Study plan

Name of study plan: Optika a nanostruktury

Faculty/Institute/Others:
Department:
Branch of study guaranteed by the department: Welcome page
Garantor of the study branch:
Program of study: Applications of Natural Sciences
Type of study: Follow-up master full-time
Required credits: 101
Elective courses credits: 19
Sum of credits in the plan: 120
Note on the plan:

Name of the block: Compulsory courses of the specialization
Minimal number of credits of the block: 101
The role of the block: PO

Code of the group: NMSONPP1
Name of the group: NMSON - povinné předměty 1. ročník
Requirement credits in the group: In this group you have to gain at least 49 credits
Requirement courses in the group: In this group you have to complete at least 13 courses
Credits in the group: 49
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
12ELDY1	**Electrodynamics 1** *Jiří Čtyroký* ***Jiří Čtyroký*** *Jiří Čtyroký (Gar.)*	Z,ZK	3	2+0	Z	PO
12ELDY2	**Electrodynamics 2** *Jiří Čtyroký* ***Jiří Čtyroký*** *Ivan Richter (Gar.)*	Z,ZK	5	4+0	L	PO
11FYPL	**Solid State Physics** *Monika Kučeráková, Kateřina Aubrechtová Dragounová, Ladislav Kalvoda* *Ladislav Kalvoda (Gar.)*	Z,ZK	4	4+0	Z	PO
12FOPT1	**Optical Physics 1** *Ivan Richter, Pavel Kwiecien* ***Pavel Kwiecien*** *Ivan Richter (Gar.)*	Z,ZK	3	3+0	Z	PO
12FOPT2	**Optical Physics 2** ***Pavel Kwiecien***	Z,ZK	2	2+0	L	PO
12KVEN	**Quantum Electronics** *Ivan Richter* ***Ivan Richter*** *Ivan Richter (Gar.)*	Z,ZK	5	3+1	Z	PO
12NAN	**Nanoscopy and Nanocharacterization**	ZK	2	2+0	Z	PO
12NLOP	**Nonlinear Optics** ***Ivan Richter***	Z,ZK	5	3+1	L	PO
12OPS	**Optical Spectroscopy** ***Martin Michl***	ZK	2	2+0	L	PO
11POR	**Surfaces and Boundaries** ***Ladislav Kalvoda***	ZK	2	2	L	PO
12SOP	**Statistical Optics** *Ivan Richter* ***Ivan Richter*** *Ivan Richter (Gar.)*	Z,ZK	2	2+0	L	PO
12VUOF1	**Research Project 1** ***Radka Mika Havlíková*** *Radka Mika Havlíková (Gar.)*	Z	6	0+12	Z,L	PO
12VUOF2	**Research Project 2** *Radka Mika Havlíková* ***Radka Mika Havlíková*** *Radka Mika Havlíková (Gar.)*	KZ	8	0+12	L,Z	PO

Characteristics of the courses of this group of Study Plan: Code=NMSONPP1 Name=NMSON - povinné předměty 1. ročník

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.			

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.			
12FOPT1	Optical Physics 1	Z,ZK	3
The lecture covers the basics of optical physics. It systematically discusses the optical wave propagation in vacuum, in isotropic and anisotropic media, and on their boundaries. It also classifies types of optical waves. Next, it describes the polarization and its applications, statistical properties of polychromatic waves, fundamentals of two and multiwave interference.			
12FOPT2	Optical Physics 2	Z,ZK	2
The lecture covers the basics of the diffractive optics. It discusses the scalar theory of diffraction and thoroughly analyses the approaches of Fresnel, Kirchhoff, Sommerfeld, and others. The rigorous theory of diffraction is also briefly mentioned. The second part of the lecture is devoted to the optical diffractive structures, thin and volume diffraction gratings, and synthetic diffractive structures. Various approaches to the analysis and synthesis of the diffractive elements are discussed. The last part is devoted to the optical holography, holographic techniques, recording materials, and various applications of holograms.			
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.			
12NAN	Nanoscopy and Nanocharacterization	ZK	2
The lecture covers the basics of nanoscopy and nanocharacterization, it systematically discusses the experimental approaches and methods, gives an overview of raster probe microscopes and electron microscopes. Further, it deals with the scanning tunneling microscopy and elements of probe microscopes, atomic force microscopy and related methods, magnetic and electrostatic force microscopy, Kelvin microscopy, thermal microscopy, scanning near field microscopy and nanotribology. The lecture also decribes the atomic manipulation, nanostructures are classified into natural and artificial nanostructures, microelectromechanical and nanoelectromechanical elements are further discussed, as well as molecular electronics, dip-pen lithography, nanoimprints, self organized nanostructures, and Lego approaches.			
12NLOP	Nonlinear Optics	Z,ZK	5
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.			
12OPS	Optical Spectroscopy	ZK	2
Basics of spectroscopic behaviour of atoms and molecules. Elementary experimental techniques for optical spectroscopy.			
11POR	Surfaces and Boundaries	ZK	2
Description is provided of basic thermodynamic properties, atomary and electronic structure of surfaces and interfaces. The physical models valid for bulk sysstems are juxtaposed with the changes due to introduction of new surface/interface. The theoretical treatment is followed by overview of experimental techniques applied to preparation of surface structures and to study of chemical composition and structural arrangement of the latter. In addition, brief overview is given of simulation approaches suitable for analysis and prediction of properties of selected systems. All the subjects are demonstrated on praktical exaples of case studies.			
12SOP	Statistical Optics	Z,ZK	2
The lecture covers both the basics and advanced topics in statistical optics, i.e. the classical theory of optical coherence. It reviews the basics of probability theory and statistics, random variables, random stochastic processes, together with the complex analytical and quasimonochromatic signals. It futher systematically discusses especially the statistical properties of radiation, in terms of the classical scalar 2nd order theory of optical coherence, including elementary concepts and definitions, correlation functions and their properties, time domain, interference law, complex degree of coherence, frequency domain, coherence time, area, volume, spectral degree of coherence, and Wiener-Khinchin theorem. It also introduces special types of fields (coherent, cross spectrally pure) and radiation from primary sources (Schell model sources). The attention is further given both to the dynamics of correlation function (Wolf equations, Van Cittert - Zernike theory) and to applications of the coherence theory (Michelson stellar interferometer, correlation spectroscopy). The course is further devoted to vectorial aspects of coherence theory (standard statistical theory of polarization, using either polarization matrices or Stokes parameters), together with the unified treatment of polarization and coherence aspects, and general vectorial correlation matrices and tensors. The final attention is given to higher order correlation functions.			
12VUOF1	Research Project 1	Z	6
Student works on the given topic according to the research project submission for a period of 2 semesters.			
12VUOF2	Research Project 2	KZ	8
Student works on the given topic according to the research project submission for a period of 2 semesters.			

