Study plan

Name of study plan: Fyzikální elektronika - Počítačová fyzika

Faculty/Institute/Others:
Department:
Branch of study guaranteed by the department: Welcome page
Garantor of the study branch:
Program of study: Physical Electronics
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 specialization
Minimal number of credits of the block: 0
The role of the block: PS

Code of the group: NMSPFEPF1
Name of the group: MDP P_FEN PF 1st year
Requirement credits in the group:
Requirement courses in the group: In this group you have to complete at least 12 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
12DRP	**Differential Equations on Computer** *Richard Liska* ***Richard Liska*** *Richard Liska (Gar.)*	Z,ZK	5	2+2	Z	PS
01DIZO	**Digital Image Processing** *Barbara Zitová* ***Barbara Zitová*** *Barbara Zitová (Gar.)*	ZK	4	2P+2C		PS
12ELDY1	**Electrodynamics 1** *Jiří Čtyroký* ***Jiří Čtyroký*** *Jiří Čtyroký (Gar.)*	Z,ZK	3	2+0	Z	PS
12ELDY2	**Electrodynamics 2** *Jiří Čtyroký* ***Jiří Čtyroký*** *Ivan Richter (Gar.)*	Z,ZK	5	4+0	L	PS
12FIF	**Inertial Fusion Physics** *Ondřej Klimo* ***Ondřej Klimo*** *Ondřej Klimo (Gar.)*	Z,ZK	4	3+1	Z	PS
01MKP	**Finite Element Method** *Michal Beneš* ***Michal Beneš*** *Michal Beneš (Gar.)*	ZK	3	1P+1C	L	PS
01PAA	**Parallel Algorithms and Architectures** *Tomáš Oberhuber* ***Tomáš Oberhuber*** *Tomáš Oberhuber (Gar.)*	KZ	4	2P+1C	L	PS
12PF1	**Computational Physics 1** *Ondřej Klimo* ***Ondřej Klimo*** *Ondřej Klimo (Gar.)*	ZK	2	2+0	Z	PS
12PF2	**Computational Physics 2** *Milan Kuchařík* ***Milan Kuchařík*** *Milan Kuchařík (Gar.)*	Z,ZK	2	1+1	L	PS
12VUFL1	**Research Project 1** ***Ivan Richter*** *Ivan Richter (Gar.)*	Z	6	0P+6C	Z	PS
12VUFL2	**Research Project 2** ***Ivan Richter*** *Ivan Richter (Gar.)*	KZ	8	0P+8C	L	PS
12ZFLP	**Fundamentals of Laser-Plasma Physics** *Ondřej Klimo, Jan Pšikal* ***Jan Pšikal*** *Ondřej Klimo (Gar.)*	ZK	2	2+0		PS

Characteristics of the courses of this group of Study Plan: Code=NMSPFEPF1 Name=MDP P_FEN PF 1st year

12DRP	Differential Equations on Computer	Z,ZK	5

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

01DIZO	Digital Image Processing	ZK	4

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

12ELDY1	Electrodynamics 1	Z,ZK	3
Fundamentals of applied electromagnetic field theory. Wave equation, potentials. Plane, cylindrical and spherical waves.. Radiation of sources with arbitrary distribution. Dipoles and multipoles.			
12ELDY2	Electrodynamics 2	Z,ZK	5
Fundamentals of electromagnetic theory of propagation of microwave and optical radiation in metallic and dielectric waveguides. Lorentz-Lorenz reciprocity theorem. Orthogonality of modes, scattering matrix and its properties. Cavity and open laser resonators, Gaussian beams. Complex frequency and quality factor. Dispersion of waveguides and its compensation in optical fibres. Kerr nonlinearity, soliton propagation in optical fibres. Periodic structures, Bloch modes, origin of photonic bandgap. Surface plasmon.			
12FIF	Inertial Fusion Physics	Z,ZK	4
These lectures aim to introduce to the topic of inertial confinement fusion (ICF). Physical processes, which take place during the individual stages before and after ignition of the fuel are discussed. The problems (instabilities etc.), which make the inertial confinement and the ignition of the fuel more demanding are discussed and their potential solutions are presented. New projects in the field of ICF including some preliminary reactor designes are reviewed.			
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.			
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.			
12PF1	Computational Physics 1	ZK	2
The course is giving an overview of some of the well-known computational physics methods in various fields of physics. The first part concentrates on particle simulation methods - molecular dynamics, Monte Carlo method and other methodsof solving the particle transport in self-consistent fields (e.g. Particle in Cell method in plasma physics). The second part concentrates on methods of solving Maxwell equations and in particular on the finite difference, finite elements methods and the method of moments. An introduction to application of computational physics methods in quantum physics (Hartree-Fock method, density functional theory) is also given.			
12PF2	Computational Physics 2	Z,ZK	2
Structure of hydrodynamic code, representation of structured and unstructured computational meshes. Tools for code debugging and profiling, error detection. Code parallelization, memory hierarchy, supercomputers. Euler equations on moving computational mesh. Eulerian, Lagrangian, and ALE methods, staggered discretization. Methods for mesh smoothing, methods for conservative interpolations of functions between meshes. Applications in simulations of laser/target interactions. Generalization for elastic materials. Methods of artificial intelligence in computational physics.			
12VUFL1	Research Project 1	Z	6
Student works on the given topic according to the research project submission for a period of 2 semesters, this course covers the first semester.			
12VUFL2	Research Project 2	KZ	8
Student works on the given topic according to the research project submission for a period of 2 semesters, this course covers the second semester.			
12ZFLP	Fundamentals of Laser-Plasma Physics	ZK	2
These lectures will review the state-of-the-art knowledge in the field of short high power laser pulse interactions with matter and its applications.			

