Study plan

Name of study plan: Matematické inženýrství

Faculty/Institute/Others:
Department:
Branch of study guaranteed by the department: Welcome page
Garantor of the study branch:
Program of study: Applications of Natural Sciences
Type of study: Follow-up master full-time
Required credits: 79
Elective courses credits: 41
Sum of credits in the plan: 120
Note on the plan:

Name of the block: Compulsory courses of the specialization
Minimal number of credits of the block: 79
The role of the block: PO

Code of the group: NMSMIPP1
Name of the group: NMSMI - povinné předměty 1. ročník
Requirement credits in the group: In this group you have to gain at least 39 credits
Requirement courses in the group: In this group you have to complete at least 10 courses
Credits in the group: 39
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	PO
01FA3	**Functional Analysis 3**	Z,ZK	3	2+1	Z	PO
01MKP	**Finite Element Method** *Michal Beneš* ***Michal Beneš*** *Michal Beneš (Gar.)*	ZK	3	1P+1C	L	PO
01PNLA	**Advanced Methods of Numerical Linear Algebra** ***Jiří Mikyška***	ZK	3	2+0	Z	PO
01TEMA	**Matrix Theory** *Edita Pelantová* ***Edita Pelantová*** *Edita Pelantová (Gar.)*	Z	3	2+0	L	PO
01NAH	**Theory of Random Processes** *Jan Vybíral* ***Jan Vybíral*** *Jan Vybíral (Gar.)*	ZK	3	3+0	Z	PO
01VAM	**Variational Methods** *Michal Beneš* ***Michal Beneš*** *Michal Beneš (Gar.)*	ZK	3	1P+1C	Z	PO
01VUMM1	**Research Project 1** *Čestmír Burdík* ***Čestmír Burdík*** *Čestmír Burdík (Gar.)*	Z	6	0+6	Z	PO
01VUMM2	**Research Project 2** *Čestmír Burdík* ***Čestmír Burdík*** *Čestmír Burdík (Gar.)*	KZ	8	0+8	L	PO
01ZTG	**Introduction to Graph Theory**	ZK	4	4+0		PO

Characteristics of the courses of this group of Study Plan: Code=NMSMIPP1 Name=NMSMI - povinné předměty 1. ročník

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.			
01FA3	Functional Analysis 3	Z,ZK	3
Advanced parts of functional analysis needed for modern quantum theory.			
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.			
01PNLA	Advanced Methods of Numerical Linear Algebra	ZK	3
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.			

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			
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.			
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.			
01VUMM1	Research Project 1	Z	6
Research project on the selected topic under the supervision. Supervision and regular checking of the research project under preparation.			
01VUMM2	Research Project 2	KZ	8
Research project on the selected topic under the supervision. Supervision and regular checking of the research project under preparation.			
01ZTG	Introduction to Graph Theory	ZK	4

Code of the group: NMSMIPP2
Name of the group: NMSMI - povinné předměty 2. ročník
Requirement credits in the group: In this group you have to gain at least 40 credits
Requirement courses in the group: In this group you have to complete at least 5 courses
Credits in the group: 40
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
01DPMM1	**Master Thesis 1** *Čestmír Burdík* ***Čestmír Burdík*** *Čestmír Burdík (Gar.)*	Z	10	0+10	Z	PO
01DPMM2	**Master Thesis 2** *Čestmír Burdík* ***Čestmír Burdík*** *Čestmír Burdík (Gar.)*	Z	20	0+20	L	PO
01MMNS	**Mathematical Modelling of Non-linear Systems** *Michal Beneš* ***Michal Beneš*** *Michal Beneš (Gar.)*	ZK	3	1P+1C	Z	PO
01NELI	**Nonlinear Programming**	ZK	4	3P+0C	Z	PO
01DSEMI	**Diploma Seminar** *Čestmír Burdík* ***Čestmír Burdík*** *Čestmír Burdík (Gar.)*	Z	3	0+2		PO

Characteristics of the courses of this group of Study Plan: Code=NMSMIPP2 Name=NMSMI - povinné předměty 2. ročník

01DPMM1	Master Thesis 1	Z	10
Master's thesis preparation.			
01DPMM2	Master Thesis 2	Z	20
Master's thesis preparation.			
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.			
01NELI	Nonlinear Programming	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.			
01DSEMI	Diploma Seminar	Z	3
Preparation of the thesis defense.			