Code of the group: NMSONPP2
Name of the group: NMSON - povinné předměty 2. ročník
Requirement credits in the group: In this group you have to gain at least 52 credits
Requirement courses in the group: In this group you have to complete at least 10 courses
Credits in the group: 52
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
12DPOF1	**Master Thesis 1**	Z	10	0+10	Z,L	PO
12DPOF2	**Master Thesis 2**	Z	20	0+25	L,Z	PO
12INTO	**Integrated Optics** *Jiří Čtyroký* ***Jiří Čtyroký*** *Jiří Čtyroký (Gar.)*	Z,ZK	2	2+0	Z	PO

12NF	**Nanophysics** *Milan Šiňor, Ivan Richter* ***Ivan Richter*** *Milan Šiňor (Gar.)*	ZK	2	2+0	Z	PO
12OSE	**Optical Sensors** *Jiří Homola* ***Jiří Homola*** *Jiří Homola (Gar.)*	ZK	2	2+0	L	PO
12OZS	**Fourier Optics and Optical Signal Processing** *Ivan Richter, Pavel Kwiecien* ***Ivan Richter*** *Ivan Richter (Gar.)*	Z,ZK	3	3+0	Z	PO
12PPRO	**Advanced Optical Laboratory** *Alexandr Jančárek* ***Alexandr Jančárek*** *Alexandr Jančárek (Gar.)*	KZ	6	0+4	Z	PO
12RFO	**X-ray Photonics** *Ladislav Pína* ***Ladislav Pína*** *Ladislav Pína (Gar.)*	ZK	2	2+0	Z	PO
12DSEOF1	**Diploma Seminar 1** *Helena Jelínková* ***Helena Jelínková*** *Helena Jelínková (Gar.)*	Z	2	0+2	Z	PO
12DSEOF2	**Diploma Seminar 2** ***Helena Jelínková***	Z	3	0+2	L	PO

Characteristics of the courses of this group of Study Plan: Code=NMSONPP2 Name=NMSON - povinné předměty 2. ročník

