# Study plan

## Name of study plan: Matematická informatika

Faculty/Institute/Others:
Department:
Branch of study guaranteed by the department: Welcome page
Garantor of the study branch:
Program of study: Mathematical Informatics
Type of study: Follow-up master full-time
Required credits: 0
Elective courses credits: 120
Sum of credits in the plan: 120
Note on the plan:

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Name of the block: Compulsory courses in the program
Minimal number of credits of the block: 0
The role of the block: P

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Code of the group: NMSPMINF1
Name of the group: MDP P_MINFN 1st year
Requirement credits in the group:
Requirement courses in the group: In this group you have to complete at least 13 courses
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 |
|---|---|---|---|---|---|---|
| 01DIZO | **Digital Image Processing** *Barbara Zitová* ***Barbara Zitová*** *Barbara Zitová (Gar.)* | ZK | 4 | 2P+2C | | P |
| 01JAU | **Languages, Automata and Computability** *Petr Ambrož* ***Petr Ambrož*** *Petr Ambrož (Gar.)* | Z,ZK | 4 | 3P+1C | | P |
| 01MAL | **Mathematical Logic** *Petr Cintula* ***Petr Cintula*** *Petr Cintula (Gar.)* | Z,ZK | 4 | 2+1 | | P |
| 01NEUR1 | **Neural Networks and their Applications 1** *Martin Holeňa, František Hakl* ***František Hakl*** *František Hakl (Gar.)* | ZK | 2 | 2+0 | | P |
| 18OOP | **Object Oriented Programming** *Miroslav Virius* ***Miroslav Virius*** *Miroslav Virius (Gar.)* | Z | 2 | 2C | Z | P |
| 01PAA | **Parallel Algorithms and Architectures** *Tomáš Oberhuber* ***Tomáš Oberhuber*** *Tomáš Oberhuber (Gar.)* | KZ | 4 | 2P+1C | L | P |
| 01TEC | **Number Theory** *Zuzana Masáková, Edita Pelantová* ***Zuzana Masáková*** *Zuzana Masáková (Gar.)* | ZK | 5 | 4P+0C | | P |
| 01TG | **Graph Theory** *Petr Ambrož, Jan Volec* ***Petr Ambrož*** *Petr Ambrož (Gar.)* | ZK | 5 | 4P+0C | | P |
| 01TIN | **Information Theory** *Tomáš Hobza* ***Tomáš Hobza*** *Tomáš Hobza (Gar.)* | ZK | 2 | 2+0 | Z | P |
| 01TEMA | **Matrix Theory** *Edita Pelantová* ***Edita Pelantová*** *Edita Pelantová (Gar.)* | Z | 3 | 2+0 | L | P |
| 01TSLO | **Complexity Theory** *Petr Ambrož* ***Petr Ambrož*** *Petr Ambrož (Gar.)* | ZK | 3 | 3+0 | Z | P |
| 01VUSI1 | **Research Project 1** *Edita Pelantová, Čestmír Burdík* ***Čestmír Burdík*** *Edita Pelantová (Gar.)* | Z | 6 | 0+6 | Z | P |
| 01VUSI2 | **Research Project 2** *Edita Pelantová, Čestmír Burdík* ***Čestmír Burdík*** *Edita Pelantová (Gar.)* | KZ | 8 | 0P+8C | L | P |

**Characteristics of the courses of this group of Study Plan: Code=NMSPMINF1 Name=MDP P_MINFN 1st year**

| | | | |
|---|---|---|---|
| 01DIZO | Digital Image Processing | ZK | 4 |

image sampling and quantization, Shannon theorem, aliasing basic image operations, histogram, contrast stretching, noise removal, image sharpening linear filtering in the spatial and frequency domains, convolution, Fourier transform edge detection, corner detection feature detection image degradations and their modelling, inverse and Wiener filtering, restoration of motion-blurred and out-of-focus blurred images image segmentation mathematical morphology image registration and matching

