UNIVERSITAS CAROLINA PRAGENSIS

FACULTAS MATHEMATICAE PHYSICAEQUE DISCIPLINAE

STUDY PLANS
Faculty of Mathematics and Physics

Doctoral Study

Contents

Introduction

There are three accredited doctoral study programmes at the Faculty of Mathematics and Physics (MFF): Study Programme of Physics, Study Programme of Mathematics, and Study Programme of Computer Sciences.

Doctoral Study conforms to the relevant regulations specified in the Higher Education Act, the Study and Examination Code of Charles University in Prague, and the Rector's and Dean's measure for organization of study at the Faculty of Mathematics and Physics all of which can be found at the university and faculty web pages.

The Doctoral Study Programme is oriented to scientific research and independent creative activity in the area of research or development. There is a long tradition of student involvement in scientific research at MFF. Students have the opportunity to work alongside the outstanding specialists who are part of MFF and who regularly cooperate with specialists abroad. In addition, specialists from the Academy of Sciences of the Czech Republic, as well as other scientific institutes and organizations participate in the postgraduate programmes.

Curricula in the Doctoral Study Programme are periodically evaluated by the Subject-area Council (OR). Each of three doctoral study programmes accredited at MFF is divided into branches, and for each of those branches there is the Council for Doctoral Study Branch (RDSO) which proposes the content of doctoral studies for individual branches, and controls its progress.

In order to be accepted into the Doctoral Study Programme one must have successfully completed a Master Study Programme. According to the Admission Procedure Code of MFF the entrance examination has two parts: an examination in a foreign language, which is English at the faculty, and an oral examination in the chosen branch of studies. The form of the examination in foreign language and conditions of a waiver of the examination for each academic year is set by the Dean with the approval of the Academic Senate of the faculty. The entrance examination in English is usually waived for those applicants who passed the examination in English during their master studies at MFF. The Dean can also waive the examination for students with English language certificates at B2 level (or higher) according to Common European Framework (CEF) (e.g. FCE, CAE, CPE, IELTS, TOEFL, CITY & GUILDS). The content of the entrance examination is set by the OR, whose members are appointed by the Dean. The decision on admission to the programme is done by the Dean on the basis of entrance examination results. The Dean then designates a supervisor, OR, RDSO and a supervising department in which the student will work during his/her studies.

Studies in the Doctoral Study Programme are regularly completed by the State Doctoral Examination and the defence of a Doctoral thesis. For the Doctoral State Examination and for the defence of a Doctoral thesis committees are appointed which have a chairperson and one or more vice-chairpersons. Each of those committees is, as a rule, set for state examinations and defences in several branches of a study programme. Those committees are designated K1 to K10. The defence of doctoral theses is held before a sub-committee appointed by the Dean of the Faculty. The sub-committee must

be appointed in advance by the Research Board of the faculty in exceptional cases, such as - if there is the need of specialists who were not appointed into any of committees K1-K10 (this especially concerns those cases when doctoral studies have taken place abroad and it would be suitable to have also foreign members in the committee).

The English language examination is compulsory in the study plan of each student of doctoral studies. Students must pass the English examination in order to be admitted to the defence of a doctoral thesis. The maximum period of studies in the Doctoral Study Programme is eight years; in full–time study, however, a maximum of four years of study are possible. Study can be interrupted on the basis of the student's written application for a minimum of one semester and a maximum of five years.

I would like to thank all the employees of the faculty who participate in the teaching of doctoral students. The support of those supervisors who assist a student during his/her work on the doctoral thesis is an inestimable gift, an experience that can only serve the student well in his/her further studies or research. I would also like to thank our partner institutes of Academy of Sciences of the Czech Republic for their help with teaching and training of doctoral students.

To all the doctoral students I wish much success in their studies.

Prof. RNDr. Lubomír Skála, DrSc.
Vice-Dean for Administrative and Academic Affairs

Study Programme PHYSICS

Council for Doctoral Studies in Physics

List of members of the Council can be found at the address http://www.mff.cuni.cz/to.en/studium/phd/obory/ors.htm#nor4-f .

4F1 Theoretical Physics, Astronomy and Astrophysics

Council of Doctoral Studies in Branch 4F1

List of members of the Council can be found at the address http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-f1.htm .

Committee for the State Doctoral Examinations K6

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk06.htm .

Cooperating Institutes

- Astronomical Institute of the ASCR, v.v.i.
  Fričova 298, 251 65 Ondřejov
  http://www.asu.cas.cz/en/

- Institute of Physics of the ASCR, v.v.i.
  Na Slovance 2, 182 21 Praha 8
  http://www.fzu.cz/

- Institute of Mathematics of the ASCR, v.v.i.
  Žitná 25, 115 67 Praha 1
  http://www.math.cas.cz

- J. Heyrovsky Institute of Physical Chemistry of the ASCR, v.v.i.
  Dolejškova 2155/3, 182 23 Praha 8
  http://www.jh-inst.cas.cz/

- Nuclear Physics Institute of the ASCR, v.v.i.
  Husinec – Řež č. p. 130, PSČ 250 68
  http://www.ujf.cas.cz/

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=F1 .

Courses Given

Ph.D. students are required to take mandatory M.Sc. courses at MFF UK in their field of study unless they have already completed equivalent courses during their previous M.Sc. program. In addition, students choose from the pool of optional M.Sc. courses especially in the fields of Astronomy and Astrophysics, Theoretical Physics, Solid State Physics, Nuclear and Subnuclear Physics, and Mathematical and Computer Modelling in Physics and Engineering. The following advanced courses are meant for Ph.D. students in particular:

Code	Subject	Credits	Winter	Summer
NMAF006	**Selected Topics on Mathematics for Physicists**	3	—	2/0 Ex
NTMF063	**Selected Topics on General Relativity**	3	2/0 Ex	—
NJSF082	**Selected Topics on Quantum Field Theory I**	5	3/0 Ex	—
NJSF083	**Selected Topics on Quantum Field Theory II**	5	—	3/0 Ex
NJSF072	**Electroweak Interactions II**	5	2/1 Ex	—
NTMF065	**Introduction to quantum field theory on curved background**	5	2/1 Ex	—
NJSF044	**Mathematical Methods of Quantum Theory II**	3	—	2/0 Ex
NTMF070	**Radiative Processes in Astrophysics**	3	—	2/0 Ex
NTMF035	**Renormalisation Theory of Phase Transitions**	3	—	2/0 Ex
NTMF047	**Probability and Mathematics of Phase Transitions II**	3	2/0 Ex	—
NTMF032	**Statistical Physics of Quantum Many-particle Systems II**	3	—	2/0 Ex
NJSF084	**Chiral Symmetry or Strong Interactions**	3	2/0 Ex	—
NJSF031	**Classical and Quantum Chaos**	3	—	2/0 Ex
NDIR058	**Hyperbolic Systems and Conservation Laws**	3	—	2/0 Ex
NGEM030	**Gauge Fields and Noncommutative Geometry**	3	2/0 Ex	—
NAST021	**Selected Chapters on Astrophysics**	3	2/0 Ex	—

NTMF008	**Seminar of the Institute of Theoretical Physics**	3	0/2 C	0/2 C
NTMF006	**Seminar on Relativity**	3	0/2 C	0/2 C
NTMF045	**Seminar on Atomic Physics**	3	0/2 C	0/2 C
NAST010	**Seminar of the Astronomical Institute, Charles University**	3	0/2 C	0/2 C

List of Requirements for the State Doctoral Examination

A Ph.D. student focusing on Theoretical Physics selects two of the topics 1-7 (one of them directly related to the thesis) and, in addition, one of the following topics from mathematics:

- Functional analysis
- Partial differential equations
- Theory of distributions
- Differential geometry
- Lie groups and algebras
- Numerical methods.

A Ph.D. student focusing primarily on Astronomy or Astrophysics are required to choose topic 10, one of topics 8 or 9, and one of the physics topics 1-7.

1. Mathematical Physics

Functional analysis in quantum theory. Equations of mathematical physics. Relativistic invariance in quantum field theory. Theory of scattering. Dynamical systems. Mathematical statistical physics. Theory of phase transitions and critical phenomena. Geometrical methods in physics. Spinors. Symmetry in physics and group theory. Supersymmetry.

2. Relativistic physics and cosmology

Basic principles of the general theory of relativity (the equivalence principle, general covariance, and minimal coupling). Equations of geodesic and geodesic deviation. Einstein field equations. Alternative theories of gravity. Experimental verification of relativistic theories of gravity. Linearized theory and approximation methods. Theory of gravitational waves: asymptotic structure of spacetime and exact radiative solutions; sources and detection of gravitational waves. Relativistic theory of stellar structure (white dwarfs, neutron stars, pulsars). Gravitational collapse and physics of black holes — general physical principles, the role of black holes in astrophysics. Initial value problem and Hamiltonian formalism in general relativity. Standard cosmological models and basic cosmological tests. Physics of the early universe. Theory of linear perturbations of cosmological models.

3. Quantum field theory and elementary particles physics

Canonical formalism in field theory. Feynman path integral. Feynman rules and perturbation theory. Gauge invariance. Quantum electrodynamics. Renormalization in field theory. Relativistic invariance. The CTP theorem, spin, and statistics. Non–Abelian gauge theories. Renormalization group method. Asymptotic freedom. Spontaneous symmetry breaking. The standard model. Unified interaction models. Supersymmetric field theory and string models.

4. Solid state theory

Gas of interacting electrons in metals and semiconductors: screened electron–electron and electron–phonon interactions, tight binding models. Fermi liquid theory. Green's functions and their analytic properties, Kramers–Kronig relations and the dissipation–fluctuation theorem. Linear response theory, the Kubo formulae. Superconductivity and superfluidity. The BSC superconductivity theory.

5. Non–relativistic quantum theory

Hermitian operators and their spectrum, the Schrödinger equation, semiclassical approximation, superposition principle, uncertainty relations, stationary states, motion in a spherically symmetric field, perturbation theory, spin, spinors, identical particles, atomic energy levels, fine structure of atomic levels, atoms in electric and magnetic fields, flux density, elastic collisions of particles, the scattering amplitude, the optical theorem, the Born series, S–matrix and its analytic structure, quasistationary states, the Jost function and Levinson's theorem.

6. Hydrodynamics, magnetohydrodynamics, and plasma theory

Boltzmann and Vlasov kinetic equations, system of fluid and magnetohydrodynamic equations, drift approximation for particles moving in electromagnetic fields, plasma equilibrium and stability, dispersion equation for waves propagating in cold plasma, kinetic theory of waves propagating in hot plasma, the Landau damping and wave instability, non–linear wave–plasma interaction; captured particles and quasilinear approximation of ponderomotive forces in plasma, weak and strong plasma turbulence, mutual wave interactions, deterministic chaos — an introduction to the theory and application in models of anomalous phenomena in plasma; low–temperature, thermonuclear, and astrophysical plasma.

7. Statistical physics and thermodynamics

Interacting statistical systems: classical and quantum liquids and gases, distribution functions and perturbation methods — virial and cluster expansions, perturbation methods in quantum statistical mechanics. Phase transition models and theory: Ising and Heisenberg models of magnetism, statistical mean field theory, the scaling hypothesis and renormalization group theory.

8. Experimental methods in astronomy

Fundamentals of optics. Telescopes, spectrographs, photometers, interferometers, detectors (according to the individual electromagnetic radiation sectors). Primary data reduction: signal and image processing, time series analysis including statistical methods. Special data analysis (solving the radial velocity curves and light curves, Doppler imaging of surface structures, etc.).

9. Classical astrophysics

Star structure and evolution, star formation, binary star evolution, final star evolution phases. Pulsations and oscillations of stars, helioseismology. Solar physics. Stellar atmospheres: radiation field, absorption, emission, generating function, statistical equilibrium equations, the concept of LTE and non–LTE, stellar atmosphere models (basic equations), spectral line formation, the Einstein coefficients, forbidden lines. Atoms and molecules in space, electronic, vibrational, and rotational spectra. Plasma and magnetic fields, waves in plasma, magnetohydrodynamic equations. Thermal and non–thermal plasma radiation. Equations of state, degeneracy. Nuclear reactions in stars, nucleogenesis. Accretion phenomena, accretion disk physics. Shock waves physics.

10. Classical astronomy, mechanics and dynamics of cosmic bodies and systems.

Celestial mechanics: two– and three–body problems, potential theory. Spherical astronomy: coordinate systems and effects acting on them, time and its measurement. The HR diagram, radiative transfer equation, black body radiation, basic ideas of star evolution, methods of determining the distance to cosmic bodies, basic morphological information (the Sun, solar system including small bodies, stars, types of variable stars, binaries), orbital elements of visual, eclipsing, and spectroscopic binaries, star clusters, dynamics. Galaxies, star clusters, components of galaxies, stellar populations, determining the age. Hubble's law, types of galaxies, high–energy sources, interstellar gas and dust, star formation, formation and evolution of galaxies.

Recommended Literature

Bičák, J., Rudenko, V. N.: **Teorie relativity a gravitační záření.** *Univerzita Karlova, Praha, 1986.*

Binney, J., Merrifield, M.: **Galactic Astronomy.** *Princeton Series in Astrophysics, 1998.*

Binney, J., Tremain, S.: **Galactic Dynamics.** *Princeton Series in Astrophysics, 1988.*

Bowers, R., Deeming, T.: **Astrophysics I–III.** *Jones Bartlet, Boston, 1984.*

De Loore, C. W. H., Doom, C.: **Structure and Evolution of Single and Binary Stars.** *Kluwer, Dordrecht, 1992.*

Formánek, J.: **Úvod do kvantové teorie.** *Academia, Praha, 1983.*

Frank, J., King, A. R., Raine, D. J.: **Accretion Power in Astrophysics.** *2nd ed. Cambridge University Press, Cambridge, 1992.*

Gilmore, G., King, I., Kruit, van der, P. C.: **The Milky Way as a Galaxy.** *University Science Books, Lecture Notes, 1989.*

Hansen, C. J., Kawaler, S. D.: **Stellar Interiors: Physical Principles, Structure and Evolution.** *Springer–Verlag, New York, 1994.*

Itzykson, C., Zuber, J.: **Quantum Field Theory.** *McGraw–Hill, New York, 1982.*

Kippenhahn, R., Weigert, A.: **Stellar Structure and Evolution.** *Springer–Verlag, Berlin, 1991.*

Mahan, G. D.: **Many–particle Physics.** *Plenum Press, New York, 1990.*

Martynov, D. J.: **Kurs Prakticeskoj astrofyziky.** *Nauka, Moskva.*

Mihalas, D.: **Stellar Atmospheres.** *W. H. Freeman & Co., San Francisco, 1978.*

Misner, C., Thorne, K. S., Wheeler, J.: **Gravitation.** *W. H. Freeman & Co., San Francisco, 1973.*

Plischke, M., Bergsen, B.: **Equilibrium Statistical Physics.** *2nd ed. World Scientific, Singapore, 1994.*

Reed, M., Simon, B.: **Methods of Modern Mathematical Physics.** *Academic Press, New York, 1979.*

Rickayzen, G.: **Green's Function and Condensed Matter.** *Academic Press, London, 1984.*

Rose, W. K.: **Advanced Stellar Astrophysics.** *Cambridge University Press, Cambridge, 1998.*

Schatzman, E. L., Praderie, F.: **The Stars.** *Astronomy and Astrophysics Library, Springer–Verlag, Berlin, 1993.*

Schwarzschild, M.: **Structure and Evolution of the Stars.** *Princeton University Press, Cambridge, 1958.*
Tanenbaum, B. S.: **Plasma Physics.** *McGraw–Hill, New York, 1967.*
Wald, R. M.: **General Relativity.** *University of Chicago Press, 1984.*
Walker, G. A. H.: **Astronomical Observations.** *Cambridge University Press, Cambridge, 1999.*
Weinberg, S.: **Quantum Theory of Fields I–III.** *Cambridge University Press, Cambridge, 1995–2000.*

4F2 Physics of Plasmas and Ionized Media

Council of Doctoral Studies in Branch 4F2

List of members of the Council can be found at the address `http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-f2.htm` .

Committee for the State Doctoral Examinations K7

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address `http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk07.htm` .

Cooperating Institutes

- Astronomical Institute of the ASCR, v.v.i.
  Fričova 298, 251 65 Ondřejov
  `http://www.asu.cas.cz/en/`

- Institute of Physics of the ASCR, v.v.i.
  Na Slovance 2, 182 21 Praha 8
  `http://www.fzu.cz/`

- J. Heyrovsky Institute of Physical Chemistry of the ASCR, v.v.i.
  Dolejškova 2155/3, 182 23 Praha 8
  `http://www.jh-inst.cas.cz/`

- Institute of Atmospheric Physics of the ASCR, v.v.i.
  Boční II/1401, 141 31 Praha 4
  `http://www.ufa.cas.cz/`

- Institute of Plasma Physics of the ASCR, v.v.i.
  Za Slovankou 1782/3, 182 00 Praha 8
  `http://www.ipp.cas.cz/`

Homepage of the Council of Doctoral Studies in Branch 4F2

`http://physics.mff.cuni.cz/kfpp/4F2/`

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in `http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=F2` .

Courses Given

Code	Subject	Credits	Winter	Summer
NEVF501	**Low Temperature Plasma and Its Applications**	3	2/0 Ex	—
NEVF502	**Elementary Processes in Plasma**	3	2/0 Ex	—
NEVF503	**Measurement Methods, Modelling and Processing of Experimental Data**	3	2/0 Ex	—
NEVF504	**Physical Processes in Solar System**	3	2/0 Ex	—
NEVF505	**Plasma Diagnostics**	3	2/0 Ex	—
NEVF506	**Magnetohydrodynamics, Hot and Laser Plasma**	3	2/0 Ex	—
NEVF507	**Seminar on computation and measuring techniques**	3	—	0/2 C
NEVF508	**Seminar on modern trends in physics**	3	—	0/2 C
NEVF518	**Introduction to Plasma Physics**	3	2/0 Ex	—
NTMF020	**Plasma Theory**	3	2/0 Ex	—
NEVF155	**Computer Networks Technology**	3	2/0 Ex	—
NEVF145	**Cosmic Plasma**	3	—	2/0 Ex
NEVF125	**Mass Spectrometry**	3	2/0 Ex	—
NEVF135	**Programming in IDL — Data Processing and Visualisation**	3	1/1 MC	—

List of Requirements for the State Doctoral Examination

I — Fundamentals

The character of the exam is synthetic, particular questions cover the following topics: Wave function, operators of physical quantities, uncertainty relations, Schroedinger equation and its application on simple problems. Approximate methods of quantum theory. Electron in periodic fields, band structure. Chemical bond. Stimulated emission, lasers, and masers. Thermodynamic potentials, equilibrium conditions. Phase transitions. Thermodynamics of irreversible processes. Theory of fluctuations. Statistical distributions, the relation of statistical to thermodynamic quantities. Entropy in statistical thermodynamics. Imperfect gas. Random processes, fluctuations, noise. Correlation, characteristic function of distribution. Properties and uncertainties of estimations.

II — Advanced topics

This part consists of two subparts — Mandatory subpart (II.1) and optional subpart (II.2) that is further divided into six subjects in accord with the lectures organized by RDSO.

II.1 — Mandatory part

Plasma definition and plasma modes. Kinetic and gasdynamic approach to the plasma description. Elementary processes, collisions, cross–section of collisions, radiation. Transport in plasmas, conductivity, diffusion and ambipolar diffusion. Discharges in gases. Chemical reactions in plasmas. Waves in plasmas. Basic diagnostic methods.

II.2 — Optional part

II.2.1 — Low–temperature plasma and its applications.

Kinetic description of the low–temperature plasma (solving of the kinetic equation, elastic and non–elastic collisions, electron–electron collisions, influence of the magnetic field on the distribution function, kinetic description of multicomponent plasma systems), plasma discharges and their applications in technology (plasma etching, polymerization, production of thin films etc.).

II.2.2 — Elementary processes in plasmas

Introduction to the physical chemistry (structure of molecules, excited and metastable states, ions, etc.), collisions (ionization, excitation, deexcitation, chemical reactions, recombination, etc.), thermodynamics and statistical thermodynamics from a point of view of physical chemistry, kinetics and dynamics of ion — molecule reactions, introduction to plasma chemistry and laser chemistry.

II.2.3 — Measuring methods and data processing, computer modeling

Analog and digital signals, analog and digital noise (continuous and discrete random processes), digital filtering (types of filters and their design, methodology, methods of smoothing, etc.), valuation of model parameters, optimal detection (statistical properties, methods) computer modeling, classification of functions.

II.2.4 — Physical processes in the Solar system

Basic principles of magnetohydrodynamics (frozen–in magnetic field, diffusion of the magnetic field, magnetic reconnection), analytic description of charged particle motion in electromagnetic field (adiabatic approximation), Solar system, description of Sun–Earth connections, interplanetary magnetic field, solar wind, bow shock, magnetopause, magnetosphere, transport of particles in the magnetosphere, corresponding measuring methods.

II.2.5 — Plasma diagnostics

Survey of diagnostics methods, optical diagnostic, microwave techniques, interferometry, probe diagnostics, corpuscular diagnostics.

II.2.6 — Magnetohydrodynamics (MHD), hot and laser plasmas

MHD approach, frozen–in magnetic field and magnetic field diffusion, magnetic energy and magnetic tension, corresponding examples. Principles of Tokamak, stability conditions in Tokamaks, interaction of high–energy density laser beams with plasma, characteristics and problems of the plasma heating in Tokamaks, description of high–energy density systems, X–ray lasers, inertial fusion.

Recommended Literature

Akasofu, S. I., Kamide, Y. (eds.): **The Solar Wind and the Earth.** *Terra Scient. Publ. Co., Tokyo, 1987.*

Atkins, P. W.: **Physical Chemistry.** *Oxford University Press, Oxford, 1988.*

Baumjohann, W., Treumann, R. A.: **Basic Space Plasma Physics.** *Imperial College Press, London, 1999.*

Biskamp, D.: **Magnetohydrodynamic Turbulence.** *Cambridge University Press, Cambridge, 2003.*

Bittencourt, J. A.: **Fundamentals of Plasma Physics.** *Springer, New York, 2004.*

Cravens, T. E.: **Physics of Solar System Plasma.** *Atmospheric and Space Science Series, Cambridge University Press, Cambridge, 1998.*

Encrenaz, T. et al.: **The Solar System.** *Springer, Berlin–Heidelberg–New York, 2004.*

Fanning, D. W.: **IDL Programming Techniques.** *2nd ed., 2000.*

Ghosh, P. K.: **Ion Traps.** *Clarendon Press, Oxford, 1995.*

Glosík, J. (ed.): **Učební texty k přednášce Elementární procesy.** *MFF UK, Praha, 1992.*

Goldston, R. J., Rutherford, P. H.: **Introduction to Pasma Physics.** *Institute of Physics Publishing, Bristol–Philadelphia, 1995.*

Gombosi, T. I.: **Physics of the Space Environment.** *Atmospheric and Space Science Series, Cambridge University Press, Cambridge, 1998.*

Gross, R.: **An Introduction to Alfven Wales.** *The Adam Hilger Series on Plasma Physics, Bristol, 1988.*

Grün, E., Gustafson, B. A. S., Dermott, S., Fechtig, H.: **Interplanetary Dust.** *Astronomy and Astrophysics Library, Springer, Berlin, 2001.*

Hargreaves, J. K.: **The Solar–terrestrial Environment.** *Cambridge Atmospheric and Space Science Series, Cambridge University Press, Cambridge, 1992.*

Horányi, M., Robertson, S., Walch, B. (eds.): **Physics of Dusty Plasma.** *AIP Conference Proceedings 446, Boulder, Colorado, 1998.*

Chen, F. F.: **Plasma Dlagnostic Techniques.** *Academic Press, New York, 1965.*

Chen, F. F.: **Úvod do fyziky plazmatu.** *Academia, Praha, 1984.*

Chung, P. M., Talbot, L., Touryan, K. J.: **Electrical Probes in Stationary and Flowing Plasmas.** *Springer, Boston, 1975 (rusky: Mir, Moskva, 1978).*

Kallenrode, M. B.: **Space Physics: An Introduction to Plasma and Particles in the Heliosphere and Magnetospheres.** *Springer–Verlag, Berlin–Heidelberg, 2001.*

Kivelson, M. G., Russell, C. T.: **Introduction to Space Physics.** *Cambridge University Press, Cambridge, 1995.*

Kracík, J., Šesták, B., Aubrechl, L.: **Základy klasické a kvantové fyziky plazmatu.** *Academia, Praha, 1977.*

Kracík, J., Tobiáš, J.: **Fyzika plazmatu.** *Academia, Praha, 1966.*

Lautrup, B.: **Physics of Continuous Matter: Exotic and Everyday Phenomena in the Macroscopic World.** *Institute of Physics Publishing, Bristol and Philadelphia, 2005.*

Ng, C.-Y., Baer, T., Powis, I.: **Unimolecular and Bimolecular Ion-molecule Reactions.** *Wiley-Interscience, New York, 1994.*
Peratt, A. L.: **Physics of the Plasma Universe.** *Springer–Verlag, New York–Heidelberg, 1991.*
Priest, E. R. (ed.): **Solar System Magnetic Fields.** *Terra Scient. Publ. Co., Tokyo, 1985.*
Schott, L.: **Plasma Diagnostics.** *North–Holland Publishing Comp., Amsterdam, 1968.*
Swamy, K.: **Dust in the Universe: Similarities and Differences.** *World Scientific Series in Astronomy and Astrophysics, World Scientific Publishing, Singapure, 2005.*
Swift, J. D., Schwar, M. I. R.: **Electrical Probes for Plasma Diagnostics.** *Illife Books, New York, 1969.*
Thompson, M. J.: **An Introduction to Astrophysical Fluid Dynamics.** *Imperial College Press, London, 2006.*
Treumann, R. A., Baumjohann, W.: **Advanced Space Plasma Physics.** *Imperial College Press, London, 2001.*
Walker, A. D. M.: **Plasma Wales in the Magnetosphere.** *Springer–Verlag, Berlin–Heidelberg, 1993.*

4F3 Physics of Condensed Matter and Materials Research

Council of Doctoral Studies in Branch 4F3

List of members of the Council can be found at the address `http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-f3.htm` .

Committee for the State Doctoral Examinations K7

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address `http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk07.htm` .

Cooperating Institutes

- Institute of Physics of the ASCR, v.v.i.
  Na Slovance 2, 182 21 Praha 8
  `http://www.fzu.cz/`

- Institute of Photonics and Electronics of the ASCR, v.v.i.
  Chaberská 57, 182 51 Praha 8
  `http://www.ufe.cz/setlang.php?lang=en&ref=/`

- Nuclear Physics Institute of the ASCR, v.v.i.
  Husinec – Řež č. p. 130, PSČ 250 68
  `http://www.ujf.cas.cz/`

- Institute of Macromolecular Chemistry of the ASCR, v.v.i.
  Heyrovského nám. 2, 162 06 Praha 6
  `http://www.imc.cas.cz/en/index.html`

- Institute of Thermomechanics of the ASCR, v.v.i.
  Dolejškova 1402/5, 182 00 Praha 8
  `http://www.it.cas.cz/?q=en/node`

Homepage of the Council of Doctoral Studies in Branch 4F3

`http://krystal.karlov.mff.cuni.cz/f3`

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in `http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=F3` .

