Study plan

Name of study plan: Aplikovaná algebra a analýza

Faculty/Institute/Others:
Department:
Branch of study guaranteed by the department: Welcome page
Garantor of the study branch:
Program of study: Applied Algebra and Analysis
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:

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

Code of the group: NMSPAAA1
Name of the group: MDP P_AAAN 1st year
Requirement credits in the group:
Requirement courses in the group: In this group you have to complete at least 11 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
01FAN3	**Functional Analysis 3** *Pavel Šťovíček* ***Pavel Šťovíček*** *Pavel Šťovíček (Gar.)*	Z,ZK	5	2P+2C	Z	P
01PDE	**Modern theory of partial differential equations** *Matěj Tušek* ***Matěj Tušek*** *Matěj Tušek (Gar.)*	Z,ZK	4	2P+1C		P
01NELO	**Nonlinear Optimization** *Radek Fučík* ***Radek Fučík*** *Radek Fučík (Gar.)*	ZK	4	3P+0C		P
01TG	**Graph Theory** *Jan Volec, Petr Ambrož* ***Petr Ambrož*** *Petr Ambrož (Gar.)*	ZK	5	4P+0C		P
01NAH	**Theory of Random Processes** *Jan Vybíral* ***Jan Vybíral*** *Jan Vybíral (Gar.)*	ZK	3	3+0	Z	P
01TR1	**Theory of representations 1** *Čestmír Burdík* ***Čestmír Burdík*** *Čestmír Burdík (Gar.)*	ZK	2	2+0		P
01TRE2	**Representation theory 2** *Severin Pošta* ***Severin Pošta*** *Severin Pošta (Gar.)*	ZK	5	4P+0C		P
01URG	**Introduction to Riemannian geometry** *David Krejčiřík* ***David Krejčiřík*** *David Krejčiřík (Gar.)*	ZK	2	2+0	Z	P
01VAM	**Variational Methods** *Michal Beneš* ***Michal Beneš*** *Michal Beneš (Gar.)*	ZK	3	1P+1C	Z	P
01VUAA1	**Research Project 1** *Čestmír Burdík* ***Čestmír Burdík*** *Čestmír Burdík (Gar.)*	Z	6	0P+6C		P
01VUAA2	**Research Project 2** *Čestmír Burdík* ***Čestmír Burdík*** *Čestmír Burdík (Gar.)*	KZ	8	0P+8C		P

Characteristics of the courses of this group of Study Plan: Code=NMSPAAA1 Name=MDP P_AAAN 1st year

01FAN3	Functional Analysis 3	Z,ZK	5

Advanced parts of functional analysis needed for theory of representations of Lie groups and quantum theory. Compact operators, their ideals, unbounded selfadjoint operators, theory of selfadjoint extension of symmetric operators, Stones theorem, quadratic forms and Bochner integral. The basics of Banach algebras and C*-algebras.

01PDE	Modern theory of partial differential equations	Z,ZK	4

1. Sobolev spaces. 2. Definition, completeness, examples. 3. Continuous and compact embedding theorems. 4. Trace theorem. 5. Weak solution (importance, derivation of the weak formulation). 6. Elliptic PDE of Second Order. 7. Existence and uniqueness of weak solutions (Lax-Milgram theorem). 8. Regularity of weak solutions. 9. Relation to the calculus of variations, Poincaré inequality. 10. Maximum principle for classical and weak solutions.

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.

