Study plan

Name of study plan: Fyzikální elektronika - Laserová fyzika a technika

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: NMSPFELFT1
Name of the group: MDP P_FEN LFT 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
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
12FLA	**Laser Physics** *Jan Šulc* ***Jan Šulc*** *Jan Šulc (Gar.)*	Z,ZK	4	4	L	PS
12FOPT1	**Optical Physics 1** ***Pavel Kwiecien***	Z,ZK	3	3+0	Z	PS
12KVEN	**Quantum Electronics** *Ivan Richter, Miroslav Dvořák* ***Miroslav Dvořák*** *Ivan Richter (Gar.)*	Z,ZK	5	3+1	Z	PS
12NOP	**Nonlinear Optics** *Ivan Richter* ***Ivan Richter*** *Ivan Richter (Gar.)*	Z,ZK	4	3+1	L	PS
12OREZ	**Open Resonators** *Václav Kubeček* ***Václav Kubeček*** *Václav Kubeček (Gar.)*	Z,ZK	4	2P+1C	Z	PS
12PDBL	**Solid-state, Diode and Dye Lasers** *Václav Kubeček, Helena Jelínková* ***Václav Kubeček*** *Helena Jelínková (Gar.)*	Z,ZK	2	2+0	L	PS
12PF1	**Computational Physics 1** *Ondřej Klimo* ***Ondřej Klimo*** *Ondřej Klimo (Gar.)*	ZK	2	2+0	Z	PS
12POEX	**Computer Control of Experiments** *Miroslav Čech* ***Miroslav Čech*** *Miroslav Čech (Gar.)*	Z	2	2+0	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

Characteristics of the courses of this group of Study Plan: Code=NMSPFELFT1 Name=MDP P_FEN LFT 1st year

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.			
12FLA	Laser Physics	Z,ZK	4
Relations of behaviour both for laser active media and for various laser types from the general principle of quantum statistical physic will be derived.			

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.			
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.			
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.			
12OREZ	Open Resonators	Z,ZK	4
Electromagnetic field-geometrical optics. Open resonators and transfer matrices.Wave optics. Huygens principle and Kirchhoff integral.Gaussian beams in one dimensional optic systems. Intensity moments for description of beam propagation. Quality of general beams . Additional beam characteristics. Diffraction theory of open resonators. Fabry-Perot interferometer. Optical dielectric layers. Passive open resonators. Stable resonators without apertures. Stable resonators limited by apertures. Resonator detuning sensitivity. Resonators on the stability limits. Unstable resonators.Unstable resonators with with variable reflectivity mirrors. Resonators containing lenses and polarizing elements.Open resonators with active medium with gain. Influence of the gain on mode structure and losses in stable and unstable resonators.			
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.			
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.			
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.			
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.			

Code of the group: NMSPFELFT2
Name of the group: MDP P_FEN LFT 2nd year
Requirement credits in the group:
Requirement courses in the group: In this group you have to complete at least 8 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
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
12UKP	**Ultra-short Pulse Generation** *Václav Kubeček* ***Václav Kubeček*** *Václav Kubeček (Gar.)*	ZK	2	2+0	Z	PS
12RGL	**Gas and X-ray Lasers** *Alexandr Jančárek* ***Alexandr Jančárek*** *Alexandr Jančárek (Gar.)*	KZ	2	2+0	L	PS
12PPLT	**Advanced Laser Technique Laboratory** ***Michal Němec*** *Václav Kubeček (Gar.)*	KZ	6	0+4	Z	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=NMSPFELFT2 Name=MDP P_FEN LFT 2nd year

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.			
12UKP	Ultra-short Pulse Generation	ZK	2
What we mean by ultrashort light pulses (USP) . History of USP generation. Characteristics of USP and their description.Methods of USP generation. Principle of mode-locking in lasers. Methods of mode-locking.Influence of dispersion on propagation and USP generation.Methods of dispersion compensation and its use.Spatio-temporal optics of USP.Methods of measurement USP characteristics. Autocorrelation methods. Spectral phase interferometry and frequency resolved optical gating - SPIDER and FROG. Methods of shaping of USP.Amplification of USP, temporal stretching and compression - chirped pulses amplification CPA.Selected application of USP.			
12RGL	Gas and X-ray Lasers	KZ	2
Gas resp. X-ray lasers currently has the highest average power resp. the shortest wavelength.			
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			
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: NMSPFELFTV
Name of the group: MDP P_FEN LFT 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
12ELA	**Electronics for Lasers** *Jaroslav Pavel* ***Jaroslav Pavel*** *Miroslav Čech (Gar.)*	ZK	2	2+0	Z	v
12EL3	**Electronics 3** *Jaroslav Pavel* ***Jaroslav Pavel*** *Jaroslav Pavel (Gar.)*	ZK	2	2+0	Z	v
12FDD	**Physics of Detection and Detectors of Optical Radiation** *Ladislav Pína* ***Ladislav Pína*** *Ladislav Pína (Gar.)*	ZK	2	2+0	Z	v
12GOP	**Geometrical Optics** *Miroslav Dvořák* ***Miroslav Dvořák*** *Miroslav Dvořák (Gar.)*	KZ	2	2P+0C	L	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
12LPST	**Laser, Plasma and Beam Technologies** *Helena Jelínková, Alexandr Jančárek, Michal Němec* ***Michal Němec*** *Michal Němec (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
12OSP	**Optical Spectroscopy** *Martin Michl* ***Martin Michl*** *Martin Michl (Gar.)*	KZ	2	2+0	L	v
12OZS	**Fourier Optics and Optical Signal Processing** *Ivan Richter, Pavel Kwiecien* ***Ivan Richter*** *Ivan Richter (Gar.)*	Z,ZK	3	3+0	Z	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
12PPRO	**Advanced Optical Laboratory** *Alexandr Jančárek* ***Alexandr Jančárek*** *Alexandr Jančárek (Gar.)*	KZ	6	0+4	Z	v
12PLM	**Laser in Medicine Practice** *Helena Jelínková* ***Michal Němec*** *Helena Jelínková (Gar.)*	KZ	6	4	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
12SOP	**Statistical Optics** *Ivan Richter* ***Ivan Richter*** *Ivan Richter (Gar.)*	Z,ZK	2	2+0	L	v
12VLS	**Fiber Lasers and Amplifiers** *Václav Kubeček, Pavel Peterka* ***Pavel Peterka*** *Václav Kubeček (Gar.)*	ZK	2	2P+0C	Z	v