Code of the group: NMSPFEPF2
Name of the group: MDP P_FEN PF 2nd year
Requirement credits in the group:
Requirement courses in the group: In this group you have to complete at least 7 courses
Credits in the group: 0
Note on the group:

Code	**Name of the course / Name of the group of courses** ***(in case of groups of courses the list of codes of their members)*** *Tutors,* ***authors*** *and guarantors (gar.)*	Completion	Credits	Scope	Semester	Role
12AF	**Atomic Physics** *Milan Šiňor* ***Milan Šiňor*** *Milan Šiňor (Gar.)*	Z,ZK	4	4+0	Z	PS
12DPFE1	**Master Thesis 1** ***Helena Jelínková*** *Helena Jelínková (Gar.)*	Z	10	10	Z	PS
12DPFE2	**Master Thesis 2** ***Helena Jelínková*** *Helena Jelínková (Gar.)*	Z	20	20	L	PS
11FYPL	**Solid State Physics** *Monika Kučeráková, Kateřina Aubrechtová Dragounová, Ladislav Kalvoda Ladislav Kalvoda (Gar.)*	Z,ZK	4	4+0	Z	PS
12RNA	**Robust Numerical Algorithms** *Pavel Váchal* ***Pavel Váchal*** *Pavel Váchal (Gar.)*	Z	2	1+1	L	PS
12DSFE1	**Diploma Seminar 1** *Helena Jelínková* ***Helena Jelínková*** *Helena Jelínková (Gar.)*	Z	2	2S	Z	PS
12DSFE2	**Diploma Seminar 2** *Helena Jelínková* ***Helena Jelínková*** *Helena Jelínková (Gar.)*	Z	2	2S	L	PS

Characteristics of the courses of this group of Study Plan: Code=NMSPFEPF2 Name=MDP P_FEN PF 2nd year

12AF	Atomic Physics	Z,ZK	4
Black-body radiation, basic experiments (Millikan's, Franck-Hertz§s, Rutherford's), photons, wave-particle duality, photoelectric effect, Compton effect, potential well, Bohr's model of the hydrogen atom, Schroedinger equation, optical spectra (hydrogen, alkali atoms), spin, Pauli exclusion principle, shell model, periodic system, X-ray spectra, Moseley's law, Zeeman effect, Stark effect, fine and hyperfine structure, intensity of spectral lines, spectral terms.			
12DPFE1	Master Thesis 1	Z	10
Student works on the given topic according to the diploma work submission for a period of 2 semesters, this course covers the first semester.			
12DPFE2	Master Thesis 2	Z	20
Student works on the given topic according to the diploma work submission for a period of 2 semesters, this course covers the second semester.			
11FYPL	Solid State Physics	Z,ZK	4
The purpose of this lecture is to introduce the undergraduate students to the study of the physical properties of solids.			