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.			
01NAH	Theory of Random Processes	ZK	3
The course is devoted in part to the basic notions of the general theory of random processes and partially to the theory of stationary processes and sequences both weakly and strongly stationary ones.			
01TR1	Theory of representations 1	ZK	2
Basic knowledge about representations of groups, with emphasize given to finite groups.			
01TRE2	Representation theory 2	ZK	5
1. Basics of representations of compact groups, Schur's lemma, orthogonality relations, Casimir operators. 2. Lie groups and algebras, matrix groups, one parametric subgroups, exponential map, group SU(n) and their representations. 3. Decomposition of representations, Clebsh-Gordan coeficients. 4. Gelfand-Tsetlin bases, Verma bases.. 5. Representations of groups and special functions. 6. Classification of irreducible representations of semisimple Lie algebras, Cartan subalgebra, roots, weights, lattices, Weyl chambers. 7. Classical and exceptional simple Lie algebras, Dynkin diagrams. 8. Realizations of Lie algebras, Weyl algebras. 9. Representations of Lie superalgerbas, osp(1,2n).			
01URG	Introduction to Riemannian geometry	ZK	2
This lecture is intended for an advanced undergraduate having possibly (but not necessarily) already taken a basic course on topological and differential manifolds. In addition to understanding the geometric meaning of curvature and its intimate relationship to topology, the student will learn the basic apparatus of Riemannian geometry suitable for further study of modern parts of mathematics and mathematical physics. Possible extension of this lecture is the geometric analysis of partial differential equations on Riemannian manifolds.			
01VAM	Variational Methods	ZK	3
The course is devoted to the methods of classical variational calculus - functional extrema by Euler equations, second functional derivative, convexity or monotonicity. Further, it contains investigation of quadratic functional, generalized solution, Sobolev spaces and variational problem for elliptic PDE's.			
01VUAA1	Research Project 1	Z	6
The research project is based on a topic approved by the administrators of the programme and by the head of the de-partment. The student is guided by the project supervisor during common regular meetings and discussions			
01VUAA2	Research Project 2	KZ	8
The research project is based on a topic approved by the administrators of the programme and by the head of the de-partment. The student is guided by the project supervisor during common regular meetings and discussions.			

Code of the group: NMSPAAA2
Name of the group: MDP P_AAAN 2nd year
Requirement credits in the group:
Requirement courses in the group: In this group you have to complete at least 7 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
01ASY	**Asymptotical Methods** *Jiří Mikyška* ***Jiří Mikyška*** *Jiří Mikyška (Gar.)*	Z,ZK	3	2+1	Z	P
01DPAA1	**Master Thesis 1** *Čestmír Burdík* ***Čestmír Burdík*** *Čestmír Burdík (Gar.)*	Z	10	0P+10C		P
01DPAA2	**Master Thesis 2** *Čestmír Burdík* ***Čestmír Burdík*** *Čestmír Burdík (Gar.)*	Z	20	0P+20C		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
01TNM	**Random Matrix Theory** *Jan Vybíral* ***Jan Vybíral*** *Jan Vybíral (Gar.)*	ZK	2	2+0	Z	P
01UTS	**Introduction to the Theory of Semigroups** *Václav Klika* ***Václav Klika*** *Václav Klika (Gar.)*	ZK	3	2P+0C		P

Characteristics of the courses of this group of Study Plan: Code=NMSPAAA2 Name=MDP P_AAAN 2nd year

01ASY	Asymptotical Methods	Z,ZK	3
Examples. Addition parts of mathematical analysis (generalized Lebesgue integral, parametric integrals.) Asymptotic relations a expansions - properties; algebraical and analytical operations. Applied asymptotics of sequences and sums; integrals of Laplace and Fourier type.			
01DPAA1	Master Thesis 1	Z	10
The diploma project is based on a topic approved by the administrators of the programme, department and by the dean. The student is guided by the project supervisor during common regular meetings and discussions.			
01DPAA2	Master Thesis 2	Z	20
The diploma project is based on a topic approved by the administrators of the programme, department and by the dean. The student is guided by the project supervisor during common regular meetings and discussions.			
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.			

01TNM	Random Matrix Theory	ZK	2

Theory of random matrices appeared first in 60's in the 20th century in connection with statistical physics and the theory of nucleis of atoms of heavy metals. The main interest of study is the distribution of eigenvalues of symmetric random matrices. In the 21st century the results of theory of random matrices were applied in theoretical computer science and numerics for design of random algorithms.

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.