Courses Given

Obligatory subjects

Code	Subject	Credits	Winter	Summer
NBCM083	**Selected Topics on Quantum Theory**	3	2/1 Ex	—
NFPL088	**Methods of Statistical Physics**	3	2/1 C+Ex	—
NFPL085	**Electronic Theory of Solids**	3	—	2/0 Ex
NFPL087	**Seminar on Solving Physical Problems**	3	—	0/2 C
NFPL086	**Experimental Methods in Condensed Matter Physics**	6	2/2 Ex	—

Subjects of obligatory choice

Code	Subject	Credits	Winter	Summer
NFPL082	**Magnetism and Electronic Structure of Metallic Systems**	3	2/0 Ex	—
NFPL120	**Modern Problems in Physics of Materials**	3	2/0 Ex	2/0 Ex
NFPL063	**Advanced Quantum Theory with Applications in Condensed Matter Physics**	4	—	2/1 Ex
NFPL093	**Selected Topics on Magnetic Resonance Theory and Methodology**	3	2/0 Ex	—

NFPL128	**Selected Topics on Positron Annihilation Spectroscopy**	3	—	1/1 C+Ex
NFPL178	**Superfluidity and Bose-Einstein Condensation**	5	—	2/1 C+Ex
NFPL195	**Selected Topics on Low Temperature Physics**	3	—	2/0 Ex
NFPL066	**Advanced Methods and Contemporary Topics on Structure Analysis**	3	2/0 C	—

Optional subjects

Code	Subject	Credits	Winter	Summer
NFPL073	**Neutron Scattering Applications in Materials Research**	3	—	2/0 Ex
NFPL154	**Neutron and Synchrotron Radiation in Magnetic Materials**	6	—	2/2 C+Ex
NFPL072	**Systems with Correlated f-electrons**	3	2/0 Ex	—
NFPL076	**Methods of Studying Interactions in Magnetic Systems**	3	—	2/0 Ex
NFPL013	**X-ray Scattering on Thin Films**	3	2/0 Ex	—
NFPL158	**Magnetic Structures**	3	2/0 Ex	—
NFPL159	**Modern Materials with Application Potential**	3	—	2/0 Ex
NFPL174	**Introduction to Fluid Dynamics and Turbulence**	3	2/0 Ex	—
NFPL197	**Fundamentals of Continuum Mechanics and Dislocation Theory**	3	—	2/0 Ex
NFPL198	**Microstructure and Mechanical Properties of Materials**	3	—	2/0 Ex

List of Requirements for the State Doctoral Examination

General questions are posed whose aim is to examine, whether the student is familiar with the given range of issues

I. Broader scientific context

I.1. Quantum description of atoms and condensed matter
I.2. Many particle systems
I.3. Electron states in atoms and condensed matter
I.4. Interaction of quantum system with electromagnetic field
I.5. Classical and quantum statistical ensembles
I.6. Thermodynamic quantities

I.7. Ideal, classical and quantum gas
I.8. Fermions and bosons at low temperatures
I.9. Phase transitions
I.10. Non–equilibrium processes in condensed matter

II. Advanced topics in the field of the study

II.1. Structure and microstructure of condensed matter systems
II.2. Phonons
II.3. Electronic and atomic structure and interactions in condensed matter systems
II.4. Metals and semiconductors
II.5. Dielectrics and ferroelectrics
II.6. Magnetism
II.7. Physics of condensed matter systems at low temperature, supraconductivity and suprafluidity

III. Specialization

The questions from the subject of specialization will be proposed by the supervisor. The committee chooses one of at least three proposed questions.

Recommended Literature

Ashcroft, N. W., Mermin, N. D.: **Solid State Physics.** *Sounders Coll. Publishing, Philadelphia, 1988.*

Barbara, B., Gignoux, D., Vettier, C.: **Lectures on Modern Magnetism.** *Springer–Verlag, Berlin, 1988.*

Buschow, K. H. J., Cahn, R. W., Flemings, M. C., Ilschner, B., Kramer, E. J., Mahajan, S.: **The Encyclopedia of Materials: Science and Technology.** *Pergamon Press, Oxford, 2001.*

Cahn, E. W., Lifshin, E.: **Concise Encyclopedia of Materials Characterization.** *Pergamon Press, Oxford, 1993.*

Ibach, H., Luth, H.: **Solid–State Physics.** *Springer–Verlag, Berlin, 1991.*

Kittel, C.: **Úvod do fyziky pevných látek.** *Academia, Praha, 1985.*

Kratochvíl, P., Lukáč, P., Sprušil, B.: **Úvod do fyziky kovů I.** *SNTL, Praha, 1984.*

Kužel, R., Saxlová, M., Šternberk, J.: **Úvod do fyziky kovů II.** *SNTL, Praha, 1985.*

Šafrata, R. a kol.: **Fyzika nízkých teplot.** *Matfyzpress, Praha, 1998.*

Valvoda, V., Polcarová, M., Lukáč, P.: **Základy strukturní analýzy.** *Karolinum, Praha, 1992.*

Ziman, J. M.: **Principles of the Theory of Solids.** *Cambridge University Press, Cambridge, 1965.*

4F4 Biophysics, Chemical and Macromolecular Physics

Council of Doctoral Studies in Branch 4F4

List of members of the Council can be found at the address http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-f4.htm .

Committee for the State Doctoral Examinations K8

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk08.htm .

Cooperating Institutes

- Institute of Physics of the ASCR, v.v.i.
  Na Slovance 2, 182 21 Praha 8
  http://www.fzu.cz/

- Institute of Physiology of the ASCR, v.v.i.
  Vídeňská 1083, 142 20 Praha 4
  http://www.biomed.cas.cz/fgu/en/index.php

- Institute of Microbiology of the ASCR, v.v.i.
  Vídeňská 1083, 142 20 Praha 4 — Krč
  http://www.biomed.cas.cz/mbu/cz/

- Institute of Photonics and Electronics of the ASCR, v.v.i.
  Chaberská 57, 182 51 Praha 8
  http://www.ufe.cz/setlang.php?lang=en&ref=/

- J. Heyrovsky Institute of Physical Chemistry of the ASCR, v.v.i.
  Dolejškova 2155/3, 182 23 Praha 8
  http://www.jh-inst.cas.cz/

- Institute of Macromolecular Chemistry of the ASCR, v.v.i.
  Heyrovského nám. 2, 162 06 Praha 6
  http://www.imc.cas.cz/en/index.html

- Institute of Organic Chemistry and Biochemistry of the ASCR, v.v.i.
  Flemingovo nám. 2, 166 10 Praha 6
  http://www.uochb.cas.cz/

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=F4 .

Compact list of the themes is available at the homepage of the branch council.

Homepage of the Council of Doctoral Studies in Branch 4F4

`http://biomolecules.mff.cuni.cz/4F4`

Courses Given

Code	Subject	Credits	Winter	Summer
NBCM198	**Electrical Properties of Molecular Materials and Systems**	3	—	2/0 Ex
NBCM091	**Seminar on Polymer Physics**	3	0/2 C	0/2 C
NBCM058	**Relaxation Behaviour of Polymers**	3	—	2/0 Ex
NBCM076	**Theory of Polymer Structures**	3	2/0 Ex	—
NBCM097	**Surface-Enhanced Raman Spectroscopy**	3	—	2/0 Ex
NBCM301	**Seminar for Ph.D. Students — Contemporary Problems in Molecular Biology**	3	0/2 C	0/2 C
NBCM304	**Molecular Mechanisms of Membrane Transport**	3	—	2/0 Ex
NBCM313	**Modern Measuring and Data Analysis Methods in Time Resolved Fluorescence Spectroscopy**	3	2/0 Ex	—
NBCM317	**Advanced Molecular Spectroscopy**	3	1/1 C+Ex	—
NOOE119	**Nonlinear Optical Spectroscopy**	3	2/0 Ex	—
NFPL193	**NMR Interactions and Relaxation Theory**	5	—	2/1 C+Ex
NBCM127	**Biophysical Methods in Photosynthesis Studies**	3	—	2/0 Ex
NBCM128	**Advanced Methods in Molecular Spectroscopy**	3	—	2/0 Ex
NBCM129	**Experimental Technology in Optical Spectroscopy and Radiometry**	3	—	2/0 Ex
NBCM130	**Seminar on Optical Spectroscopy**	3	—	0/2 C
NBCM059	**Application of Low Temperature Plasma**	3	2/0 Ex	—
NBCM208	**Fundamentals of Macromolecular Physics**	4	—	3/0 Ex
NBCM066	**Introduction to Macromolecular Chemistry**	5	2/1 C+Ex	—
NBCM228	**Polymers for Applications in Photonics and Optoelectronics**	3	2/0 Ex	—

NBCM012	**Biochemistry**	3	—	1/1 Ex
NBCM023	**Importance and Functions of Metal Ions in Biological Systems**	3	2/0 Ex	—
NBCM305	**Optical Sensors**	6	2/0 Ex	—
NBCM316	**Computer Modelling of Biomolecules**	5	1/2 C+Ex	1/2 C+Ex
NFPL179	**Quantum Description of NMR**	5	2/1 C+Ex	2/1 C+Ex
NFPL186	**Seminar on High Resolution NMR Spectroscopy**	3	0/2 C	0/2 C
NBCM046	**Seminar on Theoretical Chemical Physics**	2	0/1 C	0/1 C
NBCM055	**Molecular Simulations in Chemical Physics**	5	2/1 C+Ex	2/1 C+Ex
NBCM200	**Seminar on Plasma Polymer Studies**	3	0/2 C	0/2 C
NBCM201	**Nuclear Magnetic Resonance of Biomolecules and Macromolecular Systems**	3	2/0 Ex	—
NBCM039	**Quantum Theory of Molecules**	7	—	3/2 C+Ex
NBCM098	**X-ray Structure Analysis of Biomolecules and Macromolecules**	3	2/0 Ex	—
NBCM041	**Fundamentals of Energy Transfer in Molecular Systems I**	3	2/0 Ex	—
NBCM300	**Seminar for Ph.D. Students — Structure and Spectroscopy of Biomolecules**	3	0/2 C	0/2 C

List of Requirements for the State Doctoral Examination

I. General background

Solid knowledge of general physical concepts and laws is expected to the extent of the requirements for the state final examination in the Bc. programme Physics — study plan General Physics, and for the state final examination in the MSc. programme Physics — study plan Biophysics and Chemical Physics and study plan Physics of Condensed Matter and Materials, direction Physics of Macromolecular Matter, at Faculty of Mathematics and Physics, Charles University in Prague. This field is not the subject of principal questions, but may be supplementary asked within the context of answers to the questions based on thereinafter requirements.

II. Advanced issues of the field

II.1. Quantum theory and statistical physics of molecular systems

Main methods of molecular quantum–chemical calculations. Atomic and molecular orbitals. π–electron approximation and Hückel method. Hartree–Fock equations and Roothaan equation. Correlation of electrons, correlation energy. Configuration interaction. Bound clusters and perturbation methods of correlation energy calculation.

Density functional methods. Calculations of weak intermolecular interactions. Vibrational molecular states. Methods of electron spectra calculations. Thermodynamic potentials. Thermodynamic laws. Statistical ensembles, basic statistical distributions. Basic laws of equilibrium and nonequilibrium statistical physics. Liouville equation, Boltzmann equation, Pauli kinetic equation, generalized master equation. Molecular simulations, empirical potentials, Monte Carlo methods, molecular dynamics. Chemical kinetics. Electrochemistry.

II.2. Physics and chemistry of molecular structures

Forced determining structural organization of the molecule, conformation, phase states and transitions in molecular systems (solutions, polymers, molecular and liquid crystals, biopolymers and membrane systems). Physics and chemistry of proteins and nucleic acids (chemical composition, 3D structure, complex formation, biological function). Organization of the cell and the main molecular processes at the cellular level. Photophysics and transport phenomena in polymers.

II.3. Experimental methods

Interaction of electromagnetic field with molecular and biological structures (width and shape of spectral lines, relaxation processes). Structure determination of molecular and biological systems (X–ray and neutron diffraction, electron microscopy). Application of magnetic resonance methods (NMR, ESR, spin probes and markers, echo methods, structural determinations by using 2D methods). Methods of elastic and dynamic light scattering for determination of structure and motion of molecular objects. Application of optical spectroscopy to study structure, interactions and dynamics of energy and charge transfer in molecular and biological systems (vibrational IR spectroscopy, UV — VIS absorption and emission spectroscopy, methods of high temporal and spectral resolution, polarization phenomena, optical chiroptical methods, Raman scattering, nonlinear optical methods). Application of electric and dielectric methods.

III. Topics of Ph.D. theses

Themes are specified individually by the supervisor according to the study plan.

Recommended Literature

Blankenship, R. E.: **Molecular Mechanisms of Photosynthesis.** *Blackwell Science, Oxford, 2002.*

Cantor, C. R., Schimmel, P. R.: **Biophysical Chemistry, vol. I, II, III.** *W. H. Freeman & Co., San Francisco, 1980 (rusky: Biofizičeskaja chimija. Mir, Moskva, 1984).*

Davydov, A. S.: **Kvantová mechanika.** *SPN, Praha, 1978.*

Demtröder, W.: **Laser Spectroscopy.** *Springer, Berlin, 2005.*

Guillet, J.: **Polymer Photophysics and Photochemistry.** *Cambridge University Press, Cambridge, 1985 (rusky: Fotofizika i fotochimija polimerov. Mir, Moskva, 1988).*

Kao, K. C., Hwang, W.: **Electrical Transport In Solids, vol. 1,2.** *Pergamon Press, Oxford, 1981 (rusky: Perenos elektronov v tverdych telach. Mir, Moskva, 1984).*

Klíma, J., Šimurda, M.: **Sbírka problémů z kvantové teorie.** *Academia, Praha, 2006.*

Prosser, V. a kol.: **Experimentální metody biofyziky.** *Academia, Praha, 1989.*

Skála, L.: **Kvantová teorie molekul.** *Karolinum, Praha, 1995.*
Skála, L.: **Úvod do kvantové mechaniky.** *Academia, Praha, 2005.*
Sperling, L. H.: **Introduction to Physical Polymer Science.** *Wiley, New York, 1986.*

4F5 Surface and Interface Physics

Council of Doctoral Studies in Branch 4F5

List of members of the Council can be found at the address `http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-f5.htm` .

Committee for the State Doctoral Examinations K7

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address `http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk07.htm` .

Cooperating Institutes

- Institute of Physics of the ASCR, v.v.i.
  Na Slovance 2, 182 21 Praha 8
  `http://www.fzu.cz/`

- Institute of Photonics and Electronics of the ASCR, v.v.i.
  Chaberská 57, 182 51 Praha 8
  `http://www.ufe.cz/setlang.php?lang=en&ref=/`

- J. Heyrovsky Institute of Physical Chemistry of the ASCR, v.v.i.
  Dolejškova 2155/3, 182 23 Praha 8
  `http://www.jh-inst.cas.cz/`

Homepage of the Council of Doctoral Studies in Branch 4F5

`http://physics.mff.cuni.cz/kfpp/f5/`

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in `http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=F5` .

Courses Given

Code	Subject	Credits	Winter	Summer
NEVF514	**Physics of Surfaces**	3	2/0 Ex	—
NEVF515	**Methods of Physics of Surfaces and Thin Films I**	3	—	2/0 Ex
NEVF516	**Methods of Physics of Surfaces and Thin Films II**	3	2/0 Ex	—

NEVF517	**Seminar on Physics of Surfaces and Thin Films**	3	0/2 C	—

List of Requirements for the State Doctoral Examination

I. General basics

Electromagnetic field. Photons. Wave function. Uncertainty principle. Schrödinger's equation and its solutions for simple cases. Approximate methods of quantum theory. Electron in periodic potential, band structure. Chemical bonding. Thermodynamic potentials, equilibrium, phase rule, phase transitions. Statistical distributions, relation between thermodynamic and statistical quantities, entropy. Random processes, fluctuations, statistical characteristics. Crystallography and structure of solid materials, types of bonding. Electron structure of solid materials. Transport phenomena, continuity equation, diffusion equation, relaxation times, mechanisms of scattering. Phonons.

II. Basics of specialization

Bulk and surface processes in vacuum systems, evaporation and condensation, interaction of gass with condensed matter (surface, bulk), pumping process, ultimate pressure. Physical principles of methods for low pressure preparation and measurement. Motion of charged particles in electric and magnetic fields, basic systems of electron and ion optics. Mass spectroscopy. Interface of two solids (metal–metal, metal–semiconductor, semiconductor–semiconductor), electronic processes at interfaces, physical principles of electronic elements. Solid state surface (structure, purity, reconstruction and relaxation), electronic structure of surfaces (metals and semiconductors), surface states, band bending, work function. Physical processes at surfaces (adsorption; emission of charged particles — thermal emission of electrons and ions, surface ionization, field emission — electron tunneling, field ionization, photoemission; interaction of radiation and particles with condensed matter). Theory of thin film growth, epitaxial growth. Properties of thin films, transport in thin films.

III. Experimental methods in Physics of surfaces, thin films and interfaces

Preparation of defined surfaces and thin films, basic methods and techniques. Methods for analysis of surfaces, thin films and interfaces (microscopy techniques — TEM, SEM, FEM, FIM, STM, electron and ion spectroscopy techniques — AES, XPS, APS,..., diffraction methods — LEED, RHEED, X–ray).

Recommended Literature

Anselm, A. I.: **Úvod do teorie polovodičů.** *Academia, Praha, 1967.*

Bechstedt, F.: **Principles of Surface Physics.** *Springer–Verlag, Berlin, 2003.*

Eckertová, L. a kol.: **Fyzikální elektronika pevných látek.** *Univerzita Karlova, Praha, 1992.*

Eckertová, L. a kol.: **Metody analýzy povrchů, elektronová mikroskopie a difrakce.** *Academia, Praha, 1996.*

Eckertová, L. a kol.: **Metody analýzy povrchů, elektronová spektroskopie.** *Academia, Praha, 1990.*

Eckertová, L.: **Physics of thin films.** *SPN – Plenum Press, New York – Praha, 1986.*

Frank, L. a kol.: **Metody analýzy povrchů, iontové, sondové a speciální metody.** *Academia, Praha, 2002.*
Groszkowski, J.: **Technika vysokého vakua.** *SNTL, Praha, 1981.*
Kittel, Ch.: **Úvod do fyziky pevných látek.** *Academia, Praha, 1985.*
Pátý, L.: **Fyzika nízkých tlaků.** *Academia, Praha, 1968.*
Zangwill, A.: **Physics at surfaces.** *Cambridge University Press, Cambridge, 1988.*

4F6 Quantum Optics and Optoelectronics

Council of Doctoral Studies in Branch 4F6

List of members of the Council can be found at the address `http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-f6.htm` .

Committee for the State Doctoral Examinations K8

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address `http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk08.htm` .

Cooperating Institutes

- Institute of Physics of the ASCR, v.v.i.
  Na Slovance 2, 182 21 Praha 8
  `http://www.fzu.cz/`

- Institute of Photonics and Electronics of the ASCR, v.v.i.
  Chaberská 57, 182 51 Praha 8
  `http://www.ufe.cz/setlang.php?lang=en&ref=/`

Homepage of the Council of Doctoral Studies in Branch 4F6

`http://physics.mff.cuni.cz/kchfo/ooe/4F6.htm`

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in `http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=F6` .

Courses Given

Required courses :

Code	Subject	Credits	Winter	Summer
NOOE100	**Seminar on Quantum Optics and Optoelectronics for Ph.D. Students**	3	0/2 C	0/2 C

Optional core courses (min. 15 credits during the first three semesters from these courses, alternatively from other courses recommended by CDSB):

Code	Subject	Credits	Winter	Summer
NFPL182	**Solid State Theory**	9	4/2 C+Ex	—
NTMF002	**Advanced Quantum Theory**	6	3/1 C+Ex	—
NOOE069	**Laser Spectroscopy of Semiconductor Nanocrystals**	5	2/1 C+Ex	—
NOOE060	**Quantum Statistics of Optical Fields**	3	2/0 Ex	—
NOOE103	**Theory of Coherence**	4	3/0 Ex	—
NOOE101	**Quantum and Nonlinear Optics I**	3	2/0 Ex	—
NOOE102	**Quantum and Nonlinear Optics II**	3	—	2/0 Ex
NOOE026	**Ultrashort Light Pulses**	3	2/0 Ex	—
NOOE111	**Ultrashort Optical Pulse Applications in Spectroscopy**	3	2/0 Ex	—
NOOE121	**Methods of Laser Spectroscopy in Semiconductor Spintronics**	3	2/0 Ex	2/0 Ex
NOOE110	**Semiconductor luminescence and Its Applications**	3	—	2/0 Ex
NOOE009	**Optoelectronics and Optical Properties of Solids**	3	—	2/0 Ex
NOOE112	**Optical Interactions in Periodic Anisotropic Structures**	3	2/0 Ex	—
NOOE109	**Semiconductor Photonics**	3	2/0 Ex	—
NOOE108	**Semiconductor Optoelectronics**	3	2/0 Ex	—
NOOE003	**Materials and Technology in Optoelectronics**	3	2/0 Ex	—
NOOE107	**Detection and Detectors of Radiation**	3	—	2/0 Ex
NOOE047	**Integrated Optics**	3	2/0 Ex	—
NOOE049	**Holography**	3	2/0 Ex	—
NBCM305	**Optical Sensors**	6	2/0 Ex	—
NOOE113	**Laser Metrology**	3	2/0 Ex	—

List of Requirements for the State Doctoral Examination

I. General background

Fundamental concepts and laws of classical and quantum physics. Microscopic and macroscopic description of physical phenomena. Symmetry and its role in physics. Fundamental concepts and laws of equilibrium and nonequilibrium statistical physics. Fundamentals of nonlinear physics. Fundamental optical experiments with impact on physics.

II. Advanced parts of quantum optics and optoelectronics

II.1. Wave and quantum optics

Methods of description of the optical field (approximation of the ray, wave and quantum optics). Gaussian beams. Fourier optics. Coherence. Interference. Fundamentals of holography. Diffraction. Theory of optical imaging. Guided waves and optical waveguides. Response of quantum system to optical field. Linear and nonlinear optics. Quantization of optical field. Light–matter interaction: emission, absorption, scattering — semiclassical and quantum description. Coherent and statistical properties of optical fields (nonclassical states). Quantum theory of coherence.

II.2. Laser physics

Laser generators and amplifiers. Optical resonators. Resonator modes. Laser types according to operation regime and active medium. Laser dynamical properties. Frequency, temporal, spatial and power parameters of laser radiation. Laser systems with extremal parameters of radiation. Optical nonlinear systems for efficient light frequency transformation.

II.3. Optoelectronics

Band theory in solid state physics. Brillouin zone. Bloch function. Density of states. Quaiparticles in solids. Optical transitions. Semiconductor nanostructures. Conductivity, Boltzmann equation, scattering processes, Hall effect. Photoconductivity, luminescence. Semiconductor photodetectors. Light emitting diodes and lasers. Optical modulators. Semiconductor heterostructures. Integrated optics. Basics of semiconductor technology.

III. Special part

The candidate will be asked one out of three questions suggested by the supervisor in accord with students specialization. This part includes also a discussion based on a short written summary (a few pages) of doctoral thesis.

Recommended Literature

Born, M., Wolf, E.: **Principles of Optics.** *Pergamon Press, Oxford, 1980.*

Boyd, R. W.: **Nonlinear Optics.** *Academic Press, San Diego, USA, 1992.*

Davis, J. H.: **The Physics of Low–Dimensional Semiconductors.** *Cambridge University Press, Cambridge, 2000.*

Haken, H.: **Light, vol. 1, 2.** *North–Holland, Amsterdam, 1981/5.*

Cheo, P. K.: **Fiber Optics and Optoelectronics.** *Prentice Hall, Englewood Cliffs, New York, 1985.*

Kittel, C.: **Quantum Theory of Solids.** *Wiley, New York, 1967.*

Klingshirn, C. L.: **Semiconductor Optics.** *Springer Verlag, Berlin, 1997.*

Loudon, R.: **The Quantum Theory of Light.** *Oxford University Press, Oxford, 2000.*

Mandel, L., Wolf, E.: **Optical Coherence and Quantum Optics.** *Cambridge University Press, Cambridge, 1995.*

Peřina, J.: **Quantum Statistics of Linear and Nonlinear Optical Phenomena.** *Reidel, Dodrecht, 1991.*

Saleh, B. E. A., Teich, M. C.: **Základy fotoniky I–IV.** *Matfyzpress, Praha, 1994–96.*

Seeger, K.: **Semiconductor Physics.** *Springer–Verlag, Berlin, 1982.*

4F7 Geophysics

Council of Doctoral Studies in Branch 4F7

List of members of the Council can be found at the address http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-f7.htm .

Committee for the State Doctoral Examinations K9

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk09.htm .

Cooperating Institutes

- Institute of Geophysics of the ASCR, v.v.i.
  Boční II/1401, 141 31 Praha 4 — Spořilov
  http://www.ig.cas.cz/en/welcome/

- Institute of Rock Structure and Mechanics of the ASCR, v.v.i.
  V Holešovičkách 41, 182 09, Praha 8
  http://www.irsm.cas.cz/?Lang=ENG&Menu=0,0,0,0

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=F7 .

Courses Given

Code	Subject	Credits	Winter	Summer
NGEO078	**Continuum Mechanics I**	5	2/1 C+Ex	—
NGEO069	**Continuum Mechanics II**	3	—	2/0 Ex
NGEO005	**Fourier Spectral Analysis**	5	2/1 C+Ex	—
NGEO029	**Review of Geophysics**	3	2/0 Ex	—
NGEO017	**Gravity Field and Shape of the Earth**	5	—	2/1 C+Ex
NGEO082	**Seismology I**	5	—	2/1 C+Ex
NGEO074	**Seismology II**	3	2/0 Ex	—
NGEO080	**Geomagnetism and Geoelectricity I**	5	—	2/1 C+Ex
NGEO079	**Geomagnetism and Geoelectricity II**	3	2/0 Ex	—
NGEO022	**Numerical Methods in Fortran**	6	3/1 C+Ex	—
NGEO002	**Seismic Waves Propagation**	5	2/1 C+Ex	—
NGEO057	**Methods of Geophysical Data Processing**	5	—	2/1 C+Ex
NGEO015	**Geothermics and Radioactivity of the Earth**	5	—	2/1 C+Ex

NGEO076	**Inverse Problems and Modelling in Physics**	3	—	2/0 Ex
NGEO081	**Inverse Problems and Modelling in Geophysics**	6	—	2/2 C+Ex
NGEO016	**Structure of the Earth**	4	3/0 Ex	—
NGEO084	**Seminar on Geodynamics**	3	0/2 C	0/2 C
NGEO083	**Seminar on Seismology**	3	0/2 C	0/2 C
NGEO032	**Ray Methods in Seismology**	5	—	2/1 C+Ex
NDGF015	**Mantle and Lithosphere Dynamics for Ph.D. Students**	6	2/0 Ex	2/0 Ex
NDGF014	**Geomagnetism and Geoelectricity for Ph.D. Students**	8	2/0 Ex	2/1 C+Ex
NDGF013	**Continuum Mechanics for Ph.D. Students**	8	2/1 C+Ex	2/0 Ex
NDGF018	**Boundary Value Problems of Physical Geodesy for Ph.D. Students**	6	2/0 Ex	2/0 Ex
NDGF012	**Earth Rotation for Ph.D. Students**	6	2/0 Ex	2/0 Ex
NDGF016	**Seismology for Ph.D. Students**	8	2/0 Ex	2/1 C+Ex

List of Requirements for the State Doctoral Examination

I. General scope

Knowledge about general physical concepts and terms is presumed. Knowledge from the mechanics of material point and rigid body, potential theory, continuum mechanics, propagation of elastic waves, basic concepts of the electromagnetic field theory and thermodynamics will be examined mainly within the subjects related to the area under study.