12DPOF1	Master Thesis 1	Z	10
Student works on the given topic according to the diploma work submission for a period of 2 semesters.			
12DPOF2	Master Thesis 2	Z	20
Student works on the given topic according to the diploma work submission for a period of 2 semesters.			
12INTO	Integrated Optics	Z,ZK	2
Description of the most important integrated-optical components and devices for applications in optical communication and sensing. Theoretical backgrounds, numerical modelling and fabrication technology. Physical principles of passive, dynamic (externally controllable), active (amplifying) and optically nonlinear integrated photonic devices. Contemporary trends of their development: silicon photonics, photonic crystals, plasmonics.			
12NF	Nanophysics	ZK	2
The lecture offers a deep overview on nanophysics, clarifies the terminology, compares various forms of matter and structures, with the emphasis on nanostructures, and relates electronic and photonic nanostructures. It also reviews terms and methods form solid state physics, and applies them to quantum restricted nanostructures (quantum wells, multiple quantum wells, quantum wires, quantum dots). The attention is further given both to the electrodynamics of metals, its specifics, the lecture discusses and classifies plasmons; it further systematically explains especially the surface plasmons. Next, the lecture covers the photonic nanostructures, their properties, and relation to electronic structures, with the emphasis on photonic crystals, it gives their examples in 1D, 2D and 3D. The final attention is given to novel artificial materials, mainly metamaterials with negative refractive index. The course is concluded with the student presentations on selected given topics.			
12OSE	Optical Sensors	ZK	2
Principles, main configurations, typical implementations and applications of optical sensors.			
12OZS	Fourier Optics and Optical Signal Processing	Z,ZK	3
The lecture covers the basics of the Fourier optics and optical information processing. It systematically discusses the Fourier formalism in optics, it mentions also other optical transforms. The propagation and diffraction of light is described in terms of the Fourier optics, using the impulse response, the optical transfer function, the thin transparency, and the phase corrector. Within the recording and modulation of the optical information, the special attention is given, apart from the traditional photographic films, especially to the holography, the spatial light modulators, and the diffractive structures. The lecture also describes the basic processing of analogue, discrete, and logic optical information.			
12PPRO	Advanced Optical Laboratory	KZ	6
The practical laboratories give advanced practical skills by experimental work in optics. Laboratory records must be elaborated.			
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.			
12DSEOF1	Diploma Seminar 1	Z	2
Thesis Defense - guidelines and recommendations.			
12DSEOF2	Diploma Seminar 2	Z	3
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: NMSONVP
Name of the group: NMSON - volitelné předměty
Requirement credits in the group:
Requirement courses in the group:
Credits in the group: 0
Note on the group:

Code	**Name of the course / Name of the group of courses** ***(in case of groups of courses the list of codes of their members)*** *Tutors,* ***authors*** *and guarantors (gar.)*	**Completion**	**Credits**	**Scope**	**Semester**	**Role**
12EL3	**Electronics 3** *Jaroslav Pavel* ***Jaroslav Pavel*** *Jaroslav Pavel (Gar.)*	ZK	2	2+0	Z	V
12EOP	**Excursions to Optical Workplaces**	Z	4	0+4	Z	V
12FLP	**Physics and Human Cognition** *Vojtěch Svoboda* ***Vojtěch Svoboda*** *Vojtěch Svoboda (Gar.)*	Z	2	2+0	L	V

12FDD	**Physics of Detection and Detectors of Optical Radiation** *Ladislav Pína* ***Ladislav Pína*** *Ladislav Pína (Gar.)*	ZK	2	2+0	Z	v
12GEOP	**Geometrical Optics** ***Miroslav Dvořák***	Z,ZK	4	3+1	Z	v
12KVO	**Quantum Optics** ***Ivan Richter***	Z,ZK	4	3+1	L	v
12LPST	**Laser, Plasma and Beam Technologies** *Alexandr Jančárek, Helena Jelínková* ***Helena Jelínková*** *Helena Jelínková (Gar.)*	ZK	4	2+2	L	v
12MMEO	**Measurements Methods in Electronics and Optics** *Ladislav Pína* ***Ladislav Pína*** *Ladislav Pína (Gar.)*	ZK	2	2+0	L	v
12NCH	**Nanochemistry** *Jan Proška* ***Jan Proška*** *Jan Proška (Gar.)*	ZK	2	2+0	Z	v
12NAE	**Nanoelectronics**	ZK	2	2+0	Z	v
12OVP	**Optical Semiconductors Properties**	ZK	2	2+0	L	v
12PDBL	**Solid-state, Diode and Dye Lasers** *Helena Jelínková, Václav Kubeček* ***Václav Kubeček*** *Helena Jelínková (Gar.)*	Z,ZK	2	2+0	L	v
12RTGL	**Gas and X-ray Lasers** *Alexandr Jančárek, Miroslava Vrbová* ***Alexandr Jančárek*** *Alexandr Jančárek (Gar.)*	Z,ZK	2	2+0	L	v
12POEX	**Computer Control of Experiments** *Miroslav Čech* ***Miroslav Čech*** *Miroslav Čech (Gar.)*	Z	2	2+0	L	v
12PLS	**Advanced Laser Spectroscopy** *Martin Michl* ***Martin Michl*** *Martin Michl (Gar.)*	ZK	2	2+0	Z	v
12EP1	**Advanced Electronics Practicum 1** *Jaroslav Pavel* ***Ivan Procházka*** *Ivan Procházka (Gar.)*	KZ	3	0+2	Z	v
12EP2	**Advanced Electronics Practicum 2** *Jaroslav Pavel* ***Ivan Procházka*** *Ivan Procházka (Gar.)*	KZ	3	0+2	L	v
12PPLT	**Advanced Laser Technique Laboratory** ***Václav Kubeček*** *Václav Kubeček (Gar.)*	KZ	6	0+4	Z	v
12PN	**Preparation of Semiconductor Nanostructures** *Eduard Hulicius* ***Ivan Richter*** *Eduard Hulicius (Gar.)*	ZK	2	2+0	L	v
12SRS	**Spontaneously-grown Structures of Selected Nanomaterials**	KZ	2	2+0	Z	v
12UM	**Introduction to Management** *Petr Malát* ***Petr Malát*** *Petr Malát (Gar.)*	ZK	2	2+0	Z	v
12VLA	**Fiber Lasers and Amplifiers**	ZK	3	3+0	Z	v
12MODO	**Selected Chapters of Modern Optics** *Ivan Richter, Pavel Kwiecien* ***Pavel Kwiecien*** *Pavel Kwiecien (Gar.)*	Z	2	2+0	Z	v
12VKNS	**Selected Nanostructures Chapters** ***Milan Šiňor***	KZ	2	2+0	L	v
01ZPB1	**Introduction to Computer Security 1** *Petr Vokáč* ***Petr Vokáč*** *Petr Vokáč (Gar.)*	Z	2	1+1		v
01ZPB2	**Introduction to Computer Security 2** *Petr Vokáč* ***Petr Vokáč*** *Petr Vokáč (Gar.)*	Z	2	1+1		v