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

Code of the group: NMSMIVP
Name of the group: NMSMI - volitelné předměty
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
01ZASIG	**Analysis and Processing of Diagnostic Signals** *Zdeněk Převorovský* ***Zdeněk Převorovský*** *Zdeněk Převorovský (Gar.)*	ZK	3	3+0		V

01MADR	**Calculus Revisited** ***Václav Klika***	Z	2	0+2	L	v
01APST1	**Aperiodic Structures 1** *Zuzana Masáková* ***Zuzana Masáková*** *Zuzana Masáková (Gar.)*	Z	2	2+0		v
01APST2	**Aperiodic Structures 2** *Zuzana Masáková* ***Zuzana Masáková*** *Zuzana Masáková (Gar.)*	Z	2	2+0		v
01ASM	**Application of Statistical Methods** *Tomáš Hobza* ***Tomáš Hobza*** *Tomáš Hobza (Gar.)*	KZ	2	2+0		v
18DATS	**Database System Decomposition**	KZ	4	2+2	L	v
01DPV	**Differential Calculus on Manifolds** *Matěj Tušek* ***Matěj Tušek*** *Matěj Tušek (Gar.)*	ZK	2	2+0	L	v
12DRP	**Differential Equations on Computer** *Richard Liska Richard Liska (Gar.)*	Z,ZK	5	2+2	Z	v
01DYRO	**Dynamic Decision Making** ***Tatjana Gaj***	ZK	4	3+1		v
01DRO1	**Dynamic Decision Making 1** ***Tatjana Gaj***	ZK	2	2+0		v
01DRO2	**Dynamic Decision Making 2** *Miroslav Kárný, Tatjana Gaj* ***Miroslav Kárný*** *Miroslav Kárný (Gar.)*	ZK	2	2+0		v
01FIMA	**Financial and Insurance Mathematics** *Joel Horowitz* ***Joel Horowitz*** *Joel Horowitz (Gar.)*	ZK	2	2P+0C	Z	v
02SPEC	**Geometrical Aspects of Spectral Theory**	ZK	2	2+0	L	v
01KF	**Quantum Physics**	Z,ZK	6	4+2	L	v
02LIAG	**Lie Algebras and Lie Groups**	Z,ZK	6	3+2	L	v
01LOM	**Logic for Mathematicians** ***Petr Cintula***	ZK	2	2+0		v
01MLO	**Logic for Mathematicians**	ZK	2	2+0		v
01MAL	**Mathematical Logic** *Petr Cintula* ***Petr Cintula*** *Petr Cintula (Gar.)*	Z,ZK	4	2+1		v
01MMDT1	**Mathematical Methods in Fluid Dynamics 1**	Z	2	2+0	Z	v
01MMDT2	**Mathematical Methods in Fluid Dynamics**	ZK	2	2+0	L	v
01MBI	**Mathematical Methods in Biology and Medicine** *Václav Klika* ***Václav Klika*** *Václav Klika (Gar.)*	KZ	3	2+1	Z	v
01MKO	**Method of Finite Volumes** ***Michal Beneš***	KZ	2	1+1	Z	v
18MMC	**Monte Carlo Method**	Z	4	2+2	Z	v
01MRM	**Methods for Sparse Matrices** ***Jiří Mikyška***	ZK	2	2+0	L	v
01PDR	**Modern Theory of Partial Differential Equations** ***Matěj Tušek***	ZK	2	2+0		v
01NSAP	**Neural Computers and Their Applications** ***František Hakl***	ZK	4	3+0	Z	v
01NEUR1	**Neural Networks and their Applications 1** *Martin Holeňa, František Hakl* ***František Hakl*** *František Hakl (Gar.)*	ZK	2	2+0		v
01NSPP	**Numerical Simulations of Convection Problems**	KZ	2	1+1	L	v
01NUSO	**Numerical Software**	Z	3	2+0	Z	v
18OOP	**Object Oriented Programming** *Miroslav Virius* ***Miroslav Virius***	Z	2	2C	Z	v
01PAA	**Parallel Algorithms and Architectures** *Tomáš Oberhuber* ***Tomáš Oberhuber*** *Tomáš Oberhuber (Gar.)*	KZ	4	2P+1C	L	v
01PALG	**Advanced Algorithmization** *Tomáš Oberhuber* ***Tomáš Oberhuber*** *Tomáš Oberhuber (Gar.)*	KZ	2	1P+1C		v
01PMU	**Probabilistic Learning Models** *František Hakl* ***František Hakl*** *František Hakl (Gar.)*	ZK	2	2+0	Z	v
01UMIN	**Probabilistic Models of Artificial Intelligence** *Jiřina Vejnarová* ***Jiřina Vejnarová*** *Jiřina Vejnarová (Gar.)*	KZ	2	2+0	Z	v
01REAN	**Regression Data Analysis** ***Tomáš Hobza***	Z,ZK	4	2+2		v
01REGA	**Regression Data Analysis**	ZK	2	2+0	Z	v
01SFTO	**Special Functions and Transformations in Image Analysis** *Jan Flusser* ***Jan Flusser*** *Jan Flusser (Gar.)*	ZK	2	2+0	L	v
01STOM	**Stochastic Methods**	KZ	2	2+0		v
01STOS	**Stochastic Systems**	ZK	2	2+0	Z	v
01SVK	**Student's Scientific Conference** ***Jiří Mikyška*** *Jiří Mikyška (Gar.)*	Z	1	5 dní		v
01NEUR2	**Theoretical Fundamentals of Neural Networks** *Martin Holeňa* ***Martin Holeňa*** *Martin Holeňa (Gar.)*	ZK	3	2+0		v
01TC	**Number Theory** ***Zuzana Masáková***	ZK	4	2+0	L	v