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

Code of the group: NMSPAAAV
Name of the group: MDP P_AAAN 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
02ALT	**Algebraic Topology** *Jan Vysoký* ***Jan Vysoký*** *Jan Vysoký (Gar.)*	Z,ZK	4	2P+2C	Z	v
01ZASIG	**Analysis and Processing of Diagnostic Signals** *Zdeněk Převorovský* ***Zdeněk Převorovský*** *Zdeněk Převorovský (Gar.)*	ZK	3	3+0		v
01ASM	**Application of Statistical Methods** *Tomáš Hobza* ***Tomáš Hobza*** *Tomáš Hobza (Gar.)*	KZ	2	2+0		v
02COX	**Coxeter Groups** *Jiří Hrivnák* ***Jiří Hrivnák*** *Jiří Hrivnák (Gar.)*	Z	2	2+0		v
18DDS	**Database System Decomposition** *Dana Majerová, Jaromír Kukal* ***Dana Majerová*** *Jaromír Kukal (Gar.)*	ZK	4	2P+2C	L	v
12DRP	**Differential Equations on Computer** *Richard Liska* ***Richard Liska*** *Richard Liska (Gar.)*	Z,ZK	5	2+2	Z	v
01DIZO	**Digital Image Processing** *Barbara Zitová* ***Barbara Zitová*** *Barbara Zitová (Gar.)*	ZK	4	2P+2C		v
01DYNR1	**Dynamic Decision Making 1** *Tatjana Gaj, Miroslav Kárný* ***Tatjana Gaj*** *Tatjana Gaj (Gar.)*	Z,ZK	3	2P+1C		v
01FIMA	**Financial and Insurance Mathematics** *Joel Horowitz* ***Joel Horowitz*** *Joel Horowitz (Gar.)*	ZK	2	2P+0C	Z	v
01SPEC	**Geometrical Aspects of Spectral Theory** *David Krejčiřík* ***David Krejčiřík*** *David Krejčiřík (Gar.)*	ZK	2	2+0	L	v
01KOS	**Compressed Sensing** *Jan Vybíral* ***Jan Vybíral*** *Jan Vybíral (Gar.)*	ZK	2	2+0	Z	v
02KFA	**Quantum Physics** *Michal Jex* ***Michal Jex*** *Igor Jex (Gar.)*	Z,ZK	6	4P+2C	L	v
01KVGR1	**Quantum Groups 1** ***Čestmír Burdík*** *Čestmír Burdík (Gar.)*	Z	2	2+0	Z	v
02KVK1	**Quantum Circle 1** *Pavel Exner (Gar.)*	Z	2	0+2	Z	v
02KVK2	**Quantum Circle 2** *Pavel Exner (Gar.)*	Z	2	0+2	L	v
01MAL	**Mathematical Logic** *Petr Cintula* ***Petr Cintula*** *Petr Cintula (Gar.)*	Z,ZK	4	2+1		v
01MMDY	**Mathematical Methods in Fluid Dynamics 1** *Pavel Strachota* ***Pavel Strachota*** *Pavel Strachota (Gar.)*	ZK	2	2P+0C	Z	v
01MBM	**Mathematical techniques in biology and medicine** *Václav Klika* ***Václav Klika*** *Václav Klika (Gar.)*	Z,ZK	3	2+1	L	v
01MKP	**Finite Element Method** *Michal Beneš* ***Michal Beneš*** *Michal Beneš (Gar.)*	ZK	3	1P+1C	L	v
18MEMC	**Monte Carlo Method** *Jaromír Kukal, Miroslav Virius* ***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
01NEUR1	**Neural Networks and their Applications 1** *Martin Holeňa, František Hakl* ***František Hakl*** *František Hakl (Gar.)*	ZK	2	2+0		v
18OOP	**Object Oriented Programming** *Miroslav Virius* ***Miroslav Virius*** *Miroslav Virius (Gar.)*	Z	2	2C	Z	v