12RNA	Robust Numerical Algorithms	Z	2
This course aims to equip the students with basic knowledge, skills and sense for implementation of accurate and stable algorithms which do reliably work in real numerical computations. The theory is complemented by practical exercises and examples of applications in complex simulation codes and the students are given a possibility to participate in ongoing research projects. Basic theory of finite precision computation, types of errors, their accumulation and interactions, stability of computations and increasing of the precision. Suitable techniques for summation, processing of polynomials and matrices. Computational geometry algorithms: intersections of lines, segments and polygons, triangulation and partitioning of polygons, Voronoi diagrams and Delaunay triangulation, plane arrangement, convex hulls, robot motion planning. Unconstrained and constrained linear and nonlinear numerical optimization.			
12DSFE1	Diploma Seminar 1	Z	2
Thesis Defense - guidelines and recommendations.			
12DSFE2	Diploma Seminar 2	Z	2
Thesis Defense - guidelines and recommendations.			

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

Code of the group: NMSPFEPFV
Name of the group: MDP P_FEN PF 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
12KVEN	**Quantum Electronics** *Ivan Richter, Miroslav Dvořák* ***Miroslav Dvořák*** *Ivan Richter (Gar.)*	Z,ZK	5	3+1	Z	V
02QIC	**Quantum Information and Communication** *Aurél Gábor Gábris* ***Aurél Gábor Gábris*** *Martin Štefaňák (Gar.)*	Z,ZK	4	3P+1C	Z	V
12KOP	**Quantum Optics** *Ivan Richter, Miroslav Dvořák* ***Miroslav Dvořák*** *Ivan Richter (Gar.)*	Z,ZK	5	3+1	L	V
12LPZ	**Laser-plasma as a Source of Particles and Radiation** *Jaroslav Nejdl* ***Jaroslav Nejdl*** *Jaroslav Nejdl (Gar.)*	ZK	2	2+0	Z	V
01MAL	**Mathematical Logic** *Petr Cintula* ***Petr Cintula*** *Petr Cintula (Gar.)*	Z,ZK	4	2+1		V
01MMDY	**Mathematical Methods in Fluid Dynamics 1** *Pavel Strachota* ***Pavel Strachota*** *Pavel Strachota (Gar.)*	ZK	2	2P+0C	Z	V
01MMNS	**Mathematical Modelling of Non-linear Systems** *Michal Beneš* ***Michal Beneš*** *Michal Beneš (Gar.)*	ZK	3	1P+1C	Z	V
18MEMC	**Monte Carlo Method** *Jaromír Kukal, Miroslav Virius* ***Miroslav Virius*** *Miroslav Virius (Gar.)*	Z,ZK	4	2P+2C	Z	V
12NOP	**Nonlinear Optics** *Ivan Richter* ***Ivan Richter*** *Ivan Richter (Gar.)*	Z,ZK	4	3+1	L	V
01NEUR1	**Neural Networks and their Applications 1** *Martin Holeňa, František Hakl* ***František Hakl*** *František Hakl (Gar.)*	ZK	2	2+0		V
01NMDT	**Numerical Methods in Fluid Dynamics** *Pavel Strachota* ***Pavel Strachota*** *Pavel Strachota (Gar.)*	ZK	2	2P+0C		V
18OOP	**Object Oriented Programming** *Miroslav Virius* ***Miroslav Virius*** *Miroslav Virius (Gar.)*	Z	2	2C	Z	V
12SFMC1	**Computer Simulations in Many-particle Physics 1** *Milan Předota* ***Richard Liska*** *Richard Liska (Gar.)*	Z,ZK	4	3+1	Z	V
12SFMC2	**Computer Simulations in Many-particle Physics 2** *Milan Předota, Karel Houfek* ***Milan Šiňor*** *Richard Liska (Gar.)*	ZK	2	2+0	L	V
12RFO	**X-ray Photonics** *Ladislav Pína* ***Ladislav Pína*** *Ladislav Pína (Gar.)*	ZK	2	2+0	Z	V
01SUP	**Start-up Project** *Přemysl Rubeš* ***Přemysl Rubeš*** *Přemysl Rubeš (Gar.)*	KZ	2	2P+0C		V
01SU1	**Machine Learning 1** *Jan Flusser* ***Jan Flusser*** *Jan Flusser (Gar.)*	ZK	3	2P+1C		V
01TG	**Graph Theory** *Jan Volec, Petr Ambrož* ***Petr Ambrož*** *Petr Ambrož (Gar.)*	ZK	5	4P+0C		V
01UMF	**Introduction to Mainframe** *Tomáš Oberhuber* ***Tomáš Oberhuber*** *Tomáš Oberhuber (Gar.)*	Z	2	1P+1C	Z	V
01VAM	**Variational Methods** *Michal Beneš* ***Michal Beneš*** *Michal Beneš (Gar.)*	ZK	3	1P+1C	Z	V
01ZPB2	**Introduction to Computer Security 2** *Petr Vokáč* ***Petr Vokáč*** *Petr Vokáč (Gar.)*	Z	2	1+1		V

