Study plan

Name of study plan: Aplikované matematicko-stochastické metody

Faculty/Institute/Others:
Department:
Branch of study guaranteed by the department: Welcome page
Garantor of the study branch:
Program of study: Applied Mathematical Stochastic Methods
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: NMSPAMSM1
Name of the group: MDP P_AMSMN 1st year
Requirement credits in the group:
Requirement courses in the group: In this group you have to complete at least 9 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
01MMD	**Mathematical Modelling of Traffic** *Milan Krbálek* ***Milan Krbálek*** *Milan Krbálek (Gar.)*	Z,ZK	5	2P+2C		P
01RAD	**Regression Data Analysis** *Tomáš Hobza, Jiří Franc* ***Jiří Franc*** *Tomáš Hobza (Gar.)*	Z,ZK	5	2P+2C		P
01SKE	**System Reliability and Clinical Experiments** *Václav Kůs* ***Václav Kůs*** *Václav Kůs (Gar.)*	KZ	3	2+0	L	P
01SU2	**Machine Learning 2** *Filip Šroubek* ***Filip Šroubek*** *Filip Šroubek (Gar.)*	Z,ZK	4	2P+2C		P
01TIN	**Information Theory** *Tomáš Hobza* ***Tomáš Hobza*** *Tomáš Hobza (Gar.)*	ZK	2	2+0	Z	P
01NAH	**Theory of Random Processes** *Jan Vybíral* ***Jan Vybíral*** *Jan Vybíral (Gar.)*	ZK	3	3+0	Z	P
01VUAM1	**Research Project 1** *Čestmír Burdík* ***Čestmír Burdík*** *Čestmír Burdík (Gar.)*	Z	6	0+6	Z	P
01VUAM2	**Research Project 2** *Čestmír Burdík* ***Čestmír Burdík*** *Čestmír Burdík (Gar.)*	KZ	8	0+8	L	P
01ZLMA	**Generalized Linear Models and Applications** *Tomáš Hobza* ***Tomáš Hobza*** *Tomáš Hobza (Gar.)*	Z,ZK	5	2P+2C		P

Characteristics of the courses of this group of Study Plan: Code=NMSPAMSM1 Name=MDP P_AMSMN 1st year

01MMD	Mathematical Modelling of Traffic	Z,ZK	5

1. Basic mathematical description of vehicular traffic - macroscopic and microscopic quantities, relations between them, fundamental diagram and phase map. 2. Empirical knowledge about traffic flow - methodology of traffic data evaluation, 3s-unification procedure, two-phase theory, three-phase theory, VHM and link to capacity calculations in physics of traffic. 3. Traffic models - general overview, classification of models, examples, Greenbergs macroscopic model and its solution, Montrolls microscopic model and its solution. 4. Lighthill-Whitham model - formulation and theoretical solution, Cole-Hopf transformation, formulation of associate Cauchy problem and its solution in distributions, Burgers equation. 5. Cellular traffic models - Nagel-Schreckenberg model, Fukui-Ischibaschi model, model TASEP and its theoretical solution by MPA. 6. Thermodynamic traffic models - variants, classification by range and type of potential, Hamiltonian description, general solution methodology, solution of short-range model, connection between thermodynamic models and balance particle systems, solution of middle-ranged model with logarithmic potential. 7. Vehicular Headway Modeling - an insight into the issue, empirical and theoretical knowledge in a given area, criteria for admissibility of headway distributions, statistical rigidity and changes in its course, derivation of statistical rigidity for thermodynamic gas. 8. Statistical properties of traffic flow - Poisson and semi-Poisson mode of transport, supra-random traffic states, their detection.

01RAD	Regression Data Analysis	Z,ZK	5

1.Simple linear regression: least squares estimation, properties of parameter estimates, hypotheses tests and confi-dence intervals for parameters of the model, model-based prediction, analysis of residuals 2.Multiple linear regression: general linear model, least squares estimation, analytical and numerical solutions of the normal equations, properties of parameter estimates, coefficient of determination, F-test, prediction intervals 3.Residuals, diagnostics and transformations: residuals and residual plots, normality tests, detection of outlying and influential observations, hat matrix, Cooks distance, transformations of dependent and independent varia-ble, Box-Cox transformation 4.Selection of a regression model: criteria functions, R2 statistics, Mallows Cp statistics, Akaike and Bayes infor-mation criteria, stepwise regression and backward elimination 5.Multicollinearity: impact of multicollinearity on precision of the parameter estimates, detecting and combatting multicollinearity, ridge regression

01SKE	System Reliability and Clinical Experiments	KZ	3

The main goal of the subject is to provide the mathematical principles of reliability theory and techniques of survival data analysis, reliability of component systems, asymptotic methods for reliability, concept of experiments under censoring and their processing in clinical trials (life-time models). The techniques are illustrated and tested within practical examples originating from lifetime material experiments and clinical trials.

01SU2	Machine Learning 2	Z,ZK	4

1.Fundamental topics from the probability theory and machine learning (classical distributions, Bayes theorem, Kullback-Leibler divergence, curse of dimensionality, overfitting, maximum likelihood and maximum a posteriori estimators, Principle Component Analysis) 2.Decision trees: general schema, recursive partitioning, optimal partitioning and pruning, ensemble learning - bagging, boosting, random forests. 3.Examples of decision trees: Adaptive boosting AdaBoost, Gradient boosting, Xgboost. 4.Numerical methods for optimization (steepest descent, conjugate gradient, Newton and quasi-Newton, constrained extrema, Lagrangian). 5.Deep feedforward networks (hidden units, nonlinear activation functions, output units, loss functional, stochastic gradient descent, back-propagation algorithm) 6.Optimization for training deep models (regularization, algorithms with adaptive learning rates) 7.Convolutional neural networks 8.Recurrent neural networks 9.Advanced network architectures (autoencoders, Generative Adversarial networks) 10.Applications of deep learning (classification, segmentation, image reconstruction)

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.