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|---|---|---|---|
| 01JAU | Languages, Automata and Computability | Z,ZK | 4 |
| 1. Finite automata, regular languages and operations, star lemmas. (3 lectures) 2. Kleene theorem (2 lectures) 3. Determinisation a minimisation (2 lectures) 4. Confext-free grammas and their reductions (2 lectures) 5. Pushdown automata and context-free languages (2 lectures) 6. Star lemma for CFL, closure properties of CFL (2 lectures) 7. Turing machine, recursive and recursively enumerable languages, methods of design of turing machines (2 lectures) 8. Undecidability (1 lecture) 9. Rice theorem, Post correspondence problem, undecidable properties of CFL (2 lectures) | | | |
| 01MAL | Mathematical Logic | Z,ZK | 4 |
| Logic is in the same time an object studied by mathematics and the language used to formalize and study mathematics. The goal of the course is to introduce basic notion of results of classical mathematical logic. 1.Propositions, evaluation, tautologies, axioms, theorems, soundness, completeness, and decidability of Hilbert and Gentzen style propositional calculi. 2.Language of predicate calculus, terms, formulas, relational structures, satisfiability, truth, tautologies, axioms, theorems, soundness, model constructions. 3.Gödel completeness theorem, Skolem and Herbrand theorems. 4.The first and the second Gödel theorems on incompleteness of Peano arithmetics and undecidability of predicate calculus. | | | |
| 01NEUR1 | Neural Networks and their Applications 1 | ZK | 2 |
| Keywords: Neural networks, data separation, functional approximation, supervised learning | | | |
| 18OOP | Object Oriented Programming | Z | 2 |
| This course consists of the contributions of students concerning given topics concerned on technologies uded in program development. | | | |
| 01PAA | Parallel Algorithms and Architectures | KZ | 4 |
| This course deals with the parallel data processing. It is important in situations when one processing unit (CPU) is not powerful enough to finish given task in reasonable time. When designing parallel algorithms, good knowledge of the parallel architectures is important. Therefore these architectures are studied as a part of this course too. | | | |
| 01TEC | Number Theory | ZK | 5 |
| 1. Algebraic and transcendental numbers 2. Algebraic number fields, field isomorphisms 3. Rational approximations, continued fractions 4. Diophantic equations, Pell's equation 5. Rings of integers in algebraic number fields and divisibility 6. Number representation in non-integer bases, finite and periodic expansions | | | |
| 01TG | Graph Theory | ZK | 5 |
| 1. Basic notion of graph theory. 2. Edge and vertex connectivity (Menger Theorem). 3. Bipartite graphs. 4. Trees and forests. 5. Spanning trees (Matrix-Tree Theorem). 6. Euler tours and Hamilton cycles. 7. Maximal and perfect matching. 8. Edge coloring. 9. Flows in networks. 10. Vertex coloring. 11. Plannar graphs (Kuratowski theorem), vertex coloring of planar graphs. 12. Spectrum of the adjacency matrix. 13. Extremal graph theory. | | | |
| 01TIN | Information Theory | ZK | 2 |
| Information theory explores the fundamental limits of the representation and transmission of information. We will focus on the definition and implications of (information) entropy, the source coding theorem, and the channel coding theorem. These concepts provide a vital background for researchers in the areas of data compression, signal processing, controls, and pattern recognition. | | | |
| 01TEMA | Matrix Theory | Z | 3 |
| The subject deals mainly with: 1) similarity of matrices and canonical forms of matrices 2) Perron-Frobenius theory and its applications 3) tensor product 4) Hermitian and positive semidefinite matrices | | | |
| 01TSLO | Complexity Theory | ZK | 3 |
| The course is devoted to incorporation of complexity questions during algorithm development, introduction to NP completeness and generally to complexity classes of deterministic or nondeterministic Turing machines bounded by time or space. Emphasis is placed on mutual relations among these classes. Aside from nondeterministic classes we examine probability classes. Class of interactive protocols is presented at the end of lecture course. | | | |
| 01VUSI1 | Research Project 1 | Z | 6 |
| Research project on the selected topic under the supervision. Supervision and regular checking of the research project under preparation. | | | |
| 01VUSI2 | Research Project 2 | KZ | 8 |
| Research project on the selected topic under the supervision. Supervision and regular checking of the research project under preparation. | | | |

Code of the group: NMSPMINF2
Name of the group: MDP P_MINFN 2nd year
Requirement credits in the group:
Requirement courses in the group: In this group you have to complete at least 6 courses
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 |
|---|---|---|---|---|---|---|
| 01DPSI1 | **Master Thesis 1** *Čestmír Burdík* ***Čestmír Burdík*** *Čestmír Burdík (Gar.)* | Z | 10 | 0+10 | Z | P |
| 01DPSI2 | **Master Thesis 2** *Čestmír Burdík* ***Čestmír Burdík*** *Čestmír Burdík (Gar.)* | Z | 20 | 0+20 | L | P |
| 01KOAL | **Commutative Algebra** *Severin Pošta* ***Severin Pošta*** *Severin Pošta (Gar.)* | ZK | 3 | 1P+1C | | P |
| 01DISE | **Diploma Seminar** *Čestmír Burdík* ***Čestmír Burdík*** *Čestmír Burdík (Gar.)* | Z | 1 | 0P+2S | | P |
| 01SU1 | **Machine Learning 1** *Jan Flusser* ***Jan Flusser*** *Jan Flusser (Gar.)* | ZK | 3 | 2P+1C | | P |
| 01NEUR2 | **Theoretical Fundamentals of Neural Networks** *Martin Holeňa* ***Martin Holeňa*** *Martin Holeňa (Gar.)* | ZK | 3 | 2+0 | | P |