Characteristics of the courses of this group of Study Plan: Code=NMSPFEPFV Name=MDP P_FEN PF Optional courses

<table>
<tr><td>12KVEN</td><td>Quantum Electronics</td><td>Z,ZK</td><td>5</td></tr>
<tr><td colspan="4">The lecture covers the basics of quantum electronics. It systematically discusses the Dirac formalism and its application to quantum system description, pure and mixed states, and the statistical operator and its properties, including the time dynamics of quantum Liouvill equation. It also introduces, apart from Schrödinger, also Heisenberg and Dirac formalism of quantum system dynamics. The attention is given to time dynamics of quantum systems, with the help of evolution operator formalism, and both stationary and nonstationary perturbation theory, including semi classical theory of interaction of a quantum system with the classical field. It is further devoted to quantized electromagnetic field and basics of quantum electrodynamics. Finally, the attention is given to both Fock states and coherent states of quantized electromagnetic field, their properties and specifications, and also to the application of coherent states as a tool for description of quantum optical radiation (quasiprobability densities as, e.g. Glauber-Sudarshan representation, and quantum characteristic functions). The lectures are accompanied with practical example exercises.</td></tr>
<tr><td>02QIC</td><td>Quantum Information and Communication</td><td>Z,ZK</td><td>4</td></tr>
<tr><td colspan="4">Quantum theory brought new ideas to the theory of information leading which ultimately lead to the theory of quantum information, computation and communication. The lecture introduces the basic concepts of quantum information e.g. quantum algorithms (Shors and Grovers), entanglement, quantum teleportation, quantum cryptography and quantum error correction. It also provides an introduction to modern parts of quantum information, e.g. measurement-based and adiabatic quantum computation and quantum walks.</td></tr>
<tr><td>12KOP</td><td>Quantum Optics</td><td>Z,ZK</td><td>5</td></tr>
<tr><td colspan="4">The lecture covers the advanced topics in quantum optics, consequentially to the previous course of Quantum electronics. It systematically discusses especially the statistical properties of radiation, coherent states of electromagnetic field, quantum description of optical radiation, special states of fields, with respect to quasi-probability densities and characteristic functions. Next, the attention is given both to Dirac quantum theory of interaction of quantized electromagnetic field with a quantum system (including spontaneous emission) and quantum theory of scattering (Rayleigh, Thomson, Raman, resonance fluorescence). The attention is further given both to the quantum theory of coherence (quantum theory of detection, quantum correlation functions), in relation to classical theory. The course is further devoted to generalized higher-order coherence theory, coherent properties of special states of fields, and quantum theory of damping (quantum damped harmonic oscillator, Heisenberg-Langevin approach). Finally, the attention is given to review of nonclassical measuring techniques (photocounting, intensity interferometry, Brown-Twiss effect, stellar correlation interferometer, correlation spectroscopy), possibilities of measuring the quantum state of light, and some selected parts of modern quantum optics (squeezed states). The lectures are accompanied with practical example exercises.</td></tr>
<tr><td>12LPZ</td><td>Laser-plasma as a Source of Particles and Radiation</td><td>ZK</td><td>2</td></tr>
<tr><td colspan="4">Students will get acquinted with physical principles of interaction of intense laser beams with matter with a stress on generation of secondary sources of radiation and accelerated particles and selected applications of these sources. After definition of basic quantities and description of interaction of bound electron with low frequency field, the principles of high-order harmonic generation and generation of single attosecund pulseswill be explained followed by plasma-based x-ray lasers and radiation from hot plasma. Next block of lectures will focus on methods of generation hard x-rays from relativistic laser beams, electron and ion acceleration and selected interdisciplinary applications of these secondary sources.</td></tr>
<tr><td>01MAL</td><td>Mathematical Logic</td><td>Z,ZK</td><td>4</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td>01MMDY</td><td>Mathematical Methods in Fluid Dynamics 1</td><td>ZK</td><td>2</td></tr>