Characteristics of the courses of this group of Study Plan: Code=NMSONVP Name=NMSON - volitelné předměty

12EL3	Electronics 3	ZK	2

The goals of course is to collect advanced knowledge in optoelectronics and pulse technique.

12EOP	Excursions to Optical Workplaces	Z	4

Visit different workplaces dealing with optics.

12FLP	Physics and Human Cognition	Z	2

W. Heisenberg said that modern physics is the most important philosophical event of the 20tieth century. This course tries to show "why". It describes the present days picture of the universe based on the General theory of relativity and Quantum theory and briefly comments on important milestones of the history of physics and philosophy. It inquires the place of the physics and mathematics in the cultural history of mankind and their influence on the art and discusses some ethical problems of the scientific research.

12FDD	Physics of Detection and Detectors of Optical Radiation	ZK	2

Electromagnetic spectrum. Sources of electromagnetic radiation. Radiometric and photometric units. Ideal detector. External and internal photoefect. Quantum fluctuations of radiation. Noise of detector and electronic circuits. Dynamic range. Detectors based on external photoefect. Photocathodes. Electron multipliers. Microchannel plates. Image intensifiers. Detectors based on internal photoefect. Semiconductor detectors. Scintilators. Detectors of IR, VIS and UV radiation. X-ray detectors.. Pyroelectricity and pyrodetectors. Detector electronic circuits. Human eye.

12GEOP	Geometrical Optics	Z,ZK	4

The lecture covers the basics of geometrical and instrumental optics. It systematically discusses the theory of optical imaging, matrix description of optical systems, and optical aberrations. It is also devoted to energetics a colorimetry of optical beams, radiometric and photometric quantities and units. It describes most common optical instruments used in practice.

12KVO	Quantum Optics	Z,ZK	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.