01PNL	**Advanced Methods of Numerical Linear Algebra** *Jiří Mikyška* ***Jiří Mikyška*** *Jiří Mikyška (Gar.)*	ZK	2	2P+0C		v
01UMIN	**Probabilistic Models of Artificial Intelligence** *Jiřina Vejnarová* ***Jiřina Vejnarová*** *Jiřina Vejnarová (Gar.)*	KZ	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
02RMMF	**Solvable Models of Mathematical Physics** *Ladislav Hlavatý Ladislav Hlavatý (Gar.)*	Z	2	2+0	L	v
01SUP	**Start-up Project** *Přemysl Rubeš* ***Přemysl Rubeš*** *Přemysl Rubeš (Gar.)*	KZ	2	2P+0C		v
01SVK	**Student's Scientific Conference** ***Jiří Mikyška*** *Jiří Mikyška (Gar.)*	Z	1	5 dní		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
01TEC	**Number Theory** *Zuzana Masáková, Edita Pelantová* ***Zuzana Masáková*** *Zuzana Masáková (Gar.)*	ZK	5	4P+0C		v
01TIN	**Information Theory** *Tomáš Hobza* ***Tomáš Hobza*** *Tomáš Hobza (Gar.)*	ZK	2	2+0	Z	v
01TEMA	**Matrix Theory** *Edita Pelantová* ***Edita Pelantová*** *Edita Pelantová (Gar.)*	Z	3	2+0	L	v

Characteristics of the courses of this group of Study Plan: Code=NMSPAAAV Name=MDP P_AAAN Optional courses

02ALT	Algebraic Topology	Z,ZK	4

A study of modern mathematical and theoretical physics requires one to acquire an ever increasing knowledge of mathematical apparautus. The main goal of this course is to acquaint students with basic methods used in algebraic topology, namely elements of category theory, homototopies, homological algebra and cohomology. An important objective is to enhance the mathematical language by concepts appearing universally across disciplines like differential geometry and abstract algebra. During excercise sessions, students will try practical calculations of introduced mathematical structures.

01ZASIG	Analysis and Processing of Diagnostic Signals	ZK	3

Digital signal processing, signal transformations and filtrations, spectral and time-frequency analysis

01ASM	Application of Statistical Methods	KZ	2

The course focuses on applications of selected methods of statistical data analysis to concrete problems including their solutions using statistical software. Namely we will deal with: hypotheses tests about parameters of normal distribution, nonparametric methods, contingency tables, linear regression and correlation, analysis of variance.

02COX	Coxeter Groups	Z	2

The course is an introduction to the theory of Coxeter groups and their invariant theory. The case of the finite Coxeter groups - the reflection groups and their properties are studied. The notions of the Weyl chamber and length are defined. General theory of the Coxeter groups, the corresponding bilinear forms and the theory of their classification represent abstract generalization of the reflection groups. The study of affine Weyl groups and related objects forms basic example of infinite Coxeter groups. As an introduction to the invariant theory the MacDonald identity and the Weyl identity are presented.

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.

12DRP	Differential Equations on Computer	Z,ZK	5

Ordinary differential equations, analytical methods; Ordinary differential equations, numerical methods, Runge-Kutta methods, stability; Partial differential equations, analysis, hyperbolik, parabolic and elliptic equations, posedness of differential equaitons; Partial differential equations, numerical solution, finite difference methods, difference schemes, order of approximation, stability, convergence, modified equation, diffusion, dispersion; Conservation laws and their numerical solution, shallow water equations, Euler equations, Lagrangian methods, ALE methods; Practical computation in Matlab system for numerics and Maple for analysis of schemes.

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

01DYNR1	Dynamic Decision Making 1	Z,ZK	3

Design, control and analysis of intelligent agents (or systems) that behave appropriately in various circumstances are highly demanded (artificial intelligence and machine learning, data mining, financial modelling, natural language processing, bioinformatics, web search and information retrieval, algorithm design, system design, network analysis, and more). Such intelligent agents need to reason with uncertain information and limited computational resources. Effective decision making requires the knowledge about: . the agent's environment and its dynamics (including the presence of other intelligent agents), . the agent's goals and preferences . the agent's abilities to observe and influence the environment. This course introduces dynamic decision making under uncertainty and computational methods supporting decision-making. The course helps to develop the mathematical reasoning skills crucial for areas inherently involving uncertainty. These skills can serve as the foundation for further study in any application area you choose to pursue and may also help you to analyse the uncertainty in your everyday life. Course objectives: - Learn the basic ideas and techniques underlying design of intelligent rational agents. A specific emphasis will be on the decision-theoretic modelling paradigm. - Understand state-of-the-art of decision making (DM). - Be able to formulate decision making or learning problem and select appropriate method for a given task/application. - Be able to understand research papers in the field (main conferences: IJCAI, NeurIPS, AAMAS, ICAART, ICM; main journals: AI, JAIR, JAAMAS, IJAR). - Try out some ideas of your own.