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.

01VUAM1	Research Project 1	Z	6

Research project on the selected topic under the supervision. Supervision and regular checking of the research project under preparation.

01VUAM2	Research Project 2	KZ	8

Research project on the selected topic under the supervision. Supervision and regular checking of the research project under preparation.

01ZLMA	Generalized Linear Models and Applications	Z,ZK	5

1.Generalized linear models: exponential family, regularity conditions, score function. 2.Estimation of parameters: maximum likelihood estimates, numerical methods used for their calculation, Newton-Raphson, Fisher-scoring algorithm. 3.Testing of models: asymptotic distribution of the score function and the MLE estimates, models comparisons, residual analysis, diagnostic of influential observations. 4.Analysis of covariance (ANCOVA), general model of analysis of covariance, one factor ANCOVA, multiple comparisons. 5.Models for binary data: logistic model, normal model, Gumbel model, model parameters interpretation, odds ratio, tests, residuals. 6.Poisson regression: univariate and multivariate Poisson regression, model parameters interpretation, tests and residuals. 7. Probability models for contingency tables, log-linear models.

Code of the group: NMSPAMSM2
Name of the group: MND P_AMSMN 2nd year
Requirement credits in the group:
Requirement courses in the group: In this group you have to complete at least 6 courses
Credits in the group: 0
Note on the group:

Code	**Name of the course / Name of the group of courses** ***(in case of groups of courses the list of codes of their members)*** *Tutors, **authors** and guarantors (gar.)*	Completion	Credits	Scope	Semester	Role
01ADS	**Applications of Data Science** *Jiří Franc **Jiří Franc** Jiří Franc (Gar.)*	KZ	4	1P+2C		P
01DPAM1	**Master Thesis 1** *Čestmír Burdík **Čestmír Burdík** Čestmír Burdík (Gar.)*	Z	10	0+10		P
01DPAM2	**Master Thesis 2** *Čestmír Burdík **Čestmír Burdík** Čestmír Burdík (Gar.)*	Z	20	0+20		P
18HA	**Heuristic Algorithms** *Jaromír Kukal **Jaromír Kukal** Jaromír Kukal (Gar.)*	ZK	4	2P+2C	L	P
01NAEX	**Design of Experiments** *Jiří Franc **Jiří Franc** Jiří Franc (Gar.)*	Z,ZK	3	2P+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

Characteristics of the courses of this group of Study Plan: Code=NMSPAMSM2 Name=MND P_AMSMN 2nd year

01ADS	Applications of Data Science	KZ	4

Practical application of mathematical modeling methods, statistics and machine learning needs wide range of tasks from data preparation and collection to design of an appropriate method and its division into units for development and implementation into the production. Last, but not least, the cooperation in group and management of a modern data project is crucial. The actual standard of required tools will be presented on lectures. Further, these procedures will be applied during exercises with an emphasis on team collaboration, project planning. At the end of the course, students will present their results to other teams.

01DPAM1	Master Thesis 1	Z	10

Master's thesis preparation.

01DPAM2	Master Thesis 2	Z	20

Master's thesis preparation.

18HA	Heuristic Algorithms	ZK	4

Heuristic algorithms of optimization operates on discrete or continuous domains. Brutal force, stochastic, greedy, physically, biologically and sociologically motivated heuristic are included, used for optimum finding and compared.

01NAEX	Design of Experiments	Z,ZK	3

1.Introduction to the design of experiments and data analysis. 2.Completely randomized one-factor experiment: introduction of a fixed-effect model, tests of equality of mean values, choice of number of observations. 3.Methods of multiple comparison: Bonferroni method, Scheffy method, Tukey method 4.Randomized complete block design: model definition, equality effects tests, power of test, determining sample size. 5.Latin and Greco-Latin squares, balanced incomplete block design, model adequacy checking, residuals, multiple comparisons. 6.Two factor factorial design: statistical models and their properties for designs 2^2, 2^3 and 2^k, fractional factorial design, resolutions. 7.3^k factorial designs, confounding in 3^k factorial design. 8.Models with random effects, factorials with mixed levels.

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.

Name of the block: Compulsory elective courses
Minimal number of credits of the block: 0
The role of the block: PV

Code of the group: NMSPAMSMPV1
Name of the group: MDP P_AMSMN Required optional courses 1st year
Requirement credits in the group:
Requirement courses in the group: In this group you have to complete at least 2 courses
Credits in the group: 0
Note on the group: Studenti si volí alespoň dva předměty z této skupiny, přičemž mezi nimi musí být alespoň jeden z dvojice 01SSI a 01MEU