01TIN	**Information Theory** *Tomáš Hobza* ***Tomáš Hobza*** *Tomáš Hobza (Gar.)*	ZK	2	2+0	Z	v
01TSLO	**Complexity Theory** *Jan Volec* ***Jan Volec*** *Jan Volec (Gar.)*	ZK	3	3+0	Z	v
01UKRY	**Introduction to Cryptology**	Z	2	2+0	L	v
01ZPB1	**Introduction to Computer Security 1** *Petr Vokáč* ***Petr Vokáč*** *Petr Vokáč (Gar.)*	Z	2	1+1		v
01ZPB2	**Introduction to Computer Security 2** *Petr Vokáč* ***Petr Vokáč*** *Petr Vokáč (Gar.)*	Z	2	1+1		v
01TRLA	**Basic of Representation Theory of Lie Algebras** ***Čestmír Burdík***	ZK	2	2+0	L	v
01ROZ1	**Image Processing and Pattern Recognition 1**	ZK	4	2+2	L	v
01ROZP2	**Image Processing and Pattern Recognition 2** *Jan Flusser* ***Jan Flusser*** *Jan Flusser (Gar.)*	ZK	4	2+1		v
01ZSIG	**Diagnostic Signal Processing** ***Zdeněk Převorovský***	ZK	3	3+0	L	v

Characteristics of the courses of this group of Study Plan: Code=NMSMIVP Name=NMSMI - volitelné předměty