**Characteristics of the courses of this group of Study Plan: Code=NMSPMINF2 Name=MDP P_MINFN 2nd year**

| | | | |
|---|---|---|---|
| 01DPSI1 | Master Thesis 1 | Z | 10 |
| Master's thesis preparation. | | | |
| 01DPSI2 | Master Thesis 2 | Z | 20 |
| Master's thesis preparation. | | | |

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|---|---|---|---|
| 01KOAL | Commutative Algebra | ZK | 3 |
| 1. Rings, ideals, homomorphisms, prime and maximal ideals. 2. Rings of polynomials, symmetric polynomials, irreducibility. 3. Gröbner bases. 4. Polynomials with rational coefficients, factorization of polynomials. 5. Hilbert's Nullstellensatz, ideals and manifolds, Krull dimension. 6. Fields, extensions, finite fields. 7. Introduction to Galois theory, Galois extensions, group and correspondence. | | | |
| 01DISE | Diploma Seminar | Z | 1 |
| In the first part of the seminar, students familiarize themselves with the general principles of publishing and presenting scientific work and the formal requirements for diploma projects at the faculty. The second part is designed as a practical training for the defence of the diploma project. The students give oral presentations of the current state of the research results achieved during the work on their projects. Each presentation is followed by a discussion on scientific matters as well as on the possibilities of improving the students performance. | | | |
| 01SU1 | Machine Learning 1 | ZK | 3 |
| [1] features for description and recognition of 2-D shapes [2] invariant features, Fourier descriptors, moment invariants, differential invariants [3] statistical pattern recognition, supervised and nonsupervised classification, NN- classifier, linear classifier, Bayessian classifier [4] clustering in a feature space, iterative and hierarchical methods [5] dimensionality reduction of a feature space | | | |
| 01NEUR2 | Theoretical Fundamentals of Neural Networks | ZK | 3 |
| Keywords: Functional approximation, supervised learning, Vapnik-Chervonenkis-dimension | | | |

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

Code of the group: NMSPMINFV
Name of the group: MDP P_MINFN Optional 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 |
|---|---|---|---|---|---|---|
| 01ALTI | **Algebraic structures in theoretical informatics** *Edita Pelantová, Severin Pošta, Milena Svobodová* ***Severin Pošta*** *Severin Pošta (Gar.)* | ZK | 3 | 1+1 | | v |
| 18DDS | **Database System Decomposition** *Dana Majerová, Jaromír Kukal* ***Dana Majerová*** *Jaromír Kukal (Gar.)* | ZK | 4 | 2P+2C | L | v |
| 01FIMA | **Financial and Insurance Mathematics** *Joel Horowitz* ***Joel Horowitz*** *Joel Horowitz (Gar.)* | ZK | 2 | 2P+0C | Z | v |
| 01KOS | **Compressed Sensing** *Jan Vybíral* ***Jan Vybíral*** *Jan Vybíral (Gar.)* | ZK | 2 | 2+0 | Z | v |
| 01MMNS | **Mathematical Modelling of Non-linear Systems** *Michal Beneš* ***Michal Beneš*** *Michal Beneš (Gar.)* | ZK | 3 | 1P+1C | Z | v |
| 18MEMC | **Monte Carlo Method** *Miroslav Virius, Jaromír Kukal* ***Miroslav Virius*** *Miroslav Virius (Gar.)* | Z,ZK | 4 | 2P+2C | Z | v |
| 01MRMMI | **Methods for Sparse Matrices** *Jiří Mikyška* ***Jiří Mikyška*** *Jiří Mikyška (Gar.)* | KZ | 2 | 2P+0C | | v |
| 01SMF | **Modern Trends in Corporate Information Technologies** *Tomáš Oberhuber* ***Tomáš Oberhuber*** *Tomáš Oberhuber (Gar.)* | Z | 2 | 2 | L | v |
| 01NELO | **Nonlinear Optimization** *Radek Fučík* ***Radek Fučík*** *Radek Fučík (Gar.)* | ZK | 4 | 3P+0C | | v |
| 01PALG | **Advanced Algorithmization** *Tomáš Oberhuber* ***Tomáš Oberhuber*** *Tomáš Oberhuber (Gar.)* | KZ | 2 | 1P+1C | | v |
| 01PNL | **Advanced Methods of Numerical Linear Algebra** *Jiří Mikyška* ***Jiří Mikyška*** *Jiří Mikyška (Gar.)* | ZK | 2 | 2P+0C | | v |
| 01PMU | **Probabilistic Learning Models** *František Hakl* ***František Hakl*** *František Hakl (Gar.)* | ZK | 2 | 2+0 | Z | v |
| 01PSM1 | **Problem Seminar in Mathematical Analysis** ***Matěj Tušek*** *Matěj Tušek (Gar.)* | Z | 2 | 0P+2S | Z | v |
| 01PSM2 | **Problem Seminar in Mathematical Analysis 2** ***Matěj Tušek*** *Matěj Tušek (Gar.)* | Z | 2 | 2S | | v |
| 01PAMF | **Mainframe Programming in Assembler** ***Tomáš Oberhuber*** *Tomáš Oberhuber (Gar.)* | Z | 2 | 2 | L | v |
| 01SFTO | **Special Functions and Transformations in Image Analysis** *Jan Flusser* ***Jan Flusser*** *Jan Flusser (Gar.)* | ZK | 2 | 2+0 | L | v |
| 01SUP | **Start-up Project** *Přemysl Rubeš* ***Přemysl Rubeš*** *Přemysl Rubeš (Gar.)* | KZ | 2 | 2P+0C | | v |
| 01SMS1 | **Student's seminar in mathematics 1** ***Václav Klika*** *Václav Klika (Gar.)* | Z | 2 | 0P+2C | | v |
| 01SMS2 | **Student's seminar in mathematics 2** ***Václav Klika*** *Václav Klika (Gar.)* | Z | 2 | 0P+2C | L | v |
| 01TEH | **Game Theory** *Jan Volec* ***Jan Volec*** *Jan Volec (Gar.)* | ZK | 2 | 2+0 | L | v |