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
01BAPS	**Bayesian principles in statistics** *Václav Kůs* ***Václav Kůs*** *Václav Kůs (Gar.)*	ZK	3	3+0		PV
01DIZO	**Digital Image Processing** *Barbara Zitová* ***Barbara Zitová*** *Barbara Zitová (Gar.)*	ZK	4	2P+2C		PV
01DYNR1	**Dynamic Decision Making 1** *Taťjana Gaj, Miroslav Kárný* ***Taťjana Gaj*** *Taťjana Gaj (Gar.)*	Z,ZK	3	2P+1C		PV
01MEU	**Modelling Extremal Events** *Václav Kůs* ***Václav Kůs*** *Václav Kůs (Gar.)*	ZK	3	2P		PV
01SSI	**Social Systems and Their Simulations** *Milan Krbálek, Marek Bukáček* ***Marek Bukáček*** *Milan Krbálek (Gar.)*	KZ	4	2+1		PV

Characteristics of the courses of this group of Study Plan: Code=NMSPAMSMPV1 Name=MDP P_AMSMN Required optional courses 1st year

01BAPS	Bayesian principles in statistics	ZK	3

The main goal of the subject is to provide decision making mathematical principles with random effects, optimal and robust strategies and their mutual links together with computational aspects for the real applications. The techniques are illustrated within practical examples originating from point and interval estimation and statistical hypothesis testing.

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.

01MEU	Modelling Extremal Events	ZK	3

1.Aggregated traffic in computer nets, possible admission control, machine learning, on-off approximation. 2.Distribution-free inequalities for tail probability estimation, PC simulation of traffic. 3.Nonparametric density estimators and their tails, asymptotic properties, MISE optimality. 4.Semiparametric estimation, retransformed densities, statistical properties, score functions. 5.Phi-divergences, properties, Kolmogorov entropy, Vapnik-Chervonenkis dimension, application. 6.Fluctuation of random sums, stable and -stable distributions, their characteristics. 7.Generalized central limit theorem, domains of attraction, sub-exponential distributions. 8.Heavy-tail distribution detections, PP and QQ plots, Mean Excess function, its empirical estimator, usage. 9.Return period of (insurance) events, record counting process, Gumbel method of exceedance. 10.Fluctuation of random maxima, Fisher-Tippett law, max-stability, maximum domain of attraction. 11.Generalized extreme value distribution, generalized Pareto distribution, properties and utilization. 12.Estimates of exceedance over threshold, POT methods, estimator of quantile, application. 13.Applications to real data from hydrology, geology, insurance, finance, numerous other examples.

01SSI	Social Systems and Their Simulations	KZ	4

The course is devoted to the issue of social systems modeling. That includes stochastic methods and methods of statistical physics for description and analytical solution of social interaction systems, implementation of particular models and comparison of the computer simulations results with the empirical data.

Code of the group: NMSPAMSMPV2
Name of the group: MDP P_AMSMN Required optional courses 2nd year
Requirement credits in the group:
Requirement courses in the group: In this group you have to complete at least 2 courses
Credits in the group: 0
Note on the group:

Student si volí povinně alespoň dva předměty z této skupiny.

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
01ADS	**Applications of Data Science** *Jiří Franc* ***Jiří Franc*** *Jiří Franc (Gar.)*	KZ	4	1P+2C		PV
01DAS	**Data science** *Jiří Franc* ***Jiří Franc*** *Jiří Franc (Gar.)*	KZ	3	1P+2C		PV
01FIMA	**Financial and Insurance Mathematics** *Joel Horowitz* ***Joel Horowitz*** *Joel Horowitz (Gar.)*	ZK	2	2P+0C	Z	PV
01PRR	**Advanced and Robust Regression Models** *Tomáš Hobza, Jan Amos Víšek* ***Jan Amos Víšek*** *Jan Amos Víšek (Gar.)*	ZK	2	2P		PV
01SFTO	**Special Functions and Transformations in Image Analysis** *Jan Flusser* ***Jan Flusser*** *Jan Flusser (Gar.)*	ZK	2	2+0	L	PV

Characteristics of the courses of this group of Study Plan: Code=NMSPAMSMPV2 Name=MDP P_AMSMN Required optional courses 2nd year

01ADS	Applications of Data Science	KZ	4

Practical application of mathematical modeling methods, statistics and machine learning needs wide range of tasks from data preparation and collection to design of an appropriate method and its division into units for development and implementation into the production. Last, but not least, the cooperation in group and management of a modern data project is crucial. The actual standard of required tools will be presented on lectures. Further, these procedures will be applied during exercises with an emphasis on team collaboration, project planning. At the end of the course, students will present their results to other teams.

01DAS	Data science	KZ	3

Practical application of mathematical modeling methods, statistics and machine learning needs wide range of tasks from data preparation and collection to design of an appropriate method and its division into units for development and implementation into the production. Last, but not least, the cooperation in group and management of a modern data project is crucial. The actual standard of required tools will be presented on lectures. Further, these procedures will be applied during exercises with an emphasis on team collaboration, project planning. At the end of the course, students will present their results to other teams.

01FIMA	Financial and Insurance Mathematics	ZK	2

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

01PRR	Advanced and Robust Regression Models	ZK	2

1.Introduction to robust regression - M-estimates, qualitative and quantitative robustness, influential functions, outliers, leverage points. 2.The least median of squares, the trimmed least squares and the least trimmed squares. 3.Weighted least squares and least weighted squares, algorithms, applications. 4.Instrumental weighted variables and their robustification. 5.AR, MA, AR (I) MA, invertibility and stationarity condition. Smoothing of trend using curves, moving averages and exponential. Seasonal and cyclic components, tests of randomness, disturbance (Prais-Winsten, Cochrane-Orcutt). 6.Introduction to mixed linear models, estimation of parameters (ML, REML), generalized mixed linear models. 7.Repeated measurements, Longitudinal data, correlation structure in data. 8.Philosophical debate on mathematical modeling and regression analysis.