<tr><td colspan="4">First, the differential equations representing the conservation laws of fluid flow are briefly derived and reviewed. Next, the problems for the resulting equations are formulated, focusing on boundary conditions specification. The reference problem undergoes numerical analysis with emphasis on explaining the weak solution and its role in describing real phenomena. In the second part, important problems are introduced, involving fluid flow and other effects (heat transfer, chemical reactions, multiphase nature) and an adequate mathematical description is chosen.</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>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>12NOP</td><td>Nonlinear Optics</td><td>Z,ZK</td><td>4</td></tr>
<tr><td colspan="4">The lecture covers both the basic and advanced topics of nonlinear optics, both from classical and quantum viewpoint, consequentially to the previous courses of Physical optics. From a classical viewpoint, the attention is given to optical processes in dielectric media, macroscopic polarization vector, and microscopic description of polarization vector. Further, it deals with dispersion properties of nonlinear susceptibilities (2nd order nonlinearity for noncentrosymmetric media, 3rd order nonlinearity for centrosymmetric media), and with symmetries of nonlinear susceptibility tensors. From a quantum (poloclassical) viewpoint, the attention is given to derivation of linear, quadratic, and cubic susceptibility, and particularly to the resonant process in two-level media. The processes are classified to nonresonant (parametric) and resonant ones, conservation laws, as well as Manley-Rowe relations, phase matching and synchronisms are discussed. The lecture then separately discusses three-wave mixing (second harmonic generation, sum and difference frequency generation), four wave mixing, optical Kerr effect, third harmonic generation. Concentration is given to light induced refractive index changes, selffocusation and automodulation effects, electrooptical and photorefractive effects, nonlinear light scattering, optical phase conjugation, nonlinear absorption effects, and to nonlinear effects with short pulses. The lecture is conluded with applications of selected nonlinear optical effects.</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>01NMDT</td><td>Numerical Methods in Fluid Dynamics</td><td>ZK</td><td>2</td></tr>
<tr><td colspan="4">The course is focused on the design and properties of numerical methods for solving fluid flow equations. Focus is put mainly on the finite volume method whose classical and advanced schemes are derived. Selected schemes are analyzed in terms of stability. The second part is devoted to advanced numerical schemes used in practice. The matter is concluded by a brief summary of alternative numerical approaches for fluid flow simulation and by a demonstration of visualization techniques for simulation results.</td></tr>
<tr><td>18OOP</td><td>Object Oriented Programming</td><td>Z</td><td>2</td></tr>
<tr><td colspan="4">This course consists of the contributions of students concerning given topics concerned on technologies uded in program development.</td></tr>
<tr><td>12SFMC1</td><td>Computer Simulations in Many-particle Physics 1</td><td>Z,ZK</td><td>4</td></tr>
<tr><td colspan="4">Computer simulation types and possibilities, classical continuous and lattice model systems, principles of the Monte Carlo and molecular dynamics methods, the Ising model, model of hard spheres and of Lennard-Jones liquid, realization of simulations and measurement, simulations in various thermodynamic ensembles.</td></tr>
<tr><td>12SFMC2</td><td>Computer Simulations in Many-particle Physics 2</td><td>ZK</td><td>2</td></tr>
<tr><td colspan="4">Advanced methods of Monte Carlo and molecular dynamics and their applications to various problems: critical phenomena, complex molecules, non-equilibrium phenomena, transport coefficients, kinetic MC, optimalization problems, quantum MC, ab initio simulations, Car-Parrinello method.</td></tr>
<tr><td>12RFO</td><td>X-ray Photonics</td><td>ZK</td><td>2</td></tr>
<tr><td colspan="4">More than one hundred years has passed since the discovery of X-ray radiation. X-ray radiation has become intensively studied and used part of the electromagnetic radiation spectrum. Development of photonics in this part of the spectrum is with increasing intensity stimulated by development in the field of astrophysics, hot plasma physics, macromolecular biology, material sciences and nanotechnologies, especially X-ray lithography to enable further development of information technologies. Lectures cover sources of X-ray radiation, X-ray interaction with matter, X-ray optics and detection.</td></tr>
<tr><td>01SUP</td><td>Start-up Project</td><td>KZ</td><td>2</td></tr>
</table>