II. Advanced topics

II.1. Obligatory part

II.1.1 Fundamentals of geophysics

Motions of the Earth. Gravity field, gravity measurements and their reductions. Earth tides. Basic parameters of earthquakes. Seismicity of the Earth. Propagation of seismic waves. Description of Earth magnetic field, principal magnetic field, variations. Paleomagnetism. Sources and transport of heat in the Earth. Convection in the Earth mantle. Age of rocks.

II.1.2 Structure of the Earth

Free oscillations of the Earth and seismic reference model. Temperature, electric conductivity and viscosity distribution in the Earth, phase transitions. Global 3D models based on seismic tomography. Continental drift, sea floor spreading, plate tectonics.

II.2. Optional part

Student chooses a single section from the following ones:

II.2.1 Gravity field and figure of the Earth

Earth rotation and its temporal changes. Expansion of the gravity potential. Geoid, spheroid and reference ellipsoid. Absolute and relative gravity measurements. Gravity anomalies. Isostasy. Satellite methods of studying the gravitational field. Determination of the figure of the real Earth's surface. Theory of the Earth tides.

II.2.2 Seismology

Types of earthquakes and their geographical distribution. Macroseismic intensity, magnitude and energy of earthquakes. Earthquake source physics. Seismicity. Seismic waves, theory of their propagation. Seismic instruments and observatories. Structural seismology.

II.2.3 Geomagnetism and geoelectricity

Basic characteristics of the Earth electromagnetic field and its temporal changes. Paleomagnetism. Study of the electric conductivity in the Earth's crust and mantle. Dynamo theory of the Earth magnetic field generation. Physics of ionosphere and magnetosphere.

II.2.4 Geodynamics

Energy balance of the Earth. Earth mantle and lithosphere rheology. Laws of conservation of mass, momentum, angular momentum and energy for moving continuum. Numerical models of mantle convection. Postglacial rebound. Dynamic geoid.

Recommended Literature

Aki, P. K., Richards, P.: **Quantitative Seismology.** *University Science Books, Sausalito, 2002.*

Brokešová, J.: **Asymptotic Ray Method in Seismology. A Tutorial.** *Matfyz Press, Praha, 2008.*

Červený, V.: **Seismic Ray Theory.** *Cambridge University Press, Cambridge, 2001.*

Dahlen, F. A., Tromp, J.: **Theoretical Global Seismology.** *Princeton University Press, Princeton, 1998.*

Fowler, C. M. R.: **The Solid Earth.** *Cambridge University Press, Cambridge, 1990.*

Lay, T., Wallace, T. C.: **Modern Global Seismology.** *Academic Press, New York, 1995.*

Merrill, R. T., McElhinny, M. W., McFadden, P. L.: **The Magnetic Field of the Earth.** *Academic Press, San Diego, 1998.*

Novotný, O.: **Motions, Gravity Field and Figure of the Earth.** *UFBA, Salvador, Bahia, 1998.*

Shearer, P. M.: **Introduction to Seismology.** *Cambridge University Press, Cambridge, 1999.*

Schubert, G. (ed.): **Treatise on Geophysics.** *Elsevier, Amsterdam, 2007.*

Schubert, G., Turcotte, D. L., Olson, P.: **Mantle Convection in the Earth and Planets.** *Cambridge University Press, Cambridge, 2001.*

4F8 Meteorology and Climatology

Council of Doctoral Studies in Branch 4F8

List of members of the Council can be found at the address http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-f8.htm .

Committee for the State Doctoral Examinations K10

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk010.htm .

Cooperating Institutes

- Czech Hydrometeorological Institute
  Na Šabatce 17, 143 06 Praha 4
  http://www.chmu.cz/indexe.html

- Institute of Atmospheric Physics of the ASCR, v.v.i.
  Boční II/1401, 141 31 Praha 4
  http://www.ufa.cas.cz/

- Institute of Thermomechanics of the ASCR, v.v.i.
  Dolejškova 1402/5, 182 00 Praha 8
  http://www.it.cas.cz/?q=en/node

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=F8 .

Courses Given

Code	Subject	Credits	Winter	Summer
NMET501	**Radiation-active Gases in Atmosphere**	3	2/0 Ex	—
NMET502	**Mathematical Modelling of Atmospheric Processes**	3	2/0 Ex	—
NMET503	**Selected Topics on Dynamic Meteorology**	3	2/0 Ex	—
NMET504	**Air Pollution Transport**	3	—	2/0 Ex
NMET505	**Atmospheric Aerosols**	3	—	2/0 Ex
NMET506	**Expert Systems in Meteorology**	3	2/0 Ex	—
NMET507	**Predictability of Atmospheric Processes**	3	—	2/0 Ex
NMET508	**Numerical Forecasting Methods**	3	—	2/0 Ex
NMET509	**Dynamics of Ocean-Atmosphere System**	3	2/0 Ex	—

NMET510	**Stratosphere and Mesosphere**	3	2/0 Ex	—
NMET511	**Applied Physics of Clouds and Precipitation**	3	—	2/0 Ex
NMET512	**Applications of Multivariate Statistical Methods in Meteorology and Climatology**	3	—	2/0 Ex
NMET513	**Seminar on Contemporary Problems of Meteorology**	2	0/1 C	0/1 C
NMET514	**Seminar on Climatology**	3	—	0/2 C
NMET515	**Seminar on Dynamic and Synoptic Meteorology**	3	0/2 C	—
NMET517	**Selected Topics on Geophysical Hydrodynamics**	3	—	2/0 Ex
NMET518	**Climate Change Scenarios**	3	—	2/0 Ex
NMET519	**Climate Change Modelling**	3	—	2/0 Ex
NMET520	**Contemporary Issues in Synoptic Climatology**	3	2/0 Ex	—

List of Requirements for the State Doctoral Examination

I. General basics

General knowledge of basic physical lows and terms is required. Knowledge of mechanics, molecular physics, thermodynamics and optics will be examined as a part of questions about related subjects.

II. Advanced parts

II.1. Obligatory parts

II.1.1 Dynamic meteorology

Thermodynamics of the close and open systems, phase changes. Types of atmospheric flows, interpretation of the ageostrophic components, flow function and divergent potential. Theory of the pressure changes, interpretation of the basic equations of atmospheric dynamics, potential vorticity, circulation theorems, gravitational and inertial oscillations, waves in zonal flow, baroclinic instability, energy transformation in the atmosphere, predictability of atmospheric processes, circulation in various scales.

II.1.2 Synoptic meteorology

Objective analysis of meteorological variables fields, utilization of the numerical forecasting methods in the weather prediction, specifics of the synoptic processes over the middle Europe, statistical post–processing, prediction of the dangerous processes, regional influences on the atmospheric fronts and on the weather within air masses.

II.1.3 Atmospheric boundary layer

Turbulence in the atmosphere, transformation of the kinetic energy in the boundary layer, solutions of the closure problem, turbulence models, Monin and Obukhov length, stability parameters, interaction between the surface and atmosphere, flow over mountains, transport and reactions of air–pollution.

II.1.4 Climatology

Climate system, feedbacks, predictability of the climate. Physical and chemical processes in the climate system, horizontal and vertical structure of the atmospheric

and oceanic circulation, interaction between the atmosphere and ocean. Variability in the climate system, circulation indices, modes of variability. Structure of the climate models, global circulation models, limited area models. Anthropogenic influences on the climate system.

II.2. Optional parts

Student chooses one of the following subjects:

II.2.1 Numerical forecasting methods

Types of the partial differential equations used for the formulation of meteorological models (hyperbolic, parabolic and elliptic equations including boundary problems). Shallow water equations, baroclinic models. Mathematical formulation of the meteorological forecast, limited area models. Numerical solutions of the equations of atmospheric dynamics.

II.2.2 Physics of clouds and precipitation

Physical properties of cloud and precipitation particles, microphysical processes in the clouds, dynamics of the stratiform and convective clouds, clouds electricity, utilization of the meteorological radars for the precipitation measurement.

II.2.3 Atmospheric optics and acoustics

Scattering and absorption of the electromagnetic radiation in the atmosphere, description of the basic optical and acoustical phenomena in the atmosphere, meteorological utilization of the radars and methods of remote sensing.

II.2.4 Transport of air–pollutants

Air–pollution and its sources, air–pollution diffusion, deposition on the surface, dry and wet deposition, basics of the atmospheric chemistry, chemistry of the ozone, principal kinds of models for air–pollution transport, ecological consequences of air–pollution.

II.2.5 Higher atmospheric levels

Temperature and chemical structure of the stratosphere. Circulation in the stratosphere. Troposphere–stratosphere exchange, role of the wave processes. Role of the stratosphere in tropospheric processes. Volcanic eruptions and solar activity influence on the stratosphere. Mesosphere, basic terms and processes.

Recommended Literature

Andrews, D. G., Holton, J. R., Leovy, C. B.: **Middle Atmosphere Dynamics.** *Academic Press, New York, 1987.*

Bigg, G. R.: **The Oceans and Climate.** *Cambridge University Press, Cambridge, 1999.*

Cotton, W. R., Anthes, R. A.: **Storm and Cloud–Dynamics.** *Int. Geoph. Series, vol. 44, Academic Press, New York, 1989.*

Curry, J. A., Webster, P. J.: **Thermodynamics of Atmospheres and Oceans.** *Academic Press, New York, 1999.*

Drikakis, D., Rider, W.: **High–Resolution Methods for Incompressible and Low–Speed Flows.** *Springer, Berlin, 2005.*

Dutton, J. A.: **Dynamics of Atmospheric Motion.** *Dover, New York, 1995.*

Holton, J. R.: **The Dynamic Meteorology of the Stratosphere and Mesosphere.** *Am. Met. Soc., Boston, 1975.*

Houze Jr., R. A.: **Cloud Dynamics.** *International Geophysics Series, vol. 53, Academic Press, New York, 1993.*
Jacobson, M. Z.: **Fundamentals of Atmospheric Modeling.** *Cambridge University Press, Cambridge, 1999.*
McGuffie, K., Henderson–Sellers, A.: **A Climate Modelling Primer.** *John Wiley & Sons, New York, 1999.*
Mesinger, F., Arakawa, A.: **A Numerical Methods Used in Atmospheric Models.** *WMO–GARP Publications Series, no. 17, 1976.*
Pedlosky, J.: **Geophysical Fluid Dynamics.** *Springer–Verlag, Berlin, 1995.*
Pechala, F., Bednář, J.: **Příručka dynamické meteorologie.** *Academia, Praha, 1991.*
Peixoto, J. P., Oort, A. H.: **Physics of Climate.** *American Inst. of Physics, New York, 1992.*
Pruppacher, H. R., Klett, J. D.: **Microphysics of Clouds and Precipitation.** *Atmospheric and oceanographic sciences library, vol. 18, Kluwer Academic Publishers, Dordrecht, 1997.*
Rayner, J. N.: **Dynamic Climatology.** *Blackwell Publishers, Inc., Malden, Mass. USA, 2001.*
Zverev, A. S.: **Synoptická Meteorológia.** *Alfa–SNTL, Bratislava–Praha, 1986.*

4F9 Subnuclear Physics

Council of Doctoral Studies in Branch 4F9

List of members of the Council can be found at the address `http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-f9.htm` .

Committee for the State Doctoral Examinations K6

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address `http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk06.htm` .

Cooperating Institutes

- Institute of Physics of the ASCR, v.v.i.
  Na Slovance 2, 182 21 Praha 8
  `http://www.fzu.cz/`

- Nuclear Physics Institute of the ASCR, v.v.i.
  Husinec – Řež č. p. 130, PSČ 250 68
  `http://www.ujf.cas.cz/`

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in `http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=F9` .

Courses Given

Code	Subject	Credits	Winter	Summer
NJSF091	**Seminar on Particle and Nuclear Physics I**	3	0/2 C	—
NJSF092	**Seminar on Particle and Nuclear Physics II**	3	—	0/2 C
NJSF072	**Electroweak Interactions II**	5	2/1 Ex	—
NJSF086	**Quarks, Partons and Quantum Chromodynamics**	6	—	2/2 C+Ex
NJSF085	**Fundamentals of Electroweak Theory**	6	—	2/2 C+Ex
NJSF075	**Detectors for High Energy Physics**	3	2/0 Ex	—
NJSF057	**From Searching for Charm to Beyond Standard Model**	3	—	2/0 Ex
NJSF063	**Selected Topics on Subnuclear Physics**	3	2/0 Ex	—
NJSF074	**Experimental Checks on Standard Model II**	3	2/0 Ex	—
NJSF077	**Practical High Energy Physics**	3	0/2 C	—
NJSF080	**Probability and Stochastic Processes in Elementary Particle Physics**	3	2/0 Ex	—
NJSF082	**Selected Topics on Quantum Field Theory I**	5	3/0 Ex	—
NJSF083	**Selected Topics on Quantum Field Theory II**	5	—	3/0 Ex
NJSF062	**Quantum Field Theory I**	9	4/2 C+Ex	—
NJSF098	**Quantum Field Theory II**	9	—	4/2 C+Ex
NJSF068	**Quantum Field Theory I**	9	4/2 C+Ex	—
NJSF069	**Quantum Field Theory II**	9	—	4/2 C+Ex
NJSF100	**Selected Topics on Field Theory**	3	2/0 Ex	—
NJSF030	**Quantum Field Theory at Finite Temperature**	3	—	2/0 Ex
NJSF042	**Practical Quantum Field Theory**	5	—	2/1 C+Ex

List of Requirements for the State Doctoral Examination

I. Wider fundamentals

Formal scheme and basic postulates of quantum theory. Uncertainty relations. Schrödinger equation and its solution for simple systems in the framework of the non-relativistic quantum mechanics. Quantization and addition of angular momenta. Spin. Approximation methods. Basics of the theory of scattering. Systems of indistinguishable particles. Symmetries in quantum mechanics. Fundamentals of special theory of

relativity. Equations of the relativistic mechanics and classical field theory. Poincaré group. Relativistic quantum mechanics. Klein–Gordon and Dirac equations, their solutions for free particles and particles in electromagnetic field. Basics of quantum field theory. Feynman diagrams. Processes in quantum electrodynamics in the lowest order. Diagrams with one closed loop. Basic technics of regularization and renormalization.

II. Fundamentals of subnuclear physics

Detection methods for registration of elementary particles. Systematics and measurements of properties of elementary particles. Genesis of present Standard Model of micro–world from the experimental point of view. Particle accelerators and detectors. Quark model. Parton model. Evidence for colour. Basic principles of quantum chromodynamics: interaction Lagrangian, running coupling constant. Evolution equations. Experimental tests of quantum chromodynamics. Theoretical basics and experimental tests of the Standard Model of electroweak interactions. Neutral and charge currents. Properties of intermediate bosons. Elementary processes in the lowest order. CP–invariance violation. Kobayashi–Maskawa matrice. Neutrino oscilations.

Recommended Literature

Cahn, R., Goldhaber, G.: **Experimental foundations of particle physics.** *Cambridge University Press, Cambridge, 1989.*

Ferbel, T.: **Experimental techniques in high energy nuclear and particle physics.** *World Scientific, Singapore, 1991.*

Formánek, J.: **Úvod do kvantové teorie.** *Academia, Praha, 2004.*

Formánek, J.: **Úvod do relativistické kvantové mechaniky a kvantové teorie pole.** *Karolinum, Praha, 2000.*

Hořejší, J.: **Fundamentals of electroweak theory.** *Karolinum, Praha, 2002.*

Cheng, T.–P., Li, L.–F.: **Gauge theory of elementary particle physics.** *Clarendon Press, Oxford, 1984.*

Itzykson, C., Zuber, J.–B.: **Quantum field theory.** *McGraw–Hill, New York, 1980.*

Leo, W. R.: **Techniques for nuclear and particle physics experiments.** *Springer, Berlin, 1994.*

Peskin, M., Schroeder, D.: **An Introduction to quantum field theory.** *Addison–Wesley, Reading, 1995.*

Weinberg, S.: **The quantum theory of fields I, II.** *Cambridge University Press, Cambridge, 1995, 1996.*

Žáček, J.: **Úvod do fyziky elementárních částic.** *Karolinum, Praha, 2005.*

4F10 Nuclear Physics

Council of Doctoral Studies in Branch 4F10

List of members of the Council can be found at the address http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-f10.htm .

Committee for the State Doctoral Examinations K6

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk06.htm .

Cooperating Institutes

- Nuclear Physics Institute of the ASCR, v.v.i.
  Husinec – Řež č. p. 130, PSČ 250 68
  http://www.ujf.cas.cz/

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=F10 .

Courses Given

Code	Subject	Credits	Winter	Summer
NJSF024	**Radioanalytical Methods**	3	2/0 Ex	—
NJSF132	**Theory of nanoscale systems I**	3	2/0 Ex	—
NJSF133	**Theory of nanoscale systems II**	3	—	2/0 Ex
NJSF056	**Many Body Problem in Nuclear Structure**	3	2/0 Ex	—
NJSF031	**Classical and Quantum Chaos**	3	—	2/0 Ex
NJSF085	**Fundamentals of Electroweak Theory**	6	—	2/2 C+Ex
NJSF086	**Quarks, Partons and Quantum Chromodynamics**	6	—	2/2 C+Ex
NMAF020	**Probability and Mathematical Statistics**	5	2/0 Ex	—
NJSF058	**Nuclear Reactions with Heavy Ions**	3	2/0 Ex	—
NJSF041	**Applied Nuclear Physics**	6	4/0 Ex	—
NJSF070	**Charged Particle Accelerators**	3	2/0 Ex	—

List of Requirements for the State Doctoral Examination

I. Quantum Theory

Theory of small–number of particle systems (two–body and three–body problem in quantum mechanics). Theory of many–body systems, the second quantization, systems of identical particles, variational methods, method of selfconsistent mean field.

Mean field and residual interactions, pairing correlations, HFB, TDA, RPA. Theory of elastic and inelastic scattering. Perturbation theory. Relativistic equations (Klein–Gordon, Dirac). Quantum field theory (lagrangians of free and interacting fields, field quantization, interacting fields, S matrix, Feynman diagrams, cross sections.

II. Physics of nuclei and nuclear reactions

Symmetries and conservation laws. Nuclear forces, systems with small number of nucleons (deuteron), nuclear charecteristics (dimensions, shapes, types of spectra etc.). Degrees of freedom of nuclear motion (singleparticle and collective degrees of freedom — vibration and rotation of nuclei). Electromagnetic transitions and moments in nucleus (absolute and reduced transition probabilities, type of transition mixing ratios, conversion coefficients). Beta transitions in nuclei (spectrum, log ft quantity, helicity of created particles, parity nonconservation, V–A theory, Fermi and Gamowov–Teller transitions). Alpha transitions (spectrum, alpha transition probabilities, alpha–decay series). Basic conseptions of nuclear reactions (cross section and its connection with S–matrix, Lippmann–Schwinger equation, Born series, compound nucleus reactions, direct nuclear reactions: PWBA, DWBA, coupled channel method, optical model). Nuclear fission and nuclear reactor principle. Nuclear astrophysics.

III. Experimental methods of nuclear physics

Transit of charged particles, neutrons and photons through matter. Detectors and spectrometers of nuclear radiation. Measurement of time and angle correlations. Accelerators of charged particles and sources of neutrons. Basic dosimetry conceptions and units

IV. Subnuclear physics

Classification of elementary particles, properties of different groups of particles. Multiplets and supermultiples of mesons and baryons. Conservation laws in the particle physics, experimental tests of C, P and T invariance. Partons, elastic and inelatic scattering of electrons and hadrons, structure functions. Quark model, bound states of quarks, mesons and baryons. Basic ideas of quantum electrodynamics. Weak interactions (basic ideas of the standard model). Basic principles of chromodynamics.

Recommended Literature

Formánek, J.: **Úvod do kvantové teorie.** *Academia, Praha, 1983.*

Formánek, J.: **Úvod do relativistické kvantové mechaniky a kvantové teorie pole 2a a 2b.** *Karolinum, Praha, 2000.*

Greiner, W., Maruhn, J. A.: **Nuclear Models.** *Springer–Verlag, New York, 1996.*

Griffiths, D.: **Introduction to Elementary Particles.** *Wiley, New York, 1987.*

Heyde, K.: **Basic Ideas and Concepts in Nuclear Physics.** *Institute of Physics Publishing, London, 1994.*

Heyde, K.: **The Nuclear Shell Model.** *Springer–Verlag, New York, 1994.*

Knoll, G. F.: **Radiation Detection and Measurement.** *Wiley, New York, 2000.*

Leo, W. R.: **Techniques for Nuclear and Particle Physics Experiments.** *Springer–Verlag, New York, 1994.*

Mandl, F., Shaw, G.: **Quantum Field Theory.** *Wiley, New York, 1988.*

Nilsson, S. G., Ragnarsson, I.: **Shapes and Shells in Nuclear Structure.** *Cambridge University Press, Cambridge, 1995.*

Ring, I. P., Schuck, P.: **The Nuclear Many–Body Problem.** *Springer–Verlag, New York, 1980.*

4F11 Mathematical and Computer Modelling

Annotation

In contrast to other programmes of the doctoral study, F11 is a combined programme between mathematics and physics. It is focused on the modelling in physics of solids, fluids, gases and plasma, with possible applications in material sciences, biology, and medicine. In accord with the doctoral thesis, the student can follow the continual, particle, or hybrid modelling, with emphasis either in mathematics or physics. The continual modelling is focused on the study of problems in continuum mechanics and thermodynamics of fluids (i.e. liquids or gases) or solids, or on the related mathematical and numerical analysis of the corresponding systems of partial differential equations, and possibly their numerical solution. Particle and hybrid modelling is devoted to the study of macromolecules, thin films and surfaces of solids, and to the study of both low–temperature and high–temperature plasmas, in the close connection with experimental data, often with the aim to help to interpret experimental results and to develop new diagnostic methods.

Council of Doctoral Studies in Branch 4F11

List of members of the Council can be found at the address `http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-f11.htm` .

Committee for the State Doctoral Examinations K3

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address `http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk03.htm` .

Cooperating Institutes

- Institute of Mathematics of the ASCR, v.v.i.
  Žitná 25, 115 67 Praha 1
  `http://www.math.cas.cz`

- Institute of Thermomechanics of the ASCR, v.v.i.
  Dolejškova 1402/5, 182 00 Praha 8
  `http://www.it.cas.cz/?q=en/node`

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in `http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=F11` .

Courses Given

Code	Subject	Credits	Winter	Summer
NMOD001	**Mathematical Methods in Fluid Mechanics for Ph.D. Students**	6	2/0 —	2/0 Ex
NDIR065	**Regularity of solutions of Navier-Stokes' equations**	3	2/0 Ex	—
NDIR142	**Nonlinear Differential Equations and Inequalities for Ph.D. Students I**	3	2/0 Ex	—
NDIR143	**Nonlinear Differential Equations and Inequalities for Ph.D. Students II**	3	—	2/0 Ex
NDIR051	**Differential Equations for Advanced Students**	6	2/2 C+Ex	—
NNUM131	**Selected Chapters on Numerical Linear Algebra 1**	3	2/0 Ex	—
NNUM231	**Selected Chapters on Numerical Linear Algebra 2**	3	—	2/0 Ex
NNUM080	**Mathematical Theory of Shape Optimisation for Ph.D. Students I**	3	2/0 Ex	—
NNUM081	**Mathematical Theory of Shape Optimisation for Ph.D. Students II**	3	—	2/0 Ex
NMOD014	**Introduction to Optimisation Theory**	3	2/0 Ex	—
NDIR066	**Mathematical Analysis of Compressible Flow Equations**	3	2/0 Ex	—
NMOD042	**Mathematical Analysis of Models in Non-Newtonian Fluid Thermodynamics**	3	—	2/0 Ex
NMOD140	**Mathematical Methods in Solid State Continuum Mechanics for Ph.D. Students 1**	3	2/0 Ex	—
NMOD043	**Theory of Mixtures**	3	—	2/0 Ex
NMOD036	**Biothermodynamics**	6	2/2 C+Ex	—
NNUM070	**Finite Volume Method for Compressible Flows**	3	2/0 Ex	—
NNUM066	**Advanced Topics on Finite Element Method**	3	2/0 Ex	—
NEVF160	**Modern computational physics I**	5	2/1 MC	—
NEVF161	**Modern computational physics II**	5	—	2/1 MC
NEVF526	**Computational physics I**	6	2/2 C	—

NEVF532	**Computational physics II**	6	—	2/2 Ex
NEVF523	**Numerical methods of computational physics I**	6	2/2 Ex	—
NEVF529	**Numerical methods of computational physics II**	6	—	2/2 Ex
NEVF525	**Plasma Physics and Computer Plasma Modelling I**	6	2/2 C	—
NEVF531	**Plasma Physics and Computer Plasma Modelling II**	6	—	2/2 Ex
NPRF036	**Modern Methods of Computer Physics**	3	1/1 C	—
NEVF524	**Seminar on computational physics I**	3	0/2 C	—
NEVF530	**Seminar on computational physics II**	3	—	0/2 C
NPRF001	**Programming in FORTRAN and Data Processing**	5	—	2/1 C+Ex
NPRF005	**UNIX for Physicists**	3	2/0 C	—
NPRF006	**Advanced Methods of Programming**	3	1/1 C	—
NBCM316	**Computer Modelling of Biomolecules**	5	1/2 C+Ex	—
NEVF114	**Physics of Thin Films I**	3	2/0 Ex	—

List of Requirements for the State Doctoral Examination

The exam has four parts:

I — Foundations of modern mathematics (choice of one to three sections I.1 to I.4)
II — Foundations of modern physics (choice of one to three sections II.1 to II.4)
III — Advanced topics (choice of one section III.1 to III.3)
IV — Special topics

Altogether, one has to choose three to four sections from parts I and II.

I. Foundations of modern mathematics

I.1. Selected parts of mathematical analysis

Measure and integration theory, Fourier series, implicit function theorems. Existence theory for systems of ordinary differential equations, qualitative properties. Foundations of the theory of dissipative dynamical systems.

I.2. Fundaments of numerical methods

Numerical methods of linear algebra, interpolation and approximation of functions, methods of numerical integration, methods of solving nonlinear equations and their systems, system of difference equations, numerical solution of ordinary differential equations, optimization methods.