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.

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

Code of the group: NMSPAMSMV
Name of the group: MDP P_AMSMN 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
01ZASIG	**Analysis and Processing of Diagnostic Signals** *Zdeněk Převorovský **Zdeněk Převorovský** Zdeněk Převorovský (Gar.)*	ZK	3	3+0		v
18AMTL	**Matlab Applications** ***Jaromír Kukal***	KZ	4	2P+2C	L	v
18SQL	**SQL Applications** *Jaromír Kukal, Dana Majerová **Dana Majerová** Jaromír Kukal (Gar.)*	Z	2	0+2	Z	v
18AAD	**Applied Data Analysis** *Jaromír Kukal, Tomáš Hubínek, Karel Šimánek **Jaromír Kukal** Jaromír Kukal (Gar.)*	Z	3	1P+1C	L	v
18BI	**Business Intelligence** *Jaromír Kukal, Matej Mojzeš **Jaromír Kukal***	KZ	2	1P+1C	Z	v
01DRO2	**Dynamic Decision Making 2** *Taťjana Gaj, Miroslav Kárný **Miroslav Kárný** Miroslav Kárný (Gar.)*	ZK	2	2+0		v
01HBM	**Hierarchical Bayesian Models** *Václav Šmídl **Václav Šmídl** Václav Šmídl (Gar.)*	KZ	2	2+0		v
01IKLM	**Internet and classification methods** *Martin Holeňa **Martin Holeňa** Martin Holeňa (Gar.)*	Z,ZK	2	2P+0C		v
01KOS	**Compressed Sensing** *Jan Vybíral **Jan Vybíral** Jan Vybíral (Gar.)*	ZK	2	2+0	Z	v
01MMNS	**Mathematical Modelling of Non-linear Systems** *Michal Beneš **Michal Beneš** Michal Beneš (Gar.)*	ZK	3	1P+1C	Z	v
01MBM	**Mathematical techniques in biology and medicine** *Václav Klika **Václav Klika** Václav Klika (Gar.)*	Z,ZK	3	2+1	L	v
18MEMC	**Monte Carlo Method** *Jaromír Kukal, Miroslav Virius **Miroslav Virius** Miroslav Virius (Gar.)*	Z,ZK	4	2P+2C	Z	v
01NELO	**Nonlinear Optimization** *Radek Fučík **Radek Fučík** Radek Fučík (Gar.)*	ZK	4	3P+0C		v
01NEUR1	**Neural Networks and their Applications 1** *Martin Holeňa, František Hakl **František Hakl** František Hakl (Gar.)*	ZK	2	2+0		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
01DROS	**Seminar Course on Dynamic Decision Making** ***Taťjana Gaj*** *Taťjana Gaj (Gar.)*	Z	2	0+2		v
01SUP	**Start-up Project** *Přemysl Rubeš **Přemysl Rubeš** Přemysl Rubeš (Gar.)*	KZ	2	2P+0C		v
01SDR	**Stochastic Differential Equations** *Michal Beneš **Michal Beneš** Michal Beneš (Gar.)*	ZK	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
01NEUR2	**Theoretical Fundamentals of Neural Networks** *Martin Holeňa **Martin Holeňa** Martin Holeňa (Gar.)*	ZK	3	2+0		v
18TFT	**Financial Markets Theory** *Nichita Vatamaniuc, Quang Van Tran **Quang Van Tran** Quang Van Tran (Gar.)*	KZ	4	2P+2C	Z	v
01TG	**Graph Theory** *Jan Volec, Petr Ambrož **Petr Ambrož** Petr Ambrož (Gar.)*	ZK	5	4P+0C		v
01TEH	**Game Theory** *Jan Volec **Jan Volec** Jan Volec (Gar.)*	ZK	2	2+0	L	v
18ZDFT	**Financial Markets Data Processing** *Quang Van Tran **Quang Van Tran** Quang Van Tran (Gar.)*	KZ	4	2P+2C	L	v

Characteristics of the courses of this group of Study Plan: Code=NMSPAMSMV Name=MDP P_AMSMN Optional courses

01ZASIG	Analysis and Processing of Diagnostic Signals	ZK	3

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

18AMTL	Matlab Applications	KZ	4

Systematic application of Matlab optimization toolbox for the solution of linear, quadratic, binary, integer an nonlinear programming tasks. Simulation of chaotic systems an fractal set generation. Analysis of trajectories, attractors and fractal sets including estimation of their properties.

18SQL	SQL Applications	Z	2

Practical realization of database system according to general principles of database analysis.

18AAD	Applied Data Analysis	Z	3

A practically focused subject that guides you through the topics of Big Data, neural networks, parallel computing, graph analysis, cloud technologies, deployment, and development of software or IoT solutions.

