
Students will work on p the course the students testing the prototypes ( NI-DID	rojects using the Design Sprint method, developed by Google. THanks to this method the teams are able to go from idea to value will get familiar with the method as participants. Through practical challenges they will try the whole 5 day process starting values final presentation).  Digital drawing	lidated prototype i	n 5 days. During finishing with
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NIE-PML Personalized Machine Learning 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 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 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 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. Semantic Web and Knowledge Graphs Z,ZK 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 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. NIE-HSC Side-Channel Analysis in Hardware Z,ZK 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. NIF-DDW Z,ZK 5 Web Data Mining 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 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. MIE-SEP World Economy and Business Z,ZK 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.

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
BIE-CCN	Compiler Construction	Z,ZK	5
This is an introd	uctory class on compiler construction for bachelor students in computer science. The goal of the class is to introduce basic principles	of compilers for st	udents to
understa	and the design and implementation of programming languages. Seeing and actually understanding self-compilation is the overarching	theme of the class	8.
MI-SCE1	Computer Engineering Seminar Master I	Z	4
The Seminar of Co	mputer Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance to	o failures and attacl	ks. Students
are approached in	dividually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the	subject is work wi	th scientific
articles and other p	professional literature and/or work in K N laboratories. The capacity of the subject is limited by the possibilities of the seminar teacher	rs. The topics are n	ew 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 da	ata science. The st	udied topics
include mainly: li	inear algebra (matrix factorisations, eigenvalues, diagonalization), continuous optimisation (optimisation with constraints, duality princ	ciple, gradient meth	nods) and
	selected notions from probability theory and statistics.		
MIE-SEP	World Economy and Business	Z,ZK	4
The course introd	uces students of technical university to the international business. It does that predominantly by comparing individual countries and k	ey regions of world	d economy.
Students get to	know about different religions and cultures, necessary for doing business in diverse societies as well as indexes of economic freedor	m, corruption and e	conomic
development, which	h are needed for the right investment decision. Seminars help to improve on the knowledge in the form of discussions based on indiv	vidual readings. It is	advised to

take bachelor level of this course BIE-SEP as a prerequisite.