01FIMA	Financial and Insurance Mathematics	ZK	2

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

01SPEC	Geometrical Aspects of Spectral Theory	ZK	2

1. Motivations. The crisis of classical physics and the rise of quantum mechanics. Mathematical formulation of quantum theory. Spectral problems in classical physics. 2. Elements of functional analysis. The discrete and essential spectra. Sobolev spaces. Quadratic forms. Schrödinger operators. 3. Stability of the essential spectrum. Weyl's theorem. Bound states. Variational and perturbation methods. 4. The role of the dimension of the Euclidean space. Criticality versus subcriticality. The Hardy inequality. Stability of matter. 5. Geometrical aspects. Glazman's classification of Euclidean domains and their basic spectral properties. 6. Vibrational systems. The symmetric rearrangement and the Faber-Krahn inequality for the principal frequency. 7. Quantum waveguides. Elements of differential geometry: curves, surfaces, manifolds. Effective dynamics. 8. Geometrically induced bound states and Hardy-type inequalities in tubes.

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.			
02KFA	Quantum Physics	Z,ZK	6
The goal of the lecture is formulating and developing quantum theory as a physically motivated, but mathematically rigorous theory built upon the analysis of bounded and unbounded linear operators on separable Hilbert spaces. Previous knowledge of quantum mechanics is an advantage but not a predisposition for the course. The pivot point is the establishing of the main postulates of the theory and deriving their consequences for model systems, as well as a detailed study of the most commonly used observables in quantum mechanics. The lecture focuses on the exactness and proofs of the statements. Some common mistakes resulting from breaking the assumptions of these are also discussed.			
01KVGR1	Quantum Groups 1	Z	2
Quantum Algebra was originated in the 80s in the works of professor L. D. Faddeev and the Leningrad school on the inverse scattering method in order to solve integrable models. They have many applications in mathematics and mathematical physics such as the classification of nodes, in the theory of integrable systems and the string theory.			
02KVK1	Quantum Circle 1	Z	2
Seminars of the Doppler Institute on topics of mathematical quantum physics for students and PhD. students.			
02KVK2	Quantum Circle 2	Z	2
Seminars of the Doppler Institute on topics of mathematical quantum physics for students and PhD. students.			
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.			
01MMDY	Mathematical Methods in Fluid Dynamics 1	ZK	2
First, the differential equations representing the conservation laws of fluid flow are briefly derived and reviewed. Next, the problems for the resulting equations are formulated, focusing on boundary conditions specification. The reference problem undergoes numerical analysis with emphasis on explaining the weak solution and its role in describing real phenomena. In the second part, important problems are introduced, involving fluid flow and other effects (heat transfer, chemical reactions, multiphase nature) and an adequate mathematical description is chosen.			
01MBM	Mathematical techniques in biology and medicine	Z,ZK	3
Spatially independent models; enzyme kinetics; excitable system; reaction-diffusion equations; travelling waves; pattern formation; conditions for Turing instability, the effect of domain size; the concept of stability in PDEs, spectrum of a linear operator, semigroups.			
01MKP	Finite Element Method	ZK	3
The course is devoted to the mathematical theory of the finite element method numerically solving boundary-value and initial-boundary-value problems for partial differential equations. Mathematical properties of the method are explained. The approximation error estimates are derived.			
18MEMC	Monte Carlo Method	Z,ZK	4
This courseis devoted to the numerical method Monte Carlo and to its selected applications.			
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.			
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.			
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.			
01UMIN	Probabilistic Models of Artificial Intelligence	KZ	2
The course is devoted to the survey of methods used for uncertainty processing in the field of artificial inteligence. The main attention is paid to so-called graphical Markov models, particularly to Bayesian networks.			
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.			
02RMMF	Solvable Models of Mathematical Physics	Z	2
Elementary methods for solving nonlinear differential equations occuring in mathematical physics are explained.			
01SUP	Start-up Project	KZ	2
01SVK	Student's Scientific Conference	Z	1
This is the active participation of the student in one of the approved student conferences. The list of such conferences is defined by the course guarantor.			
01SMS1	Student's seminar in mathematics 1	Z	2
01SMS2	Student's seminar in mathematics 2	Z	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			