<table>
<tr><td>18BI</td><td>Business Intelligence</td><td>KZ</td><td>2</td></tr>
<tr><td colspan="4">The aim of the subject is to explain to the students different characteristics of production and analytical databases and a set of processes, know-how and tools (not only) to support decision-making activities within the organization. In addition to the basic concept of BI, listeners will get acquainted with the general methodology of implementation of custom algorithms derived from other theories and subjects into the BI environment.</td></tr>
<tr><td>01DRO2</td><td>Dynamic Decision Making 2</td><td>ZK</td><td>2</td></tr>
<tr><td colspan="4">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</td></tr>
<tr><td>01HBM</td><td>Hierarchical Bayesian Models</td><td>KZ</td><td>2</td></tr>
<tr><td colspan="4">Keywords: Bayesian theory, linear regression, signal separation, mixture models, Bayesian filtering</td></tr>
<tr><td>01IKLM</td><td>Internet and classification methods</td><td>Z,ZK</td><td>2</td></tr>
<tr><td colspan="4">Attending the course, the students get acquainted with classification methods used in three important internet or general-network applications: spam filtering, recommender systems, and intrusion detection systems. However, they learn more than only how classification is performed when facing these three problems. On the background of the above applications, they get an overall overview about the fundamentals of classification methods. The course is taught in a 2-week cycle, always a 2h lecture and a 2h practice at computer labs.</td></tr>
<tr><td>01KOS</td><td>Compressed Sensing</td><td>ZK</td><td>2</td></tr>
<tr><td colspan="4">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.</td></tr>
<tr><td>01MMNS</td><td>Mathematical Modelling of Non-linear Systems</td><td>ZK</td><td>3</td></tr>
<tr><td colspan="4">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.</td></tr>
<tr><td>01MBM</td><td>Mathematical techniques in biology and medicine</td><td>Z,ZK</td><td>3</td></tr>
<tr><td colspan="4">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.</td></tr>
<tr><td>18MEMC</td><td>Monte Carlo Method</td><td>Z,ZK</td><td>4</td></tr>
<tr><td colspan="4">This courseis devoted to the numerical method Monte Carlo and to its selected applications.</td></tr>
<tr><td>01NELO</td><td>Nonlinear Optimization</td><td>ZK</td><td>4</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td>01NEUR1</td><td>Neural Networks and their Applications 1</td><td>ZK</td><td>2</td></tr>
<tr><td colspan="4">Keywords: Neural networks, data separation, functional approximation, supervised learning</td></tr>
<tr><td>01UMIN</td><td>Probabilistic Models of Artificial Intelligence</td><td>KZ</td><td>2</td></tr>
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<tr><td>01PSM1</td><td>Problem Seminar in Mathematical Analysis</td><td>Z</td><td>2</td></tr>
<tr><td colspan="4">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.</td></tr>
<tr><td>01PSM2</td><td>Problem Seminar in Mathematical Analysis 2</td><td>Z</td><td>2</td></tr>
<tr><td colspan="4">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.</td></tr>
<tr><td>01DROS</td><td>Seminar Course on Dynamic Decision Making</td><td>Z</td><td>2</td></tr>
<tr><td colspan="4">The seminar is devoted to the actual topics and trends in decision making, machine learning (ML) and artificial intelligence (AI). It will extend the topics learned in the lecture course 01DRO1, in particular formalisation of DM problem and its solution incl. techniques to tackle the problem; multi-agent DM and related tasks incl. possible ways of agents? interaction. A sub-selection of relevant articles presented at the main DM, ML and AI conferences will be discussed.</td></tr>
<tr><td>01SUP</td><td>Start-up Project</td><td>KZ</td><td>2</td></tr>
<tr><td>01SDR</td><td>Stochastic Differential Equations</td><td>ZK</td><td>2</td></tr>
<tr><td colspan="4">The class is devoted to an introduction to stochastic differential equations and their applications. The content includes stochastic processes, Itô integral and solution of stochastic differential equations. The applications in filtering, diffusion and optimal control are mentioned as well.</td></tr>
<tr><td>01SVK</td><td>Student's Scientific Conference</td><td>Z</td><td>1</td></tr>
<tr><td colspan="4">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.</td></tr>
<tr><td>01SMS1</td><td>Student's seminar in mathematics 1</td><td>Z</td><td>2</td></tr>
<tr><td>01SMS2</td><td>Student's seminar in mathematics 2</td><td>Z</td><td>2</td></tr>
<tr><td>01NEUR2</td><td>Theoretical Fundamentals of Neural Networks</td><td>ZK</td><td>3</td></tr>
<tr><td colspan="4">Keywords: Functional approximation, supervised learning, Vapnik-Chervonenkis-dimension</td></tr>
<tr><td>18TFT</td><td>Financial Markets Theory</td><td>KZ</td><td>4</td></tr>
<tr><td colspan="4">Since financial instrument prices are unknown in advance to financial market participants, financial derivatives are currently being used as common instruments to eliminate risks arising from price instability of financial assets. The theory of financial markets uses the knowledge of mathematical analysis and statistics to manage the portfolio of risk assets and the valuation of sophisticated financial instruments in the form of derivatives such as swaps, forwards, futures and options.</td></tr>
<tr><td>01TG</td><td>Graph Theory</td><td>ZK</td><td>5</td></tr>
<tr><td colspan="4">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.</td></tr>
<tr><td>01TEH</td><td>Game Theory</td><td>ZK</td><td>2</td></tr>
<tr><td colspan="4">1. Combinatorial games, normal games - impartial and partizan games. 2. Multidimensional tic-tac-toe, Hales Jewett theorem. 3. Game tree, Zermelo's Theorem, Strategy stealing. 4. Arithmetic on normal games, equivalence on games, MEX principle, Sprague-Grundy theorem. 5. Strategic games, pure and mixed strategies, dominated strategies. 6. Zero-sum games, MAX-min principle, von Neumann theorem. 7. Nash equilibrium, Nash theorem. 8. Cooperation of two players, Nash arbitration. 9. Coalitional games, Shapley value.</td></tr>
</table>

18ZDFT	Financial Markets Data Processing	KZ	4
The course enables students to combine knowledge of numerical methods, Matlab programming and financial mathematics to solve practical problems in finance such as portfolio optimization, risk management and valuation of financial derivatives, especially options of different types. Upon completion of the course the student will be able to formulate and numerically solve concrete problems in the given field and subsequently implement their solutions in practice.			