01ZASIG	Analysis and Processing of Diagnostic Signals	ZK	3

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

01MADR	Calculus Revisited	Z	2

The term function - development of the term; misleading character of generality of the term; 'a statistical aspect'; discontinuous functions are still 'close' to continuous ones Limit passage - supremum, limsup, lim have the same scheme; definition of term filter; usage of filter for all limit passages Problem of definition of the length of curve - classical approach and its problems; term curve in analysis; the necessity of defining new terms: rectifiable curve; Lebesgue's approach (leads to necessity of definition of new integral - Lebesgue's integral); functional approach: curve length as a lower semi-continuous functional in curve space Integral theory - historical introduction; determination of surface area of complex figure; effort for finding an universal methodology: Cauchy's approach, Riemann's approach; persisting problems lead Lebesgue to a definition of a new integral; the two fundamental Lebesgue's thoughts; Lebesgue's measure and measurability; existence (and construction) of unmeasurable set (in Lebesgue sense) and the axiom of choice; comparison of Riemann's and Lebesgue's integral and finding the essence of difference; weak spots of Lebesgue's integral; the essence of measure theory; new perspectives in integral theory

01APST1	Aperiodic Structures 1	Z	2

The seminar is devoted to combinatorics on infinite words, non-standard numeration systems and aperiodic tilings of the space. The seminar often hosts foreign researcher. Students participate actively in solution of open problems in the field.

01APST2	Aperiodic Structures 2	Z	2

The seminar is a continuation of 01APST1. It is devoted to advanced issues of combinatorics on infinite words, non-standard numeration systems and aperiodic tilings of the space. The seminar often hosts foreign researcher. Students participate actively in solution of open problems in the field.

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.

18DATS	Database System Decomposition	KZ	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.

01DPV	Differential Calculus on Manifolds	ZK	2

Smooth manifold, tangent space differential forms, tensors, Riemannian metrics and manifold, covariant derivative, parallel transport, orientation of manifold, itegration on manifold and Stokes theorem.

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.

01DYRO	Dynamic Decision Making	ZK	4
01DRO1	Dynamic Decision Making 1	ZK	2

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, NIPS, AAMAS, ICAART, ICM; main journals: AI, JAIR, JAAMAS, IJAR). - Try out some ideas of your own.

01DRO2	Dynamic Decision Making 2	ZK	2

1.Overview of the formalised decision-making task and tools for its solution 2.Application of the general fully probabilistic design of decision-making strategies for Markov chains and linear-Gaussian models 3.Aproximation and completion of probabilities serving to processing data-based as well as probabilistic knowledge and preferences for Markov chains 4.Introduction into multi-participants decision making and its formalisation 5.Usability of general tools for knowledge sharing and cooperation within multiple-participants decision making 6.Illustrative case studies of solving decision-making tasks 7.Open decision-making problems

01FIMA	Financial and Insurance Mathematics	ZK	2

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

02SPEC	Geometrical Aspects of Spectral Theory	ZK	2

Spectral theory is an extremely rich field which has found its application in many areas of physics and mathematics. One of the reason which makes it so attractive on the formal level is that it provides a unifying framework for problems in various branches of mathematics, for example partial differential equations, calculus of variations, geometry, stochastic analysis, etc. The goal of the lecture is to acquaint the students with spectral methods in the theory of linear differential operators coming both from modern as well as classical physics, with a special emphasis put on geometrically induced spectral properties. We give an overview of both classical results and recent developments in the field, and we wish to always do it by providing a physical interpretation of the mathematical theorems.