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| 01UMF | **Introduction to Mainframe**<br>*Tomáš Oberhuber* ***Tomáš Oberhuber*** *Tomáš Oberhuber (Gar.)* | Z | 2 | 1P+1C | Z | v |
| 01UTS | **Introduction to the Theory of Semigroups**<br>*Václav Klika* ***Václav Klika*** *Václav Klika (Gar.)* | ZK | 3 | 2P+0C | | v |
| 01ZPB2 | **Introduction to Computer Security 2**<br>*Petr Vokáč* ***Petr Vokáč*** *Petr Vokáč (Gar.)* | Z | 2 | 1+1 | | v |

**Characteristics of the courses of this group of Study Plan: Code=NMSPMINFV Name=MDP P_MINFN Optional courses**

| | | | |
|---|---|---|---|
| 01ALTI | Algebraic structures in theoretical informatics | ZK | 3 |

The course is devoted to the applications of some special algebraic structures. The first part of the course is devoted to the Gröbner bases of ideals of polynomial rings and their use for solving of systems of algebraic equations and other applications. The second part of the course is devoted to the ring of integers of algebraic number fields, used to constructions of various representations of numbers utilized in fast effective algorithms for arithmetic operations and evaluations of elementary functions.

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| 18DDS | Database System Decomposition | ZK | 4 |

The lectures are oriented to basic terms, database objects, their properties and relationships together with the accent to logics of decomposition and applications of database operations.

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| 01FIMA | Financial and Insurance Mathematics | ZK | 2 |

This course is an introduction to the problems of life and non-life insurance and financial mathematics.

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| 01KOS | Compressed Sensing | ZK | 2 |

The lecture will introduce basic concepts of the theory of compressed sensing an area founded in 2006 in the works of D. Donoho, E. Candes, and T. Tao. This theory studies the search for sparse solutions of underdetermined systems of linear equations. Due to the applications of sparse representations in electric engeneering and signal processing, this theory was quickly used in many different fields. After the first survey lecture, we will study the mathematical foundations of the theory. We prove general NP-completeness of the search for sparse solutions of systems of linear equations. We introduce conditions which ensure also existence of more effective solvers and show, that these are satisfied for example for Gaussian random matrices. As an effective solution method, we will analyze l1-minimization and Orthogonal Matching Pursuit. We will also study stability and robustness of the obtained results with respect to the corruption of measurements and the optimality of the results.

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|---|---|---|---|
| 01MMNS | Mathematical Modelling of Non-linear Systems | ZK | 3 |

The course consists of basic terms and results of the theory of finite- and infinitedimensional dynamical systems generated by evolutionary differential equations, and description of bifurcations and chaos. Second part is devoted to the explanation of basic results of the fractal geometry dealing with attractors of such dynamical systems.

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|---|---|---|---|
| 18MEMC | Monte Carlo Method | Z,ZK | 4 |

This courseis devoted to the numerical method Monte Carlo and to its selected applications.

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|---|---|---|---|
| 01MRMMI | Methods for Sparse Matrices | KZ | 2 |

The course is aimed at utilization of sparse matrices in direct methods for solution of large systems of linear algebraic equations. The course will cover the decomposition theory for symmetric and positive definite matrices. Theoretic results will be further applied for solution of more general systems. Main features of the methods and common implementation issues will be covered.