List of courses of this pass:

Code	Name of the course	Completion	Credits
01ADS	Applications of Data Science	KZ	4
Practical application of mathematical modeling methods, statistics and machine learning needs wide range of tasks from data preparation and collection to design of an appropriate method and its division into units for development and implementation into the production. Last, but not least, the cooperation in group and management of a modern data project is crucial. The actual standard of required tools will be presented on lectures. Further, these procedures will be applied during exercises with an emphasis on team collaboration, project planning. At the end of the course, students will present their results to other teams.			
01BAPS	Bayesian principles in statistics	ZK	3
The main goal of the subject is to provide decision making mathematical principles with random effects, optimal and robust strategies and their mutual links together with computational aspects for the real applications. The techniques are illustrated within practical examples originating from point and interval estimation and statistical hypothesis testing.			
01DAS	Data science	KZ	3
Practical application of mathematical modeling methods, statistics and machine learning needs wide range of tasks from data preparation and collection to design of an appropriate method and its division into units for development and implementation into the production. Last, but not least, the cooperation in group and management of a modern data project is crucial. The actual standard of required tools will be presented on lectures. Further, these procedures will be applied during exercises with an emphasis on team collaboration, project planning. At the end of the course, students will present their results to other teams.			
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			
01DPAM1	Master Thesis 1	Z	10
Master's thesis preparation.			
01DPAM2	Master Thesis 2	Z	20
Master's thesis preparation.			
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			
01DROS	Seminar Course on Dynamic Decision Making	Z	2
The seminar is devoted to the actual topics and trends in decision making, machine learning (ML) and artificial intelligence (AI). It will extend the topics learned in the lecture course 01DRO1, in particular formalisation of DM problem and its solution incl. techniques to tackle the problem; multi-agent DM and related tasks incl. possible ways of agents? interaction. A sub-selection of relevant articles presented at the main DM, ML and AI conferences will be discussed.			
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.			
01HBM	Hierarchical Bayesian Models	KZ	2
Keywords: Bayesian theory, linear regression, signal separation, mixture models, Bayesian filtering			
01IKLM	Internet and classification methods	Z,ZK	2
Attending the course, the students get acquainted with classification methods used in three important internet or general-network applications: spam filtering, recommender systems, and intrusion detection systems. However, they learn more than only how classification is performed when facing these three problems. On the background of the above applications, they get an overall overview about the fundamentals of classification methods. The course is taught in a 2-week cycle, always a 2h lecture and a 2h practice at computer labs.			
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			