01KF	Quantum Physics	Z,ZK	6
Basic quantum theory presented via rigorous mathematical methods.			
02LIAG	Lie Algebras and Lie Groups	Z,ZK	6
Definitions and properties of Lie groups and Lie algebras. Different types of Lie algebras, root systems and classification of complex simple Lie algebras. Introduction to theory of representations.			
01LOM	Logic for Mathematicians	ZK	2
01MLO	Logic for Mathematicians	ZK	2
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.			
01MMDT1	Mathematical Methods in Fluid Dynamics 1	Z	2
The contents of the course is the introduction to mathematical methods in fluid dynamice. Concretely: mathematical modelling of fundamentals physical laws by means of partial differential equations, formulation of associated boundary or initial-boundary value problems for various type sof fluids as well as various type sof flows, properties and some speciál solutions of these problems.			
01MMDT2	Mathematical Methods in Fluid Dynamics	ZK	2
The course is devoted to mathematical fundamentals of fluid mechanics models, classical and advanced finite difference and finite volume techniques applied to numerical solution of simplified problems as well as multi - dimensional problems of inviscid and viscous flow.			
01MBI	Mathematical Methods in Biology and Medicine	KZ	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			
01MKO	Method of Finite Volumes	KZ	2
The subject is devoted to the numerical solutions of linear partial differential equations of first and second order using the finite difference and the finite volume methods. The lecture discusses the basic properties of numerical methods for solving elliptic, parabolic and hyperbolic equations, the modified equation and the numerical viscosity.			
18MMC	Monte Carlo Method	Z	4
This courseis devoted to the numerical method Monte Carlo and to its selected applications.			
01MRM	Methods for Sparse Matrices	ZK	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.			
01PDR	Modern Theory of Partial Differential Equations	ZK	2
Sobolev spaces, continuous and compact embedding theorems, trace theorem. Elliptic PDE of Second Order, Lax-Milgram theorem, regularity, maximum principle, harmonic functions.			
01NSAP	Neural Computers and Their Applications	ZK	4
Introduction into the theory of artificial neural networks, some important kinds of neural networks, threshold vectors analysis of binary nets, neural networks evaluation of Boolean functions, neural networks from the point of view of function approximation, neural networks from the point of view of probability theory, numerical properties of learning algorithms.			
01NEUR1	Neural Networks and their Applications 1	ZK	2
Keywords: Neural networks, data separation, functional approximation, supervised learning			
01NSPP	Numerical Simulations of Convection Problems	KZ	2
Students will be acquainted with the 2D and 3D numerical simulations of flow problems described by potential, inviscid and viscous flow. It is a transonic flow around a wing profile, in a 2D and 3D lattice, in 2D and 3D channels of different shape, in the boundary layer, and in the modeling of cardiovascular problems. Some cases of turbulent flow simulations are also mentioned.			
01NUSO	Numerical Software	Z	3
The course deals with the implementation of several numerical methods in existing software libraries. The attention will be paid to libraries for solution of problems of linear algebra with full and sparse matrices, and to the solution of ODE and PDE			
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.			
01PALG	Advanced Algorithmization	KZ	2
Keywords: String algorithms, graph algorithms, dynamic programming, suffix tress, graph cuts, numerical methods for solution of partial differential equations.			
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.			
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.			
01REAN	Regression Data Analysis	Z,ZK	4
Key words: Regression model, cross-sectinal and panel data, classical and robust estimators.			
01REGA	Regression Data Analysis	ZK	2
Classical and robust regression analysis, estimators, diagnostics, time series, dynamic model.			
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.			
01STOM	Stochastic Methods	KZ	2
Keywords: Markov processes, transition probabilities, stationary distribution, hitting probabilities, transition rates, Poisson process, queuing theory.			