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|---|---|---|---|
| 01SMF | Modern Trends in Corporate Information Technologies | Z | 2 |

The course is devoted to mainframe administration basics. After introduction to mainframe hardware the following lectures covers security, transaction systems, virtualization and non-relational databases in the mainframe environment.

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|---|---|---|---|
| 01NELO | Nonlinear Optimization | ZK | 4 |

Nonlinear optimization problems find their application in may areas of applied mathematics. The lecture covers the basics of mathematical programming theory with emphasis on convex optimization and basic methods for unconstrained and constrained optimization. The lecture is supplemented by illustrative examples.

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|---|---|---|---|
| 01PALG | Advanced Algorithmization | KZ | 2 |

Keywords: String algorithms, graph algorithms, dynamic programming, suffix tress, graph cuts, numerical methods for solution of partial differential equations.

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|---|---|---|---|
| 01PNL | Advanced Methods of Numerical Linear Algebra | ZK | 2 |

Representation of real numbers in computers, behaviour of rounding errors during numerical computations, sensitivity of a problem, numerical stability of an algorithm. We will analyse sensitivity of the eigenvalues of a given matrix and sensitivity of roots of systems of linear algebraic equations. Then, the backward analysis of these problems will be performed. The second part of the course is devoted to the methods of QR-decomposition, least squares problem, and to several modern Krylov subspace methods for the solution of systems of linear algebraic equations and the Lanczos method for approximation of the eigenvalues of a symmetric square matrix.

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|---|---|---|---|
| 01PMU | Probabilistic Learning Models | ZK | 2 |

Introduction into the theory PAC learning model, VC-dimension of finite sets, Sauer, Cover and Radon's lemma, VC-dimension of composed mappings, application of VC-dimension for lower bound of necessary patterns, analysis of properties of delta rule based learning processes, PAC learning model extensions and PAO learning, Fourier coefficients search for Boolean functions.

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|---|---|---|---|
| 01PSM1 | Problem Seminar in Mathematical Analysis | Z | 2 |

This course is a seminar in advanced mathematical analysis and its applications. Seminar talks will be delivered by students, department staff, and invited quests. There are no exams but students will be assigned by some homework and they will give at least one talk per semester. The seminar is held in English and attendance is mandatory.

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|---|---|---|---|
| 01PSM2 | Problem Seminar in Mathematical Analysis 2 | Z | 2 |

This course is a seminar in advanced mathematical analysis and its applications. Seminar talks will be delivered by students, department staff, and invited quests. There are no exams but students will be assigned by some homework and they will give at least one talk per semester. The seminar is held in English and attendance is mandatory.

| | | | |
|---|---|---|---|
| 01PAMF | Mainframe Programming in Assembler | Z | 2 |

In this course the basics of programming in z/OS are explained namely the programming in assembler. Basic instructions, macros, I/O operations, DLL library loading and some other topics are discussed.

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| 01SFTO | Special Functions and Transformations in Image Analysis | ZK | 2 |

The course broadens topics of the courses ROZ1 and ROZ2. Main attention will be paid to several special functions and transformations (especially moment functions and wavelet transform) and their use in selected tasks of image processing - edge detection, noise removal, recognition of deformed objects, image registration, image compression, etc. Both the theory and practical applications will be discussed.

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|---|---|---|---|
| 01SUP | Start-up Project | KZ | 2 |
| 01SMS1 | Student's seminar in mathematics 1 | Z | 2 |
| 01SMS2 | Student's seminar in mathematics 2 | Z | 2 |
| 01TEH | Game Theory | ZK | 2 |

1. Combinatorial games, normal games - impartial and partizan games. 2. Multidimensional tic-tac-toe, Hales Jewett theorem. 3. Game tree, Zermelo's Theorem, Strategy stealing. 4. Arithmetic on normal games, equivalence on games, MEX principle, Sprague-Grundy theorem. 5. Strategic games, pure and mixed strategies, dominated strategies. 6. Zero-sum games, MAX-min principle, von Neumann theorem. 7. Nash equilibrium, Nash theorem. 8. Cooperation of two players, Nash arbitration. 9. Coalitional games, Shapley value.

| | | | |
|---|---|---|---|
| 01UMF | Introduction to Mainframe | Z | 2 |

In this course we teach the mainframe architecture. We explain how to operate the system z/OS, how to start a job using the JCL and we explain some differences when programming in C/C++ for z/OS:

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|---|---|---|---|
| 01UTS | Introduction to the Theory of Semigroups | ZK | 3 |
| It is known that a system of linear ordinary differential equations can be solved by virtue of the matrix exponential. However, the extension to partial differential equations is not straightforward. For example in the case of heat equation the matrix is replaced by Laplace operator which is not bounded and the series for the exponential will not converge. Moreover, solutions of the heat equation exist in general only for positive times and hence the solution operator can be at best a semigroup. The aim of the course is to provide a mathematical foundation for these types of problems and extend the concept of stability from ordinary differential equations, which is again in relation to spectrum of a linear operator. | | | |
| 01ZPB2 | Introduction to Computer Security 2 | Z | 2 |