12LPST	Laser, Plasma and Beam Technologies	ZK	4
Theoretical and practical lessons on selected applications of electromagnetic radiation, laser, plasma, X-ray, and ion beams in medicine and technology. Excursions to renowned companies and institutes.			
12MMEO	Measurements Methods in Electronics and Optics	ZK	2
Selected measurement methods of physical electronics and optics include typical measurements of photon and ion beams in modern physical laboratory experiments. Namely: Measurements of extremely small electrical currents. Measurements of extremely low light intensities. Synchronous detection and gated integrators. Measurements of extremely high light intensities. Nanosecond and picosecond pulse techniques. Measurement of nanosecond, picosecond and femtosecond pulses. Detection in IR, UV, XUV, SXR, XR and HXR radiation bands. Multichannel analysis. Radiation spectrometry. Measurement of charged particles velocity, mass and ionisation state. Measurements of extremely high electrical currents and magnetic fields. Imaging and metrology of micro and nano objects together with optical surfaces characterisation are also included.			
12NCH	Nanochemistry	ZK	2
This is a multidisciplinary course which is open to students with different background (physics, chemistry biology, engineering). Course is devoted to advanced research in the chemistry, physical chemistry, and chemical physics in the process of creation nanostructures and study of proceses in 1,2,3- dimensional restricted nanovolumes up to molecular and atomic level.			
12NAE	Nanoelectronics	ZK	2
The subject is oriented on the present nanotechnologies in the connection with their electronic, photonic and spintronic applications. Quantum theory basics are used to explain the effects observed in nanostructures. Basic nanoelectronic structures are described with their possible applications. Modern computer methods and models, which are able to simulate the operation of nanoelectronic structures and which are the important tools for their design and optimization, are studied.			
12OVP	Optical Semiconductors Properties	ZK	2
Recapitulation of solid materials physics (optical translation, excitons, electron-hole plasma), non-linear optical properties, luminescence, recombination in semiconductor, stimulation emission, examples of practical materials.			
12PDBL	Solid-state, Diode and Dye Lasers	Z,ZK	2
Activators of solid-state lasers. Raman lasers, up-conversion lasers, second harmonic generation. Dye lasers. Optical parametric oscillator. Diode lasers, high power diode lasers, VECSEL, tunable diode lasers.			
12RTGL	Gas and X-ray Lasers	Z,ZK	2
Gas resp. X-ray lasers currently has the highest average power resp. the shortest wavelength.			
12POEX	Computer Control of Experiments	Z	2
Introduction. Basic design of computers, microcomputers. Hardware: computer-experiment interconnection (interfaces RS232C,IEE488, A/D and D/A converters, sensors, drivers, etc.) Software: operating systems for control of experiments (real time OS, multitasking, multiuser). Basic theory of control systems. Programming languages for control (assembler, C, etc.) Introduction to TCP/IP protocols. Control of experiments via Internet.			
12PLS	Advanced Laser Spectroscopy	ZK	2
Spectroscopic application of the unique properties of laser radiation, selected advanced laser spectroscopy techniques			
12EP1	Advanced Electronics Practicum 1	KZ	3
The aim of the practicum is 1) to acquire basics skills in electronics and 2) to learn independent problem solving, formulation of a task and formulation of the results. The practicum consists of blocks lasting 4 hours.			
12EP2	Advanced Electronics Practicum 2	KZ	3
The aim of the practicum is 1) to acquire basics skills in electronics and 2) to learn independent problem solving, formulation of a task and formulation of the results. The practicum consists of blocks lasting 4 hours.			
12PPLT	Advanced Laser Technique Laboratory	KZ	6
Principles and measurement of parameters of infrared erbium and femtosecond lasers.Design of laser resonator for passively mode-locked laser. High power pulse laser diode for pumping of neodymium lasers and principle of side-pumped Nd:YAG laser.Basic properties and differences of most frequently used visible lasers (He-Ne laser, green and red laser pointer) and laser diodes			
12PN	Preparation of Semiconductor Nanostructures	ZK	2
Lectures will introduce students to modern methods of preparation of semiconductors, their compounds and structures. Differences between nanoelectronics and microelectronics will be explained. Physico-chemical fundaments of different technologies will be discussed. Substantive attention will be devoted to epitaxial technologies, which are substantial for semiconductor nanostructure preparation. Particular emphasis will be focused on characterization "in situ" and "ex situ" techniques. Optical, structural, electron and other methods will be described, their application to heterostructure and nanostructure growths will be discussed. Some supportive technical methods - lithography, diffusion, evaporation, ion implantation, contact and dielectric layer preparation will be mentioned as well as soldering and encasement. Examples of exploitation of nanostructures and heterostructures for semiconductor sources of radiation and detectors will be discussed at the end.			
12SRS	Spontaneously-grown Structures of Selected Nanomaterials	KZ	2
The course is under way of essential convergence of the nano-bio-info fields in nanoscale. The course is focused on the self-assembly of nanostructures, their characterization, and application in nano-electro-mechanical systems, new materials, medicine, new sources of energy, and biomimetics. The course covers examples of self-assembly in nature.			
12UM	Introduction to Management	ZK	2
Modern management conception, managerial functions, managerial activities . Managerial decision tasks, business strategy. Human resources management, Staff motivation and evaluation, teamwork, labour code. System marketing conception, marketing goals, marketing strategy. Marketing planning and decision making. Marketing mix, product life cycle, publicity campaign.			
12VLA	Fiber Lasers and Amplifiers	ZK	3
Introduction: optical fibres, passive components, pump lasers. Spectroscopy of rare earth elements. Erbium-doped fibre amplifier, rate equations, gain saturation. Complex theoretical model and optimization of the amplifier. Amplifier characterization (gain, noise figure). Erbium doped fibre laser, continuous wave and pulse regime. Fibre amplifiers and lasers doped with other rare earth ions, high-power fibre lasers utilizing cladding pumping, Raman fibre amplifiers. Implementation of fibre amplifiers in optical communication systems.			
12MODO	Selected Chapters of Modern Optics	Z	2
The subject contents selected lectures of different fields of modern optics which are given by both academic and industry experts. The lectures mainly include the fields which are not covered in common courses of optics.			
12VKNS	Selected Nanostructures Chapters	KZ	2
The set of lectures is divided into two parts - first six two-hours lectures treats with theoretical base of nanoelectronics. The next - eight one-hour specialised lectures will be focused on selected nanoelectronic materials. The last two lessons are reserved for preparation and presentation of semestral works. Their parameters and quality of their presentation will serve for student evaluation (classified credit). The first part will contains: theoretical fundaments of nanostructures; transport within them; their optical properties; microscopic nanocharacterisation (STM, AFM) and nanomanipulation and nanolithography; role of surfaces and boundaries in nanostructures, spintronics. The specialised part will contain: properties and application of dielectrics with nanoscopic structures; computer simulation of nanosystems; preparation and characterisation of: nanocrystalic silicon; carbon graphen structures; A(III)B(V) nanostructures (QD, QW); nanodiamant thin layers for optics, biosensors and MEMS; Raman spectroscopy for nanostructures; nanocomposits of magnetic materials for biomedical applications.			
01ZPB1	Introduction to Computer Security 1	Z	2
01ZPB2	Introduction to Computer Security 2	Z	2

List of courses of this pass:

Code	Name of the course	Completion	Credits
01ZPB1	Introduction to Computer Security 1	Z	2
01ZPB2	Introduction to Computer Security 2	Z	2
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.		
11POR	Surfaces and Boundaries	ZK	2
	Description is provided of basic thermodynamic properties, atomary and electronic structure of surfaces and interfaces. The physical models valid for bulk sysstems are juxtaposed with the changes due to introduction of new surface/interface. The theoretical treatment is followed by overview of experimental techniques applied to preparation of surface structures and to study of chemical composition and structural arrangement of the latter. In addition, brief overview is given of simulation approaches suitable for analysis and prediction of properties of selected systems. All the subjects are demonstrated on praktical exaples of case studies.		
12DPOF1	Master Thesis 1	Z	10
	Student works on the given topic according to the diploma work submission for a period of 2 semesters.		
12DPOF2	Master Thesis 2	Z	20
	Student works on the given topic according to the diploma work submission for a period of 2 semesters.		
12DSEOF1	Diploma Seminar 1	Z	2
	Thesis Defense - guidelines and recommendations.		
12DSEOF2	Diploma Seminar 2	Z	3
	Thesis Defense - guidelines and recommendations.		
12EL3	Electronics 3	ZK	2
	The goals of course is to collect advanced knowledge in optoelectronics and pulse technique.		
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.		
12EOP	Excursions to Optical Workplaces	Z	4
	Visit different workplaces dealing with optics.		
12EP1	Advanced Electronics Practicum 1	KZ	3
	The aim of the practicum is 1) to acquire basics skills in electronics and 2) to learn independent problem solving, formulation of a task and formulation of the results. The practicum consists of blocks lasting 4 hours.		
12EP2	Advanced Electronics Practicum 2	KZ	3
	The aim of the practicum is 1) to acquire basics skills in electronics and 2) to learn independent problem solving, formulation of a task and formulation of the results. The practicum consists of blocks lasting 4 hours.		
12FDD	Physics of Detection and Detectors of Optical Radiation	ZK	2
	Electromagnetic spectrum. Sources of electromagnetic radiation. Radiometric and photometric units. Ideal detector. External and internal photoefect. Quantum fluctuations of radiation. Noise of detector and electronic circuits. Dynamic range. Detectors based on external photoefect. Photocathodes. Electron multipliers. Microchannel plates. Image intensifiers. Detectors based on internal photoefect. Semiconductor detectors. Scintilators. Detectors of IR, VIS and UV radiation. X-ray detectors.. Pyroelectricity and pyrodetectors. Detector electronic circuits. Human eye.		
12FLP	Physics and Human Cognition	Z	2
	W. Heisenberg said that modern physics is the most important philosophical event of the 20tieth century. This course tries to show "why". It describes the present days picture of the universe based on the General theory of relativity and Quantum theory and briefly comments on important milestones of the history of physics and philosophy. It inquires the place of the physics and mathematics in the cultural history of mankind and their influence on the art and discusses some ethical problems of the scientific research.		
12FOPT1	Optical Physics 1	Z,ZK	3
	The lecture covers the basics of optical physics. It systematically discusses the optical wave propagation in vacuum, in isotropic and anisotropic media, and on their boundaries. It also classifies types of optical waves. Next, it describes the polarization and its applications, statistical properties of polychromatic waves, fundamentals of two and multiwave interference.		
12FOPT2	Optical Physics 2	Z,ZK	2
	The lecture covers the basics of the diffractive optics. It discusses the scalar theory of diffraction and thoroughly analyses the approaches of Fresnel, Kirchhoff, Sommerfeld, and others. The rigorous theory of diffraction is also briefly mentioned. The second part of the lecture is devoted to the optical diffractive structures, thin and volume diffraction gratings, and synthetic diffractive structures. Various approaches to the analysis and synthesis of the diffractive elements are discussed. The last part is devoted to the optical holography, holographic techniques, recording materials, and various applications of holograms.		
12GEOP	Geometrical Optics	Z,ZK	4
	The lecture covers the basics of geometrical and instrumental optics. It systematically discusses the theory of optical imaging, matrix description of optical systems, and optical aberrations. It is also devoted to energetics a colorimetry of optical beams, radiometric and photometric quantities and units. It describes most common optical instruments used in practice.		
12INTO	Integrated Optics	Z,ZK	2
	Description of the most important integrated-optical components and devices for applications in optical communication and sensing. Theoretical backgrounds, numerical modelling and fabrication technology. Physical principles of passive, dynamic (externally controllable), active (amplifying) and optically nonlinear integrated photonic devices. Contemporary trends of their development: silicon photonics, photonic crystals, plasmonics.		
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.

12KVO	Quantum Optics	Z,ZK	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.

12LPST	Laser, Plasma and Beam Technologies	ZK	4

Theoretical and practical lessons on selected applications of electromagnetic radiation, laser, plasma, X-ray, and ion beams in medicine and technology. Excursions to renowned companies and institutes.