01SU1	Machine Learning 1	ZK	3
[1] features for description and recognition of 2-D shapes [2] invariant features, Fourier descriptors, moment invariants, differential invariants [3] statistical pattern recognition, supervised and nonsupervised classification, NN- classifier, linear classifier, Bayessian classifier [4] clustering in a feature space, iterative and hierarchical methods [5] dimensionality reduction of a feature space			
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.			
01UMF	Introduction to Mainframe	Z	2
In this course we teach the mainframe architecture. We explain how to operate the system z/OS, how to start a job using the JCL and we explain some differences when programming in C/C++ for z/OS:			
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.			
01ZPB2	Introduction to Computer Security 2	Z	2

List of courses of this pass:

Code	Name of the course	Completion	Credits
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			
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.			
01MKP	Finite Element Method	ZK	3
The course is devoted to the mathematical theory of the finite element method numerically solving boundary-value and initial-boundary-value problems for partial differential equations. Mathematical properties of the method are explained. The approximation error estimates are derived.			
01MMDY	Mathematical Methods in Fluid Dynamics 1	ZK	2
First, the differential equations representing the conservation laws of fluid flow are briefly derived and reviewed. Next, the problems for the resulting equations are formulated, focusing on boundary conditions specification. The reference problem undergoes numerical analysis with emphasis on explaining the weak solution and its role in describing real phenomena. In the second part, important problems are introduced, involving fluid flow and other effects (heat transfer, chemical reactions, multiphase nature) and an adequate mathematical description is chosen.			
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.			
01NEUR1	Neural Networks and their Applications 1	ZK	2
Keywords: Neural networks, data separation, functional approximation, supervised learning			
01NMDT	Numerical Methods in Fluid Dynamics	ZK	2
The course is focused on the design and properties of numerical methods for solving fluid flow equations. Focus is put mainly on the finite volume method whose classical and advanced schemes are derived. Selected schemes are analyzed in terms of stability. The second part is devoted to advanced numerical schemes used in practice. The matter is concluded by a brief summary of alternative numerical approaches for fluid flow simulation and by a demonstration of visualization techniques for simulation results.			
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.			
01SU1	Machine Learning 1	ZK	3
[1] features for description and recognition of 2-D shapes [2] invariant features, Fourier descriptors, moment invariants, differential invariants [3] statistical pattern recognition, supervised and nonsupervised classification, NN- classifier, linear classifier, Bayessian classifier [4] clustering in a feature space, iterative and hierarchical methods [5] dimensionality reduction of a feature space			
01SUP	Start-up Project	KZ	2
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.			
01UMF	Introduction to Mainframe	Z	2
In this course we teach the mainframe architecture. We explain how to operate the system z/OS, how to start a job using the JCL and we explain some differences when programming in C/C++ for z/OS:			
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.			
01ZPB2	Introduction to Computer Security 2	Z	2