## List of courses of this pass:

| Code | Name of the course | Completion | Credits |
|---|---|---|---|
| 01ALTI | Algebraic structures in theoretical informatics | ZK | 3 |
| The course is devoted to the applications of some special algebraic structures. The first part of the course is devoted to the Gröbner bases of ideals of polynomial rings and their use for solving of systems of algebraic equations and other applications. The second part of the course is devoted to the ring of integers of algebraic number fields, used to constructions of various representations of numbers utilized in fast effective algorithms for arithmetic operations and evaluations of elementary functions. | | | |
| 01DISE | Diploma Seminar | Z | 1 |
| In the first part of the seminar, students familiarize themselves with the general principles of publishing and presenting scientific work and the formal requirements for diploma projects at the faculty. The second part is designed as a practical training for the defence of the diploma project. The students give oral presentations of the current state of the research results achieved during the work on their projects. Each presentation is followed by a discussion on scientific matters as well as on the possibilities of improving the students performance. | | | |
| 01DIZO | Digital Image Processing | ZK | 4 |
| image sampling and quantization, Shannon theorem, aliasing basic image operations, histogram, contrast stretching, noise removal, image sharpening linear filtering in the spatial and frequency domains, convolution, Fourier transform edge detection, corner detection feature detection image degradations and their modelling, inverse and Wiener filtering, restoration of motion-blurred and out-of-focus blurred images image segmentation mathematical morphology image registration and matching | | | |
| 01DPSI1 | Master Thesis 1 | Z | 10 |
| Master's thesis preparation. | | | |
| 01DPSI2 | Master Thesis 2 | Z | 20 |
| Master's thesis preparation. | | | |
| 01FIMA | Financial and Insurance Mathematics | ZK | 2 |
| This course is an introduction to the problems of life and non-life insurance and financial mathematics. | | | |
| 01JAU | Languages, Automata and Computability | Z,ZK | 4 |
| 1. Finite automata, regular languages and operations, star lemmas. (3 lectures) 2. Kleene theorem (2 lectures) 3. Determinisation a minimisation (2 lectures) 4. Confext-free grammas and their reductions (2 lectures) 5. Pushdown automata and context-free languages (2 lectures) 6. Star lemma for CFL, closure properties of CFL (2 lectures) 7. Turing machine, recursive and recursively enumerable languages, methods of design of turing machines (2 lectures) 8. Undecidability (1 lecture) 9. Rice theorem, Post correspondence problem, undecidable properties of CFL (2 lectures) | | | |
| 01KOAL | Commutative Algebra | ZK | 3 |
| 1. Rings, ideals, homomorphisms, prime and maximal ideals. 2. Rings of polynomials, symmetric polynomials, irreducibility. 3. Gröbner bases. 4. Polynomials with rational coefficients, factorization of polynomials. 5. Hilbert's Nullstellensatz, ideals and manifolds, Krull dimension. 6. Fields, extensions, finite fields. 7. Introduction to Galois theory, Galois extensions, group and correspondence. | | | |
| 01KOS | Compressed Sensing | ZK | 2 |
| The lecture will introduce basic concepts of the theory of compressed sensing an area founded in 2006 in the works of D. Donoho, E. Candes, and T. Tao. This theory studies the search for sparse solutions of underdetermined systems of linear equations. Due to the applications of sparse representations in electric engeneering and signal processing, this theory was quickly used in many different fields. After the first survey lecture, we will study the mathematical foundations of the theory. We prove general NP-completeness of the search for sparse solutions of systems of linear equations. We introduce conditions which ensure also existence of more effective solvers and show, that these are satisfied for example for Gaussian random matrices. As an effective solution method, we will analyze l1-minimization and Orthogonal Matching Pursuit. We will also study stability and robustness of the obtained results with respect to the corruption of measurements and the optimality of the results. | | | |
| 01MAL | Mathematical Logic | Z,ZK | 4 |
| Logic is in the same time an object studied by mathematics and the language used to formalize and study mathematics. The goal of the course is to introduce basic notion of results of classical mathematical logic. 1.Propositions, evaluation, tautologies, axioms, theorems, soundness, completeness, and decidability of Hilbert and Gentzen style propositional calculi. 2.Language of predicate calculus, terms, formulas, relational structures, satisfiability, truth, tautologies, axioms, theorems, soundness, model constructions. 3.Gödel completeness theorem, Skolem and Herbrand theorems. 4.The first and the second Gödel theorems on incompleteness of Peano arithmetics and undecidability of predicate calculus. | | | |
| 01MMNS | Mathematical Modelling of Non-linear Systems | ZK | 3 |
| The course consists of basic terms and results of the theory of finite- and infinitedimensional dynamical systems generated by evolutionary differential equations, and description of bifurcations and chaos. Second part is devoted to the explanation of basic results of the fractal geometry dealing with attractors of such dynamical systems. | | | |
| 01MRMMI | Methods for Sparse Matrices | KZ | 2 |
| The course is aimed at utilization of sparse matrices in direct methods for solution of large systems of linear algebraic equations. The course will cover the decomposition theory for symmetric and positive definite matrices. Theoretic results will be further applied for solution of more general systems. Main features of the methods and common implementation issues will be covered. | | | |
| 01NELO | Nonlinear Optimization | ZK | 4 |
| Nonlinear optimization problems find their application in may areas of applied mathematics. The lecture covers the basics of mathematical programming theory with emphasis on convex optimization and basic methods for unconstrained and constrained optimization. The lecture is supplemented by illustrative examples. | | | |
| 01NEUR1 | Neural Networks and their Applications 1 | ZK | 2 |
| Keywords: Neural networks, data separation, functional approximation, supervised learning | | | |
| 01NEUR2 | Theoretical Fundamentals of Neural Networks | ZK | 3 |
| Keywords: Functional approximation, supervised learning, Vapnik-Chervonenkis-dimension | | | |
| 01PAA | Parallel Algorithms and Architectures | KZ | 4 |
| This course deals with the parallel data processing. It is important in situations when one processing unit (CPU) is not powerful enough to finish given task in reasonable time. When designing parallel algorithms, good knowledge of the parallel architectures is important. Therefore these architectures are studied as a part of this course too. | | | |

