University of West Bohemia

Faculty of Applied Sciences

Doctoral Study

List of Courses - 2020/2021

Mathematics

Algorithms and Problems of Combinatorial Optimization

Algoritmy a úlohy kombinatorické optimalizace

Doc. Ing. Roman Čada, Ph.D.

Integer optimization. Vector, semidefinite, cone optimization. Submodular functions and discrete convex optimization. Separation. Fenchel duality. Approximation schemes, interactive protocols and non-approximability. Randomized algorithms and derandomization. Parallel algorithms. Standard problems (flows in matroids, TSP, MAX-SAT, MAX-CUT, colouring, clustering, QAP) and extensions.

Bifurcation Theory

Teorie bifurkací

Prof. RNDr. Pavel Drábek, DrSc., Doc. Ing. Petr Girg, Ph.D.,

Prof. RNDr. Milan Kučera, DrSc., Doc. Ing. Gabriela Holubová, Ph.D.

Fundamental theorems concerning bifurcation of solutions of nonlinear operator equations. Crandall-Rabinowitz, Krasnoselskij, bifurcation based on degree theory, potential bifurcation theorem. Bifurcation of periodic solutions – Hopf bifurcation, bifurcation of variational inequalities.

Coding Theory

Teorie kódů

Prof. RNDr. Tomáš Kaiser, DSc.

Recapitulation of the basic theory of error-correcting codes. Main code classes: linear codes, cyclic codes, perfect codes, BCH codes. Connections to combinatorics. Properties of Golay codes. Asymptotic properties of codes. The Shannon theorem and the inverse Shannon theorem. Algebraic geometry codes, convolutional codes, iterative decoding.

Combinatorial Geometry

Kombinatorická geometrie

Prof. RNDr. Tomáš Kaiser, DSc.

Convex sets. Recapitulation of basic properties, separation theorems. The Helly, Radon and Carathéodory Theorems. Lattices and Minkowski's Theorem, applications in number theory. Convex independence in the plane, connections to Ramsey Theory. Extremal problems. Tverberg's Theorem and its generalisations. Convex polytopes.

Dynamical Systems

Metody studia dynamických systémů

Prof. RNDr. Pavel Drábek, DrSc., Doc. Ing. Gabriela Holubová, Ph.D., Doc. Ing. Radek Cibulka, Ph.D.

Structural stability, bifurcation of finite-dimensional dynamical systems, semigroups, invariant sets, attractors. Dissipative evolution partial differential equations of the first order, wave equations. Ljapunov exponents and dimensions of attractors. Non-smooth dynamical systems and their stability,

Geometric Methods for Applications

Geometrické metody pro aplikace

Prof. RNDr. Miroslav Lávička, Ph.D.

Fundamentals of projective geometry (projective space, projective mappings). Projective differential geometry (curves, surfaces, duality, description of curves and surfaces). Applied algebraic geometry (definitions and algorithms, properties of algebraic varieties, duality). Sphere geometries (Laguerre, Möbius and Lie geometry, canal surfaces and cyclides). Line geometry (fundamentals of line geometry, using linear complexes, developable surfaces). Quaternions and dual quaternions. Fundamentals of Hermitian geometry.

Geometry and Geometric Modelling

Geometrické modelování

Doc. Ing. Bohumír Bastl, Ph.D.

Fundamentals of geometric modelling, geometric spaces. Geometric transformations (linear, TPS, reverse Coons patch). Modern algebra in geometric modelling (symbolic calculus, Gröbner bases, resultants). NURBS (Non-Uniform Rational B-Splines), special classes and their generalisation. Subdivision techniques for curves and surfaces. PH and LN objects and their generalisation. Offsets. Volume modelling, Euler's operators. Variational geometry (Chyz's graph, constructive sets). Geometric algorithms, invariance and relation to graph algorithms. Methods of geometric modelling in reverse engineering.

Hamiltonian Graph Theory

Hamiltonovská teorie grafů

Prof. RNDr. Zdeněk Ryjáček, DrSc., doc. Ing. Roman Čada, Ph.D., doc. RNDr. Přemysl Holub, Ph.D.

Properties of Hamiltonian graphs – connectivity, toughness. Fundamental sufficient conditions of hamiltonicity of a graph – Erdös-Chvátal theorem, degree conditions and the Bondy-Chvátal closure, closure operations based on structural conditions. Further Hamiltonian properties – traceability, uncyclicity, Hamilton-connectedness, Hamiltonian properties of graphs from special classes – planar

graphs and Tutte's theorem, line graphs and their preimages, forbidden subgraphs and Hamiltonian properties.

Chromatic Graph Theory

Chromatická teorie grafů

Prof. RNDr. Tomáš Kaiser, DSc.

Graph colouring. Recapitulation of basic results (Brooks' Theorem, Vizing's Theorem). List colouring. Colouring of graphs on surfaces (plane graphs, Heawood Theorem). Duality and flows. Critical graphs. Polynomial graph invariants (chromatic polynomial, Tutte polynomial) and connections to knot theory. Algorithmic aspects of graph colouring

Matching Theory

Teorie párování

Prof. RNDr. Zdeněk Ryjáček, DrSc., Doc. RNDr. Přemysl Holub, Ph.D.