I.3. Linear functional analysis

Metric spaces, vector spaces, normed linear spaces, theory of linear operators, Hilbert and Banach spaces, continuous linear functionals, Hahn–Banach theorem, Fredholm theorems, methods of solving integral equations, Lebesgue spaces and their duals.

I.4. Linear partial differential equations

Linear equations of the first order, method of characteristics, formulation of basic problems for particular types of second–order equations, their solvability, properties of harmonic functions, heat equation, wave equation, integral transforms. Sobolev and Bochner spaces, modern theory of linear partial differential equations.

II. Foundations of modern physics

II.1. Continuum mechanics

Tensor formulation of continuum mechanics, tensor of large deformation, infinitesimal deformation. Stress tensor, constitutive relations, material frame indifference, material symmetries. Ideal Newtonean visco–elastic properties and non–Newtonean fluids, elastic and visco–elastic solids. Balance equations, equations of fluid mechanics, transport theorem, boundary conditions, formulation of boundary valued problem, simplified models.

II.2. Thermodynamics

Basic laws of thermodynamics. Thermodynamical quantities, state of the system — First law of thermodynamics, thermodynamical process, entropy, Second law of thermodynamics. Consequences of time irreversibility of processes and of the principle of maximal probability of the state, constitutive relations for the thermo–visco–elastic body, thermo–visco–elastic fluid and thermodynamical stability conditions of their state. Classical nonequilibrium thermodynamics, generalized definition of entropy for locally nonequilibrium states.

II.3. Quantum theory

Fundamental conceptions and postulates of quantum mechanics, Schrödinger equation, uncertainty principle, one– and two–particles problems, linear harmonic oscilator, particle in potential well, approximative methods of quantum mechanics, spin. Quantum theory of solids and molecules.

II.4. Statistical physics

Sets in statistical physics. Liouville equation, microcanonical, canonical and large canonical set, Maxwell–Boltzmann, Fermi–Dirac and Bose–Einstein statistics, black–body radiation, state equation for gases.

III. Advanced topics

III.1. Methods of modern mathematical analysis

Nonlinear functional analysis, modern theory of selected nonlinear partial differential equations and partial differential inequalities, mathematical theory of solid and fluid mechanics, basics of optimization.

III.2. Numerical mathematics

Finite element methods (conformal and non–conformal elements), finite difference method, finite volume method.

III.3. Methods of computational physics

Continuous and particle modelling — Monte Carlo method, molecular dynamics method, continuous modelling, hybrid modelling. Algebraic manipulations, integral transforms, computer graphics, image processing, visualization, advanced methods of programming, advanced methods of computational physics — wavelets, use of neural networks in physics, evolutionary modelling. Basics of paralel computing.

IV. Special topics

The requirements will be decided in accord with the doctoral thesis and the individual plan of each doctorand.

Recommended Literature

Addison, P. S.: **The Illustrated Wavelet Transform Handbook.** *Institute of Physics Publishing, Bristol, 2002.*

Callen, H. B.: **Thermodynamics and an introduction to thermostatics.** *John Wiley & Sons, New York, 1985.*

Ciarlet, P. G., Lions, J.L. (eds.): **Finite Element Methods. Handbook of Numerical Analysis, part 1.** *3rd ed. North–Holland–Elsevier, 2007.*

Davydov, S.: **Kvantová mechanika.** *SPN, Praha, 1978.*

Elman, H., Silvester, D., Wathen, A.: **Finite Elements and Fast Iterative Solvers (with applications in incompressible fluid dynamics).** *Oxford Science Publications, Oxford University Press, Oxford, 2008.*

Evans, L.: **Partial Differential Equations.** *AMS, 1998.*

Feireisl, E., Novotný, A.: **Singular Limits in Thermodynamics of Viscous Fluids.** *Advances in Mathematical Fluid Mechanics, Birkhäuser Basel, 2009.*

Feireisl, E.: **Dynamics of viscous compressible fluids.** *Oxford Lecture Series in Mathematics and its Applications, 26. Oxford University Press, Oxford, 2004.*

Feistauer, M., Felcman, J., Straškraba, I.: **Mathematical and computational methods for compressible flow.** *Numerical Mathematics and Scientific Computation. The Clarendon Press–Oxford University Press, Oxford, 2003.*

Feistauer, M.: **Mathematical Methods in Fluid Mechanics.** *Longman Scientific and Technical Series, Harlow, 1993.*

Gershenfeld, N.: **The Nature of Mathematical Modelling.** *Cambridge University Press, Cambridge, 1999.*

Gurtin, M. E.: **An introduction to continuum mechanics.** *Mathematics in Science and Engineering, 158. Academic Press, Inc., New York–London, 1981.*

Haille, J. M.: **Molecular Dynamics Simulation: Elementary Methods.** *J. Willey, New York, 1992.*

Hockney, R. W., Eastwood, J. W.: **Computer Simulation Using Particles.** *Taylor & Francis, New York, 1988*

Hrach, R.: **Počítačová fyzika I.** *PF UJEP, Ústí nad Labem, 2003.*

Hrach, R.: **Počítačová fyzika II.** *PF UJEP, Ústí nad Labem, 2004.*

Chadwick, P.: **Continuum Mechanics: Concise Theory and Problems.** *2nd ed. Dover Publications, Dover 1999.*

Chen, F. F.: **Introduction to Plasma Physics and Controlled Fusion.** *Springer, New York, 2006.*

Kvasnica, J.: **Statistická fyzika.** *Academia, Praha, 1983.*

Landau, D. P., Binder, K.: **A Guide to Monte Carlo Simulation in Statistical Physics.** *Cambridge University Press, Cambridge, 2005.*

Lukeš, J.: **Zápisky z funkcionální analýzy.** *MFF UK, Karolinum, 1998.*

Málek, J., Nečas, J., Rokyta, M., Růžička, M.: **Weak and Measure–valued solutions to evolutionary equations.** *Chapmann & Hall, 1996.*

Málek, J., Rajagopal, K.R.: **Mathematical issues concerning the Navier–Stokes equations and some of its generalizations.** *Evolutionary equations,*

vol. II, p. 371–459, Handb. Differ. Equ., ed. C.M. Dafermos, E. Feireisl. Elsevier–North–Holland, Amsterdam, 2005.

Maršík, F., Dvořák, I.: **Biotermodynamika.** *Academia, Praha, 1998.*

Maršík, F.: **Termodynamika kontinua.** *Academia, Praha, 1999.*

Nezbeda, I., Kolafa, J., Kotrla, M.: **Počítačové simulace.** *MFF UK, Praha, 1998.*

Novotný, A., Straškraba, I.: **Introduction to the mathematical theory of compressible flow.** *Oxford Lecture Series in Mathematics and its Applications, 27. Oxford University Press, Oxford, 2004.*

Perthame, B.: **Transport equations in biology.** *Frontiers in Mathematics. Birkhäuser Verlag, Basel, 2007.*

Phan—Thien, N.: **Understanding Viscoelasticty.** *Springer, 2002.*

Pratt, W. K.: **Digital Image Processing.** *Wiley, New York, 1991.*

Press, W. H. et al.: **Numerical Recipes — The Art of Scientific Computing.** *3rd ed. Cambridge University Press, Cambridge, 2007.*

Rapaport, D. C.: **The Art of Molecular Dynamics Simulations.** *Cambridge University Press, Cambridge, 1995.*

Roubíček, T.: **Nonlinear Partial Differential Equations with Applications.** *Birkhäuser, Basel, 2005.*

Spencer, A. J. M.: **Continuum Mechanics.** *Dover Books on Physics, Dover Publications, Dover, 2004.*

Temam, R.: **Navier–Stokes equations and nonlinear functional analysis.** *2nd ed. CBMS–NSF Regional Conference Series in Applied Mathematics, 66. Society for Industrial and Applied Mathematics (SIAM), Philadelphia, PA, 1995.*

Temam, R.: **Navier–Stokes equations. Theory and numerical analysis.** *Reprint of the 1984 edition. AMS Chelsea Publishing, Providence, RI, 2001.*

Zeidler, E.: **Applied Functional Analysis.** *Springer–Verlag, Berlin, 1995.*

Zeidler, E.: **Nonlinear Functional Analysis and its Applications, vol. I–V.** *Springer–Verlag, Berlin, 1986–1995.*

4F12 Physics Education and General Problems of Physics

Council of Doctoral Studies in Branch 4F12

List of members of the Council can be found at the address `http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-f12.htm` .

Committee for the State Doctoral Examinations K1

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address `http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk01.htm` .

Cooperating Institutes

- Astronomical Institute of the ASCR, v.v.i.
  Fričova 298, 251 65 Ondřejov
  http://www.asu.cas.cz/en/

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=F12 .

Courses Given

Code	Subject	Credits	Winter	Summer
NDFY029	**Problems of Physics Education**	3	0/2 C	—
NDFY054	**Modern Trends in Physics Education**	3	—	0/2 C
NDFY064	**Ph.D. Students' Seminar f12 I**	1	0/1 C	—
NDFY065	**Ph.D. Students' Seminar f12 II**	1	—	0/1 C
NDFY066	**Physical Worldview II**	3	—	0/2 C
NPOZ007	**Philosophical Problems of Physics**	2	0/1 C	0/1 C
NDFY071	**Introduction to Bibliographic and Scientific Research I**	1	0/1 C	—
NDFY072	**Introduction to Bibliographic and Scientific Research II**	1	—	0/1 C
NDFY042	**Development of Physical Experiments**	3	0/2 C	—
NDFY070	**Development of Physical Experiments II**	3	—	0/2 C
NDFY068	**Physics in the Cultural History of Mankind I**	3	2/0 Ex	—
NDFY069	**Physics in the Cultural History of Mankind II**	3	—	2/0 Ex
NPED040	**Introduction to Methodology of Pedagogical and Educational Research**	3	0/2 C	—
NPED041	**Methods in Pedagogical and Educational Research**	3	—	2/0 Ex
NDFY067	**Contemporary Trends in Pedagogy and Physics Education**	3	—	0/2 C
NDPP001	**Doctoral Seminar on Pedagogy and Psychology I**	3	0/2 C	—
NDPP002	**Doctoral Seminar on Pedagogy and Psychology II**	3	—	0/2 C

NPSY001	**Psychology of Teaching Profession**	3	2/0 Ex	—

List of Requirements for the State Doctoral Examination

The exam consists of three parts: I. General background, II. Areas of physics related to the topics of the dissertation thesis, III. Subspecialization.

I. General background

1. Conservation laws in physics, continuity equation. 2. Space and time, inertial and noninertial frames, kinematics and dynamics of special relativity. 3. Energy, momentum and angular momentum in various parts of physics. 4. Dynamics of various systems (equations of motion, variational formulation of physical laws, field equations). 5. Oscillators in classical and quantum mechanics. 6. Elements of classical electrodynamics (building theory from experiments and deduction from Maxwell equations). 7. Potentials and their physical meaning. 8. Waves (mechanical, electromagnetic, propagation, generation). 9. Interaction of electromagnetic waves with matter (both on the classical and the quantum level). 10. Physical laws in atomic and smaller dimensions (quantum description, basic ideas of nuclear and particle physics, applications). 11. Basic principles and applications of thermodynamic and statistical description. 12. Macroscopic properties of matter and their microscopic explanation. 13. Measurement of physical quantities (quantities and units, methods of measurements, basic physical constants and their measurements). 14. Physical basis of everyday phenomena and technologies (theoretical explanation of observed phenomena, application of results of physics). 15. Limits of validity of physical theories (relations between classical, quantum and relativistic physics, other examples like electrostatics – electrodynamics etc.).

General knowledge of physics in the spirit of Feynman's course is expected, including the ability to explain how basic physical laws and their consequences are connected with experimental results and applications. The ability to explain the topics by elementary means is also important.

II. Areas of physics related to the topics of the dissertation thesis

Because of the broad range of topics belonging to this specialization the Council of Doctoral Studies in specialization 4F12 sets the requirements individually for each candidate. The candidate should prove deeper physical insight into the part of physics connected with the topic of his or her dissertation.

III. Subspecialization

According to the topic of the dissertation thesis the candidate chooses one of three subspecializations: a) Physics Education, b) Philosophy and Methodology of Physics, c) History of Physics.

The candidate should prove their general knowledge of the area, be able to explain its roots, basic concepts and their connections (including their relations to various parts of physics), methods and most importantly results. In physics education it comprises for example the setting of educational goals, choice of teaching methods, methods of problem solving, didactic role of experiments and evaluation of results of education.

The scope of the exam corresponds to the Recommended literature below. The Council of Doctoral Studies in specialization 4F12 can adjust the requirements individually for each candidate according to the particular topic of the dissertation thesis.

Recommended Literature

Arons, A. B.: **Teaching introductory physics.** *Wiley, 1997.*

Bell, J.: **Doing your research project: a guide for first–time researchers in education, health and social science.** *Open Univ. Press, Maidenhead, 2005.*

Bennett, J.: **Teaching and Learning Science. A Guide to Recent Research and its Applications.** *Continuum, London, N.Y., 2003.*

Bertrand, Y.: **Contemporary theories and practice in education.** *Magna Publications, Madison, 1995.*

Cohen, L., Manion, L., Morrison, K.: **Research Methods in Education.** *Routledge–Falmer, 2000.*

Driver, R. et al.: **Making Sense of Secondary Science. Research into Children's Ideas.** *Routledge–Falmer, 1994.*

Feynman, R. P. et al.: **The Feynman Lectures on Physics.** *Addison–Wesley, 2005 (or other edition).*

Gorard, S., Taylor, C.: **Combining methods in educational and social research.** *Open Univ. Press, 2004.*

Griffiths, D. J.: **Introduction to quantum mechanics.** *Prentice Hall, 1995.*

Jackson, J. D.: **Classical Electrodynamics.** *Wiley, 1998.*

Kittel, Ch.: **Introduction to Solid State Physics.** *Wiley, 2004.*

Kragh, H.: **Quantum generations: a history of physics in the twentieth century.** *Princeton University Press, 2002.*

Kuhn, T. S.: **The Structure of Scientific Revolutions.** *University Of Chicago Press, 1995 (or any other edition).*

Landau, L. D., Lifshits, E. M.: **Mechanics.** *(or other textbook on theoretical mechanics)*

Popper, K.: **The Logic of Scientific Discovery.** *Routledge, 2002.*

Viennot, L.: **Teaching Physics.** *Kluwer, 2003.*

Wellington, J.: **Educational Research, Contemporary Issues and Practical Approaches.** *Continuum, London, 2000.*

Note: Further books and sources of information could be recommended by a supervisor and the Council of Doctoral Studies in specialization 4F12 according to the subspecialization of a candidate and the topic of his or her disertation thesis.

4F13 Physics of Nanostructures

Council of Doctoral Studies in Branch 4F13

List of members of the Council can be found at the address http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-f13.htm .

Committee for the State Doctoral Examinations K7

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk07.htm .

Cooperating Institutes

- Institute of Physics of the ASCR, v.v.i.
  Na Slovance 2, 182 21 Praha 8
  http://www.fzu.cz/

- Institute of Macromolecular Chemistry of the ASCR, v.v.i.
  Heyrovského nám. 2, 162 06 Praha 6
  http://www.imc.cas.cz/en/index.html

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=F13 .

Courses Given

Code	Subject	Credits	Winter	Summer
NEVF534	**Physics of Low-dimensional Structures**	3	2/0 Ex	2/0 Ex
NFPL199	**Physical Methods in Nanostructure Studies**	3	2/0 Ex	2/0 Ex
NEVF535	**Nanomaterials: Preparation, Properties and Applications**	3	2/0 Ex	2/0 Ex
NEVF533	**Physical Methods of Nanostructure Technology**	3	2/0 Ex	2/0 Ex
NFPL187	**Seminar on Nanomaterials: Physics, Technology, Applications I**	3	0/2 C	—
NFPL188	**Seminar on Nanomaterials: Physics, Technology, Applications II**	3	—	0/2 C

List of Requirements for the State Doctoral Examination

I. Broad basis

I.1. Structure properties and lattice dynamics

Crystallography of 2D and 3D lattices, surface relaxation and reconstructions, types of bonds. Phonons, surface phonon states, mechanical properties of nanostructures, plastic and elastic deformation.

I.2. Electronic structure, optical and magnetic properties

Electrons in a periodic medium, band structure, chemical bonds. Transport properties, continuity equation, transport equation, relaxation times, mechanisms of carrier scattering. Surface electron states, work function, electron states in low–dimensional systems. Linear response theory, optical transitions, quantum–confinement effect. Mangetic properties of low–dimensional structures.

II. Physical fundamentals

II.1. Basics of technology

Physical and chemical methods of growth of thin layers and nanoparticles. Growth methods used in the Ph.D. thesis. Classical nucleation theory, theory of thin film growth, processes of self–organization.

II.2. Methods of the nanlysis of nanostructures

Diffraction methods (x–ray and electron diffraction, neutron scattering), electron microscopy, ion microscopy, AFM, STM and other scanning methods. Methods of surface electron and ion spectroscopies (UPS, XPS, AES and others), optical methods (UV/VIS/IR spectroscopy, ellipsometry, Raman scattering, non–linear optical spectroscopy. Electrical and transport measurements (electrical conductivity, potentiostatic and potentiodynamic methods) and other experimental techniques according to the subject of the Ph.D. thesis.

Recommended Literature

Bhushan, B. (ed.): **Springer Handbook of Nanotechnology.** *2nd ed. Springer, 2007.*

Bimberg, D. et al.: **Quantum Dot Heterostructures.** *J. Wiley, 1999.*

Delerue, C., Lannoo, M.: **Nanostructures, theory and modeling.** *Springer, 2004.*

Edelstein, A. S., Cammarata, R.: **Nanomaterials, Synthesis, Properties and Application.** *Inst. of Physics Publishing, 1996.*

Frank, L., Král, J.: **Metody analýzy povrchu, iontové, sondové a speciální techniky.** *Academia, Praha, 2002.*

Gabrys, B. J. (ed.): **Applications of Neutron Scattering to Soft Condensed Matter.** *Gordon and Breach Science Publisher, 2000.*

Grundmann, M.: **Nano–optoelectronics.** *Springer, 2002.*

Guozhong, C.: **Nanostructures and Nanomaterials.** *Imp. Coll. Press, 2004.*

Herman, M. A., Richter, W., Sitter, H.: **Epitaxy: Physical Principles and Technical Implementation.** *Springer, 2004.*

Hirsch, P.: **Electron Microscopy of Thin Crystals.** *R. E. Krieger Publishing, 1977.*

Lowe, T. C., Valiev, R. Z. (eds.) **Investigations and Applications of Severe Plastic Deformation.** *NATO Science Series 80, Kluwer Academic Publishers, Dordrecht, 2000.*

Lu, G. Q., Zhao, X. S.: **Nanoporous Materials Science and Engineering.** *Imperial College Press, 2004.*

Michely, T., Krug, J.: **Atoms, Mounds and Atoms, Patterns and Processes in Crystal Growth Far from Equilibrium.** *Springer, 2004.*

Mills, D. J., Bland, J. A. C. (eds): **Nanomagnetism.** *Elsevier, 2006.*

Ozin, G. A., Arsenault, A. C.: **Nanochemistry.** *RSC Publ., 2005.*

Pietsch, U. et al.: **High–resolution x–ray scattering from thin films and nanostructures.** *Springer, 2004.*

Reich, S., Thomsen, C., Maultzsch, J.: **Carbon Nanotubes.** *J. Wiley, 2003.*

Roe, R.–J.: **Methods of x–ray and Neutron Scattering in Polymer Science.** *Oxford University Press, Oxford, 2000.*

Shchukin, V. A., Ledentsov, N. N., Bimberg, D.: **Epitaxy of Nanostructures.** *Springer, 2004.*

Venables, J. A.: **Introduction to Surface and Thin Film Processes.** *Cambridge University Press, Cambridge, 2000.*

Williams, D. B., Carter, C. B.: **Transmission Electron Microscopy, a Textbook for Material Science.** *Plenum Press, New York, 1996.*

Wolf, E. L.: **Nanophysics and Nanotechnology, An Introduction to Modern Concepts in Nanoscience.** *Wiley–VCH, Berlin, 2006.*

Study Programme COMPUTER SCIENCE

Council for Doctoral Studies in Computer Science

List of members of the Council can be found at the address http://www.mff.cuni.cz/to.en/studium/phd/obory/ors.htm#nor4-i .

4I1 Theoretical Computer Science

Council of Doctoral Studies in Branch 4I1

List of members of the Council can be found at the address http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-i1.htm .

Committee for the State Doctoral Examinations K2

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk02.htm .

Cooperating Institutes

- Institute of Mathematics of the ASCR, v.v.i.
  Žitná 25, 115 67 Praha 1
  http://www.math.cas.cz

- Institute of Computer Science of the ASCR, v.v.i.
  Pod vodárenskou věží 2, 182 07 Praha 8
  http://www.cs.cas.cz/

- Institute of Information Theory and Automation of the ASCR, v.v.i.
  Pod vodárenskou věží 4/1143, 182 08 Praha 8
  http://www.utia.cas.cz

- Institute of Thermomechanics of the ASCR, v.v.i.
  Dolejškova 1402/5, 182 00 Praha 8
  http://www.it.cas.cz/?q=en/node

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=I1 .

Courses Given

Code	Subject	Credits	Winter	Summer
NDMI018	**Approximation and Online Algorithms**	3	—	2/1 C+Ex
NDMI025	**Randomized Algorithms**	3	—	2/1 C+Ex
NTIN050	**Seminar on Computational Complexity**	3	0/2 C	0/2 C
NAIL076	**Logic Programming I**	3	2/0 Ex	—
NAIL077	**Logic Programming II**	3	—	2/0 Ex
NAIL078	**Lambda Calculus and Functional Programming I**	5	2/1 C+Ex	—
NAIL079	**Lambda Calculus and Functional Programming II**	5	—	2/1 C+Ex
NTIN088	**Algorithmic Randomness I**	3	2/0 Ex	—
NTIN089	**Algorithmic Randomness II**	3	—	2/0 Ex
NAIL013	**Applications of Neural Networks Theory**	3	—	2/0 Ex
NAIL026	**Theoretical Issues in Neural Networks — Approximation**	3	2/0 Ex	—
NAIL021	**Boolean Functions and Their Applications**	3	2/0 Ex	—
NAIL031	**Representations of Boolean Functions**	3	2/0 Ex	—
NTIN081	**Structural Complexity I**	3	2/0 Ex	—
NTIN082	**Structural Complexity II**	3	—	2/0 Ex
NTIN006	**Algebraic Algorithms**	3	2/0 Ex	—
NOPT042	**Constraint Programming**	5	2/1 Ex	—
NAIL071	**Planning and Scheduling**	3	—	2/0 Ex
NAIL029	**Machine Learning**	3	2/0 Ex	—
NAIL025	**Evolutionary Algorithms I**	6	2/2 C+Ex	—
NDBI029	**Statistical Aspects of Data Mining**	3	—	1/1 Ex

List of Requirements for the State Doctoral Examination

For branch 4I1 Theoretical Computer Science are obligatory three themes from suggested themes, at least one must be 1. or 2., and profiling theme choosen by supervisor:

1. Logic, algebra

Propositional and predicate logic, syntax and semantics, their connections. Formal systems, elementary arithmetics, Peano arithmetics, Presburger arithmetics, complete arithmetics, consistency and completeness, Goedel's theorems. Turing machines. Algorithmically undecidable problems, undecidability of predicate logic, undecidability of consistent extensions of elementary arithmetic. Undefinability of truth in arithmetics. Recursion theorems. Theory of formal languages and finite automata. Selected algebraic structures, universal algebras. Introduction to model theory, standard model of

arithmetics, existence of non–standard models of arithmetics, algebraic specification of programs.

2. Complexity theory

Models of sequential and parallel computers. Boolean formulas and circuits, branching programs. Complexity measures. Nondeterministic, alternating and interactive computations. Complexity classes, reduction and complete problems, polynomial hierarchy. Propositional calculi and their complexity. Lower bounds for explicit functions and formulas. Randomness and pseudorandomness. Communication complexity and its applications.

3. Discrete mathematics

Graph theory, graph algoritms. Linear programming and duality. Fundamentals of game theory, types of games, their solutions. Combinatorial principles and their applications. Extremal problems in combinatorics. Probabilistic methods in combinatorics. Self–repairing codes.

4. Algorithms

Deterministic, probalistic and parallel algorithms. Design of effective algorithms and their analysis. Effective data structures and their analysis. Effective algorithms for linear programming and their applications. Methods for solving hard problems: approximation algorithms, schemes, and heuristic methods. Basic cryptographic protocols.

5. Artificial intelligence

Automatic reasoning, resolution method, proving in equality theories. Declarative programming languages. Knowledge representation, uncertainity, multiagent systems, machine learning, methods for data mining. Cognitive systems. Search in state space, metaheuristics, their examples and applications, local search. Planning, constraint satisfaction, boolean satifiability. Neural nets and their models, applications and properties. Genetic algorithms and evolutionary programming.

Recommended Literature

1. Logic, algebra:

Birkhoff, G., MacLane, S.: **Prehlad modernej algebry.** *Alfa, Bratislava, 1979.*

Demuth, O., Kryl, R., Kučera, A.: **Teorie algoritmů I, II.** *SPN, Praha, 1989.*

Hájek, P., Pudlák, P.: **Metamathematics of first–order arithmetic.** *Springer–Verlag, Berlin, 1993.*

Ježek, J.: **Univerzální algebra a teorie modelů.** *SNTL, Praha, 1976.*

Nies, A.: **Computability and randomness.** *Oxford University Press, Oxford, 2009.*

Shoenfield, J. R.: **Mathematical logic.** *Addison–Wesley, Reading, MA, 1967.*

Soare, R. I.: **Recursively enumerable sets and degrees.** *Springer–Verlag, Berlin–Heidelberg–New York, 1987.*

Štěpánek, P.: **Meze formální metody.** `http://ktiml.mff.cuni.cz/index.php?select=teaching&section=sources&lang=czech` .

Štěpánek, P.: **Predikátová logika.** `http://ktiml.mff.cuni.cz/index.php?select=teaching&section=sources&lang=czech` .