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			

List of courses of this pass:

Code	Name of the course	Completion	Credits
01ASM	Application of Statistical Methods	KZ	2
The course focuses on applications of selected methods of statistical data analysis to concrete problems including their solutions using statistical software. Namely we will deal with: hypotheses tests about parameters of normal distribution, nonparametric methods, contingency tables, linear regression and correlation, analysis of variance.			
01ASY	Asymptotical Methods	Z,ZK	3
Examples. Addition parts of mathematical analysis (generalized Lebesgue integral, parametric integrals.) Asymptotic relations a expansions - properties; algebraical and analytical operations. Applied asymptotics of sequences and sums; integrals of Laplace and Fourier type.			
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			
01DPAA1	Master Thesis 1	Z	10
The diploma project is based on a topic approved by the administrators of the programme, department and by the dean. The student is guided by the project supervisor during common regular meetings and discussions.			
01DPAA2	Master Thesis 2	Z	20
The diploma project is based on a topic approved by the administrators of the programme, department and by the dean. The student is guided by the project supervisor during common regular meetings and discussions.			
01DYNR1	Dynamic Decision Making 1	Z,ZK	3
Design, control and analysis of intelligent agents (or systems) that behave appropriately in various circumstances are highly demanded (artificial intelligence and machine learning, data mining, financial modelling, natural language processing, bioinformatics, web search and information retrieval, algorithm design, system design, network analysis, and more). Such intelligent agents need to reason with uncertain information and limited computational resources. Effective decision making requires the knowledge about: . the agent's environment and its dynamics (including the presence of other intelligent agents), . the agent's goals and preferences . the agent's abilities to observe and influence the environment. This course introduces dynamic decision making under uncertainty and computational methods supporting decision-making. The course helps to develop the mathematical reasoning skills crucial for areas inherently involving uncertainty. These skills can serve as the foundation for further study in any application area you choose to pursue and may also help you to analyse the uncertainty in your everyday life. Course objectives: - Learn the basic ideas and techniques underlying design of intelligent rational agents. A specific emphasis will be on the decision-theoretic modelling paradigm. - Understand state-of-the-art of decision making (DM). - Be able to formulate decision making or learning problem and select appropriate method for a given task/application. - Be able to understand research papers in the field (main conferences: IJCAI, NeurIPS, AAMAS, ICAART, ICM; main journals: AI, JAIR, JAAMAS, IJAR). - Try out some ideas of your own.			
01FAN3	Functional Analysis 3	Z,ZK	5
Advanced parts of functional analysis needed for theory of representations of Lie groups and quantum theory. Compact operators, their ideals, unbounded selfadjoint operators, theory of selfadjoint extension of symmetric operators, Stones theorem, quadratic forms and Bochner integral. The basics of Banach algebras and C*-algebras.			
01FIMA	Financial and Insurance Mathematics	ZK	2
This course is an introduction to the problems of life and non-life insurance and financial mathematics.			
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.			
01KVGR1	Quantum Groups 1	Z	2
Quantum Algebra was originated in the 80s in the works of professor L. D. Faddeev and the Leningrad school on the inverse scattering method in order to solve integrable models. They have many applications in mathematics and mathematical physics such as the classification of nodes, in the theory of integrable systems and the string theory.			
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.			