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| 01PALG | Advanced Algorithmization | KZ | 2 |
| Keywords: String algorithms, graph algorithms, dynamic programming, suffix tress, graph cuts, numerical methods for solution of partial differential equations. | | | |
| 01PAMF | Mainframe Programming in Assembler | Z | 2 |
| In this course the basics of programming in z/OS are explained namely the programming in assembler. Basic instructions, macros, I/O operations, DLL library loading and some other topics are discussed. | | | |
| 01PMU | Probabilistic Learning Models | ZK | 2 |
| Introduction into the theory PAC learning model, VC-dimension of finite sets, Sauer, Cover and Radon's lemma, VC-dimension of composed mappings, application of VC-dimension for lower bound of necessary patterns, analysis of properties of delta rule based learning processes, PAC learning model extensions and PAO learning, Fourier coefficients search for Boolean functions. | | | |
| 01PNL | Advanced Methods of Numerical Linear Algebra | ZK | 2 |
| Representation of real numbers in computers, behaviour of rounding errors during numerical computations, sensitivity of a problem, numerical stability of an algorithm. We will analyse sensitivity of the eigenvalues of a given matrix and sensitivity of roots of systems of linear algebraic equations. Then, the backward analysis of these problems will be performed. The second part of the course is devoted to the methods of QR-decomposition, least squares problem, and to several modern Krylov subspace methods for the solution of systems of linear algebraic equations and the Lanczos method for approximation of the eigenvalues of a symmetric square matrix. | | | |
| 01PSM1 | Problem Seminar in Mathematical Analysis | Z | 2 |
| This course is a seminar in advanced mathematical analysis and its applications. Seminar talks will be delivered by students, department staff, and invited quests. There are no exams but students will be assigned by some homework and they will give at least one talk per semester. The seminar is held in English and attendance is mandatory. | | | |
| 01PSM2 | Problem Seminar in Mathematical Analysis 2 | Z | 2 |
| This course is a seminar in advanced mathematical analysis and its applications. Seminar talks will be delivered by students, department staff, and invited quests. There are no exams but students will be assigned by some homework and they will give at least one talk per semester. The seminar is held in English and attendance is mandatory. | | | |
| 01SFTO | Special Functions and Transformations in Image Analysis | ZK | 2 |
| The course broadens topics of the courses ROZ1 and ROZ2. Main attention will be paid to several special functions and transformations (especially moment functions and wavelet transform) and their use in selected tasks of image processing - edge detection, noise removal, recognition of deformed objects, image registration, image compression, etc. Both the theory and practical applications will be discussed. | | | |
| 01SMF | Modern Trends in Corporate Information Technologies | Z | 2 |
| The course is devoted to mainframe administration basics. After introduction to mainframe hardware the following lectures covers security, transaction systems, virtualization and non-relational databases in the mainframe environment. | | | |
| 01SMS1 | Student's seminar in mathematics 1 | Z | 2 |
| 01SMS2 | Student's seminar in mathematics 2 | Z | 2 |
| 01SU1 | Machine Learning 1 | ZK | 3 |
| [1] features for description and recognition of 2-D shapes [2] invariant features, Fourier descriptors, moment invariants, differential invariants [3] statistical pattern recognition, supervised and nonsupervised classification, NN- classifier, linear classifier, Bayessian classifier [4] clustering in a feature space, iterative and hierarchical methods [5] dimensionality reduction of a feature space | | | |
| 01SUP | Start-up Project | KZ | 2 |
| 01TEC | Number Theory | ZK | 5 |
| 1. Algebraic and transcendental numbers 2. Algebraic number fields, field isomorphisms 3. Rational approximations, continued fractions 4. Diophantic equations, Pell's equation 5. Rings of integers in algebraic number fields and divisibility 6. Number representation in non-integer bases, finite and periodic expansions | | | |
| 01TEH | Game Theory | ZK | 2 |