Švejdar, V.: **Logika: neúplnost, složitost a nutnost.** *Academia, Praha, 2002.*

2. Complexity theory:

Arora, S., Barak, B.: **Computational Complexity: A Modern Approach.** `http://www.cs.princeton.edu/theory/index.php/Compbook/Draft` .
Hopcroft, J. E., Ullman, J. D.: **Introduction to Automata Theory, Languages and Computation.** *Addison–Wesley, Reading, MA, 1979.*
Hromkovič, J.: **Communication Complexity and Parallel Computing.** *Springer–Verlag, Berlin, 1997.*
Kushilevitz, E., Nisan, N.: **Communication complexity.** *Cambridge University Press, Cambridge, 1997.*
Papadimitriou, C. H.: **Computational Complexity.** *Addison–Wesley, Reading, MA, 1994.*
Sipser, M.: **Introduction to the Theory of Computation.** *PWS Publishing Company, Boston, 1997.*

3. Discrete mathematics:

Alon, N., Spencer, J.: **The Probabilistic Method.** *Wiley, 2001.*
Diestel, R.: **Graph Theory.** *2nd ed. Springer–Verlag, 2000.*
MacWilliams, F. J., Sloane, N. J. A.: **The Theory of Error–Correcting Codes.** *North–Holland, Amsterdam, 1977.*
Matoušek, J., Nešetřil, J.: **Kapitoly z diskrétní matematiky.** *Karolinum, Praha, 2000.*
Matoušek, J.: **Lineární programování a lineární algebra pro informatiky.** *ITI Series 2006–311.*
Schrijver, A.: **Theory of linear and integer programming.** *Wiley, 1998.*

4. Algorithms:

Cormen, T. H., Leiserson, C. E., Rivest, R. L., Stein, C.: **Introduction to Algorithms.** *2nd ed. MIT Press, 2001.*
Jájá, J.: **An Introduction to Parallel Algorithms.** *Addison–Wesley, Reading, MA, 1992.*
Kleinberg, J., Tardos, E.: **Algorithms Design.** *Addison–Wesley, Reading, MA, 2005.*
Motwani, R., Raghavan, P.: **Randomized algorithms.** *Cambridge University Press, Cambridge, 1995.*
Vazirani, V. V.: **Approximation Algorithms.** *Springer–Verlag, 2001.*

5. Artificial intelligence:

De Raedt, L.: **Logical and Relational Learning.** *Springer–Verlag, Berlin, 2008.*
Ghallab, M., Nau, D., Traverso, P.: **Automated Planning: Theory and Practice.** *Morgan Kaufmann, 2004.*

Haykin, S.: **Neural Networks: A Comprehensive Foundation.** *2nd ed. Prentice Hall, 1999.*
Michalewicz, Z.: **Genetic Algorithms + Data Structures = Evolution Programs.** *Springer–Verlag, 1999.*
Nolfi, S., Floreanoà D.: **Evolutionary robotics, the biology, intelligence and technology of self–organizing machines.** *The MIT Press, Cambridge, 2000.*
Pfeifer, R., Scheier, C.: **Understanding Intelligence.** *The MIT Press, Cambridge, 2001.*
Robinson, A., Voronkov, A. (eds.): **Handbook of Automated Reasoning I, II.** *Elsevier, Amsterdam, The MIT Press, Cambridge, 2001.*
Rossi, F., Beek van, P., Walsh, T. (eds.): **Handbook of Constraint Programming.** *Elsevier, 2006.*
Russell, S. J., Norvig, P.: **Artificial Intelligence: A Modern Approach.** *Prentice Hall, 2003.*
Šíma, J., Neruda, R.: **Teoretické otázky neuronových sítí.** *Matfyz Press, Praha, 1996.*

4I2 Software Systems

Council of Doctoral Studies in Branch 4I2

List of members of the Council can be found at the address `http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-i2.htm` .

Committee for the State Doctoral Examinations K2

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address `http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk02.htm` .

Cooperating Institutes

- Institute of Mathematics of the ASCR, v.v.i.
  Žitná 25, 115 67 Praha 1
  `http://www.math.cas.cz`

- Institute of Computer Science of the ASCR, v.v.i.
  Pod vodárenskou věží 2, 182 07 Praha 8
  `http://www.cs.cas.cz/`

- Institute of Information Theory and Automation of the ASCR, v.v.i.
  Pod vodárenskou věží 4/1143, 182 08 Praha 8
  `http://www.utia.cas.cz`

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in `http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=I2` .

Courses Given

Code	Subject	Credits	Winter	Summer
NTIN055	**Parallel Architectures**	3	2/0 Ex	—
NTIN044	**Semantics of Programming Languages**	5	—	2/1 C+Ex
NDBI016	**Transactions**	3	—	2/0 Ex
NSWI104	**Company Project Management**	3	—	0/2 C
NSWI057	**Advanced topics in distributed and component-based systems I**	6	0/4 C	—
NSWI058	**Advanced topics in distributed and component-based systems II**	6	—	0/4 C
NSWI068	**Object and Component Systems**	5	2/1 C+Ex	—
NSWI132	**Program Analysis and Code Verification**	6	2/2 C+Ex	—
NSWI101	**System Behaviour Models and Verification**	6	—	2/2 C+Ex
NPRG042	**Programming in Parallel Environment**	5	—	2/1 C+Ex
NSWI080	**Middleware**	5	—	2/1 C+Ex
NDBI019	**Stochastic Methods in Databases**	3	—	2/0 Ex
NTIN083	**Seminar on Data Structures**	3	0/2 C	—
NPRG021	**Selected Topics on Java Language**	3	—	0/2 C
NDBI033	**Non-traditional Database Models, Architectures and Languages**	3	2/0 Ex	—

List of Requirements for the State Doctoral Examination

Topic groups 1 and 2 are obligatory. In addition to these, the candidate selects two additional topic groups from the list below, and one specialization topic based on his/her field of study. The selection is consulted with the advisor. State of the art knowledge in the specialization topic, based on the directions of the advisor, is required. The specialization topic does not necessarily belong to any of the topic groups, but is assigned by the chairman of the Council of Doctoral Studies in Branch 4I2 on recommendation of the advisor. The entire selection of the topic groups is also subject to approval of the Council of Doctoral Studies in Branch 4I2.

1. Theoretial foundations of computer science

Discrete mathematics: Fundamentals of graph theory, representation of graphs in memory, graph algorithms. **Algebra, logic, algorithms:** Selected algebraic structures, universal algebras. Predicate calculus. Formal systems, consistency and completeness, Goedel's theorems. Decidability of formal systems, model theory. Unification. Computability theory, Turing machines and equivalent models of computation.

Algorithms and their complexity, NP–complete problems. Algoritmically undecidable problems. Theorems on recursion.

2. Teoretical foundations of software systems

Formal languages, grammars, and automata. Formal models and specification of semantics of languages. Attribute grammars. Formal semantics of parallel systems, transitional systems as the low level semantics; equivalence, model checking, models of parallel systems, Petri nets, algebraic models, CCS and CSP. Verification of parallel systems in practice. Methods of formal and algebraic specifications. Lambda calculus, type systems.

3. Languages and compilers:

Programming language concepts, procedural and non–procedural languages. Architecture of a procedural–language compiler. Parsing, LL, LR and GLR parsers, RRP grammars. Attribute grammars. Implementation of languages with nested procedures and object languages, late binding. Sequential and non–sequential intermediate representation, basic blocks. Dependency analysis, SSA code. The impact of modern processor architectures on code generation. Register allocation. Code generation and optimization with instruction–level parallelism. Scheduling, list scheduling, trace scheduling, software pipelining.

4. Distributed systems

Distributed systems architectures. Communication, messaging, RPC, group communication, communication protocols. Distributed synchronization, mutual exclusion, election, global state, distributed consensus. Distributed file systems, replication, naming. Process migration, load balancing. Distributed shared memory, consistency models, distributed paging.

5. Operating systems

Computer architecture. Concepts and protocols in computer networks. Concepts and structure in operating systems. Kernel level abstractions. Mikrokernel, abstractions and techniques for memory management and process management outside kernel. Process synchronization, synchronization tools, implementation on multiprocessor and parallel systems. Virtualized memory with large address spaces. Distributed and networked file systems, file systems for special storage devices, low overhead file systems, high reliability file systems, transactional file systems, journalled file systems.

6. Database systems

Conceptual models. Relational data model — theory of functional dependencies, query languages — their expressive power and complexity, incomplete information, complex objects. Logic as a language for databases: Datalog and its semantics, deductive databases. Models of object databases, object query languages, types theory. Implementation problems of databases — data structures suitable for indexing, transactional models, optimization problems. New databases architectures: data warehouses, multidimensional databases, databases and Web, XML databases.

7. Object oriented systems

Class based language concepts (inheritance, delegation, subsumption, type information, covariance, contravariance, typing of self, separating of subclassing from subtyping, parametrized and generic types). Prototype based language concepts (prototypes, clones, delegation, dynamic inheritance). Mixins. Aspect oriented programming. Object oriented models for distributed enviroments. Component models. Behavior

models for objects and components. Object oriented modeling and design, principles of supporting tools. Model driven development. Implementation of object oriented language constructs.

8. Middleware systems

Network and distributed application architectures, client–server, multi–tier, services, agents. Communication middleware, standards, interfaces. Client–server and multi–tier application technologies, applets, servlets, transactional middleware, application servers. Mobile computing platforms. Ad–hoc and sensor networks. Interoperability, data formats, protocols. Security, algorithms for authentication and encryption.

9. Software engineering

Subject of SW engineering, reasons of success and failure of SW projects. Strategic goals of information systems, stakeholders. Social consequences of usage of information technologies. Basics of computer ergonomics (RSI). Preparation of SW projects, risk analysis, marketing and principles of negotiations. Business process reengineering, outsourcing. Requirements analysis techniques. Reviews in software development. SW prototypes. Software development processes. Software metrics. SW estimation methods (COCOMO, Function Points). Principles of project management and software teams organizations. SW architectures, middleware, XML. Diagrams for specification and design of SW. Notations and diagrams for SW artefacts documentation, SW modeling. Testing and configurations management. SW delivery and maintenance. SW documentation. SW evaluation. User interface development techniques.

Recommended Literature

Topic 1:

Cormen, T. H., Leiserson, C. E., Rivest, R. L., Stein, C.: **Introduction to Algorithms.** *2nd ed. MIT Press, 2001.*

Demuth. O., Kryl, R., Kučera, A.: **Teorie algoritmů I, II.** *SPN, Praha, 1989.*

Garey, M. R., Johnson, D. S.: **Computers and Intractability: A Guide to the Theory of NP–completeness.** *W. H. Freeman, San Francisco, 1978.*

Hopcroft, J. E., Motwani, R., Ullman, J. D.: **Introduction to Automata Theory, Languages and Computation.** *3rd ed. Addison–Wesley, 2007.*

McKenzie, R. N., McNulty, G. F., Taylor, W. F.: **Algebras, Lattices, Varieties.** *Advanced Books and Software, Wadsworth and Brooks/Cole, Monterey, 1987.*

Mehlhorn, K.: **Data Structures and Algorithms 2: Graph Algorithms and NP–completeness.** *EATCS – monograph, Springer–Verlag, 1984.*

Soare, R. I.: **Recursively enumerable sets and degrees.** *Springer–Verlag, 1987.*

Tarjan, R. E.: **Data Structures and Network Algorithms.** *Society for Industrial and Applied Mathematics, Philadelphia, 1983.*

Topic 2:

Emerson, E. A.: **Temporal and Modal Logic.** *Volume B of Handbook of TCS, Elsevier, 1990, p. 995–1072.*

Esparza, J.: **Decidability and Complexity of Petri Net Problems – an Introduction.** *Lectures on Petri Nets I: Basic Models. Advances in Petri Nets, LNCS 1491, Springer–Verlag, 1988, p. 374–428.*
Glaabeek van, R.: **The Linear Time–Branching Time Spectrum.** *Proc. of Concur 90, LNCS 458, Springer–Verlag, 1990, p. 278–297.*
McMillan, K.: **Symbolic Model–Checking.** *Kluwer, 1993.*
Milner, R.: **Communication and Concurrency.** *Prentice Hall, 1995.*
Peterson, J. L.: **Petri Net Theory and the Modelling of Systems.** *Prentice Hall, 1981.*
Stirling, C.: **Modal and Temporal Logics.** *Handbook of Logic in Computer Science, Oxford, 1992, p. 477–563.*
Thomas, W.: **Automata on Infinite Objects.** *Volume B of Handbook of TCS, Elsevier, 1990, p. 135–192.*
Vardi, M.: **An Automata–Theoretic Approach to LTL.** *Logics for Concurrency, LNCS 1043, Springer–Verlag, 1996, p. 238–263.*

Topic 3:

Aho, A. V., Sethi, R., Ullman, J. D.: **Compilers: Principles, Techniques and Tools.** *Addison–Wesley, 1988.*
Allan, V. H., Jones, R. B., Lee, R. M., Allan, S. J.: **Software Pipelining.** *In ACM Computing Surveys 27, 3 (September), ACM, 1995, p. 367–432.*
Grune, D., Bal, H. E., Jacobs, C. J. H., Langendoen, K. G.: **Modern Compiler Design.** *J. Wiley, 2000.*
Mak, R.: **Writing Compilers And Interpreters.** *Wiley Computer Publishing, 1996.*
Penrose, D. E. M., Palmer, C.: **Advanced Compiler Design and Implementation.** *Morgan Kaufmann Publishers, 1997.*
Wall, D.: **Limits to instruction level parallelism.** *Proc. 4th Architectural Support for Programming Languages and Operating Systems, ACM, 1991, p. 176–188.*

Topic 4:

Attiya, H., Welch, R.: **Distributed Computing — Fundamentals, Simulations and Advanced Topics.** *2nd ed. Wiley Interscience, 2004.*
Dollimore, J.: **Distributed Systems: Concepts and Design.** *4th ed. Addison–Wesley, 2005.*
Goscinski, A.: **Distributed Operating Systems — The Logical Design.** *Addison–Wesley, 1992.*
Mullender, S.: **Distributed Systems.** *2nd ed. Addison–Wesley, 1993.*
Tanenbaum, A.: **Distributed Operating Systems.** *Prentice Hall, 1994.*
Tanenbaum, A.: **Distributed Systems: Principles and Paradigms.** *2nd ed. Prentice Hall, 2006.*

Topic 5:

Boykin, J., Kirschen, D., Langerman, A., LoVerso, S.: **Programming under Mach.** *Addison–Wesley, 1993.*
Herlihy, M.: **The Art of Multiprocessor Programming.** *Morgan Kaufmann, 2008.*
Chow, R., Johnson, T.: **Distributed Operating Systems and Algorithms.** *Addison–Wesley, 1997.*
Love, R.: **Linux Kernel Development.** *2nd ed. Novell Press, 2005.*
Plášil, F., Staudek, F.: **Operační systémy.** *SNTL, Praha, 1991.*
Russinovich, M.: **Microsoft Windows Internals.** *4th ed. Microsoft Press, 2005.*
Schimmel, C.: **Unix Systems for Modern Architectures.** *Addison–Wesley, 1994.*
Stallings, W.: **Operating Systems, Internals and Design Principles.** *6th ed. Prentice Hall, 2008.*
Vahalia, U.: **Unix Internals.** *2nd ed. The new Frontiers, Prentice Hall, 2001.*

Topic 6:

Abiteboul, S., Buneman, P., Suciu, D.: **Data on the web: from relations to semistructured data and XML.** *Morgan Kaufmann, San Francisco, 2000.*
Abiteboul, S., Hull, R., Vianu, V.: **Foundations of Databases.** *Addison–Wesley, 1995.*
Atzeni, P., DeAntonellis, V.: **Relational Database Theory.** *Benjamin & Cummings Publ. Co., Menlo Park California, 1993.*
Atzeni, P.: **Database systems: concepts, languages and architectures.** *McGraw–Hill, London, 1999.*
Garcia–Molina, H., Ullman, J., Widom, J.: **Database System Implementation.** *Prentice Hall, 2000.*
Gray, J., Reuter, A.: **Transaction processing: concepts and techniques.** *Kaufmann, San Mateo, 1993.*
Silberschatz, A. H., Korth, H. F., Sudarashan, S.: **Database system concepts.** *3rd ed. McGraw–Hill, Boston, 1999.*
Thalheim, B.: **Entity–Relationship Modeling Foundations of Database Technology.** *Springer–Verlag, 2000.*
Ullman, J. D.: **Principles of Database and Knowledge–Base Systems.** *Volume I. Computer Science Press, 1988.*
Ullman, J. D.: **Principles of Database and Knowledge–Base Systems.** *Volume II. Computer Science Press, 1989.*

Topic 7:

Abadi, M., Cardelli, L.: **A theory of Objects.** *Corrected ed. Springer–Verlag, 1998.*
Eliens, A.: **Principles of Object–Oriented Software Development.** *2nd ed. Addison–Wesley, 2000.*

Leavens, G. T., Sitaraman, M. (eds.): **Foundations of Component–based Systems.** *Cambridge University Press, Cambridge, 2000.*
Miles, R.: **AspectJ Cookbook.** *O'Reilly, 2004.*
Pierce, B.: **Types and Programming Languages.** *MIT Press, 2002.*
Plášil, F., Stahl, M.: **An Architectural view of distributed objects and components in CORBA, Java RMI and COM/DCOM.** *Software Concepts andvTools, vol. 19, no. 1, Springer–Verlag, 1998.*
Rausch, A. et al.: **The Common Component Modeling Example: Comparing Software Component Models.** *Springer–Verlag, 2008.*
Stahl, T., Volter, M.: **Model–driven Software Development.** *J. Wiley & Sons, 2006.*
Szyperski, C.: **Component Software: Beyond Object–Oriented Programming.** *2nd ed. Addison–Wesley, 2002.*

Topic 8:

Attiya, H., Welch, R.: **Distributed Computing — Fundamentals, Simulations and Advanced Topics.** *2nd ed. Wiley Interscience, 2004.*
Baker, S.: **CORBA Distributed Objects, Using Orbix.** *Addison–Wesley, 1997.*
Krakowiak, S. et al: **Advances in Distributed Computing: From Algorithms to Systems.** *Springer–Verlag, 2000.*
Microsoft: **Microsoft .NET Architecture.** `http://www.microsoft.com` .
OASIS: **Web Service Standard Specifications.** `http://www.oasis-open.org` .
Object Management Group: **Common Object Request Broker Architecture.** `http://www.omg.org` .
Orfali, R. et al: **Client/Server Survival Guide.** *3rd ed. J. Wiley & Sons, 1999.*
Pfleeger, Ch.: **Security In Computing.** *4th ed. Prentice Hall, 2006.*
Sun Microsystems: **Enterprise Java.** `http://www.sun.com` .

Topic 9:

Adair, J.: **Vytváření efektivních týmů.** *Management Press, Praha, 1994.*
Arlow, J., Neustadt, I.: **UML 2 a unifikovaný proces vývoje aplikací.** *Computer Press, 2007.*
Fowler, M.: **UML Distilled: A Brief Guide to the Standard Object Modeling Language.** *3rd ed. Addison–Wesley, 2003.*
Hall, E. M.: **Managing Risks — Methods for Software Systems Development.** *Addison–Wesley, 1998.*
Jarvis, A., Kehoe, R.: **A Tool for Software Products and Process Improvement.** *Springer–Verlag, 1996.*
Koubek, J.: **Řízení lidských zdrojů — Základy moderní personalistiky.** *Management Press, Praha, 1999.*
Král, J.: **Informační systémy.** *Science Veletiny, 1998.*
Landauer, T. K.: **The Trouble with Computers.** *MIT Press, 1995.*

Larman, C.: **Applying UML and Patterns: An Introduction to Object–Oriented Analysis and Design and Iterative Development.** *3rd ed. Prentice Hall, 2007.*
Lax, D. A., Sebenius, J. K.: **Manažer jako vyjednavač.** *Victoria Publ., Praha, 1994.*
Moore, J. W.: **Software Engineering Standards — A User Road Map.** *IEEE, Los Alamitos, Ca., 1998.*
Nielsen, J.: **Usability Engineering.** *Academic Press, 1995.*
Pressman, R. S.: **Software Engineering — A Practiticioner Approach.** *6th ed. McGraw–Hill, 2004.*
Sommerville, I.: **Software Engineering.** *8th ed. Addison–Wesley, 2008.*
Steward, C. J., Steward, C.: **Interviewing Principles and Practices.** *Oracle Co., Berkshire, 1994.*

4I3 Mathematical Linguistics

Council of Doctoral Studies in Branch 4I3

List of members of the Council can be found at the address `http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-i3.htm` .

Committee for the State Doctoral Examinations K2

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address `http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk02.htm` .

Cooperating Institutes

- Institute of Mathematics of the ASCR, v.v.i.
  Žitná 25, 115 67 Praha 1
  `http://www.math.cas.cz`

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in `http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=I3` .

Courses Given

Code	Subject	Credits	Winter	Summer
NPFL004	**Seminar on Formal Linguistics**	3	0/2 C	0/2 C
NPFL006	**Introduction to Formal Linguistics**	3	2/0 Ex	—
NPFL024	**Syntactic Parsing of Czech**	3	—	0/2 C
NPFL051	**Syntax without Transformations**	3	0/2 C	—

NPFL012	**Introduction to Computer Linguistics**	3	2/0 Ex	—
NPFL015	**Tools of Automated Translation**	3	0/2 C	—
NPFL007	**Computer Processing of Natural Language**	3	2/0 C	—
NPFL044	**Automatic Speech Recognition**	3	2/0 Ex	—
NPFL054	**Introduction to Machine Learning (in computer linguistics)**	6	2/2 C+Ex	—
NPFL035	**Grammatical Exercises for Ph.D. Students**	3	—	0/2 C
NPFL067	**Statistical Methods in Natural Language Processing I**	6	2/2 C+Ex	—
NPFL068	**Statistical Methods in Natural Language Processing II**	6	—	2/2 C+Ex
NPFL042	**Text-to-speech Synthesis**	3	—	2/0 Ex
NPFL064	**Reading Texts in General Linguistics**	2	—	0/1 C
NPFL066	**Corpus Linguistics — Applications**	3	—	0/2 C
NPFL071	**Selected Problems in Linguistics I**	3	2/0 Ex	—
NPFL072	**Selected Problems in Linguistics II**	3	—	2/0 Ex
NPFL074	**Mathematical Methods in Linguistics II**	3	—	0/2 C
NPFL076	**Language Data Resources II**	3	—	0/2 MC
NPFL077	**Seminar for Ph.D. Students — Presentation of Research Results**	3	0/2 C	0/2 C
NPFL083	**Linguistic Theory and Grammar Formalisms**	5	—	2/1 C+Ex
NPFL079	**Algorithms in Speech Recognition**	6	—	2/2 C+Ex
NPFL087	**Statistical Machine Translation**	3	—	0/2 MC
NPFL075	**Prague Dependency Treebank**	5	2/1 Ex	—
NPFL086	**Lexicology — Words and Meanings**	3	—	0/2 C

List of Requirements for the State Doctoral Examination

Modules 1 and 2 are obligatory, the choice of the third part will depend on the postgraduate student's profile.

1. Mathematical foundations of computational linguistics

Propositional calculus and predicate logic and its specific cases, syntax and semantics, their mutual relationship. Extensional and intensional logic, lambda–calculus.

Formal languages and automata, Chomsky's hierarchy of languages and grammars. Categorial grammars and lexicalized grammars. Basic terms of graph theory.

2. Formal linguistics

Structural linguistics and its sources. Formal description of natural language. Development of Chomsky's theory of grammar: standard theory, extended standard theory, theory of principles and parameters, universal grammar, the minimalist program. Optimality theory, lexical functional grammar, HPSG. Dependency–based approaches, stratificational approaches, Meaning–Text Theory, Tree Adjoining Grammar. Functional Generative Description. Formal semantics.

3. Computational and corpus linguistics

Morphological and syntactic analysis (symbolic methods, statistical methods). Natural language generation. Human–machine communication: knowledge–based systems, artificial intelligence, neural networks. Machine translation. Quantitative linguistics. Automatic speech recognition and speech synthesis. Text corpora. Annotated corpora and their types. Computational lexicography.

4. Natural language processing: Statistical methods and machine learning

Hidden Markov Models (Baum–Welch algorithm, Forward–Backward algorithm, Viterbi algorithm). Probabilistic context–free grammars. Language models. Translation models. Smoothing. Linear and non–linear classification methods. Clustering. Decision trees. Evaluation metrics.. Classification comparison. Tests for the statistical significance of experiment result.

Recommended Literature

Topic 1:

Bach, E.: **Informal Lectures on Formal Semantics.** *State University of New York, 1989.*
Hopcroft, J. E., Rajeev, M., Ullman, J. D.: **Introduction to Automata Theory, Languages and Computation.** *3rd ed. Adison Wesley, 2006.*
Chytil, M: **Automaty a gramatiky.** *SNTL, Praha, 1984.*
Nešetřil, J.: **Teorie grafů.** *SNTL, Praha, 1979.*
Partee, B. H., Meulen ter, A., Wall, R.: **Mathematical Methods in Linguistics.** *corrected 1st ed. Kluwer, Dordrecht, 1993.*
Peregrin, J.: **Úvod do teoretické sémantiky.** *FF MU, Brno, 1994.*
Štěpánek, P.: **Predikátová logika.** `http://ktiml.mff.cuni.cz/index.php?select=teaching&section=sources&lang=czech` .

Topic 2:

Abeillé, A., Rambow, O. (eds.): **Tree Adjoining Grammar: An Overview.** *Tree Adjoining Grammars. Formalisms, Linguistic Analysis and Processing. The University of Chicago Press, 2000.*
Čermák, F.: **Jazyk a jazykověda.** *3. vydání. Karolinum, 1997.*
Černý, J.: **Dějiny lingvistiky.** *Votobia, Olomouc, 1997.*

Hajičová, E., Sgall, P., Panevová, J.: **Úvod do teoretické a počítačové lingvistiky.** *Svazek 1 Teoretická lingvistika. Karolinum, Praha, 2002.*
Chomsky, N.: **Syntaktické struktury.** *Academia, Praha, 1966.*
Kahane, S.: **The Meaning–Text Theory.** *In Agel, V. et al (eds.) Dependency and Valency. An International Handbook of Contemporary Research. De Gruyter, Berlin, 2004, p. 546–569.*
Lopatková, M., Plátek, M., Sgall, P.: **Towards a Formal Model for Functional Generative Description: Analysis by Reduction and Restarting Automata.** *The Prague Bulletin of Mathematical Linguistics 87, 2007, p. 7–26.*
Mathesius, M.: **Jazyk, kultura a slovesnost.** *Odeon, Praha, 1982.*
Mel'chuk, I. A.: **Dependency Syntax: Theory and Practice.** *State University of New York, Albany, 1988.*
Panevová, J.: **Formy a funkce ve stavbě české věty.** *Academia, Praha, 1980.*
Saussure de, F.: **Kurs obecné lingvistiky.** *Odeon, Praha, 1989.*
Sgall, P.: **Language in Its Multifarious Aspects.** *Karolinum, Praha, 2006.*
Skalička, V.: **Typ češtiny.** *Souborné dílo V. Skaličky, díl II. Karolinum, Praha, 2004, s. 475 – 536.*
Steedman, M.: **The Syntactic Process (Language, Speech and Communication).** *The MIT Press, 2001.*
Šmilauer, V.: **Novočeská skladba.** *SPN, Praha, 1966.*

Topic 3:

Allen, J.: **Natural Language Understanding.** *The Benjamins/Cummings Publishing Company, Inc., Rewood City, 1994.*
Cruse, D. A.: **Lexical Semantics.** *Cambridge University Press, Cambridge, 1986.*
Čermák F., Blatná R. (eds.): **Korpusová lingvistika: Stav a modelové přístupy.** *Nakl. Lidové noviny, Praha, 2006.*
Čermák, F., Klímová, J., Petkevič, V. (eds.): **Studie z korpusové lingvistiky.** *AUC – Philologica 3–4. Karolinum, Praha, 2000.*
Hajič, J.: **Disambiguation of Rich Inflection: Computational Morphology of Czech.** *Karolinum, Praha, 2004.*
Russel, S., Norvig, P.: **Artifitial Intelligence: A Modern Approach.** *Prentice Hall, 2002.*
Těšitelová, M.: **Otázky lexikální statistiky.** *Academia, Praha, 1974.*

Topic 4:

Alpaydin, E.: **Introduction to Machine Learning.** *MIT Press, 2004.*
Bishop, Ch.: **Pattern Recognition and Machine Learning.** *Springer, 2007.*
Duda, R. O., Hart, P. E.: **Pattern Classification** *2nd ed. Wiley–Interscience, 2000.*
Hatie, T., Tibshirani, R., Friedman, J.: **The Elements of Statistical Learning: Data Mining, Inference and Prediction.** *Springer, 2001.*
Jelinek, F.: **Statistical Methods for Speech Recognition.** *MIT Press, 1997.*
Manning C. D., Schuetze, H.: **Foundations of Statistical Natural Language Processing.** *MIT Press, Cambridge, 1999.*

Ripley, B. D.: **Pattern Recognition and Neural Networks.** *Cambridge University Press, Cambridge, 1996.*
Venables, W. N., Ripley, B. D.: **Modern Applied Statistics with S.** *4th ed. Springer, 2003.*

4I4 Discrete Models and Algorithms

Council of Doctoral Studies in Branch 4I4

List of members of the Council can be found at the address `http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-i4.htm` .