02QIC	Quantum Information and Communication	Z,ZK	4
Quantum theory brought new ideas to the theory of information leading which ultimately lead to the theory of quantum information, computation and communication. The lecture introduces the basic concepts of quantum information e.g. quantum algorithms (Shors and Grovers), entanglement, quantum teleportation, quantum cryptography and quantum error correction. It also provides an introduction to modern parts of quantum information, e.g. measurement-based and adiabatic quantum computation and quantum walks.			
11FYPL	Solid State Physics	Z,ZK	4
The purpose of this lecture is to introduce the undergraduate students to the study of the physical properties of solids.			
12AF	Atomic Physics	Z,ZK	4
Black-body radiation, basic experiments (Millikan's, Franck-Hertz§s, Rutherford's), photons, wave-particle duality, photoelectric effect, Compton effect, potential well, Bohr's model of the hydrogen atom, Schroedinger equation, optical spectra (hydrogen, alkali atoms), spin, Pauli exclusion principle, shell model, periodic system, X-ray spectra, Moseley's law, Zeeman effect, Stark effect, fine and hyperfine structure, intensity of spectral lines, spectral terms.			
12DPFE1	Master Thesis 1	Z	10
Student works on the given topic according to the diploma work submission for a period of 2 semesters, this course covers the first semester.			
12DPFE2	Master Thesis 2	Z	20
Student works on the given topic according to the diploma work submission for a period of 2 semesters, this course covers the second semester.			
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.			
12DSFE1	Diploma Seminar 1	Z	2
Thesis Defense - guidelines and recommendations.			
12DSFE2	Diploma Seminar 2	Z	2
Thesis Defense - guidelines and recommendations.			
12ELDY1	Electrodynamics 1	Z,ZK	3
Fundamentals of applied electromagnetic field theory. Wave equation, potentials. Plane, cylindrical and spherical waves.. Radiation of sources with arbitrary distribution. Dipoles and multipoles.			
12ELDY2	Electrodynamics 2	Z,ZK	5
Fundamentals of electromagnetic theory of propagation of microwave and optical radiation in metallic and dielectric waveguides. Lorentz-Lorenz reciprocity theorem. Orthogonality of modes, scattering matrix and its properties. Cavity and open laser resonators, Gaussian beams. Complex frequency and quality factor. Dispersion of waveguides and its compensation in optical fibres. Kerr nonlinearity, soliton propagation in optical fibres. Periodic structures, Bloch modes, origin of photonic bandgap. Surface plasmon.			
12FIF	Inertial Fusion Physics	Z,ZK	4
These lectures aim to introduce to the topic of inertial confinement fusion (ICF). Physical processes, which take place during the individual stages before and after ignition of the fuel are discussed. The problems (instabilities etc.), which make the inertial confinement and the ignition of the fuel more demanding are discussed and their potential solutions are presented. New projects in the field of ICF including some preliminary reactor designes are reviewed.			
12KOP	Quantum Optics	Z,ZK	5
The lecture covers the advanced topics in quantum optics, consequentially to the previous course of Quantum electronics. It systematically discusses especially the statistical properties of radiation, coherent states of electromagnetic field, quantum description of optical radiation, special states of fields, with respect to quasi-probability densities and characteristic functions. Next, the attention is given both to Dirac quantum theory of interaction of quantized electromagnetic field with a quantum system (including spontaneous emission) and quantum theory of scattering (Rayleigh, Thomson, Raman, resonance fluorescence). The attention is further given both to the quantum theory of coherence (quantum theory of detection, quantum correlation functions), in relation to classical theory. The course is further devoted to generalized higher-order coherence theory, coherent properties of special states of fields, and quantum theory of damping (quantum damped harmonic oscillator, Heisenberg-Langevin approach). Finally, the attention is given to review of nonclassical measuring techniques (photocounting, intensity interferometry, Brown-Twiss effect, stellar correlation interferometer, correlation spectroscopy), possibilities of measuring the quantum state of light, and some selected parts of modern quantum optics (squeezed states). The lectures are accompanied with practical example exercises.			
12KVEN	Quantum Electronics	Z,ZK	5
The lecture covers the basics of quantum electronics. It systematically discusses the Dirac formalism and its application to quantum system description, pure and mixed states, and the statistical operator and its properties, including the time dynamics of quantum Liouvill equation. It also introduces, apart from Schrödinger, also Heisenberg and Dirac formalism of quantum system dynamics. The attention is given to time dynamics of quantum systems, with the help of evolution operator formalism, and both stationary and nonstationary perturbation theory, including semi classical theory of interaction of a quantum system with the classical field. It is further devoted to quantized electromagnetic field and basics of quantum electrodynamics. Finally, the attention is given to both Fock states and coherent states of quantized electromagnetic field, their properties and specifications, and also to the application of coherent states as a tool for description of quantum optical radiation (quasiprobability densities as, e.g. Glauber-Sudarshan representation, and quantum characteristic functions). The lectures are accompanied with practical example exercises.			
12LPZ	Laser-plasma as a Source of Particles and Radiation	ZK	2
Students will get acquinted with physical principles of interaction of intense laser beams with matter with a stress on generation of secondary sources of radiation and accelerated particles and selected applications of these sources. After definition of basic quantities and description of interaction of bound electron with low frequency field, the principles of high-order harmonic generation and generation of single attosecund pulseswill be explained followed by plasma-based x-ray lasers and radiation from hot plasma. Next block of lectures will focus on methods of generation hard x-rays from relativistic laser beams, electron and ion acceleration and selected interdisciplinary applications of these secondary sources.			
12NOP	Nonlinear Optics	Z,ZK	4
The lecture covers both the basic and advanced topics of nonlinear optics, both from classical and quantum viewpoint, consequentially to the previous courses of Physical optics. From a classical viewpoint, the attention is given to optical processes in dielectric media, macroscopic polarization vector, and microscopic description of polarization vector. Further, it deals with dispersion properties of nonlinear susceptibilities (2nd order nonlinearity for noncentrosymmetric media, 3rd order nonlinearity for centrosymmetric media), and with symmetries of nonlinear susceptibility tensors. From a quantum (poloclassical) viewpoint, the attention is given to derivation of linear, quadratic, and cubic susceptibility, and particularly to the resonant process in two-level media. The processes are classified to nonresonant (parametric) and resonant ones, conservation laws, as well as Manley-Rowe relations, phase matching and synchronisms are discussed. The lecture then separately discusses three-wave mixing (second harmonic generation, sum and difference frequency generation), four wave mixing, optical Kerr effect, third harmonic generation. Concentration is given to light induced refractive index changes, selffocusation and automodulation effects, electrooptical and photorefractive effects, nonlinear light scattering, optical phase conjugation, nonlinear absorption effects, and to nonlinear effects with short pulses. The lecture is conluded with applications of selected nonlinear optical effects.			
12PF1	Computational Physics 1	ZK	2
The course is giving an overview of some of the well-known computational physics methods in various fields of physics. The first part concentrates on particle simulation methods - molecular dynamics, Monte Carlo method and other methodsof solving the particle transport in self-consistent fields (e.g. Particle in Cell method in plasma physics). The second part concentrates on methods of solving Maxwell equations and in particular on the finite difference, finite elements methods and the method of moments. An introduction to application of computational physics methods in quantum physics (Hartree-Fock method, density functional theory) is also given.			