NI-AML	Advanced machine learning	Z,ZK	5
	ces students to selected advanced topics of machine learning and artificial intelligence. The topics present techniques in the field of recessful and interconnection of physical love with the field of machine learning. The sim of the exercise is to familiarize students with	-	- 1
	control and interconnection of physical laws with the field of machine learning. The aim of the exercise is to familiarize students with	ne methods discu	
NI-DID	Digital drawing oduce students to the basic principals of digital drawing and graphical design. Students will gain understanding of composition, persp	∠ vective and color th	2
	apply in their own design works. Students will also gain experience in drawing and painting with digital and analog tools. The course		-
	learn drawing and painting. The course is organized as a thematic practices covering parts of theory and practical exercise to practi	-	
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 valida	ed prototype in 5	days. During
the course the stu	udents will get familiar with the method as participants. Through practical challenges they will try the whole 5 day process starting wit	n research and fini	ishing with
O. D	testing the prototypes (plus final presentation).	<b>-</b> -1.	
NI-GLR	Games and reinforcement learning	Z,ZK	4
The field of reinior	cement learning is very hot recently, because of advances in deep learning, recurrent neural networks and general artificial intelliger give you both theoretical and practical background so you can participate in related research activities. Presented in Englis		intended to
NI-GRI	Grid Computing	Z,ZK	5
W ON	Grid computing and gain knowledge about the world-wide network and computing infrastructure.	2,210	' '
NIE-ADM	Data Mining Algorithms	Z,ZK	5
	s on algorithms used in the fields of machine learning and data mining. However, this is not an introductory course, and the students		_
basics. The empha	sis is put on advanced algorithms (e.g., gradient boosting) and non-basic kinds of machine learning tasks (e.g., recommendation sys	ems) and models	(e.g., kernel
	methods).		
NIE-ADP	Architecture and Design patterns	Z,ZK	5
•	s course is to provide students with both work knowledge about the underlying foundations of object-oriented design and analysis as		٠ ا
_	ues, and tradeoffs of advanced software design. In the first part of the course, the students will refresh and deepen their knowledge on the commonly used object-oriented design patterns that represent the best practices for solving common software design problems.		
_	o the principles of software architecture design and analysis. This includes the classical architectural styles, component based systems	· ·	
	architectures used in large-scale distributed systems.		
NIE-AIB	Algorithms of Information Security	Z,ZK	5
Students will get ac	quainted with the algorithms of secure key generation and cryptographic error (not only biometric) data processing. Furthermore, stude	nts will learn the m	athematical
principles of cryp	otographic protocols (identification, authentication, and signature schemes). Another part of the course is dedicated to malware detec		f machine
NUE	learning in detection systems. The last topic includes practical steganographic methods and attacks on steganographic syste		
NIE-AM1	Middleware Architectures 1	Z,ZK	5
	dy new trends, concepts, and technologies in the area of service-oriented architectures. The will gain an overview of information syste lication servers. The will also study principles and technologies for middleware focused on application integrations, asynchronous comm		
architecture and ap	of applications. This course replaces the course MIE-MDW.	arnoations and mg	Travallability
NIE-AM2	Middleware Architectures 2	Z,ZK	5
	new trends and technologies on the Web including theoretical foundations. They will gain an overview of Web application architecture		
	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 implementa	tion units.	
NIE-BKO	Error Control Codes	Z,ZK	5
· · · · · · · · · · · · · · · · · · ·	is the basic knowledge of security codes used in current systems for error detection and correction. It provides the necessary mathen des and codes for the correction of multiple errors, clusters of errors and whole syllables (bytes). Students will also learn how to imple		
, ,	rections for different types of transmissions (parallel, serial) when storing data in memory and when transmitting over telecommunica		lions and
NIE-BLO	Blockchain	Z,ZK	5
	stand the foundations of blockchain technology, smart contract programming, and gain an overview of most notable blockchain platforu	,	
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 emph	nasis on the
relationship betwe	en blockchains and information security. It is concluded with a defense of a research or applied semester project, which prepares the	students for imple	ementing or
	supervising implementation of blockchain-based solutions in both academia and business.		
NIE-BPS	Wireless Computer Networks	Z,ZK	4
	n about the modern technologies, protocols, and standards for wireless networks. They will understand the routing mechanisms in ad nisms, and data flow control mechanisms. They will also learn about principles of communication in sensor networks. They get knowle		
broadcast mechai	for wireless networks and get skills of configuration of wireless network elements and simulation of wireless networks using suital		Conamisms
NIE-BVS	Embedded Security	Z,ZK	5
	knowledge in selected topics of cryptography and cryptanalysis. The course focuses particularly on efficient implementations of cryptography	,	
and software (in em	bedded systems). Students gain a good overview of functionality of (hardware) cryptographic accelerators, smart cards, and resources	for securing interr	nal functions
	of computer systems.		
NIE-CPX	Complexity Theory	Z,ZK	5
Students will lear	n about the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of the	theory concerning	g practical
NIE-DDW	(in)tractability of difficult problems.  Web Data Mining	Z,ZK	5
	vveb Data Milling  rn latest methods and technologies for web data acquisition, analysis and utilization of the discovered knowledge. Students will gain	•	
	crawling, Web structure analysis, Web usage analysis, Web content mining and information extraction. Students will also gain an overvie		- 1
	in the field of social web and recommendation systems.		
NIE-DIP	Diploma Project	Z	30
NIE-DSV	Distributed Systems and Computing	Z,ZK	5
	uced to methods for coordination of processes in distributed environment characterised by nondeterministic time responses of computing	-	
channels. They lear	rn basic algorithms that assure correctness of computations realized by a group of loosely coupled processes and mechanisms that s	upport high availa	bility of both
NIE DVO	data and services, and safety in case of failures.	フフレ	
NIE-DVG The course intends	Introduction to Discrete and Computational Geometry to introduce the students to the discipline of Discrete and Computational Geometry. The main goal of the course is to get familiar with	Z,ZK the most fundame	5 ental notions
Juliano interius		idiludille	
	of this discipline, and to be able to solve simple algorithmic problems with a geometric component.		I