12MMEO	Measurements Methods in Electronics and Optics	ZK	2

Selected measurement methods of physical electronics and optics include typical measurements of photon and ion beams in modern physical laboratory experiments. Namely: Measurements of extremely small electrical currents. Measurements of extremely low light intensities. Synchronous detection and gated integrators. Measurements of extremely high light intensities. Nanosecond and picosecond pulse techniques. Measurement of nanosecond, picosecond and femtosecond pulses. Detection in IR, UV, XUV, SXR, XR and HXR radiation bands. Multichannel analysis. Radiation spectrometry. Measurement of charged particles velocity, mass and ionisation state. Measurements of extremely high electrical currents and magnetic fields. Imaging and metrology of micro and nano objects together with optical surfaces characterisation are also included.

12MODO	Selected Chapters of Modern Optics	Z	2

The subject contents selected lectures of different fields of modern optics which are given by both academic and industry experts. The lectures mainly include the fields which are not covered in common courses of optics.

12NAE	Nanoelectronics	ZK	2

The subject is oriented on the present nanotechnologies in the connection with their electronic, photonic and spintronic applications. Quantum theory basics are used to explain the effects observed in nanostructures. Basic nanoelectronic structures are described with their possible applications. Modern computer methods and models, which are able to simulate the operation of nanoelectronic structures and which are the important tools for their design and optimization, are studied.

12NAN	Nanoscopy and Nanocharacterization	ZK	2

The lecture covers the basics of nanoscopy and nanocharacterization, it systematically discusses the experimental approaches and methods, gives an overview of raster probe microscopes and electron microscopes. Further, it deals with the scanning tunneling microscopy and elements of probe microscopes, atomic force microscopy and related methods, magnetic and electrostatic force microscopy, Kelvin microscopy, thermal microscopy, scanning near field microscopy and nanotribology. The lecture also decribes the atomic manipulation, nanostructures are classified into natural and artificial nanostructures, microelectromechanical and nanoelectromechanical elements are further discussed, as well as molecular electronics, dip-pen lithography, nanoimprints, self organized nanostructures, and Lego approaches.

12NCH	Nanochemistry	ZK	2

This is a multidisciplinary course which is open to students with different background (physics, chemistry biology, engineering). Course is devoted to advanced research in the chemistry, physical chemistry, and chemical physics in the process of creation nanostructures and study of proceses in 1,2,3- dimensional restricted nanovolumes up to molecular and atomic level.

12NF	Nanophysics	ZK	2

The lecture offers a deep overview on nanophysics, clarifies the terminology, compares various forms of matter and structures, with the emphasis on nanostructures, and relates electronic and photonic nanostructures. It also reviews terms and methods form solid state physics, and applies them to quantum restricted nanostructures (quantum wells, multiple quantum wells, quantum wires, quantum dots). The attention is further given both to the electrodynamics of metals, its specifics, the lecture discusses and classifies plasmons; it further systematically explains especially the surface plasmons. Next, the lecture covers the photonic nanostructures, their properties, and relation to electronic structures, with the emphasis on photonic crystals, it gives their examples in 1D, 2D and 3D. The final attention is given to novel artificial materials, mainly metamaterials with negative refractive index. The course is concluded with the student presentations on selected given topics.

12NLOP	Nonlinear Optics	Z,ZK	5

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.

12OPS	Optical Spectroscopy	ZK	2

Basics of spectroscopic behaviour of atoms and molecules. Elementary experimental techniques for optical spectroscopy.

12OSE	Optical Sensors	ZK	2

Principles, main configurations, typical implementations and applications of optical sensors.

12OVP	Optical Semiconductors Properties	ZK	2

Recapitulation of solid materials physics (optical translation, excitons, electron-hole plasma), non-linear optical properties, luminescence, recombination in semiconductor, stimulation emission, examples of practical materials.

12OZS	Fourier Optics and Optical Signal Processing	Z,ZK	3

The lecture covers the basics of the Fourier optics and optical information processing. It systematically discusses the Fourier formalism in optics, it mentions also other optical transforms. The propagation and diffraction of light is described in terms of the Fourier optics, using the impulse response, the optical transfer function, the thin transparency, and the phase corrector. Within the recording and modulation of the optical information, the special attention is given, apart from the traditional photographic films, especially to the holography, the spatial light modulators, and the diffractive structures. The lecture also describes the basic processing of analogue, discrete, and logic optical information.

12PDBL	Solid-state, Diode and Dye Lasers	Z,ZK	2

Activators of solid-state lasers. Raman lasers, up-conversion lasers, second harmonic generation. Dye lasers. Optical parametric oscillator. Diode lasers, high power diode lasers, VECSEL, tunable diode lasers.