| 1. Combinatorial games, normal games - impartial and partizan games. 2. Multidimensional tic-tac-toe, Hales Jewett theorem. 3. Game tree, Zermelo's Theorem, Strategy stealing. 4. Arithmetic on normal games, equivalence on games, MEX principle, Sprague-Grundy theorem. 5. Strategic games, pure and mixed strategies, dominated strategies. 6. Zero-sum games, MAX-min principle, von Neumann theorem. 7. Nash equilibrium, Nash theorem. 8. Cooperation of two players, Nash arbitration. 9. Coalitional games, Shapley value. | | | |
| 01TEMA | Matrix Theory | Z | 3 |
| The subject deals mainly with: 1) similarity of matrices and canonical forms of matrices 2) Perron-Frobenius theory and its applications 3) tensor product 4) Hermitian and positive semidefinite matrices | | | |
| 01TG | Graph Theory | ZK | 5 |
| 1. Basic notion of graph theory. 2. Edge and vertex connectivity (Menger Theorem). 3. Bipartite graphs. 4. Trees and forests. 5. Spanning trees (Matrix-Tree Theorem). 6. Euler tours and Hamilton cycles. 7. Maximal and perfect matching. 8. Edge coloring. 9. Flows in networks. 10. Vertex coloring. 11. Plannar graphs (Kuratowski theorem), vertex coloring of planar graphs. 12. Spectrum of the adjacency matrix. 13. Extremal graph theory. | | | |
| 01TIN | Information Theory | ZK | 2 |
| Information theory explores the fundamental limits of the representation and transmission of information. We will focus on the definition and implications of (information) entropy, the source coding theorem, and the channel coding theorem. These concepts provide a vital background for researchers in the areas of data compression, signal processing, controls, and pattern recognition. | | | |
| 01TSLO | Complexity Theory | ZK | 3 |
| The course is devoted to incorporation of complexity questions during algorithm development, introduction to NP completeness and generally to complexity classes of deterministic or nondeterministic Turing machines bounded by time or space. Emphasis is placed on mutual relations among these classes. Aside from nondeterministic classes we examine probability classes. Class of interactive protocols is presented at the end of lecture course. | | | |
| 01UMF | Introduction to Mainframe | Z | 2 |
| In this course we teach the mainframe architecture. We explain how to operate the system z/OS, how to start a job using the JCL and we explain some differences when programming in C/C++ for z/OS: | | | |
| 01UTS | Introduction to the Theory of Semigroups | ZK | 3 |
| It is known that a system of linear ordinary differential equations can be solved by virtue of the matrix exponential. However, the extension to partial differential equations is not straightforward. For example in the case of heat equation the matrix is replaced by Laplace operator which is not bounded and the series for the exponential will not converge. Moreover, solutions of the heat equation exist in general only for positive times and hence the solution operator can be at best a semigroup. The aim of the course is to provide a mathematical foundation for these types of problems and extend the concept of stability from ordinary differential equations, which is again in relation to spectrum of a linear operator. | | | |
| 01VUSI1 | Research Project 1 | Z | 6 |
| Research project on the selected topic under the supervision. Supervision and regular checking of the research project under preparation. | | | |
| 01VUSI2 | Research Project 2 | KZ | 8 |
| Research project on the selected topic under the supervision. Supervision and regular checking of the research project under preparation. | | | |
| 01ZPB2 | Introduction to Computer Security 2 | Z | 2 |
| 18DDS | Database System Decomposition | ZK | 4 |
| The lectures are oriented to basic terms, database objects, their properties and relationships together with the accent to logics of decomposition and applications of database operations. | | | |

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| 18MEMC | Monte Carlo Method | Z,ZK | 4 |
| | This courseis devoted to the numerical method Monte Carlo and to its selected applications. | | |
| 18OOP | Object Oriented Programming | Z | 2 |
| | This course consists of the contributions of students concerning given topics concerned on technologies uded in program development. | | |

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