01MBM	Mathematical techniques in biology and medicine	Z,ZK	3
Spatially independent models; enzyme kinetics; excitable system; reaction-diffusion equations; travelling waves; pattern formation; conditions for Turing instability, the effect of domain size; the concept of stability in PDEs, spectrum of a linear operator, semigroups.			
01MKP	Finite Element Method	ZK	3
The course is devoted to the mathematical theory of the finite element method numerically solving boundary-value and initial-boundary-value problems for partial differential equations. Mathematical properties of the method are explained. The approximation error estimates are derived.			
01MMDY	Mathematical Methods in Fluid Dynamics 1	ZK	2
First, the differential equations representing the conservation laws of fluid flow are briefly derived and reviewed. Next, the problems for the resulting equations are formulated, focusing on boundary conditions specification. The reference problem undergoes numerical analysis with emphasis on explaining the weak solution and its role in describing real phenomena. In the second part, important problems are introduced, involving fluid flow and other effects (heat transfer, chemical reactions, multiphase nature) and an adequate mathematical description is chosen.			
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.			
01NAH	Theory of Random Processes	ZK	3
The course is devoted in part to the basic notions of the general theory of random processes and partially to the theory of stationary processes and sequences both weakly and strongly stationary ones.			
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			
01PDE	Modern theory of partial differential equations	Z,ZK	4
1. Sobolev spaces. 2. Definition, completeness, examples. 3. Continuous and compact embedding theorems. 4. Trace theorem. 5. Weak solution (importance, derivation of the weak formulation). 6. Elliptic PDE of Second Order. 7. Existence and uniqueness of weak solutions (Lax-Milgram theorem). 8. Regularity of weak solutions. 9. Relation to the calculus of variations, Poincaré inequality. 10. Maximum principle for classical and weak solutions.			
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.			
01SMS1	Student's seminar in mathematics 1	Z	2
01SMS2	Student's seminar in mathematics 2	Z	2
01SPEC	Geometrical Aspects of Spectral Theory	ZK	2
1. Motivations. The crisis of classical physics and the rise of quantum mechanics. Mathematical formulation of quantum theory. Spectral problems in classical physics. 2. Elements of functional analysis. The discrete and essential spectra. Sobolev spaces. Quadratic forms. Schrödinger operators. 3. Stability of the essential spectrum. Weyl's theorem. Bound states. Variational and perturbation methods. 4. The role of the dimension of the Euclidean space. Criticality versus subcriticality. The Hardy inequality. Stability of matter. 5. Geometrical aspects. Glazman's classification of Euclidean domains and their basic spectral properties. 6. Vibrational systems. The symmetric rearrangement and the Faber-Krahn inequality for the principal frequency. 7. Quantum waveguides. Elements of differential geometry: curves, surfaces, manifolds. Effective dynamics. 8. Geometrically induced bound states and Hardy-type inequalities in tubes.			
01SUP	Start-up Project	KZ	2
01SVK	Student's Scientific Conference	Z	1
This is the active participation of the student in one of the approved student conferences. The list of such conferences is defined by the course guarantor.			
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			
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.			
01TNM	Random Matrix Theory	ZK	2
Theory of random matrices appeared first in 60's in the 20th century in connection with statistical physics and the theory of nucleis of atoms of heavy metals. The main interest of study is the distribution of eigenvalues of symmetric random matrices. In the 21st century the results of theory of random matrices were applied in theoretical computer science and numerics for design of random algorithms.			
01TR1	Theory of representations 1	ZK	2
Basic knowledge about representations of groups, with emphasize given to finite groups.			