Committee for the State Doctoral Examinations K2

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address `http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk02.htm` .

Cooperating Institutes

- Institute of Mathematics of the ASCR, v.v.i.
  Žitná 25, 115 67 Praha 1
  `http://www.math.cas.cz`

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in `http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=I4` .

Courses Given

Code	Subject	Credits	Winter	Summer
NTIN022	**Probabilistic Method**	6	2/2 C+Ex	—
NDMI035	**Geometric Representations of Graphs II**	3	—	2/0 Ex
NDMI009	**Combinatorial and Computational Geometry I**	6	2/2 C+Ex	—
NDMI013	**Combinatorial and Computational Geometry II**	6	—	2/2 C+Ex
NDMI041	**Seminar on Combinatorics for Advanced Students**	3	0/2 C	0/2 C
NDMI028	**Linear Algebra Applications in Combinatorics**	6	2/2 C+Ex	—
NDMI036	**Combinatorial Structures**	3	—	2/0 Ex
NDMI015	**Combinatorial Counting**	3	—	2/0 Ex
NDMI042	**Graphs and Homomorphisms**	3	2/0 Ex	—

NDMI070	**Selected Chapters on Graph Theory**	3	2/0 Ex	2/0 Ex
NDMI045	**Analytic and Combinatorial Number Theory**	3	—	2/0 Ex
NDMI066	**Algebraic Number Theory**	3	2/0 Ex	—
NDMI058	**Flows and Cycles in Graphs**	3	—	2/0 Ex
NDMI055	**Selected Chapters on Combinatorics I**	3	2/0 Ex	—
NDMI056	**Selected Chapters on Combinatorics II**	3	—	2/0 Ex

List of Requirements for the State Doctoral Examination

The student chooses 4 out of 10 given topics. Two of them are chosen among topics 1., 2., 3. and two of them are chosen among topics 4.–10.

1. Discrete mathematics

Basic graph theory, graph representations, graph algorithms. Linear algebra. Basics of topology. Selected algebraic structures, universal algebra. Combinatorial probability theory.

2. Logic

Introduction to model theory, algebraic specification of programs. Propositional and predicate calculus, syntax and semantics, their relation. Formal systems, consistency and completeness, Goedel's theorems.

3. Computability and complexity

Turing machines and equivalent models. Algorithms and their complexity. NP–completeness and NP–complete problems. Algorithmic undecidability, the recursion theorem.

4. Combinatorial optimization

Polyhedral combinatorics. Linear programming, duality. Integral programming. Combinatorial algorithms.

5. Combinatorics

Advanced combinatorics, problems of selection. Ramsey theory and decomposition theory. Extremal theory. Advanced graph theory.

6. Algebra in combinatorics

Enumeration. Methods of linear algebra, eigenvalues, application. Matroid theory.

7. Structure theory

Categorical and structural questions about combinatorial objects.

8. The probabilistic method

Nonconstructive methods in combinatorics, probabilistic algorithms. Random graphs.

9. Topological methods

General topology and algebraic topology. Topological methods in theoretical computer science.

10. Discrete geometry

Combinatorics of geometric configurations in Euclidean spaces. Computational geometry. Geometrical representations of graphs.

Recommended Literature

Topic 1:

Bollobás, B.: **Graph theory, An introductory course.** *Graduate Text in Mathematics 63, Springer–Verlag, New York, 1979.*
Bollobás, B.: **Modern graph theory.** *Graduate Text in Mathematics 184, Springer–Verlag, New York, 1998.*
Hell, P., Nešetřil, J.: **Graphs and homomorphisms.** *Oxford University Press, Oxford, 2004.*
Matoušek, J., Nešetřil, J.: **Invitation to discrete mathematics.** *Oxford University Press, Oxford, 2008.*

Topic 2:

Handbook of Logic in Computer Science. *Clarendon Press, Oxford, 1992.*
Shoenfield, J. R.: **Mathematical logic.** *Addison–Wesley, Reading, 1967.*

Topic 3:

Garey, M. R., Johnson, D. S.: **Computers and Intractability, A guide to the theory of NP–completness.** *W. H. Freeman, San Francisco, 1979.*
Papadimitriou, C. H.: **Computational Complexity.** *Addison–Wesley, Reading, 1994.*
Sipser, M.: **Introduction to the Theory of Computation.** *PWS Publishing Company, Boston, 1997.*

Topic 4:

Cook, W. J., Cunnigham, W. H., Pulleyblank, W. R., Schrijver, A.: **Combinatorial optimization.** *Wiley, New York, 1998.*
Schrijver, A.: **Theory of linear and integer programming.** *Wiley, New York, 1998.*

Topic 5:

Bollobás, B.: **Modern graph theory.** *Graduate Text in Mathematics 184, Springer–Verlag, New York, 1997.*
Graham, R. L., Spencer, J., Rothschild, B.: **Ramsey Theory.** *Wiley, New York, 1990.*
Hall, M.: **Combinatorial Theory.** *Wiley, New York, 1986.*
Lint van, J. H., Wilson, R. H.: **A course in combinatorics.** *Cambridge University Press, Cambridge, 1992.*

Topic 6:

Biggs, N. L.: **Algebraic graph theory.** *Cambridge University Press, Cambridge 1994.*
Cvetkovic, D. M., Doob, M., Sachs, H.: **Spectra of graphs, Theory and applications.** *J. A. Barth Verlag, Leipzig, 1995.*
Oxley, J.: **Matroid theory.** *Oxford University Press, Oxford, 1992.*

Topic 7:

Adámek, J., Herrlich, H., Strecker, G. E.: **Abstract and Concrete Categories.** *Wiley, New York, 1990.*
MacLane, S.: **Categories for the working mathematician.** *Graduate Texts in Mathematics 5, Springer–Verlag, New York, 1971.*

Topic 8:

Alon, N., Spencer, J.: **The Probabilistic Method.** *Wiley, New York, 2000.*
Grimmet, G. R., Stirzaker, D. R.: **Probability and random processes: Problems and solutions.** *Claredon Press, Oxford, 1992.*
Motwani, R., Raghavan, P.: **Randomized algorithms.** *Cambridge University Press, Cambridge, 1995.*

Topic 9:

Handbook of Logic in Computer Science. *Claredon Press, Oxford, 1992.*
Johnstone, P. T.: **Stone spaces.** *Cambridge University Press, Cambridge, 1982.*
Kelly, J.: **General Topology.** *Van Nostrand, New York, 1955.*
Pultr, A.: **Podprostory eukleidovských prostorů.** *SNTL, Praha 1984.*

Topic 10:

Berg de, M., Kreveld van, M., Overmars, M., Schwarzkopf, O.: **Computational Geometry: Algorithms and applications.** *Springer–Verlag, Berlin, 2000.*
Pach, J., Agarwal, P.: **Combinatorial Geometry.** *Cambridge University Press, Cambridge, 1995.*

Study Programme MATHEMATICS

Council for Doctoral Studies in Mathematics

List of members of the Council can be found at the address http://www.mff.cuni.cz/to.en/studium/phd/obory/ors.htm#nor4-m .

4M1 Algebra, Theory of Numbers and Mathematical Logic

Council of Doctoral Studies in Branch 4M1

List of members of the Council can be found at the address http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-m1.htm .

Committee for the State Doctoral Examinations K3

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk03.htm .

Cooperating Institutes

- Institute of Mathematics of the ASCR, v.v.i.
  Žitná 25, 115 67 Praha 1
  http://www.math.cas.cz

- Institute of Computer Science of the ASCR, v.v.i.
  Pod vodárenskou věží 2, 182 07 Praha 8
  http://www.cs.cas.cz/

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=M1 .

Courses Given

Code	Subject	Credits	Winter	Summer
NALG021	**Group Representations**	6	2/2 C+Ex	—
NALG124	**Group Representations II**	6	—	2/2 C+Ex

NALG022	**Representation Theory of Finite-dimensional Algebras**	6	—	3/1 C+Ex
NALG125	**Homological and Homotopic Algebra**	3	—	2/0 Ex
NALG028	**Rings and Modules**	6	2/2 C+Ex	—
NALG029	**Categories of Modules and Homological Algebra**	6	—	2/2 C+Ex
NALG030	**Algebra Seminar**	3	0/2 C	0/2 C
NALG031	**Algebra and Infinite Combinatorics**	3	2/0 Ex	—
NALG052	**Introduction to Finite Groups Theory**	6	2/0 —	2/0 Ex
NALG068	**Sporadic Groups**	6	2/0 —	2/0 Ex
NALG073	**Structure of Modules and Rings**	6	2/0 —	2/0 Ex
NALG077	**Approximations of Modules**	3	—	2/0 Ex
NALG080	**Seminar on Combinatorial, Algorithmic and Finitary Algebra**	3	0/2 C	0/2 C
NALG081	**Cohen-Macaulay Rings**	6	0/2 C	0/2 C
NALG100	**Commutative Rings**	6	4/0 Ex	—
NALG123	**Tame congruences Theory Seminar**	3	—	0/2 C
NALG118	**Seminar on CSP**	3	—	0/2 C
NALG021	**Group Representations**	6	2/2 C+Ex	—
NALG033	**Combinatorial Group Theory**	9	2/2 C	2/0 Ex
NALG017	**Introduction to Group Theory**	6	2/2 C+Ex	—
NALG109	**Lattice Theory**	3	2/0 Ex	—
NALG129	**Lattice Theory II**	3	—	2/0 Ex
NALG083	**Combinatorics on Words**	3	2/0 Ex	—
NALG080	**Seminar on Combinatorial, Algorithmic and Finitary Algebra**	3	0/2 C	0/2 C
NTIN071	**Automata and Grammars**	6	—	2/2 C+Ex
NAIL062	**Propositional and Predicate Logic**	6	2/2 C+Ex	—
NAIL063	**Set Theory**	3	—	2/0 Ex
NLTM001	**Set Theory**	6	—	2/2 C+Ex
NLTM003	**Forcing**	3	2/0 Ex	—
NLTM004	**Seminar on Forcing**	3	—	0/2 C
NLTM005	**Topological Dynamics**	3	—	2/0 Ex
NLTM006	**Fundamentals of Mathematical Logic**	3	—	2/0 Ex
NLTM010	**Mathematical Logic and Arithmetic**	3	—	2/0 Ex
NLTM011	**Model Theory**	6	—	2/2 C+Ex
NLTM014	**Nonstandard Seminar I**	3	0/2 C	—

NLTM015	**Nonstandard Seminar II**	3	—	0/2 C
NLTM026	**Boolean Algebras**	3	2/0 Ex	—
NLTM030	**Introduction to Set Theory**	6	2/2 C+Ex	—
NLTM034	**Seminar on Calculus I**	3	0/2 C	—
NLTM035	**Seminar on Calculus II**	3	—	0/2 C
NLTM036	**Basic Nonstandard Seminar**	3	—	0/2 C
NMAI020	**Fundamentals of Theory of Metric Spaces**	3	—	2/0 Ex
NMUE023	**Logic and Set Theory**	3	2/0 Ex	—
NTIN062	**Complexity I**	5	2/1 C+Ex	—
NTIN063	**Complexity II**	5	—	2/1 C+Ex
NTIN064	**Computability I**	3	2/0 Ex	—
NTIN065	**Computability II**	3	—	2/0 Ex
NTIN073	**Recursion I**	5	2/1 C+Ex	—
NTIN074	**Recursion II**	5	—	2/1 C+Ex
NTIN085	**Selected Topics in Computational Complexity I**	5	2/1 C+Ex	—
NTIN086	**Selected Topics in Computational Complexity II**	5	—	2/1 C+Ex
NTIN088	**Algorithmic Randomness I**	3	2/0 Ex	—
NTIN089	**Algorithmic Randomness II**	3	—	2/0 Ex
NTIN090	**Introduction to Complexity and Computability Theory**	5	2/1 C+Ex	—
NRFA071	**Descriptive Set Theory I**	3	2/0 Ex	—
NRFA072	**Descriptive Set Theory II**	3	—	2/0 Ex
NRFA081	**Descriptive Set Theory — Borel Equivalence Relations**	3	—	2/0 Ex
NMAI067	**Logic in Computer Science**	3	2/0 Ex	—
NAIL021	**Boolean Functions and Their Applications**	3	2/0 Ex	—
NAIL056	**Seminar on Logic I**	3	0/2 C	—
NAIL080	**Seminar on Logic II**	3	—	0/2 C
NMIB002	**Complexity for Cryptography**	6	4/0 Ex	—
NALG050	**Students' Seminar on Logic I**	3	0/2 C	—
NALG051	**Students' Seminar on Logic II**	3	—	0/2 C
NALG108	**Introduction to Mathematical Logic**	3	2/0 Ex	—
NMAI040	**Introduction to Number Theory**	3	2/0 Ex	—
NDMI066	**Algebraic Number Theory**	3	2/0 Ex	—
NDMI045	**Analytic and Combinatorial Number Theory**	3	—	2/0 Ex
NMIB004	**Error-correcting Codes**	6	4/0 Ex	—
NMIB001	**Number Theory and RSA**	6	—	2/2 C+Ex
NMIB013	**Algebraic Geometry in Positive Characteristic**	6	—	4/0 Ex

NMIB015	**Elliptic Curves**	6	4/0 Ex	—
NMIB021	**Seminar on Mathematics Inspired by Cryptography**	3	—	0/2 C
NALG079	**Algebraic Tests of Primality**	3	—	2/0 Ex

List of Requirements for the State Doctoral Examination

Algebra

I Elements of Algebra

Group theory: finite groups, Sylow theorems, structure of finitely generated abelian groups, free groups and their subgroups.

Rings, modules, and representations of algebras: noetherian rings, Groebner bases, projective and injective modules, Krull–Schmidt Theorem. Linear representations of graphs and modules over path algebras.

Universal algebra: Varieties of algebras, Birkhoff Theorem, Congruence lattices. Rewrite systems.

II. Advanced topics

The student will choose two different advanced topics in the specialization of "Algebra", "Number Theory" and "Mathematical Logic". However, at least one of them must be one of II.1-II.9 listed below. The choice has to be approved by the advisor.

II.1. Group Theory

Groups acting on sets. Permutation, solvable, and nilpotent groups. Linear groups. Finite simple groups, simplicity of A_n and $PSL_n(K)$. Basics of group extensions, semidirect products of groups. The group algebra and group representations, Maschke's Theorem, character tables, modular and integral representations.

II.2 Binary Systems

Selfdistributive groupoids (free, monogenerated, word problem), connection to braid groups. Medial and distributive groupoids, equational theory of medial idempotent groupoids. Normal subquasigroups and congruences of loops and quasigroups, nuclei, center, nilpotence. Connections to the multiplication group. LCC, CC, extra, Bol and Moufang loops. Inverse properties, diassociativity. Isotopy, central and medial quasigroups. Toyoda's theorem.

II.3 Commutative Algebra I

Commutative noetherian rings: spectrum, localization, primary decompositions, Krull's dimension theorem. Integral extensions, Dedekind domains, factorization of ideals. Algebraic sets, radical ideals, Hilbert's Nullstellensatz.

II.4 Commutative Algebra II

Galois extensions, groups, and correspondence. Norm and trace. Cyclic and radical extensions, unsolvability of polynomial equations by radicals. Tensor product, localization and completion of modules. Regular sequences, depth, Auslander–Buchsbaum theorem. Cohen–Macaulay and Gorenstein rings.

II.5 Module Theory

Direct limits. Pure–injective modules, connections to model theory. Ext functors and the long exact sequence. Filtrations. Deconstructibility for regular and singular

cardinals (dependence on extension of ZFC, Hill Lemma, Shelah's Singular Compactness Theorem). Structure of Whitehead and Baer modules. Module categories, Morita Theorem.

II.6 Representation Theory of Algebras

Finite dimensional algebras as factors of path algebras of quivers. Almost split maps. AR–sequences. AR–quiver of a finite dimensional algebra. Hereditary algebras. Finite, tame, and wild types. Gabriel Theorem. Tilting modules and tilted algebras. Derived categories.

II.7 Universal Algebra and Lattice Theory

Lattices of varieties, representation theorems, finitely based varieties, Malcev conditions, primal algebras and their generalizations, equational logic, arithmetic of free lattices, algebraic representations of lattices, varieties of lattices, modular and geometric lattices

II.8 Universal Algebra Methods in CSP

Minimal sets of finite algebras, their types, uniformity, separation and density. The structure of minimal sets. Abelianness and solvability for general algebras. Characterizations of omitting types for locally finite varieties. Connection between complexity of CSP and the clone of polymorphisms. Schaefer's theorem. Maltsev CSPs, bounded width problems.

II.9 Combinatorcs on Words

Dickson's lemma, F–semigroups (minimal set of generators, codes, stability condition, ranks). Chomsky's hierarchy (formal grammars and corresponding machines, Kleene's theorem, pumping lemmas, Parikh's theorem). Equations in free monoids (compactness property, graph lemma, defect effects, equivalence languages and test sets) Post Correspondence Problem.

Recommended Literature

Anderson, F. W., Fuller, K. R.: **Rings and Categories of Modules. GTM 13.** *2nd ed. Springer, New York, 1992.*

Assem I., Simson, D., Skowronski, A.: **Elements of the Representation Theory of Associative Algebras I. LMSST 65.** *Cambridge University Press, Cambridge, 2006.*

Berstel, J., Perrin, D.: **Theory of Codes.** *Academic Press, London, 1985.*

Bruck, R. H.: **A Survey of Binary Systems.** *Springer, Berlin, 1971.*

Bruns, W., Herzog, J.: **Cohen–Macaulay Rings. CSAM 39.** *Cambridge University Press, Cambridge, 1998.*

Bulatov, A., Krokhin, A., Larose, B.: **Dualities for constraint satisfaction problems.** *In: Complexity of Constraints, LNCS 5250. Springer, New York, 2008.*

Bulatov, A., Valeriote, M.: **Results on the algebraic approach to the CSP.** *Proc. Dagstuhl Sem., LNCS, Springer, New York, 2008.*

Burris, S., Sankappanavar, H. P.: **A Course in Universal Algebra.** *Springer, New York, 1981.*

Crawley, P., Dilworth, R. P.: **Algebraic Theory of Lattices.** *Prentice Hall, 1973.*

Dehornoy, P.: **Braids and Self Distributivity. Birkhauser.** *Basel, 2000.*

Eilenberg, S.: **Automata, languages and machines A and B.** *Academic Press, 1973, 1974.*
Eisenbud, D.: **Commutative Algebra. GTM 150.** *Springer, New York, 1995.*
Eklof, P. C., Mekler, A. H.: **Almost–Free Modules.** *2nd ed. Elsevier, Amsterdam, 2002.*
Enochs, E. E., Jenda, O. M. G.: **Relative Homological Algebra. GEM 30.** *W. de Gruyter, Berlin, 2000.*
Facchini, A.: **Module Theory.** *Birkhauser, Basel, 1998.*
Goebel, R., Trlifaj, J.: **Approximations and Endomorphism Algebras of Modules. GEM 41.** *W. de Gruyter, Berlin, 2006.*
Gratzer, G.: **General Lattice Theory.** *2nd ed. Birkauser, Basel, 1998.*
Hobby, D., McKenzie, R.: **The structure of finite algebras, Contemp. Math. 76.** *AMS, Providence, 1988.*
Jezek, J.: **Universal Algebra.** `http://www.karlin.mff.cuni.cz/~jezek` .
Lallement, G.: **Semigroups and combinatorial applications.** *Wiley, 1979.*
Lang, S.: **Algebra.** *3rd ed. Academic Press, New York, 1993.*
Lothaire, M.: **Algebraic Combinatorics on Words.** *Cambridge University Press, Cambridge, 2002.*
Lothaire, M.: **Applied Combinatorics on Words.** *Cambridge University Press, Cambridge, 2005.*
Lothaire, M.: **Combinatorics on Words.** *Cambridge University Press, Cambridge, 1997.*
Matsumura, H.: **Commutative Ring Theory. CSAM 8.** *Cambridge University Press, Cambridge, 1994.*
Pflugfelder, H. O.: **Quasigroups and Loops: Introduction.** *Heldermann Vlg, Berlin, 1990.*
Prochazka, L. a kolektiv: **Algebra.** *Academia, Praha, 1990.*
Rotman, J. J.: **An introduction to the theory of groups.** *Springer, New York, 1995.*
Rowen, L .H.: **Graduate Algebra: Commutative View. GSM 73.** *AMS, Providence, 2006.*
Rowen, L. H.: **Graduate Algebra: Noncommutative View. GSM 91.** *AMS, Providence, 2008.*
Rozenberg, G., Salomaa, A. (eds.): **Handbook of Formal Languages, vol. 1 – 3.** *Springer, 2004.*
Weibel, C.: **An Introduction to Homological Algebra. CSAM 38.** *Cambridge University Press, Cambridge, 1994.*
Weintraub, S. H.: **Representation Theory of Finite groups. GSM 59.** *AMS, Providence, 2003.*

Mathematical logic

I Basic logic

Propositional logic and first–order logic. First–order structures, Tarski's truth definition. Predicate calculus, provability. Completeness and compactness theorems. Set theory as a first–order theory. Godel's theorems on incompleteness and on unprovability of consistency. Turing machines: universal machine, algorithmically undecidable problems, halting problem. Quantifier elimination in the real closed ordered field.

II. Advanced topics

The student will choose two different topics out of the six advanced topics listed below. The choice has to be approved by the advisor.

II.1. General model theory

Basic concepts: substructure and elemenatry substructure, diagram, homomorphism, embedding and elementary embedding, isomorphism. Lowenheim–Skolem theorems. Model completeness. Definable sets, types, quantifier elimination. Model constructions: omitting types, Henkin construction, Skolemization, Craig interpolation, elementary chains, Robinson's join consistency theorem, indiscernibles. Saturated and homogenenous models, prime models. Ultraproduct and its basic properties. Elementary classes.

II.2 Applied model theory

Real closed ordered fields a their reducts and expansions. Theorems of Tarski and Wilkie. o–minimal structures and their basic geometric and topological properties. Stable and omega–stable theories, uncountable categoricity, Morley's theorem. Minimal and strongly minimal structures, general closure operations, geometry and dimension in a strongly minimal structure. Omega–stable groups, Cherlin–Zilber conjecture. Hrushovski's amalgamation construction.

II.3. Set theory

Axioms of ZFC. Axiom of choice AC, Zorn lemma, well–orderings. Ordinal and cardinal arithmetic, transfinite induction. Infinite combinatorics: disjoint and quasi–disjoint set systems, Ramsey theorem, clubs and stationary sets, diamond principle, Martin's axiom. Trees (Suslin, Aronszajn, Kurepa), Suslin hypothesis. Boolean algebras, ultrafilters, Stone duality. GCH. Constructive sets, axiom V=L. GCH and AC v L. Forcing and Boolean–valued models, the independence of CH. Inaccessible and measurable cardinals, elementary embeddings. Descriptive set theory: Borel, analytic and projective sets, infinite games, determinacy. Uniformization theorems. Borel equivalences. Polish spaces, Polish groups and their actions.

II.4. Computability theory

Partial recursive functions, recursive sets and recursively enumerable sets. Universal partial recursive functions, index. Recursion theorem and Rice theorem. Creative sets. Effective inseparability. Jump operation. Arithmetic hierarchy. Degrees of unsolvability. Arithmetic forcing and priority methods. Kolmogorov's complexity and basic of algorithmic randomness.

II.5 Proof theory and formal arithmetic

Gentzen's sequent calculus, cut elimination, Herbrand's theorem. Craig's interpolation. Robinson's arithmetic Q and Peano arithmetic PA. Interpretability of theories. Undecidability of Q and PA. Provably total recusive functions. Non–finite axiomatizability of PA. Second–order logic, simple type theory, infinitary logic. Reverse mathematics. Non–classical logics: intuitionistic, modal, manyvalued.

II.6 Logic and complexity

Time and space complexity of algorithms, basic complexity classes. Boolean circuits and main known size lower bounds. The concept of natural proofs of lower bounds (Razborov — Rudich). Finite model theory, descriptive complexity theory. Definability in finite structures, Fagin's theorem. Fixed–point logics. 0–1 laws. Ehrenfeucht–Fraisse method. Locality and theorems of Gaifman and Hanf. Pebbling games. The spectrum

problem. Proof complexity, propositional proof systems (Cook — Reckhow). Resolution, DPLL algorithm for SAT and their relation. Frege and Extended Frege systems. Lengths–of–proofs lower bound for resolution. Bounded arithmetic. Definability of the polynomial–time hierarchy. Witnessing functions and search problems. The finite axiomatizability problem.