Maximum matching in bipartite graphs, Hall's Theorem and Hungarian method. Matching in general graphs, alternating paths and Berge's Theorem, Tutte Theorem, Edmonds algorithm, Edmonds-Gallai decomposition. Extendable matching, factorcritical graphs.

Methods of Computer Modelling

Metody počítačového modelování

Doc. Ing. Marek Brandner, Ph.D.,

Doc. Ing. Josef Daněk, Ph.D.

Mathematical and numerical modeling. Numerical methods for partial differential equations: finite difference method, Galerkin method, finite element method, finite volume method. Numerical methods for systems of linear algebraic equations.

Numerical Modelling of Conservation Laws

Numerické modelování zákonů zachování

Doc. Ing. Marek Brandner, Ph.D.

Hyperbolic partial differential equations, classical and weak solutions. Vanishing viscosity solution and entropy solution. Riemann problem. Finite difference method. Finite volume method, consistency, stability and convergence. Godunov type methods, high-resolution schemes. Approximate Riemann solvers. Finite element method, discontinuous Galerkin finite element method, residual distribution schemes.

Selected Chapters of Modern Algebra

Vybrané kapitoly z moderní algebry

Prof. RNDr. Roman Nedela, DrSc.

Selection is done according to student's theme.

- a) Finite groups: group actions, simple groups, alternating and classical groups, composition series, Jordan-Holder theorem, Fundametal theorem on abelian groups, Smith form of a matrix, p-groups, Sylow theorems, nilpotent groups, solvable groups
- b) Linear representations of groups: characters, irreducible representations, group algebra, applications of the character theory.
- c) Algebraic structures with two operations and Galois theory: Rings, fields and vector spaces, Rings of polynomials, field extensions, rings of polynomials,

solvability of polynomials in radicals, groups associated to polynomials, Galois theorem. Moduls, canonical decomposition of a module, Jordan form of a matrix, decomposition of abelian groups.

Selected Parts of Theoretical Numerical Analysis

Vybrané kapitoly z numerické analýzy

Doc. Ing. Josef Daněk, Ph.D.

Direct and iterative methods of numerical linear algebra and their applications to solving partial differential equations. Methods based on the matrix factorisations and iterative methods. LU factorisation, QR factorisation and other decompositions of matrices, their properties and their applications in computational methods. Classical iterative methods (Jacobi, GS, SOR), their properties and use. The conjugate gradients method, modern iterative methods for non-symmetric problems (e.g. GMRES). Preconditioning and construction of pre-conditioners. The multi-grid method, algebraic multi-grid. Methods and algorithms based on the domain decomposition principle. FETI and ADI methods. Splines and wavelets and their use in numerical analysis.

Selected Topics of Functional Analysis

Vybrané partie funkcionální analýzy

Prof. RNDr. Pavel Drábek, DrSc., Doc. Ing. Petr Girg, Ph.D.,

Doc. RNDr. Jiří Benedikt, Ph.D., Doc. Ing. Radek Cibulka, Ph.D.

Basic properties of linear and nonlinear operators in normed linear spaces, abstract integral and differential calculus, local properties of differentiable mappings, differential and integral calculus on manifolds. Non-smooth and multivalued mappings.

Selected Topics of Partial Differential Equations

Vybrané kapitoly z teorie parciálních diferenciálních rovnic

Prof. RNDr. Eduard Feireisl, DrSc., RNDr. Šárka Nečasová, CSc., DSc.

Fundamentals of modern methods. Introduction to Sobolev spaces, traces, compactness. Variational formulation of a boundary value problem for a linear elliptic 2nd order equation. Galerkin method. Spectrum. Generalized mixed problém for a hyperbolic equation. Introduction to compressible flow theory. Mathematical model, weak formulation. A priori estimates, compactness, approximative solutions.

Topology

Topologie

Prof. RNDr. Tomáš Kaiser, DSc.

Overview of basic general topology: topological space, connectedness, convergence and compactness. Homotopy. Elements of algebraic topology. Fundamental group. The Seifert-Van Kampen Theorem. Applications: the Jordan Curve Theorem, the Borsuk-Ulam Theorem. Classification of compact surfaces. Homology.

Topological Methods for Differential Equations

Topologické metody řešení diferenciálních rovnic

Prof. RNDr. Pavel Drábek, DrSc., Doc. Ing. Petr Girg, Ph.D., Doc. Ing. Gabriela Holubová, Ph.D.

Abstract implicit function theorem, theorem on local diffeomorphism, fixed point theorems. Monotone operators. Brouwer and Leray-Schauder degree of mapping.

Method of upper and lower solutions and the link to the degree of mapping. Applications to the boundary value problems for ODEs and PDEs.

Variational Methods for Differential Equations

Variační metody řešení diferenciálních rovnic Prof. RNDr. Pavel Drábek, DrSc., Doc. Ing. Petr Girg, Doc. Ing. Gabriela Holubová, Ph.D., Prof. RNDr. Milan Kučera, DrSc., Doc. Ing. Radek Cibulka, Ph.D.

Local and global extrema. Weak lower semicontinuity and weak compactness. Ekeland variational principle. Palais-Smale condition and its modifications. Mountain Pass Theorem of Ambrosetti and Rabinowitz. Saddle Point Theorem of Rabinowitz. Applications to the boundary value problems for ODEs and PDEs.