01STOS	Stochastic Systems	ZK	2
The course is devoted to the theory of Markov processes as mathematical models for stochastic systems, i.e. dynamic systems influenced by randomness. The main goal consists in investigating the time limit behavior for different instances according the type of the system states. The models with discrete and continuous time are distinguished, an application for practical tasks is demonstrated, in particular for queuing systems.			
01SVK	Student's Scientific Conference	Z	1
01NEUR2	Theoretical Fundamentals of Neural Networks	ZK	3
Keywords: Functional approximation, supervised learning, Vapnik-Chervonenkis-dimension			
01TC	Number Theory	ZK	4
The subject is devoted to number theory with focus on continued fractions and fundamentals of algebraic number 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.			
01UKRY	Introduction to Cryptology	Z	2
An introductive survey of cryptography and cryptoanalysis starting with classical ciphers, passing through mechanical rotor machines, symmetric and asymmetric cryptography to quantum cryptography.			
01ZPB1	Introduction to Computer Security 1	Z	2
01ZPB2	Introduction to Computer Security 2	Z	2
01TRLA	Basic of Representation Theory of Lie Algebras	ZK	2
Lie algebra is an integral part of many theories in natural sciences. The lecture formulates the fundamentals of Lie algebras and their representations.			
01ROZ1	Image Processing and Pattern Recognition 1	ZK	4
An introductory course on image processing and pattern recognition. Major attention is paid to image sampling and quantization, image preprocessing (noise removal, contrast stretching, sharpening, and de-blurring, Wiener filtering, blind deconvolution), edge detection, morphology and geometric transformations and warping. Numerous applications and experimental results are presented in addition to the theory.			
01ROZP2	Image Processing and Pattern Recognition 2	ZK	4
The course is a continuation of ROZ1. Major attention is paid to features for shape description and recognition, and to general pattern recognition techniques. Numerous applications and experimental results are presented in addition to the theory.			
01ZSIG	Diagnostic Signal Processing	ZK	3
The course is devoted to modern techniques of the analog and digital signal processing used in physics, measurements and information science. Basic signal transforms and their discrete equivalents are explained to describe signals and their transfer in different representations. Practical training is based on MATLAB software with Signal and Wavelet Toolboxes.			

List of courses of this pass:

Code	Name of the course	Completion	Credits
01APST1	Aperiodic Structures 1	Z	2
The seminar is devoted to combinatorics on infinite words, non-standard numeration systems and aperiodic tilings of the space. The seminar often hosts foreign researcher. Students participate actively in solution of open problems in the field.			
01APST2	Aperiodic Structures 2	Z	2
The seminar is a continuation of 01APST1. It is devoted to advanced issues of combinatorics on infinite words, non-standard numeration systems and aperiodic tilings of the space. The seminar often hosts foreign researcher. Students participate actively in solution of open problems in the field.			
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.			
01DPMM1	Master Thesis 1	Z	10
Master's thesis preparation.			
01DPMM2	Master Thesis 2	Z	20
Master's thesis preparation.			
01DPV	Differential Calculus on Manifolds	ZK	2
Smooth manifold, tangent space differential forms, tensors, Riemannian metrics and manifold, covariant derivative, parallel transport, orientation of manifold, itegration on manifold and Stokes theorem.			
01DRO1	Dynamic Decision Making 1	ZK	2
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, NIPS, AAMAS, ICAART, ICM; main journals: AI, JAIR, JAAMAS, IJAR). - Try out some ideas of your own.		
01DRO2	Dynamic Decision Making 2	ZK	2
	1.Overview of the formalised decision-making task and tools for its solution 2.Application of the general fully probabilistic design of decision-making strategies for Markov chains and linear-Gaussian models 3.Aproximation and completion of probabilities serving to processing data-based as well as probabilistic knowledge and preferences for Markov chains 4.Introduction into multi-participants decision making and its formalisation 5.Usability of general tools for knowledge sharing and cooperation within multiple-participants decision making 6.Ilustrative case studies of solving decision-making tasks 7.Open decision-making problems		
01DSEMI	Diploma Seminar	Z	3
	Preparation of the thesis defense.		
01DYRO	Dynamic Decision Making	ZK	4
01FA3	Functional Analysis 3	Z,ZK	3
	Advanced parts of functional analysis needed for modern quantum theory.		
01FIMA	Financial and Insurance Mathematics	ZK	2
	This course is an introduction to the problems of life and non-life insurance and financial mathematics.		
01KF	Quantum Physics	Z,ZK	6
	Basic quantum theory presented via rigorous mathematical methods.		
01LOM	Logic for Mathematicians	ZK	2
01MADR	Calculus Revisited	Z	2
	The term function - development of the term; misleading character of generality of the term; 'a statistical aspect'; discontinuous functions are still 'close' to continuous ones Limit passage - supremum, limsup, lim have the same scheme; definition of term filter; usage of filter for all limit passages Problem of definition of the length of curve - classical approach and its problems; term curve in analysis; the necessity of defining new terms: rectifiable curve; Lebesgue's approach (leads to necessity of definition of new integral - Lebesgue's integral); functional approach: curve length as a lower semi-continuous functional in curve space Integral theory - historical introduction; determination of surface area of complex figure; effort for finding an universal methodology: Cauchy's approach, Riemann's approach; persisting problems lead Lebesgue to a definition of a new integral; the two fundamental Lebesgue's thoughts; Lebesgue's measure and measurability; existence (and construction) of unmeasurable set (in Lebesgue sense) and the axiom of choice; comparison of Riemann's and Lebesgue's integral and finding the essence of difference; weak spots of Lebesgue's integral; the essence of measure theory; new perspectives in integral 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.		
01MBI	Mathematical Methods in Biology and Medicine	KZ	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		
01MKO	Method of Finite Volumes	KZ	2
	The subject is devoted to the numerical solutions of linear partial differential equations of first and second order using the finite difference and the finite volume methods. The lecture discusses the basic properties of numerical methods for solving elliptic, parabolic and hyperbolic equations, the modified equation and the numerical viscosity.		
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.		
01MLO	Logic for Mathematicians	ZK	2
01MMDT1	Mathematical Methods in Fluid Dynamics 1	Z	2
	The contents of the course is the introduction to mathematical methods in fluid dynamice. Concretely: mathematical modelling of fundamentals physical laws by means of partial differential equations, formulation of associated boundary or initial-boundary value problems for various type sof fluids as well as various type sof flows, properties and some speciál solutions of these problems.		
01MMDT2	Mathematical Methods in Fluid Dynamics	ZK	2
	The course is devoted to mathematical fundamentals of fluid mechanics models, classical and advanced finite difference and finite volume techniques applied to numerical solution of simplified problems as well as multi - dimensional problems of inviscid and viscous flow.		
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.		
01MRM	Methods for Sparse Matrices	ZK	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.		
01NELI	Nonlinear Programming	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		
01NSAP	Neural Computers and Their Applications	ZK	4
	Introduction into the theory of artificial neural networks, some important kinds of neural networks, threshold vectors analysis of binary nets, neural networks evaluation of Boolean functions, neural networks from the point of view of function approximation, neural networks from the point of view of probability theory, numerical properties of learning algorithms.		
01NSPP	Numerical Simulations of Convection Problems	KZ	2
	Students will be acquainted with the 2D and 3D numerical simulations of flow problems described by potential, inviscid and viscous flow. It is a transonic flow around a wing profile, in a 2D and 3D lattice, in 2D and 3D channels of different shape, in the boundary layer, and in the modeling of cardiovascular problems. Some cases of turbulent flow simulations are also mentioned.		