12PF2	Computational Physics 2	Z,ZK	2
Structure of hydrodynamic code, representation of structured and unstructured computational meshes. Tools for code debugging and profiling, error detection. Code parallelization, memory hierarchy, supercomputers. Euler equations on moving computational mesh. Eulerian, Lagrangian, and ALE methods, staggered discretization. Methods for mesh smoothing, methods for conservative interpolations of functions between meshes. Applications in simulations of laser/target interactions. Generalization for elastic materials. Methods of artificial intelligence in computational physics.			
12RFO	X-ray Photonics	ZK	2
More than one hundred years has passed since the discovery of X-ray radiation. X-ray radiation has become intensively studied and used part of the electromagnetic radiation spectrum. Development of photonics in this part of the spectrum is with increasing intensity stimulated by development in the field of astrophysics, hot plasma physics, macromolecular biology, material sciences and nanotechnologies, especially X-ray lithography to enable further development of information technologies. Lectures cover sources of X-ray radiation, X-ray interaction with matter, X-ray optics and detection.			
12RNA	Robust Numerical Algorithms	Z	2
This course aims to equip the students with basic knowledge, skills and sense for implementation of accurate and stable algorithms which do reliably work in real numerical computations. The theory is complemented by practical exercises and examples of applications in complex simulation codes and the students are given a possibility to participate in ongoing research projects. Basic theory of finite precision computation, types of errors, their accumulation and interactions, stability of computations and increasing of the precision. Suitable techniques for summation, processing of polynomials and matrices. Computational geometry algorithms: intersections of lines, segments and polygons, triangulation and partitioning of polygons, Voronoi diagrams and Delaunay triangulation, plane arrangement, convex hulls, robot motion planning. Unconstrained and constrained linear and nonlinear numerical optimization.			
12SFMC1	Computer Simulations in Many-particle Physics 1	Z,ZK	4
Computer simulation types and possibilities, classical continuous and lattice model systems, principles of the Monte Carlo and molecular dynamics methods, the Ising model, model of hard spheres and of Lennard-Jones liquid, realization of simulations and measurement, simulations in various thermodynamic ensembles.			
12SFMC2	Computer Simulations in Many-particle Physics 2	ZK	2
Advanced methods of Monte Carlo and molecular dynamics and their applications to various problems: critical phenomena, complex molecules, non-equilibrium phenomena, transport coefficients, kinetic MC, optimalization problems, quantum MC, ab initio simulations, Car-Parrinello method.			
12VUFL1	Research Project 1	Z	6
Student works on the given topic according to the research project submission for a period of 2 semesters, this course covers the first semester.			
12VUFL2	Research Project 2	KZ	8
Student works on the given topic according to the research project submission for a period of 2 semesters, this course covers the second semester.			
12ZFLP	Fundamentals of Laser-Plasma Physics	ZK	2
These lectures will review the state-of-the-art knowledge in the field of short high power laser pulse interactions with matter and its applications.			
18MEMC	Monte Carlo Method	Z,ZK	4
This courseis devoted to the numerical method Monte Carlo and to its selected applications.			
18OOP	Object Oriented Programming	Z	2
This course consists of the contributions of students concerning given topics concerned on technologies uded in program development.			

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