<table>
<tr><td colspan="4">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.</td></tr>
<tr><td>01MBM</td><td>Mathematical techniques in biology and medicine</td><td>Z,ZK</td><td>3</td></tr>
<tr><td colspan="4">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.</td></tr>
<tr><td>01MEU</td><td>Modelling Extremal Events</td><td>ZK</td><td>3</td></tr>
<tr><td colspan="4">1.Aggregated traffic in computer nets, possible admission control, machine learning, on-off approximation. 2.Distribution-free inequalities for tail probability estimation, PC simulation of traffic. 3.Nonparametric density estimators and their tails, asymptotic properties, MISE optimality. 4.Semiparametric estimation, retransformed densities, statistical properties, score functions. 5.Phi-divergences, properties, Kolmogorov entropy, Vapnik-Chervonenkis dimension, application. 6.Fluctuation of random sums, stable and -stable distributions, their characteristics. 7.Generalized central limit theorem, domains of attraction, sub-exponential distributions. 8.Heavy-tail distribution detections, PP and QQ plots, Mean Excess function, its empirical estimator, usage. 9.Return period of (insurance) events, record counting process, Gumbel method of exceedance. 10.Fluctuation of random maxima, Fisher-Tippett law, max-stability, maximum domain of attraction. 11.Generalized extreme value distribution, generalized Pareto distribution, properties and utilization. 12.Estimates of exceedance over threshold, POT methods, estimator of quantile, application. 13.Applications to real data from hydrology, geology, insurance, finance, numerous other examples.</td></tr>
<tr><td>01MMD</td><td>Mathematical Modelling of Traffic</td><td>Z,ZK</td><td>5</td></tr>
<tr><td colspan="4">1. Basic mathematical description of vehicular traffic - macroscopic and microscopic quantities, relations between them, fundamental diagram and phase map. 2. Empirical knowledge about traffic flow - methodology of traffic data evaluation, 3s-unification procedure, two-phase theory, three-phase theory, VHM and link to capacity calculations in physics of traffic. 3. Traffic models - general overview, classification of models, examples, Greenbergs macroscopic model and its solution, Montrolls microscopic model and its solution. 4. Lighthill-Whitham model - formulation and theoretical solution, Cole-Hopf transformation, formulation of associate Cauchy problem and its solution in distributions, Burgers equation. 5. Cellular traffic models - Nagel-Schreckenberg model, Fukui-Ischibaschi model, model TASEP and its theoretical solution by MPA. 6. Thermodynamic traffic models - variants, classification by range and type of potential, Hamiltonian description, general solution methodology, solution of short-range model, connection between thermodynamic models and balance particle systems, solution of middle-ranged model with logarithmic potential. 7. Vehicular Headway Modeling - an insight into the issue, empirical and theoretical knowledge in a given area, criteria for admissibility of headway distributions, statistical rigidity and changes in its course, derivation of statistical rigidity for thermodynamic gas. 8. Statistical properties of traffic flow - Poisson and semi-Poisson mode of transport, supra-random traffic states, their detection.</td></tr>
<tr><td>01MMNS</td><td>Mathematical Modelling of Non-linear Systems</td><td>ZK</td><td>3</td></tr>
<tr><td colspan="4">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.</td></tr>
<tr><td>01NAEX</td><td>Design of Experiments</td><td>Z,ZK</td><td>3</td></tr>
<tr><td colspan="4">1.Introduction to the design of experiments and data analysis. 2.Completely randomized one-factor experiment: introduction of a fixed-effect model, tests of equality of mean values, choice of number of observations. 3.Methods of multiple comparison: Bonferroni method, Scheffy method, Tukey method 4.Randomized complete block design: model definition, equality effects tests, power of test, determining sample size. 5.Latin and Greco-Latin squares, balanced incomplete block design, model adequacy checking, residuals, multiple comparisons. 6.Two factor factorial design: statistical models and their properties for designs 2^2, 2^3 and 2^k, fractional factorial design, resolutions. 7.3^k factorial designs, confounding in 3^k factorial design. 8.Models with random effects, factorials with mixed levels.</td></tr>
<tr><td>01NAH</td><td>Theory of Random Processes</td><td>ZK</td><td>3</td></tr>
<tr><td colspan="4">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.</td></tr>
<tr><td>01NELO</td><td>Nonlinear Optimization</td><td>ZK</td><td>4</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td>01NEUR1</td><td>Neural Networks and their Applications 1</td><td>ZK</td><td>2</td></tr>
<tr><td colspan="4">Keywords: Neural networks, data separation, functional approximation, supervised learning</td></tr>
<tr><td>01NEUR2</td><td>Theoretical Fundamentals of Neural Networks</td><td>ZK</td><td>3</td></tr>
<tr><td colspan="4">Keywords: Functional approximation, supervised learning, Vapnik-Chervonenkis-dimension</td></tr>
<tr><td>01PRR</td><td>Advanced and Robust Regression Models</td><td>ZK</td><td>2</td></tr>
<tr><td colspan="4">1.Introduction to robust regression - M-estimates, qualitative and quantitative robustness, influential functions, outliers, leverage points. 2.The least median of squares, the trimmed least squares and the least trimmed squares. 3.Weighted least squares and least weighted squares, algorithms, applications. 4.Instrumental weighted variables and their robustification. 5.AR, MA, AR (I) MA, invertibility and stationarity condition. Smoothing of trend using curves, moving averages and exponential. Seasonal and cyclic components, tests of randomness, disturbance (Prais-Winsten, Cochrane-Orcutt). 6.Introduction to mixed linear models, estimation of parameters (ML, REML), generalized mixed linear models. 7.Repeated measurements, Longitudinal data, correlation structure in data. 8.Philosophical debate on mathematical modeling and regression analysis.</td></tr>
<tr><td>01PSM1</td><td>Problem Seminar in Mathematical Analysis</td><td>Z</td><td>2</td></tr>
<tr><td colspan="4">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.</td></tr>
<tr><td>01PSM2</td><td>Problem Seminar in Mathematical Analysis 2</td><td>Z</td><td>2</td></tr>
<tr><td colspan="4">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.</td></tr>
<tr><td>01RAD</td><td>Regression Data Analysis</td><td>Z,ZK</td><td>5</td></tr>
<tr><td colspan="4">1.Simple linear regression: least squares estimation, properties of parameter estimates, hypotheses tests and confi-dence intervals for parameters of the model, model-based prediction, analysis of residuals 2.Multiple linear regression: general linear model, least squares estimation, analytical and numerical solutions of the normal equations, properties of parameter estimates, coefficient of determination, F-test, prediction intervals 3.Residuals, diagnostics and transformations: residuals and residual plots, normality tests, detection of outlying and influential observations, hat matrix, Cooks distance, transformations of dependent and independent varia-ble, Box-Cox transformation 4.Selection of a regression model: criteria functions, R2 statistics, Mallows Cp statistics, Akaike and Bayes infor-mation criteria, stepwise regression and backward elimination 5.Multicollinearity: impact of multicollinearity on precision of the parameter estimates, detecting and combatting multicollinearity, ridge regression</td></tr>
<tr><td>01SDR</td><td>Stochastic Differential Equations</td><td>ZK</td><td>2</td></tr>
<tr><td colspan="4">The class is devoted to an introduction to stochastic differential equations and their applications. The content includes stochastic processes, Itô integral and solution of stochastic differential equations. The applications in filtering, diffusion and optimal control are mentioned as well.</td></tr>
<tr><td>01SFTO</td><td>Special Functions and Transformations in Image Analysis</td><td>ZK</td><td>2</td></tr>
<tr><td colspan="4">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.</td></tr>
<tr><td>01SKE</td><td>System Reliability and Clinical Experiments</td><td>KZ</td><td>3</td></tr>
<tr><td colspan="4">The main goal of the subject is to provide the mathematical principles of reliability theory and techniques of survival data analysis, reliability of component systems, asymptotic methods for reliability, concept of experiments under censoring and their processing in clinical trials (life-time models). The techniques are illustrated and tested within practical examples originating from lifetime material experiments and clinical trials.</td></tr>
</table>