01NUSO	Numerical Software	Z	3
The course deals with the implementation of several numerical methods in existing software libraries. The attention will be paid to libraries for solution of problems of linear algebra with full and sparse matrices, and to the solution of ODE and PDE			
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.			
01PALG	Advanced Algorithmization	KZ	2
Keywords: String algorithms, graph algorithms, dynamic programming, suffix tress, graph cuts, numerical methods for solution of partial differential equations.			
01PDR	Modern Theory of Partial Differential Equations	ZK	2
Sobolev spaces, continuous and compact embedding theorems, trace theorem. Elliptic PDE of Second Order, Lax-Milgram theorem, regularity, maximum principle, harmonic functions.			
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.			
01PNLA	Advanced Methods of Numerical Linear Algebra	ZK	3
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.			
01REAN	Regression Data Analysis	Z,ZK	4
Key words: Regression model, cross-sectinal and panel data, classical and robust estimators.			
01REGA	Regression Data Analysis	ZK	2
Classical and robust regression analysis, estimators, diagnostics, time series, dynamic model.			
01ROZ1	Image Processing and Pattern Recognition 1	ZK	4
An introductory course on image processing and pattern recognition. Major attention is paid to image sampling and quantization, image preprocessing (noise removal, contrast stretching, sharpening, and de-blurring, Wiener filtering, blind deconvolution), edge detection, morphology and geometric transformations and warping. Numerous applications and experimental results are presented in addition to the theory.			
01ROZP2	Image Processing and Pattern Recognition 2	ZK	4
The course is a continuation of ROZ1. Major attention is paid to features for shape description and recognition, and to general pattern recognition techniques. Numerous applications and experimental results are presented in addition to the theory.			
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.			
01STOM	Stochastic Methods	KZ	2
Keywords: Markov processes, transition probabilities, stationary distribution, hitting probabilities, transition rates, Poisson process, queuing theory.			
01STOS	Stochastic Systems	ZK	2
The course is devoted to the theory of Markov processes as mathematical models for stochastic systems, i.e. dynamic systems influenced by randomness. The main goal consists in investigating the time limit behavior for different instances according the type of the system states. The models with discrete and continuous time are distinguished, an application for practical tasks is demonstrated, in particular for queuing systems.			
01SVK	Student's Scientific Conference	Z	1
01TC	Number Theory	ZK	4
The subject is devoted to number theory with focus on continued fractions and fundamentals of algebraic number theory.			
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			
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.			
01TRLA	Basic of Representation Theory of Lie Algebras	ZK	2
Lie algebra is an integral part of many theories in natural sciences. The lecture formulates the fundamentals of Lie algebras and their representations.			
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.			
01UKRY	Introduction to Cryptology	Z	2
An introductive survey of cryptography and cryptoanalysis starting with classical ciphers, passing through mechanical rotor machines, symmetric and asymmetric cryptography to quantum cryptography.			
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.			
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.			
01VUMM1	Research Project 1	Z	6
Research project on the selected topic under the supervision. Supervision and regular checking of the research project under preparation.			
01VUMM2	Research Project 2	KZ	8
Research project on the selected topic under the supervision. Supervision and regular checking of the research project under preparation.			

01ZASIG	Analysis and Processing of Diagnostic Signals	ZK	3
	Digital signal processing, signal transformations and filtrations, spectral and time-frequency analysis		
01ZPB1	Introduction to Computer Security 1	Z	2
01ZPB2	Introduction to Computer Security 2	Z	2
01ZSIG	Diagnostic Signal Processing	ZK	3
	The course is devoted to modern techniques of the analog and digital signal processing used in physics, measurements and information science. Basic signal transforms and their discrete equivalents are explained to describe signals and their transfer in different representations. Practical training is based on MATLAB software with Signal and Wavelet Toolboxes.		
01ZTG	Introduction to Graph Theory	ZK	4
02LIAG	Lie Algebras and Lie Groups	Z,ZK	6
	Definitions and properties of Lie groups and Lie algebras. Different types of Lie algebras, root systems and classification of complex simple Lie algebras. Introduction to theory of representations.		
02SPEC	Geometrical Aspects of Spectral Theory	ZK	2
	Spectral theory is an extremely rich field which has found its application in many areas of physics and mathematics. One of the reason which makes it so attractive on the formal level is that it provides a unifying framework for problems in various branches of mathematics, for example partial differential equations, calculus of variations, geometry, stochastic analysis, etc. The goal of the lecture is to acquaint the students with spectral methods in the theory of linear differential operators coming both from modern as well as classical physics, with a special emphasis put on geometrically induced spectral properties. We give an overview of both classical results and recent developments in the field, and we wish to always do it by providing a physical interpretation of the mathematical theorems.		
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.		
18DATS	Database System Decomposition	KZ	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.		
18MMC	Monte Carlo Method	Z	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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