Recommended Literature

Balcar, B., Stěpánek, P.: **Teorie množin.** *Academia, Praha, 1986, 2001.*

Bartoszynski, T., Judah, H.: **Set Theory, On the Structure of Real Line.** *A. K. Peters, Wellesley, Massachussets, 1995.*

Barwise, J. (ed.): **Handbook of Mathematical Logic.** *NHPC, 1972 (rusky Nauka, Moskva, 1982).*

Buss, S. R. (ed.): **Handbook of Proof Theory, Studies in Logic and the Foundations of Mathematics 137.** *Elsevier, Amsterdam, 1998.*

Cook, S. A., Nguyen, P.: **Logical foundations of proof complexity.** *Cambridge University Press.*

Demuth, O., Kryl, R., Kučera, A.: **Teorie algoritmů I, II.** *SPN, Praha, 1984, 1989.*

Devlin, K. J.: **Constructibility.** *Springer–Verlag, Heidelberg, 1984.*

Dries van den, L.: **Tame Topology and O–minimal Structures.** *London Mathematical Society Lecture Note Series, no. 248, 1998.*

Ebbinghaus, H.–D., Flum, J., Thomas, W.: **Mathematical Logic.** *Springer–Verlag, Heidelberg, 1984.*

Ebbinghaus, H.–D., Flum, J.: **Finite Model Theory.** *Springer–Verlag, 2005.*

Gabbay, D., Guenthner, F. (eds.): **Handbook of Philosophical Logic I–IV.** *D. Riedel Publishing comp., 1983.*

Hájek, P., Pudlák, P.: **Metamathematics of First–Order Arithmetic.** *Springer–Verlag, Heidelberg, 1993.*

Hodges, W.: **Model Theory.** *Cambridge University Press, Cambridge, 1993.*

Chang, C. C., Keisler, H. J.: **Model–Theory.** *NHPC, New York, 1973 (rusky Mir, Moskva, 1977).*

Jech, T.: **Set Theory.** *Springer–Verlag, 2002.*

Kechris, A.: **Classical descriptive set theory.** *Springer–Verlag, New York, 1994.*

Krajíček, J.: **Bounded arithmetic, propositional logic, and complexity theory.** *Cambridge University Press, Cambridge, 1995.*

Kunen, K.: **Set Theory, An Introduction to Independence Proofs.** *NHPC, New York, 1980.*

Laxembourgh, W. A. J., Stroyan, K. D.: **Introduction to the Theory of Infinitesimals.** *Academic Press, London, 1976.*

Li, M., Vitanyi, P.: **An Introduction to Kolmogorov Complexity and Its Applications.** *Springer, 1997.*

Marker, D.: **Model Theory — An Introduction.** *Springer, 2002.*

Moschovakis, Y.: **Descriptive Set Theory.** *North–Holland, 1980.*

Odifreddi, P.: **Classical Recursion Theory. The Theory of Functions and Sets of Natural Numbers.** *NHPC, New York, 1989.*

Papadimitriou, C. H.: **Computational Complexity.** *Addison Wesley, 1994.*

Pillay, A.: **Geometric Stability Theory.** *Clarendon Press, Oxford, 1996.*
Priest, G.: **An Introduction to Non–Classical Logic** *Cambridge University Press, 2001.*
Rogers, H., Jr.: **Theory of Recursive Functions and Effective Computability.** *Mc Graw–Hill, New York, 1967.*
Shelah, S.: **Classification Theory.** *NHPC, New York, 1990.*
Shelah, S.: **Proper and Unproper Forcing.** *Springer–Verlag, Heidelberg, 1998.*
Shoenfield, J. R.: **Mathematical Logic.** *Addison Wesley Publishing Company, Reading, 1967 (rusky Nauka, Moskva, 1975).*
Simpson, S.: **Subsystems of second order arithmetic.** *Springer–Verlag, New York, 1999.*
Soare, R. I.: **Recursively Enumerable Dets and Degrees, A Study of Computable Functions and Computably Generated Sets.** *Springer–Verlag, Heidelberg, 1987.*
Takeuti, G.: **Proof Theory.** *Elsevier, Amsterdam, 1987.*

Number theory

I. Basic Number Theory

Number Theory: Density of prime numbers, Legendre and Jacobi symbols, quadratic reciprocity, continued fractions, quadratic number fields, Rabin–Miller algorithm and RSA, quadratic sieve.

Cryptology: Generators of pseudorandom numbers, symmetric and stream ciphers, hash functions, provable security, cryptographic protocols, zero–knowledge proofs.

Computer algebra: Berlekamp's algorithm, Groebner bases and Buchberger's algorithm. Factorization of polynomials with integer coefficients.

II. Advanced topics

The student will choose two different advanced topics in the specialization of "Algebra", "Number Theory" and "Mathematical Logic". However, at least one of them must be one of II.1-II.4 listed below. The choice has to be approved by the advisor.

II.1 Advanced cryptanalytic methods:

Theory of Boolean functions, S–boxes and their cryptographic properties, linear and differential cryptanalysis, LLL–algorithm and its cryptanalytic applications.

II.2 Factorization

Structure of number fields (norm, prime ideals, ramification, units). Factorization of ideals into prime ideals in number fields (Pohst–Zassenhaus theorem, Dedekind criterion). Orders and integral bases. Dual bases. Number field sieve and related algorithms (square root, selection of a polynomial etc.) Further factorization algorithms (p-1, p+1, rho, application of elliptic curves) and their significance for the number field sieve. Tests and proofs of primality (quadratic Frobenius test, N–1 test, ECPP, polynomial time algorithms).

II.3 Self–correcting codes

Classical theory of cyclic codes. Selfdual codes and the theory of invariants. Convolutional codes. Turbo codes. Algorithms for decoding, in particular the Viterbi algorithm and various algorithms for Reed–Solomon codes. Quaternary codes. Covering radius and applications to steganography. Detailed knowledge of BCH, alternant, Kerdock, Preparata, Justensen, Reed–Muller and QR codes. Asymptotic bounds and

construction of asymptotically good codes. LDPC codes. MDS codes. Basic bounds (Plotkin, Hamming, Griesmer, Singleton, Johnson, Gilbert–Varshamov, linear programming).

II.4 Elliptic curves

p–adic numbers. Varieties over finite fields (Frobenius morphism, theorem of Hasse–Weil for Jacobians, Tate's isogeny theorem). Arithmetic of elliptic curves (group law, rational points, torsion points, isomorphisms and isogenies). Montgomery's scalar multiplication. Pairings and its implementation. Point counting (elementary methods, Schoof and Satoh algorithms, complex multiplication). Computing discrete logarithms (Chinese remaindering, baby–step giant–step, Pollard's methods). Pairing–Based Cryptography. Applications of elliptic curves in factoring and in primality tests.

Recommended Literature

Cassels, J. W. S.: **Local Fields.** *Cambridge University Press, Cambridge, 1986.*

Cohen H.: **A course in computational algebraic number theory.** *Springer, Berlin, 1993.*

Cohen, H., Frey, G. et al. (eds.): **Handbook of Elliptic and Hyperelliptic Curve Cryptography.** *Chapman & Hall–CRC, Boca Raton, 2005.*

Crandall, R., Pomerance, C.: **Prime Numbers — A Computational Perspective.** *2nd ed. Springer, New York, 2005.*

Goldreich, O.: **Foundations of Cryptography, Basic Tools.** *Cambridge University Press, Cambridge, 2001.*

Gôuvea, F. Q.: **P–adic Numbers: An Introduction.** *Springer, New York, 1997.*

Hardy, G. H., Wright, E. M.: **An Introduction to the Theory of Numbers.** *Clarendon Press, Oxford, 1945.*

Irelan, K., Rosen, M.: **A classical introduction to modern number theory.** *Springer, Berlin, 1990.*

Koblitz, N.: **Introduction to Elliptic Curves and Modular Forms.** *Springer, 1993.*

Koblitz, N.: **P–adic Numbers, P–adic Analysis and Zeta–Functions.** *Springer, 1984.*

Lang, S.: **Algebra.** *Springer, New York, 2003.*

Lang, S.: **Algebraic Number Theory.** *Springer, New York, 1994.*

Marcus, D. A.: **Number Fields.** *Springer, 1977.*

Menezes, A.J. et al. (eds.): **Handbook of Applied Cryptography.** *Chapman & Hall–CRC. Boca Raton, 2006.*

Milne, J. S.: **Algebraic Number Theory.** `http://www.jmilne.org/math/` .

Milne, J. S.: **Elliptic Curves.** `http://www.jmilne.org/math/` .

Pless, V. S., Brualdi, R. A., Huffman, W. C. (eds.): **Handbook of Coding Theory.** *North Holland, 1998.*

Silverman, J. H.: **The Arithmetic of Elliptic Curves.** *Springer, 1986.*

Steuding, J.: **Diophantine Analysis.** *Chapman & Hall, 2005.*

Stinson, D. R.: **Cryptography: Theory and Practice.** *CRC Press, Boca Raton, 2006.*

Sudan, M.: **Algorithmic Introduction to Coding Theory.** `http://theory.lcs.mit.edu/~madhu/FT01/course.html` .

4M2 Geometry, Topology, Global Analysis and General Structures

Council of Doctoral Studies in Branch 4M2

List of members of the Council can be found at the address `http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-m2.htm` .

Committee for the State Doctoral Examinations K3

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address `http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk03.htm` .

Cooperating Institutes

- Institute of Mathematics of the ASCR, v.v.i.
  Žitná 25, 115 67 Praha 1
  `http://www.math.cas.cz`

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in `http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=M2` .

Courses Given

Code	Subject	Credits	Winter	Summer
NMAT007	**Algebraic Topology 1**	6	2/2 C+Ex	—
NMAT008	**Algebraic Topology 2**	6	—	2/2 C+Ex
NGEM003	**Representation of Lie Groups 1**	6	2/2 C+Ex	—
NGEM011	**Fundamentals of Riemannian Geometry 1**	6	—	2/2 C+Ex
NGEM001	**Introduction to Algebraic Geometry**	3	—	2/0 Ex
NGEM013	**Seminar on Harmonic Analysis and Representation Theory I**	3	0/2 C	—
NGEM014	**Seminar on Harmonic Analysis and Representation Theory II**	3	—	0/2 C
NGEM004	**Seminar on Differential Geometry I**	3	0/2 C	—
NGEM005	**Seminar on Differential Geometry II**	3	—	0/2 C
NLTM003	**Forcing**	3	2/0 Ex	—
NLTM034	**Seminar on Calculus I**	3	0/2 C	—
NLTM035	**Seminar on Calculus II**	3	—	0/2 C
NMAT005	**Seminar on Topology**	3	0/2 C	0/2 C

NMAT001	**Fundamentals of Category Theory**	6	2/2 C+Ex	—

List of Requirements for the State Doctoral Examination

I. General topics of the field

A choice of at least three topics from the following:

I.1. General topology

Basic notions. Urysohn lemma. Tietze theorem. Connectedness and local connectedness. Compactness and local compactness. Tichonov theorem, Stone–Weierstrass theorem, Čech–Stone compactification. Paracompactness. Stone theorem about the paracompactness of metric spaces. Metrizable spaces, metrizability theorems, complete metric spaces. Topological groups, basic properties. Uniform spaces and uniformly continuous mappings, metrizability, completeness.

I.2. Set theory

Axiomatics of set theory. Ordinal and cardinal numbers, their basic arithmetics. Axiom of choice and its equivalents, transfinite recursion. Infinite combinatorics, stationary sets. Ramsey theorem, Erdos–Rado theorem, lemma about delta system, independent systems. Partial orderings.

I.3. Category theory

Categories and functors, examples. Natural transormations and equivalences, examples. Limits and colimits, completeness, the form of limits and colimits in concrete categories. Adjunction, reflectivity and coreflectivity. Closed and cartesian closed categories. Small categories. MacLane representation.

I.4. Selected parts from algebra

Tensor algebra, especially multilinear algebra. Selected parts from ring theory and module theory (extension, reso;ution, graduation, filtration). Foundations of homological algebra (homology of complexes, cohomology of groups and other algebraic systems).

I.5. Riemannian manifolds

Theory of connections. Parallel transport. Riemannian metric, Riemannian connection, curvature tensor and its properties. Sectional curvature and its properties. Geodesic curves. Homogeneous Riemannian manifolds. Hermitian metric. Submanifolds of the Euclidean space. Holonomy groups.

I.6. Analysis on manifolds

Vector bundles and their classification. Differential operators, invariant differential operators on homogeneous manifolds. Integration on manifolds. Foundations of integral geometry on manifolds. Fourier and Radon transform. Complex manifolds, holomorphic and meromorphic functions.

I.7. Lie groups and algebras

Classification of simple Lie algebras and their finite dimensional representations. Decomposition of a tensor product into irreducible components. Klimyk formula. Characters of representations and character formulas (Weyl, Freudenthal etc.)

I.8. Algebraic topology

Derived functors. Spectral sequences and their applications. Fibrations, homology and homotopy theory of fibrations. Topology of Lie groups and classifying spaces.

Characteristic classes of vector bundles. Chern–Weil homomorphism. Foundations of K–theory. Cohomology operations. Obstruction theory. Index theorems. Operads, operad algebras.

II. Advances parts of the field

A choice of one of the following topics:

II.1. General topology

Point–free approaches to topology. Various versions of the Stone duality.The Boolean algebra, the Heyting algebra, continuous lattices and the corresponding dualities. Strengthening of structures of a point–free topology. Spaces of continuous functions, their possible topologies, the Arzel–Ascoli theorem, Cp(X). Cardinal invariants of topological spaces and their mutual relations. Spaces of ultrafilters, cardinal characteristics. Computer topology. Topological dynamics, almost periodic points, classification of dynamical systems, the Ellis envelope, recurrence in dynamical systems, applications in combinatorics. Properties of topological spaces connected with combinatorial principles of set theory. Structures of continuity, theory of miform and proximity spaces.

II.2. Set theory

Boolean algebra, partial orderings. The Stone duality, structural properties. Combinatorial principles, the Martin axiom, the Fodorov–Solovay theorem, the Silver theorem, the Suslin and Aronszajn trees. The Kurep hypotesis, the Hausdorff gap. Basics of forcing. PFA. Elementary substructures, ultraproduct, basics of pcf theory.

II.3. Category theory

Monads and monadic categories. Categroies and logic. Basics of theory of topos. Specific categorial questions of special structures. Theories of cpecific categories and structures.Initial and terminal creation of objects. Algebraic and topological categories. Complete and almost complete embeddings. Rigid objects and rigid graphs, algebras and spaces. Universality and almost universality, almost universality of category of paracompact spaces.

II.4. Geometry of homogeneous and symmetric spaces

Homogeneous spaces, reductive spaces, canonical connections. Invariant metrics and differential operators on homogeneous spaces (in particular Riemannian). Theory of Riemanian symmetric spaces, examples, classification. Generalizations of symmetric spaces, Eisnstein spaces.

II.5. Parabolic structures on manifolds

Graded Lie algebras and their real forms. Principla fibre bundles, connections,covariant derivatives and their curvatures. Homogeneous differential operators. The Cartan and parabolic geometries, the Cartan connections and their curvatures. Conformal projective, quaternionic geometries, further examples of parabolic geometries.

II.6. Integral geometry and complex analysis

Functions of several complex variables. Complex manifolds, Hermitean and Kaehler manifolds.Sheaves and presheaves. Differential forms on complex manifolds and the Dolbeault cohomology. The Radon and the Penrose transforms.

II.7. Invariant differential operators

Spin structures on Riemannian manifolds. The Dirac operator, its properties, the Laplace operator. Spectral properties of differential operators. Theory of the Dirac type

operators. Conformal invariance of operators on conformal manifolds. The Bochner and the Weitzenbock formulae. Invariant operators for othe geometric structures.

II.8. Algebraic topology

Derived functors. Spectral sequences and their applications. Fibrations, homology and homotopy theory of fibrations. Topology of Lie groups and classifying spaces. Characteristic classes of vector bundles. Chern–Weil homomorphism. Foundations of K–theory. Cohomology operations. Obstruction theory. Index theorems. Operads, operad algebras.

Recommended Literature

Adámek, J., Herrlich H., Strecker G.: **Abstract and Concrete Categories.** *Wiley, New York, 1990.*

Adámek, J.: **Matematické struktury a kategorie.** *SNTL, Praha, 1982.*

Balcar, B., Štěpánek, P.: **Teorie množin.** *Academia, Praha, 1980.*

Borceaux, F., Bosche van den, G.: **Algebra in a Localic Topos with Applications to Ring Theory.** *Springer, 1983.*

Ellis, R.: **Lectures in Topological Dynamics.** *Benjamin, New York, 1967.*

Engelking, R.: **General Topology.** *PWN, Warsawa, 1977.*

Friedrich, Th.: **Dirac Operatoren in der Riemannschen Geometrie.** *Wiesbaden, 1997.*

Fulton, W., Harris, J.: **Representation Theory.** *A first course, GTM 129. Springer, New York, 1991.*

Fustenberg, H.: **Reccurence in Ergodic Theory and Combinatorial Number Theory.** *Princeton University Press, Princeton, 1981.*

Gillmann, L., Jerison, M.: **Rings of continuous functions.** *D. van Nostrand, New York, 1960.*

Harris, J.: **Algebraic geometry.** *A first course, GTM 133. Springer, New York, 1992.*

Hatcher A.: **Algebraic Topology.** `http://www.math.cornell.edu/~hatcher/AT/ATpage.html` .

Helgason, S.: **Differential geometry, Lie groups and Symmetric spaces.** *Pure and Appl. Math. 80, Ac. Press, 1978.*

Isbell J. R.: **Uniform spaces.** *Amer. Math. Soc., Providence, 1964.*

Johnstone, P. T.: **Stone Spaces.** *Cambridge University Press, Cambridge, 1982.*

Johnstone, P. T.: **Topos Theory.** *Academic Press, London, 1972.*

Juhásy, I.: **Cardinal functions in topology — Ten Years Later.** *Math Centre Tracts 125, Amsterdam, 1980.*

Juhásy, I.: **Cardinal Functions in Topology.** *Math. Centre Tracts 34, Amsterdam, 1975.*

Kelley, J. L.: **General Topology.** *Van Nostrand, New York, 1955.*

Kunen, K.: **Set Theory — An Introduction to Independence Proofs.** *North–Holland, Amsterdam, 1980.*

Lawson, B. L., Michelsohn, M. L.: **Spin Geometry.** *Princeton Math. Series, Princeton, 1989.*

MacLane, S.: **Categories for the Working Mathematician.** *GTM5. Springer–Verlag, New York, 1970.*

MacLane, S.: **Homology.** *Academic Press, New York, 1963.*
Massey, W.: **Singular Homology theory.** *GTM 70. Springer, New York, 1976.*
Monk, J. D., Bonnet, R.: **Handbook of Boolean Algebras, vol 1.** *North–Holland, Amsterdam, 1989.*
Pult, A.: **Podprostory Euklidových prostorů.** *SNTL, Praha, 1986.*
Pultr, A., Trnková, V.: **Combinatorial, Algebraic and Topological Representations of Groups, Semigroups and Categories.** *Academia, Praha, 1980.*
Rudin, M. E.: **Lectures on Set Theoretic Topology.** *Amer. Math. Soc., Providence, 1975.*
Samelson, H.: **Notes on Lie algebras.** *Van Nostrand, New York, 1969.*
Sharpe, R. W.: **Differential geometry.** *GTM 166. Cartans Generalization of Kleins Erlangen Program, Springer, 1997.*
Wells, R. O. jr.: **Differential analysis on complex manifolds.** *GTM65. Springer New York, 1979.*

4M3 Mathematical Analysis

Council of Doctoral Studies in Branch 4M3

List of members of the Council can be found at the address `http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-m3.htm` .

Committee for the State Doctoral Examinations K3

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address `http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk03.htm` .

Cooperating Institutes

- Institute of Mathematics of the ASCR, v.v.i.
  Žitná 25, 115 67 Praha 1
  `http://www.math.cas.cz`

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in `http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=M3` .

Courses Given

Code	Subject	Credits	Winter	Summer
NMOD042	**Mathematical Analysis of Models in Non-Newtonian Fluid Thermodynamics**	3	—	2/0 Ex
NDIR066	**Mathematical Analysis of Compressible Flow Equations**	3	2/0 Ex	—

NRFA057	**Quasi-conformal Mappings**	6	2/0 —	2/0 Ex
NRFA079	**Topological Methods in Functional Analysis I**	3	2/0 Ex	—
NRFA080	**Topological Methods in Functional Analysis II**	3	—	2/0 Ex
NRFA041	**Borel and Analytic Sets in Analysis I**	3	2/0 Ex	—
NRFA043	**Borel and Analytic Sets in Analysis II**	3	—	2/0 Ex
NMAT055	**Modern Variational Analysis**	6	—	4/0 Ex
NRFA033	**Real Methods in Harmonic Analysis**	6	2/0 —	2/0 Ex
NRFA027	**Classical and Fourier Approach to Function Spaces**	6	2/0 —	2/0 Ex
NDIR240	**Analysis of Mathematical Models of Bodies Moving through Fluids I**	3	2/0 C	—
NRFA008	**Choquet Theory, Boundaries and Applications I**	3	2/0 Ex	—
NRFA044	**Choquet Theory, Boundaries and Applications II**	3	—	2/0 Ex
NDIR057	**Non-Newtonian Fluid Mechanics**	3	2/0 Ex	—
NDIR010	**Mathematical Theory of Navier-Stokes Equations**	3	—	2/0 Ex
NDIR065	**Regularity of solutions of Navier-Stokes' equations**	3	2/0 Ex	—
NDIR062	**Variational Calculus for Advanced Students I**	3	2/0 Ex	—
NDIR063	**Variational Calculus for Advanced Students II**	3	—	2/0 Ex
NMAA075	**Theory of Integration for Advanced Students I**	3	2/0 Ex	—
NMAA076	**Theory of Integration for Advanced Students II**	3	—	2/0 Ex
NMAA077	**Theory of Differentiation for Advanced Students I**	3	2/0 Ex	—
NMAA078	**Theory of Differentiation for Advanced Students II**	3	—	2/0 Ex
NDIR067	**Selected Topics on Differential Equations**	6	2/0 Ex	2/0 Ex
NDIR068	**Control Theory**	6	2/0 Ex	2/0 Ex
NDIR008	**Potential Theory I**	3	2/0 Ex	—
NDIR055	**Potential Theory II**	3	—	2/0 Ex

NRFA045	**Introduction to Modern Real Interpolation Theory I**	3	2/0 Ex	—
NRFA076	**Introduction to Modern Theory of Real Interpolation II**	3	—	2/0 Ex
NRFA074	**Introduction to Approximation Theory**	6	2/0 —	2/0 Ex
NDIR069	**Theory of Global and Exponential Attractors**	3	—	2/0 Ex
NDIR058	**Hyperbolic Systems and Conservation Laws**	3	—	2/0 Ex
NDIR142	**Nonlinear Differential Equations and Inequalities for Ph.D. Students I**	3	2/0 Ex	—
NDIR143	**Nonlinear Differential Equations and Inequalities for Ph.D. Students II**	3	—	2/0 Ex
NRFA073	**Topological and Geometric Properties of Convex Sets**	6	2/0 Ex	2/0 Ex
NRFA028	**Seminar on Operator Theory**	3	0/2 C	0/2 C
NRFA053	**Functional Analysis**	3	0/2 C	0/2 C
NRFA001	**Seminar on Real and Abstract Analysis**	3	0/2 C	0/2 C
NRFA012	**Seminar on Real Functions Theory**	3	0/2 C	0/2 C
NMOD037	**Seminar on Bifurcations and Their Interpretations in Biology**	3	0/2 C	0/2 C
NMAA009	**Seminar on Mathematical Analysis**	3	0/2 C	0/2 C
NRFA035	**Seminar on Function Spaces**	3	0/2 C	0/2 C
NRFA049	**Basic Properties of Function Spaces**	3	0/2 C	0/2 C
NDIR035	**Seminar on Partial Differential Equations**	5	0/3 C	0/3 C
NSTP148	**Seminar on Stochastic Evolution Equations**	3	0/2 C	0/2 C

List of Requirements for the State Doctoral Examination

The examination consists of two parts.

I. Classical topics of the research area

The first part of the exam concerns real, complex, and functional analysis (Part A) or ordinary and partial differential equations (Part B), or an individually prescribed subject (if this is considered useful by RDSO and the supervisor). Such a subject should consist of topics chosen from those of any of both parts or of other topic so

that the extent and content of the exam remain appropriate. The specification of the requirements has to be suggested by the superviser and approved by RDSO.

I.1. Part A

Part A contains topics from real analysis, complex analysis, and functional analysis which cover basic classical results of these theories. Namely, it covers basic results of the modern theory of measure and integral (e.g., Radon measure, Haar measure, Hausdorff measure, Bochner and Pettis integral, Fourier transform), of classical complex analysis, and basic topics of functional analysis (e.g., Banach algebras, spectral analysis in Hilbert spaces, elements of the theory of distributions, differential calculus in Banach spaces, nonlinear operator equations, degree of a mapping).

I.2. Part

Part B contains topics from ordinary differential equations, partial differential equations, and potential theory. It covers main modern topics of this theory, e.g. dynamical systems, optimal control, bifurcation theory, variational methods, applications of semigroups, conservation laws, Perron–Wiener–Brelot method in potential theory.

II. Advanced topics of the research area

The second part of examination concerns more special topics which are related to Ph.D. Thesis and set down by the supervisor (after being approved by RDSO).

Recommended Literature

Arnold, V. I.: **Geometrical Methods in the Theory of Ordinary Differential Equations.** *Springer, New York, 1988.*

Axler, S., Bourdon, P., Ramey, W.: **Harmonic Function Theory.** *Springer, New York, 1992.*

Deimling, K.: **Nonlinear functional analysis.** *Springer, Berlin, 1985.*

Evans, L. C.: **Partial Differential Equations.** *American Math. Society, Providence, 1998.*

Renardy, M., Rogers, R. C.: **An Introduction to Partial Differential Equations.** *Springer, New York, 1993.*

Rudin, W.: **Functional analysis.** *McGraw–Hill, New York, 1973.*

Rudin, W.: **Real and complex analysis.** *McGraw–Hill, New York, 1974.*

4M4 Probability and Mathematical Statistics

Council of Doctoral Studies in Branch 4M4

List of members of the Council can be found at the address `http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-m4.htm` .

Committee for the State Doctoral Examinations K4

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address `http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk04.htm` .

Cooperating Institutes

- Institute of Mathematics of the ASCR, v.v.i.
  Žitná 25, 115 67 Praha 1
  http://www.math.cas.cz

- Institute of Information Theory and Automation of the ASCR, v.v.i.
  Pod vodárenskou věží 4/1143, 182 08 Praha 8
  http://www.utia.cas.cz

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=M4 .

Courses Given

Code	Subject	Credits	Winter	Summer
NSTP029	**Advanced Topics on Probability, Statistics and Stochastic Processes I**	5	3/0 Ex	—
NSTP030	**Advanced Topics on Probability, Statistics and Stochastic Processes II**	5	—	3/0 Ex
NSTP135	**Asymptotic Methods of Mathematical Statistics**	3	0/2 C	0/2 C
NSTP143	**Selected Topics on Stochastics 1**	5	3/0 Ex	—
NSTP173	**Selected Topics on Stochastics 2**	5	—	3/0 Ex
NSTP148	**Seminar on Stochastic Evolution Equations**	3	0/2 C	—
NSTP151	**Time Series 1**	3	2/0 Ex	—
NSTP152	**Time Series 2**	3	—	2/0 Ex
NSTP153	**Probability and Stochastic Analysis**	6	4/0 Ex	—
NSTP154	**Spatial Modelling, Spatial Statistics 2**	6	—	2/2 C+Ex
NSTP155	**Seminar on Probability for Ph.D. Students I**	3	0/2 C	—
NSTP156	**Seminar on Probability for Ph.D. Students II**	3	—	0/2 C
NSTP178	**Problems of Applied Statistics**	3	—	0/2 C
NSTP189	**Colloquium of the Department of Probability and Mathematical Statistics**	3	0/2 C	—
NEKN031	**Stochastic Modelling in Economics and Finance 1**	3	0/2 C	—
NSTP048	**Nonparametric Methods**	3	2/0 Ex	—

NSTP049	**Robust Statistical Methods**	3	2/0 Ex	—
NSTP157	**Limit Theorems for Random Variable Sums**	3	—	2/0 Ex
NSTP158	**Statistical Decision Theory**	3	—	2/0 Ex
NSTP176	**Markov Processes**	6	—	4/0 Ex
NSTP180	**Estimation Theory**	3	—	2/0 Ex
NSTP181	**Hypothesis Testing**	3	2/0 Ex	—
NSTP182	**Hypothesis Testing — exercises**	3	0/2 C	—
NSTP187	**Quantum Probability Theory**	3	—	2/0 Ex
NDIR041	**Stochastic Differential Equations**	6	—	4/0 Ex
NSTP139	**Markov Chain Monte Carlo Methods**	6	2/2 C+Ex	—
NMAT011	**Point Processes**	3	—	2/0 Ex
NSTP021	**Bayesian Methods**	3	2/0 Ex	—
NSTP183	**Bayesian Methods — exercises**	3	0/2 C	—
NSTP172	**Simulation Methods and Statistics**	6	2/2 C+Ex	—
NSTP126	**Generalised Linear Models**	6	—	2/2 C+Ex
NSTP197	**Generalised Linear Models — exercises**	3	—	0/2 C

Standards for the state doctoral examination

I. General background

Differential equations, functional analysis, complex analysis, matrix calculus, measure theory.