01SMS1	Student's seminar in mathematics 1	Z	2	
01SMS2	Student's seminar in mathematics 2	Z	2	
01SSI	Social Systems and Their Simulations	KZ	4	The course is devoted to the issue of social systems modeling. That includes stochastic methods and methods of statistical physics for description and analytical solution of social interaction systems, implementation of particular models and comparison of the computer simulations results with the empirical data.
01SU2	Machine Learning 2	Z,ZK	4	1.Fundamental topics from the probability theory and machine learning (classical distributions, Bayes theorem, Kullback-Leibler divergence, curse of dimensionality, overfitting, maximum likelihood and maximum a posteriori estimators, Principle Component Analysis) 2.Decision trees: general schema, recursive partitioning, optimal partitioning and pruning, ensemble learning - bagging, boosting, random forests. 3.Examples of decision trees: Adaptive boosting AdaBoost, Gradient boosting, Xgboost. 4.Numerical methods for optimization (steepest descent, conjugate gradient, Newton and quasi-Newton, constrained extrema, Lagrangian). 5.Deep feedforward networks (hidden units, nonlinear activation functions, output units, loss functional, stochastic gradient descent, back-propagation algorithm) 6.Optimization for training deep models (regularization, algorithms with adaptive learning rates) 7.Convolutional neural networks 8.Recurrent neural networks 9.Advanced network architectures (autoencoders, Generative Adversarial networks) 10.Applications of deep learning (classification, segmentation, image reconstruction)
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.
01TEH	Game Theory	ZK	2	1. Combinatorial games, normal games - impartial and partizan games. 2. Multidimensional tic-tac-toe, Hales Jewett theorem. 3. Game tree, Zermelo's Theorem, Strategy stealing. 4. Arithmetic on normal games, equivalence on games, MEX principle, Sprague-Grundy theorem. 5. Strategic games, pure and mixed strategies, dominated strategies. 6. Zero-sum games, MAX-min principle, von Neumann theorem. 7. Nash equilibrium, Nash theorem. 8. Cooperation of two players, Nash arbitration. 9. Coalitional games, Shapley value.
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.
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.
01VUAM1	Research Project 1	Z	6	Research project on the selected topic under the supervision. Supervision and regular checking of the research project under preparation.
01VUAM2	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
01ZLMA	Generalized Linear Models and Applications	Z,ZK	5	1.Generalized linear models: exponential family, regularity conditions, score function. 2.Estimation of parameters: maximum likelihood estimates, numerical methods used for their calculation, Newton-Raphson, Fisher-scoring algorithm. 3.Testing of models: asymptotic distribution of the score function and the MLE estimates, models comparisons, residual analysis, diagnostic of influential observations. 4.Analysis of covariance (ANCOVA), general model of analysis of covariance, one factor ANCOVA, multiple comparisons. 5.Models for binary data: logistic model, normal model, Gumbel model, model parameters interpretation, odds ratio, tests, residuals. 6.Poisson regression: univariate and multivariate Poisson regression, model parameters interpretation, tests and residuals. 7. Probability models for contingency tables, log-linear models.
18AAD	Applied Data Analysis	Z	3	A practically focused subject that guides you through the topics of Big Data, neural networks, parallel computing, graph analysis, cloud technologies, deployment, and development of software or IoT solutions.
18AMTL	Matlab Applications	KZ	4	Systematic application of Matlab optimization toolbox for the solution of linear, quadratic, binary, integer an nonlinear programming tasks. Simulation of chaotic systems an fractal set generation. Analysis of trajectories, attractors and fractal sets including estimation of their properties.
18BI	Business Intelligence	KZ	2	The aim of the subject is to explain to the students different characteristics of production and analytical databases and a set of processes, know-how and tools (not only) to support decision-making activities within the organization. In addition to the basic concept of BI, listeners will get acquainted with the general methodology of implementation of custom algorithms derived from other theories and subjects into the BI environment.
18HA	Heuristic Algorithms	ZK	4	Heuristic algorithms of optimization operates on discrete or continuous domains. Brutal force, stochastic, greedy, physically, biologically and sociologically motivated heuristic are included, used for optimum finding and compared.
18MEMC	Monte Carlo Method	Z,ZK	4	This courseis devoted to the numerical method Monte Carlo and to its selected applications.
18SQL	SQL Applications	Z	2	Practical realization of database system according to general principles of database analysis.
18TFT	Financial Markets Theory	KZ	4	Since financial instrument prices are unknown in advance to financial market participants, financial derivatives are currently being used as common instruments to eliminate risks arising from price instability of financial assets. The theory of financial markets uses the knowledge of mathematical analysis and statistics to manage the portfolio of risk assets and the valuation of sophisticated financial instruments in the form of derivatives such as swaps, forwards, futures and options.

18ZDFT	Financial Markets Data Processing	KZ	4
The course enables students to combine knowledge of numerical methods, Matlab programming and financial mathematics to solve practical problems in finance such as portfolio optimization, risk management and valuation of financial derivatives, especially options of different types. Upon completion of the course the student will be able to formulate and numerically solve concrete problems in the given field and subsequently implement their solutions in practice.			

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