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. Embedded Software 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. Efficient Text Pattern Matching 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-GAK Graph theory and combinatorics Z,ZK 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 undestanding 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. NIE-GPU GPU Architectures and Programming 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. History of Mathematics and Informatics 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 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. Hardware Security 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. **Data Compression** 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. Combinatorial Optimization 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. NIF-KRY Advanced Cryptology Z,ZK 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 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 7.7K 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 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 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-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. Computational Intelligence Methods 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. Nonlinear Continuous Optimization and Numerical Methods 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. **NIE-NSS** Normalized Software Systems 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. User Interface Design 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-PAM Parameterized Algorithms Z,ZK 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. NIF-PDB Advanced Database Systems 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. Practical Deep Learning 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. Parallel and Distributed Programming 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. Advanced Information Systems 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 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 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 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. System Security and Forensics 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). Computer Engineering Seminar Master I 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.

NIE-SCE2	Computer Engineering Seminar Master II	Z	4
The Seminar of Co	mputer Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance to	ı o failures and attad	cks. Students
are approached in	dividually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the	subject is work w	rith scientific
articles and other p	professional literature and/or work in K N laboratories. The capacity of the subject is limited by the possibilities of the seminar teacher	rs. The topics are	new for each
	semester.	·	
NIE-SIB	Network Security	Z,ZK	5
	qain theoretical and practical knowledge and experience in the area of current security threats in computer networks, specifically abo	,	lefense. The
`	basic pricipals of security monitoring, packet-based and flow-based analysis, in order to detect anomalies and suspicious network tra		
-	practical examples of various mechanisms of securing network infrastructure and detection in real time. The course covers general pr		II
	security events (i.e. incident handling and incident response).	·	
NIE-SIM	Digital Circuit Simulation and Verification	Z,ZK	5
!	e is to acquaint the students with principles of digital circuit simulation at RTL (Register Transfer Level) and TLM (Transaction Level N	· '	nd with the
	properties of proper tools. The course covers today recent verification methods, too.	O,	
NIE-SWE	Semantic Web and Knowledge Graphs	Z,ZK	5
!	learn the most recent concepts and technologies of the Semantic Web. The course will provide an overview of the Semantic Web tec		1 1
	delling, integration, publishing, querying and consumption of semantic data. The students will also gain skills in creation of knowledge	•	
	quality assurance.		
NIE-SYP	Parsing and Compilers	Z,ZK	5
	upon the knowledge of fundamentals of automata theory, formal language and formal translation theories. Students gain knowledge of v	'	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, humankin	Id has the ability to develop systems of incredible complexity (e.g., trains, microprocessors, airplanes, nuclear power plants). However	r, the costs of mar	naging 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 m		
aanaata of the avet		odels that describ	e only those
aspects of the syst	tems that are important for the task at hand, and automated tools for analyzing those models. This subject will present theory and alg		· ·
aspects of the syst	tems that are important for the task at hand, and automated tools for analyzing those models. This subject will present theory and alg the modeling and analysis of complex systems.		· ·
NIE-TSP			· ·
NIE-TSP	the modeling and analysis of complex systems.	orithms that form Z,ZK	the basis for
NIE-TSP Students will gain I	the modeling and analysis of complex systems.  Testing and Reliability	orithms that form  Z,ZK pare a test set wit	the basis for 5 h the help of
NIE-TSP Students will gain I	the modeling and analysis of complex systems.  Testing and Reliability  knowledge about circuit testing and about methods for increasing reliability and security. They will get practical skills to be able to pre	orithms that form  Z,ZK pare a test set wit	the basis for 5 h the help of
NIE-TSP Students will gain I	the modeling and analysis of complex systems.  Testing and Reliability  knowledge about circuit testing and about methods for increasing reliability and security. They will get practical skills to be able to prepensitization and to use an ATPG for automatic test generation. They will be able to design easily testable circuits and systems with bu	orithms that form  Z,ZK pare a test set wit	the basis for 5 h the help of
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Computability
Classical theory of recursive functions and effective computability.

Z,ZK

For updated information see <a href="http://bilakniha.cvut.cz/en/FF.html">http://bilakniha.cvut.cz/en/FF.html</a> Generated: day 2024-05-20, time 02:57.

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