12PLS	Advanced Laser Spectroscopy	ZK	2
Spectroscopic application of the unique properties of laser radiation, selected advanced laser spectroscopy techniques			
12PN	Preparation of Semiconductor Nanostructures	ZK	2
Lectures will introduce students to modern methods of preparation of semiconductors, their compounds and structures. Differences between nanoelectronics and microelectronics will be explained. Physico-chemical fundaments of different technologies will be discussed. Substantive attention will be devoted to epitaxial technologies, which are substantial for semiconductor nanostructure preparation. Particular emphasis will be focused on characterization "in situ" and "ex situ" techniques. Optical, structural, electron and other methods will be described, their application to heterostructure and nanostructure growths will be discussed. Some supportive technical methods - lithography, diffusion, evaporation, ion implantation, contact and dielectric layer preparation will be mentioned as well as soldering and encasement. Examples of exploitation of nanostructures and heterostructures for semiconductor sources of radiation and detectors will be discussed at the end.			
12POEX	Computer Control of Experiments	Z	2
Introduction. Basic design of computers, microcomputers. Hardware: computer-experiment interconnection (interfaces RS232C,IEE488, A/D and D/A converters, sensors, drivers, etc.) Software: operating systems for control of experiments (real time OS, multitasking, multiuser). Basic theory of control systems. Programming languages for control (assembler, C, etc.) Introduction to TCP/IP protocols. Control of experiments via Internet.			
12PPLT	Advanced Laser Technique Laboratory	KZ	6
Principles and measurement of parameters of infrared erbium and femtosecond lasers.Design of laser resonator for passively mode-locked laser. High power pulse laser diode for pumping of neodymium lasers and principle of side-pumped Nd:YAG laser.Basic properties and differences of most frequently used visible lasers (He-Ne laser, green and red laser pointer) and laser diodes			
12PPRO	Advanced Optical Laboratory	KZ	6
The practical laboratories give advanced practical skills by experimental work in optics. Laboratory records must be elaborated.			
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.			
12RTGL	Gas and X-ray Lasers	Z,ZK	2
Gas resp. X-ray lasers currently has the highest average power resp. the shortest wavelength.			
12SOP	Statistical Optics	Z,ZK	2
The lecture covers both the basics and advanced topics in statistical optics, i.e. the classical theory of optical coherence. It reviews the basics of probability theory and statistics, random variables, random stochastic processes, together with the complex analytical and quasimonochromatic signals. It futher systematically discusses especially the statistical properties of radiation, in terms of the classical scalar 2nd order theory of optical coherence, including elementary concepts and definitions, correlation functions and their properties, time domain, interference law, complex degree of coherence, frequency domain, coherence time, area, volume, spectral degree of coherence, and Wiener-Khinchin theorem. It also introduces special types of fields (coherent, cross spectrally pure) and radiation from primary sources (Schell model sources). The attention is further given both to the dynamics of correlation function (Wolf equations, Van Cittert - Zernike theory) and to applications of the coherence theory (Michelson stellar interferometer, correlation spectroscopy). The course is further devoted to vectorial aspects of coherence theory (standard statistical theory of polarization, using either polarization matrices or Stokes parameters), together with the unified treatment of polarization and coherence aspects, and general vectorial correlation matrices and tensors. The final attention is given to higher order correlation functions.			
12SRS	Spontaneously-grown Structures of Selected Nanomaterials	KZ	2
The course is under way of essential convergence of the nano-bio-info fields in nanoscale. The course is focused on the self-assembly of nanostructures, their characterization, and application in nano-electro-mechanical systems, new materials, medicine, new sources of energy, and biomimetics. The course covers examples of self-assembly in nature.			
12UM	Introduction to Management	ZK	2
Modern management conception, managerial functions, managerial activities . Managerial decision tasks, business strategy. Human resources management, Staff motivation and evaluation, teamwork, labour code. System marketing conception, marketing goals, marketing strategy. Marketing planning and decision making. Marketing mix, product life cycle, publicity campaign.			
12VKNS	Selected Nanostructures Chapters	KZ	2
The set of lectures is divided into two parts - first six two-hours lectures treats with theoretical base of nanoelectronics. The next - eight one-hour specialised lectures will be focused on selected nanoelectronic materials. The last two lessons are reserved for preparation and presentation of semestral works. Their parameters and quality of their presentation will serve for student evaluation (classified credit). The first part will contains: theoretical fundaments of nanostructures; transport within them; their optical properties; microscopic nanocharacterisation (STM, AFM) and nanomanipulation and nanolithography; role of surfaces and boundaries in nanostructures, spintronics. The specialised part will contain: properties and application of dielectrics with nanoscopic structures; computer simulation of nanosystems; preparation and characterisation of: nanocrystalic silicon; carbon graphen structures; A(III)B(V) nanostructures (QD, QW); nanodiamant thin layers for optics, biosensors and MEMS; Raman spectroscopy for nanostructures; nanocomposits of magnetic materials for biomedical applications.			
12VLA	Fiber Lasers and Amplifiers	ZK	3
Introduction: optical fibres, passive components, pump lasers. Spectroscopy of rare earth elements. Erbium-doped fibre amplifier, rate equations, gain saturation. Complex theoretical model and optimization of the amplifier. Amplifier characterization (gain, noise figure). Erbium doped fibre laser, continuous wave and pulse regime. Fibre amplifiers and lasers doped with other rare earth ions, high-power fibre lasers utilizing cladding pumping, Raman fibre amplifiers. Implementation of fibre amplifiers in optical communication systems.			
12VUOF1	Research Project 1	Z	6
Student works on the given topic according to the research project submission for a period of 2 semesters.			
12VUOF2	Research Project 2	KZ	8
Student works on the given topic according to the research project submission for a period of 2 semesters.			

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