Characteristics of the courses of this group of Study Plan: Code=NMSPFELFTV Name=MDP P_FEN LFT Optional courses

12ELA	Electronics for Lasers	ZK	2
The goals of course is to collect advanced knowledge in laser technics.			
12EL3	Electronics 3	ZK	2
The goals of course is to collect advanced knowledge in optoelectronics and pulse technique.			
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.			
12GOP	Geometrical Optics	KZ	2
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.			
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.			
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.			
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.			
12OSP	Optical Spectroscopy	KZ	2
Basics of spectroscopic behaviour of atoms and molecules. Elementary experimental techniques for optical spectroscopy.			
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.			
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.			
12PPRO	Advanced Optical Laboratory	KZ	6
The practical laboratories give advanced practical skills by experimental work in optics. Laboratory records must be elaborated.			
12PLM	Laser in Medicine Practice	KZ	6
Practical verification of the interaction of laser radiation with tissue substitute			
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.			
01SUP	Start-up Project	KZ	2

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.

12VLS	Fiber Lasers and Amplifiers	ZK	2

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.

List of courses of this pass:

Code	Name of the course	Completion	Credits
01SUP	Start-up Project	KZ	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.

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.

12DSFE1	Diploma Seminar 1	Z	2

Thesis Defense - guidelines and recommendations.

12DSFE2	Diploma Seminar 2	Z	2

Thesis Defense - guidelines and recommendations.

12EL3	Electronics 3	ZK	2

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

12ELA	Electronics for Lasers	ZK	2

The goals of course is to collect advanced knowledge in laser technics.

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.

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.

12FLA	Laser Physics	Z,ZK	4

Relations of behaviour both for laser active media and for various laser types from the general principle of quantum statistical physic will be derived.

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.

12GOP	Geometrical Optics	KZ	2

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.

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.

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.

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.

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.

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.

12OREZ	Open Resonators	Z,ZK	4

Electromagnetic field-geometrical optics. Open resonators and transfer matrices.Wave optics. Huygens principle and Kirchhoff integral.Gaussian beams in one dimensional optic systems. Intensity moments for description of beam propagation. Quality of general beams . Additional beam characteristics. Diffraction theory of open resonators. Fabry-Perot interferometer. Optical dielectric layers. Passive open resonators. Stable resonators without apertures. Stable resonators limited by apertures. Resonator detuning sensitivity. Resonators on the stability limits. Unstable resonators.Unstable resonators with with variable reflectivity mirrors. Resonators containing lenses and polarizing elements.Open resonators with active medium with gain. Influence of the gain on mode structure and losses in stable and unstable resonators.

12OSP	Optical Spectroscopy	KZ	2

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

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.

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.

12PLM	Laser in Medicine Practice	KZ	6

Practical verification of the interaction of laser radiation with tissue substitute

12PLS	Advanced Laser Spectroscopy	ZK	2

Spectroscopic application of the unique properties of laser radiation, selected advanced laser spectroscopy techniques

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.		
12RGL	Gas and X-ray Lasers	KZ	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.		
12UKP	Ultra-short Pulse Generation	ZK	2
	What we mean by ultrashort light pulses (USP) . History of USP generation. Characteristics of USP and their description.Methods of USP generation. Principle of mode-locking in lasers. Methods of mode-locking.Influence of dispersion on propagation and USP generation.Methods of dispersion compensation and its use.Spatio-temporal optics of USP.Methods of measurement USP characteristics. Autocorrelation methods. Spectral phase interferometry and frequency resolved optical gating - SPIDER and FROG. Methods of shaping of USP.Amplification of USP, temporal stretching and compression - chirped pulses amplification CPA.Selected application of USP.		
12VLS	Fiber Lasers and Amplifiers	ZK	2
	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.		
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.		

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