01TRE2	Representation theory 2	ZK	5
1. Basics of representations of compact groups, Schur's lemma, orthogonality relations, Casimir operators. 2. Lie groups and algebras, matrix groups, one parametric subgroups, exponential map, group SU(n) and their representations. 3. Decomposition of representations, Clebsh-Gordan coeficients. 4. Gelfand-Tsetlin bases, Verma bases.. 5. Representations of groups and special functions. 6. Classification of irreducible representations of semisimple Lie algebras, Cartan subalgebra, roots, weights, lattices, Weyl chambers. 7. Classical and exceptional simple Lie algebras, Dynkin diagrams. 8. Realizations of Lie algebras, Weyl algebras. 9. Representations of Lie superalgerbas, osp(1,2n).			
01UMIN	Probabilistic Models of Artificial Intelligence	KZ	2
The course is devoted to the survey of methods used for uncertainty processing in the field of artificial inteligence. The main attention is paid to so-called graphical Markov models, particularly to Bayesian networks.			
01URG	Introduction to Riemannian geometry	ZK	2
This lecture is intended for an advanced undergraduate having possibly (but not necessarily) already taken a basic course on topological and differential manifolds. In addition to understanding the geometric meaning of curvature and its intimate relationship to topology, the student will learn the basic apparatus of Riemannian geometry suitable for further study of modern parts of mathematics and mathematical physics. Possible extension of this lecture is the geometric analysis of partial differential equations on Riemannian manifolds.			
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.			
01VAM	Variational Methods	ZK	3
The course is devoted to the methods of classical variational calculus - functional extrema by Euler equations, second functional derivative, convexity or monotonicity. Further, it contains investigation of quadratic functional, generalized solution, Sobolev spaces and variational problem for elliptic PDE's.			
01VUAA1	Research Project 1	Z	6
The research project is based on a topic approved by the administrators of the programme and by the head of the de-partment. The student is guided by the project supervisor during common regular meetings and discussions			
01VUAA2	Research Project 2	KZ	8
The research project is based on a topic approved by the administrators of the programme and by the head of the de-partment. The student is guided by the project supervisor during common regular meetings and discussions.			
01ZASIG	Analysis and Processing of Diagnostic Signals	ZK	3
Digital signal processing, signal transformations and filtrations, spectral and time-frequency analysis			
02ALT	Algebraic Topology	Z,ZK	4
A study of modern mathematical and theoretical physics requires one to acquire an ever increasing knowledge of mathematical apparautus. The main goal of this course is to acquaint students with basic methods used in algebraic topology, namely elements of category theory, homototopies, homological algebra and cohomology. An important objective is to enhance the mathematical language by concepts appearing universally across disciplines like differential geometry and abstract algebra. During excercise sessions, students will try practical calculations of introduced mathematical structures.			
02COX	Coxeter Groups	Z	2
The course is an introduction to the theory of Coxeter groups and their invariant theory. The case of the finite Coxeter groups - the reflection groups and their properties are studied. The notions of the Weyl chamber and length are defined. General theory of the Coxeter groups, the corresponding bilinear forms and the theory of their classification represent abstract generalization of the reflection groups. The study of affine Weyl groups and related objects forms basic example of infinite Coxeter groups. As an introduction to the invariant theory the MacDonald identity and the Weyl identity are presented.			
02KFA	Quantum Physics	Z,ZK	6
The goal of the lecture is formulating and developing quantum theory as a physically motivated, but mathematically rigorous theory built upon the analysis of bounded and unbounded linear operators on separable Hilbert spaces. Previous knowledge of quantum mechanics is an advantage but not a predisposition for the course. The pivot point is the establishing of the main postulates of the theory and deriving their consequences for model systems, as well as a detailed study of the most commonly used observables in quantum mechanics. The lecture focuses on the exactness and proofs of the statements. Some common mistakes resulting from breaking the assumptions of these are also discussed.			
02KVK1	Quantum Circle 1	Z	2
Seminars of the Doppler Institute on topics of mathematical quantum physics for students and PhD. students.			
02KVK2	Quantum Circle 2	Z	2
Seminars of the Doppler Institute on topics of mathematical quantum physics for students and PhD. students.			
02RMMF	Solvable Models of Mathematical Physics	Z	2
Elementary methods for solving nonlinear differential equations occuring in mathematical physics are explained.			
12DRP	Differential Equations on Computer	Z,ZK	5
Ordinary differential equations, analytical methods; Ordinary differential equations, numerical methods, Runge-Kutta methods, stability; Partial differential equations, analysis, hyperbolik, parabolic and elliptic equations, posedness of differential equaitons; Partial differential equations, numerical solution, finite difference methods, difference schemes, order of approximation, stability, convergence, modified equation, diffusion, dispersion; Conservation laws and their numerical solution, shallow water equations, Euler equations, Lagrangian methods, ALE methods; Practical computation in Matlab system for numerics and Maple for analysis of schemes.			
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.			
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.			

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