II. Probability

Markov chains, martingales, processes with independent increments, spatial modelling, invariance principles, stationary processes, stochastic analysis, stochastic differential equations, reliability theory.

III. Mathematical statistics

Estimation theory and hypothesis testing, decision functions, multivariate analysis, regression, sampling survey, robust and nonparametric methods, Bayesian and sequential analysis, spatial statistics, computational aspects of statistical methods, survival analysis.

Recommended Literature

Anděl, J.: **Základy matematické statistiky.** *Matfyzpress, Praha, 2007.*

Billingsley, P.: **Convergence of Probability Measures.** *Wiley, New York, 1999.*

Daley, D., Vere–Jones, D.: **Introduction to the Theory of Point Processes I.** *2nd ed. Springer, New York, 2003.*

Daley. D., Vere–Jones, D.: **Introduction to the Theory of Point Processes II.** *2nd ed. Springer, New York, 2008.*

Hewitt, E., Stromberg, K.: **Real and Abstract Analysis.** *Wiley, New York, 1969.*

Jurečková, J., Sen, P. K.: **Robust Statistical Procedures.** *Wiley, New York, 1996.*
Kallenberg, O.: **Foundations of Modern Probability.** *Springer–Verlag, Berlin, 1997.*
Lehmann, E. L.: **Testing Statistical Hypothesis.** *Chapman & Hall, New York, 1993.*
Lehmann, E. L.: **Theory of Point Estimation.** *Wadsworth & Brook/Cole, Pacific Grove, 1991.*
Sen, P. K., Singer, J. M.: **Large Sample Methods in Statistics.** *Chapman & Hall, London, 1993.*
Shorack, G. R.: **Probability for Statisticians.** *Springer–Verlag, New York, 2000.*
Štěpán, J.: **Teorie pravděpodobnosti.** *Academia, Praha, 1987.*

4M5 Econometrics and Operational Research

Council of Doctoral Studies in Branch 4M5

List of members of the Council can be found at the address `http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-m5.htm` .

Committee for the State Doctoral Examinations K4

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address `http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk04.htm` .

Cooperating Institutes

- Institute of Information Theory and Automation of the ASCR, v.v.i.
  Pod vodárenskou věží 4/1143, 182 08 Praha 8
  `http://www.utia.cas.cz`

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in `http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=M5` .

Courses Given

Code	Subject	Credits	Winter	Summer
NEKN031	**Stochastic Modelling in Economics and Finance 1**	3	0/2 C	—
NEKN032	**Stochastic Modelling in Economics and Finance 2**	3	—	0/2 C
NSTP134	**Stochastic Programming and Approximation** [1]	3	0/2 C	0/2 C

NSTP135	**Asymptotic Methods of Mathematical Statistics** [1]	3	0/2 C	0/2 C
NSTP151	**Time Series 1**	3	2/0 Ex	—
NSTP152	**Time Series 2**	3	—	2/0 Ex
NSTP018	**Multivariate Statistical Analysis**	6	2/2 C+Ex	—
NMAT055	**Modern Variational Analysis**	6	—	4/0 Ex
NEKN027	**Advanced Topics on Optimisation and Convex Analysis 1**	5	3/0 Ex	—
NEKN028	**Advanced Topics on Optimisation and Convex Analysis 2**	5	—	3/0 Ex
NEKN029	**Game Theory and Multicriterial Optimisation**	6	4/0 Ex	—
NFAP040	**Insurance and Financial Mathematics 1**	6	4/0 Ex	—
NFAP041	**Insurance and Financial Mathematics 2**	3	—	2/0 Ex
NSTP153	**Probability and Stochastic Analysis**	6	4/0 Ex	—
NSTP172	**Simulation Methods and Statistics**	6	2/2 C+Ex	—
NSTP048	**Nonparametric Methods**	3	2/0 Ex	—
NSTP049	**Robust Statistical Methods**	3	2/0 Ex	—
NSTP194	**Regression**	6	4/0 Ex	—
NEKN007	**Advanced Topics on Econometrics**	3	—	2/0 Ex
NEKN026	**Optimisation II with Applications in Finance**	6	—	4/0 Ex
NSTP029	**Advanced Topics on Probability, Statistics and Stochastic Processes I**	5	3/0 Ex	—
NSTP030	**Advanced Topics on Probability, Statistics and Stochastic Processes II**	5	—	3/0 Ex
NEKN037	**Dynamic Economics and Econometrics**	3	—	0/2 C
NEKN038	**Robust Econometrics**	3	—	0/2 C
NSTP021	**Bayesian Methods**	3	2/0 Ex	—
NSTP175	**Stochastic Analysis in Financial Mathematics**	3	2/0 Ex	—
NSTP185	**Advanced Topics on Financial Mathematics**	3	—	2/0 Ex
NSTP051	**Probability Theory 2**	3	—	2/0 Ex

[1] Can be subscribed repeatedly, in winter and summer term.

List of Requirements for the State Doctoral Examination

The exam consists of 3 main parts: One topic is chosen from Part I. Fundamentals, one from Part II. Advanced Topics and the last one according to the subject of the dissertation.

Part I. Fundamentals.

Convex and functional analysis. Difference and differential equations. Fundamentals of differential calculus in linear spaces. Matrix theory. Probability theory and mathematical statistics. Combinatorics and graph theory.

Part II. Advanced Topics.

II.1.

Econometric models. Multivariate statistical analysis. Time series analysis.

II.2.

Sample surveys. Robust, nonparametric and Bayesian methods.

II.3.

Optimization in finite dimension spaces (convex, multiobjective, parametric, stochastic, dynamic). Nonsmooth analysis and theory of multivalued mappings.

II.4.

Integer programming and combinatorial optimization. Optimization on graphs and nets.

II.5.

Mathematical models of conflict situations. Game theory and oligopoly theory.

II.6.

Probability theory and stochastic processes. Continuous, discrete and stochastic optimal control. Markov decision processes.

II.7.

Numerical methods of nonlinear and stochastic programming. Numerical methods of nonsmooth optimization. Economic modelling and its computer realizations. Simulation methods.

II.8.

Fundamentals of mathematical economics. Utility theory. Consumer theory. Theory of firm — production functions. Macroeconomic models (Leontief model etc.). Economic dynamics.

II.9.

Inaccurate data systems. Sensitivity analysis and results validation.

II.10.

Selected methods and problems of operational research (scheduling and network analysis, storage and queuing theory, quality and reliability control, marketing).

II.11.

Application of probability, mathematical statistics and operational research in finance, insurance and other economic areas.

Recommended Literature

Anděl, J.: **Matematická statistika.** *SNTL, Praha, 1978.*
Cipra, T.: **Finanční ekonometrie.** *Ekopress, Praha, 2008.*
Cipra, T.: **Matematika cenných papírů.** *HZ, Praha, 2000.*
Clarke, R.: **Optimization and Nonsmooth Analysis.** *Wiley Interscience, New York, 1983.*
Davidson, J.: **Stochastic Limit Theory. Advanced Texts in Econometrics.** *Oxford University Press, Oxford, 1994.*
Dupačová, J., Hurt, J., Štěpán, J.: **Stochastic Modeling in Economics and Finance.** *Kluwer, Dordrecht, 2002.*
Dupačová, J.: **Portfolio Optimization and Risk Management.** *Osaka University Press, Osaka, 2009.*
Elton, E. J., Gruber, M. J.: **Modern Portfolio Theory and Investment Analysis.** *Wiley, New York, 1987.*
Fan, J., Yao, Q.: **Nonlinear Time Series.** *Springer, New York, 2003.*
Hamilton, J. D.: **Time Series Analysis.** *Princeton University Press, Princeton, 1994.*
Mendelson, E.: **Introducing Game Theory and Its Applications.** *Chapman&Hall/CRC, Boca Raton, 2004.*
Rockafellar, R. T., Wets, R. J.–B.: **Variational Analysis.** *Springer Verlag, Berlin, 1998.*
Rockafellar, R. T.: **Convex Analysis.** *Princeton University Press, Princeton, 1970.*
Schott, J.: **Matrix Analysis for Statistics.** *Wiley, New York, 1997.*
Schrijver, A.: **Theory of Linear and Integer Programming.** *Wiley, New York, 1986.*
Taylor, A. E.: **Úvod do funkcionální analýzy.** *Academia, Praha, 1973.*
Zvára, K.: **Regresní analýza.** *Academia, Praha, 1989.*

4M6 Scientific and Technical Calculations

Council of Doctoral Studies in Branch 4M6

List of members of the Council can be found at the address `http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-m6.htm` .

Committee for the State Doctoral Examinations K3

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address `http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk03.htm` .

Cooperating Institutes

- Institute of Mathematics of the ASCR, v.v.i.
  Žitná 25, 115 67 Praha 1
  http://www.math.cas.cz

- Institute of Computer Science of the ASCR, v.v.i.
  Pod vodárenskou věží 2, 182 07 Praha 8
  http://www.cs.cas.cz/

- Institute of Thermomechanics of the ASCR, v.v.i.
  Dolejškova 1402/5, 182 00 Praha 8
  http://www.it.cas.cz/?q=en/node

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=M6 .

Courses Given

Code	Subject	Credits	Winter	Summer
NNUM014	**Seminar on Numerical Mathematics**	3	0/2 C	0/2 C
NNUM068	**Discontinuous Galerkin Method**	3	—	2/0 Ex
NNUM083	**Seminar on Aerodynamics Problems**	6	0/2 C	0/2 C
NDIR064	**Theory of Nonlinear Differential Equations**	3	—	2/0 Ex
NRFA058	**Fundamentals of Theory of Monotone and Potential Operators**	3	2/0 Ex	—
NMOD001	**Mathematical Methods in Fluid Mechanics for Ph.D. Students**	6	2/0 —	2/0 Ex
NMOD004	**Mathematical Modelling in Physics for Ph.D. Students**	6	2/0 —	2/0 Ex
NNUM070	**Finite Volume Method for Compressible Flows**	3	2/0 Ex	—
NNUM065	**Finite Element Methods — Course for Ph.D. Students**	3	2/0 Ex	—
NNUM080	**Mathematical Theory of Shape Optimisation for Ph.D. Students I**	3	2/0 Ex	—
NNUM081	**Mathematical Theory of Shape Optimisation for Ph.D. Students II**	3	—	2/0 Ex

NNUM180	**Numerical Methods in Bifurcation Theory**	3	2/0 Ex	—
NNUM066	**Advanced Topics on Finite Element Method**	3	2/0 Ex	—
NNUM140	**Selected Topics on Modern Theory of Quadratures and Cubatures 1**	3	2/0 Ex	—
NNUM240	**Selected Topics on Modern Theory of Quadratures and Cubatures 2**	3	—	2/0 Ex
NNUM111	**Numerical Solution of Nonstationary Problems**	6	2/2 C+Ex	—
NNUM084	**Applications of Multilevel Methods**	6	2/0 —	2/0 Ex
NMOD060	**Seminar on Modelling Particle Transport**	6	0/2 C	0/2 C
NNUM082	**Applications of Stochastic Methods**	12	2/2 C	2/2 C+Ex
NNUM102	**Theory of Splines and Wavelets for Ph.D. Students**	6	2/0 —	2/0 Ex
NNUM131	**Selected Chapters on Numerical Linear Algebra 1**	3	2/0 Ex	—
NNUM231	**Selected Chapters on Numerical Linear Algebra 2**	3	—	2/0 Ex
NNUM224	**Numerical Simulation in Electrical Engineering 1**	3	2/0 Ex	—
NNUM225	**Numerical Simulation in Electrical Engineering 2**	3	—	2/0 Ex
NNUM132	**Nonlinear Numerical Algebra for Ph.D. Students I**	6	2/2 C+Ex	—
NNUM232	**Nonlinear Numerical Algebra for Ph.D. Students II**	6	—	2/2 C+Ex
NMOD042	**Mathematical Analysis of Models in Non-Newtonian Fluid Thermodynamics**	3	—	2/0 Ex
NMOD140	**Mathematical Methods in Solid State Continuum Mechanics for Ph.D. Students 1**	3	2/0 Ex	—
NMOD044	**Mathematical Methods in Solid State Continuum Mechanics 2**	3	—	2/0 Ex

List of Requirements for the State Doctoral Examination

1. Mathematical and Functional analysis

Ordinary and partial differential equations, classical and weak solutions. Integral equations. Fourier transform. Linear operators. Spectral theory. Distributions.

Sobolev spaces. Monotone operators. Potential operators. Nonlinear differential equations.

2. Numerical methods

Methods for solving the systems of linear equations. Solving the eigenvalue problem. Methods for solving the systems of nonlinear equations. Approximation, interpolation and extrapolation in numerical analysis. Numerical methods of solving ODE. Numerical integration. Solving PDE: Finite differences, finite elements and finite volumes. Multigrid techniques.

3.Optional subjects related to the particular Ph.D.–project

Recommended Literature

Axelsson, O., Barker, V. A.: **Finite Element Solution of Boundary Value Problems, Theory and Computation.** *Academic Press, New York, 1984.*

Ciarlet, P. G.: **The Finite Element Method for Elliptic Problems.** *North–Holland, Amsterdam, 1978.*

Demmel, J. W.: **Applied Numerical Linear Algebra.** *PA, SIAM, Philadelphia, 1997.*

Feistauer, M., Felcman, J., Straskraba, I.: **Mathematical and Computational Methods for Compressible Flow.** *Clarendon Press, Oxford, 2003.*

Feistauer, M.: **Mathematical Methods in Fluid Dynamics.** *Longmann Scientific & Technical, Harlow, 1993.*

Fiedler, M.: **Speciální matice a jejich použití v numerické matematice.** *SNTL, Praha, 1981.*

Fučík, S., Kufner, A.: **Nelineární diferenciální rovnice.** *SNTL, Praha, 1978.*

Golub, G. H., Loan van, C. F.: **Matrix Computations.** *3rd ed., Johns Hopkins University Press, Baltimore, 1996.*

Johnson, C.: **Numerical Solution of Partial Differential Equations by the Finite Element Method.** *Cambridge University Press, Cambridge, 1988.*

Křížek, M., Neittaanmaki, P.: **Mathematical and Numerical Modelling in Electrical Engineering, Theory and Applications.** *Kluwer, Dordrecht, 1996.*

Lukeš, J.: **Zápisky z funkcionální analýzy.** *Karolinum, Praha, 1998.*

Lukšan, L.: **Metody s proměnnou metrikou.** *Academia, Praha, 1990.*

Nečas, J.: **Introduction to the Theory of Nonlinear Elliptic Equations.** *Teubner, Band 52, 1983.*

Ortega, J. M., Rheinboldt, W. C.: **Iterative Solution of Nonlinear Equations in Several Variables.** *Academic Press, New York–London, 1970.*

Rudinà W.: **Analýza v reálném a komplexním oboru** *Academia, Praha, 2003.*

Saad, Y.: **Iterative Methods for Sparse Linear Systems.** *PWS Publishing Company, 1996.*

Segeth, K.: **Numerický software I.** *Karolinum, Praha, 1998.*

Trefthen, L. N., Bau, D.: **Numerical Linear Algebra.** *SIAM, Philadelphia, 1997.*

Ueberhuben, C. W.: **Numerical Computation 2.** *Springer, Berlin, 1995.*

Yosida, K.: **Functional Analysis.** *Springer Verlag, Berlin, 1980.*

4M7 Financial and Insurance Mathematics

Council of Doctoral Studies in Branch 4M7

List of members of the Council can be found at the address http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-m7.htm .

Committee for the State Doctoral Examinations K5

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk05.htm .

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=M7 .

Courses Given

Code	Subject	Credits	Winter	Summer
NFAP036	**Selected Topics on Financial Mathematics 1**	3	0/2 C	—
NFAP037	**Selected Topics on Financial Mathematics 2**	3	—	0/2 C
NFAP011	**Seminar on Actuarial Sciences**	3	0/2 C	0/2 C
NSTP018	**Multivariate Statistical Analysis**	6	2/2 C+Ex	—
NSTP020	**Survival Data Analysis**	3	2/0 Ex	—
NFAP012	**Stochastic Financial Models**	3	2/0 Ex	—
NFAP049	**Advanced Topics on Non-life Actuarial Mathematics**	3	2/0 Ex	—
NFAP050	**Advanced Topics on Risk Theory**	3	—	2/0 Ex
NFAP051	**Financial Modelling in Life Insurance**	3	2/0 Ex	—
NFAP052	**International Accounting Standards for Insurance Contracts**	3	—	2/0 Ex

List of Requirements for the State Doctoral Examination

The examination consists of three parts: I. Broader scientific background, II. Advanced topics of concentration, III. Specialization. The examined areas pertaining to parts I, II are determined by the chairman of the examination board on the proposal of the supervisor. The contents of Part I should serve to extend the knowledge acquired during the Master's Degree studies. The contents of Part II should be determined with regard to the scientific concentration of the candidate. The examiner of Part III is

usually the supervisor. The topic examined should be closely related to the subject of the dissertation.

I. Broader scientific background

I.1. Applied probability

I.1.1 Survival data analysis

Parametric survival models. Censored samples. Estimates in censored samples. Maximum likelihood method. Bayesian methods. Kaplan–Meier estimate. Proportional hazard model. Cox regression model. Applications in insurance.

I.1.2 Multivariate statistical methods

Multivariate normal distribution. Wishart distribution. Hotelling T–square. Testing hypotheses. Canonical correlations. Principal component method. Discrimination analysis. Factor analysis. Cluster analysis.

I.1.3 Extreme value theory

Convergence of centered and standardized maxima. Max–stable distributions. Fisher–Tippet theorem. Extreme value distributions and their characteristics. Generalized extreme value distributions and their characteristics. Modeling of excesses and of exceeding values. Generalized Pareto distribution. Statistical analysis of extreme values.

I.2.Theory of random processes

I.2.1 Stochastic analysis

Wiener process. Time dynamics of random events. Stochastic integral and differential. Linear stochastic differential equations. Diffusion processes. Backward Kolmogorov differential equation. Fokker–Planck equation. Diffusion approximation. Multivariate processes. Girsanov theorem. Statistics in diffusion processes. Integral representation of martingales.

I.2.2 Multistate models

Laplace transform. Lerch's theorem. Point processes. Renewal processes. Semimarkovian processes. Regenerative processes. Limit theorems for regenerative processes. Transition intensities. British model of health insurance. Statistical methods in multivariate processes.

I.2.3 Linear systems

Discrete time linear systems. Transfer function. Frequency transfer function. State space models of linear systems. Poles of the transfer functions. Applications in financing of pension funds. Laplace transform. Continuous time linear systems. System identification. Stochastic linear systems.

II. Advanced topics of concentration

II.1. Financial mathematics

II.1.1 Stochastic financial models

Binomial and continuous Black–Scholes models. Applications to currency exchange rates, to stocks with dividend payments, contracts with payment in foreign currency. Replication portfolio, hedging. Market price of risk. Risk neutral probability measure. Heath–Jarow–Morton model of forward interest rate. Diffusion models of forward interest rate.

II.1.2 Risk management

Risk measures. Value at risk. Portfolio. Return. Expected return and risk of a portfolio. Capital asset pricing model (CAPM). Matching of assets and liabilities. Hedging instruments and their evaluation.

II.1.3 Yield curves

Term structure of interest rates. Risk premium. Liquidity premium. Yields of obligations in dependence on rating. The influence of callability on the value of a bond. Mapping. Approximation of yield curves.

II.2. Insurance Mathematics

II.2.1. Mortality tables

Interpreting the mortality table. Model of a stationary population. Model of random life length. Estimating probabilities of death. Adjustment methods of death probabilities. Gompertz–Makeham curve. King–Hardy method. Adjustment by means of spline functions and moving averages. Selection tables. Generation tables. Multi-decrement model.

II.2.2. Credibility theory

Insurance ratemaking fundamentals. American credibility theory. Bayesian methods in credibility theory. Bühlmann model. Exact Credibility. Bühlmann–Straub model. Hachemeister regression model. Estimates of structural parameters. Evolutionary credibility models.

II.2.3 Risk modeling

Ruin theory. Modeling the development of technical reserves. Economic capital. Theory of capital adequacy. Risk and value oriented insurance company management. Financial reporting of insurance companies. Internal risk models.

Recommended Literature

Baxter, M., Rennie, A.: **Financial Calculus.** *Cambridge University Press, Cambridge, 1996.*

Blum, C., Overbeck, L., Wagner, C.: **An Introduction to Credit Risk Modelling.** *Chapman & Hall–CRC, London, 2003.*

Booth, P. et al.: **Modern Actuarial Theory and Practice.** *2nd ed. Chapman & Hall–CRC, London, 2005.*

Bowers, N. et al.: **Actuarial Mathematics.** *Society of Actuaries, Schaumburg, IL, 1997.*

Bühlmann, H., Gisler, A.: **A Course in Credibility Theory and its Applications.** *Springer–Verlag, Berlin–Heidelberg, 2005.*

Denuit, M. et al.: **Actuarial Theory for Dependent Risks.** *J. Wiley, Chichester, 2005.*

Höglund, T.: **Mathematical Asset Management.** *J. Wiley, Hoboken, 2008.*

Nguyen, T.: **Handbuch der wert–und risikoorientierten Steuerung von Versicherungsunternehmen.** *VVW. Karlsruhe, 2008.*

Panjer, H. H. (ed.): **Financial Economics: with applications to investment, insurance and pensions.** *The Actuarial Foundation, Schaumburg IL, 1998.*

Panjer, H. H., Wilmot, G. E.: **Insurance Risk Models.** *Society of Actuaries, Schaumburg, IL, 1992.*

Pitacco, E. et al.: **Modelling Longevity Dynamics for Pensions and Annuity Business.** *Oxford University Press, Oxford, 2009.*

4M8 General Problems of Mathematics and Computer Science

Council of Doctoral Studies in Branch 4M8

List of members of the Council can be found at the address `http://www.mff.cuni.cz/to.en/studium/phd/obory/obor/nor4-m8.htm` .

Committee for the State Doctoral Examinations K1

Members of the committees for the State Doctoral Examinations and Defence of the Ph.D. thesis are selected from the list given at the address `http://www.mff.cuni.cz/to.en/studium/phd/komise/komise/nk01.htm` .

Cooperating Institutes

- Institute of Mathematics of the ASCR, v.v.i.
  Žitná 25, 115 67 Praha 1
  `http://www.math.cas.cz`

Homepage of the Council of Doctoral Studies 4M8

`http://www.karlin.mff.cuni.cz/~becvar/pgs/pgs.htm`

Proposed Topics of Ph.D. Thesis

Proposed topics can be seen in the Student Information System in `http://is.cuni.cz/eng/studium/dipl_st/redir.php?redir=szn_obor&fak=11320&obor=M8` .

Courses Given

Code	Subject	Credits	Winter	Summer
NUMP015	**History of Mathematics I**	3	—	2/0 MC
NUMV001	**History of Mathematics II**	3	2/0 MC	—
NUMV053	**History of Mathematics III**	3	2/0 MC	—
NUMV074	**History of Mathematics in Antiquity**	3	2/0 Ex	—
NUMV066	**Seminar (didactics and history) I**	3	0/2 C	—
NUMV067	**Seminar (didactics and history) II**	3	—	0/2 C
NUMV075	**Seminars for PhD students I**	3	0/2 C	—
NUMV076	**Seminars for PhD students II**	3	—	0/2 C
NUMV065	**Development of Mathematics Education**	3	—	0/2 C

NUMV072	**Mathematics Teaching Reforms**	3	—	2/0 C
NUMV049	**Elementary Mathematics of Felix Klein**	3	—	0/2 C
NUMV068	**Differential Geometry on Computer**	6	2/2 C+Ex	—
NUMV077	**Computer Solutions of Geometrical Problems I**	3	2/0 Ex	—
NUMV078	**Computer Solutions of Geometrical Problems II**	3	—	2/0 Ex
NGEM008	**Geometric Problems of Robotics 1**	5	3/0 Ex	—
NGEM009	**Geometric Problems of Robotics 2**	5	—	3/0 Ex
NUMV073	**Additional Topics in Integration Theory**	3	2/0 Ex	—
NUMV043	**Methods of Solving Mathematical Problems**	3	0/2 C	—
NUMV069	**Mathematical Problems and Their Solutions**	3	—	0/2 C
NUMV084	**ICT in Mathematics Teaching I**	3	0/2 C	—
NUMV085	**ICT in Mathematics Teaching II**	3	—	0/2 C
NUMV079	**Didactics of Probability Theory and Statistics I**	3	2/0 Ex	—
NUMV080	**Didactics of Probability Theory and Statistics II**	3	—	2/0 Ex
NDIN010	**Didactics of Computer Science I**	3	0/2 C	—
NDIN013	**Didactics of Computer Science II**	3	—	0/2 MC
NUMV024	**Mathematical Analysis, Second Reading**	3	—	2/0 MC
NPGR020	**Geometry for Computer Graphics**	3	2/0 Ex	—
NPGR021	**Geometric Modelling**	5	—	2/1 C+Ex

List of Requirements for the State Doctoral Examination

Ph.D. studies in General questions of mathematics and information science were opened in the school year 1992–93 at MFF UK Prague. The studies are divided into three areas.

The first one, Elementary mathematics, offers a range of possibilities for teachers. After finishing these studies they wil1 be better qualified for their teaching work generally and for work with the talented students in particular. By elementary mathematics, we mean the classic parts of mathematics which are relevant to both the secondary mathematics curriculum and the content of mathematics for future teachers, and which

broaden them. One of the important aims of work in elementary mathematics should be to keep historical continuity of mathematics and to strengthen the respect for traditional mathematical values. The methodological–didactic conclusion of the whole studies in Elementary mathematics is a thesis.

In the second area, The history of mathematics and information science, attention is paid mainly to mathematics and information science in 19th and 20th centuries in our countries however biographic and bibliographic aspects are not neglected, too. The history of mathematics is closely connected with teaching mathematics because its development is also conditional upon the passing on of knowledge by teachers and through textbooks. The history of mathematics as a science and an area of scientific education has not been offered as a field of study at Charles University in the last few decades.

The study of the third area, Teaching mathematics and information science, is usually offered only to practising teachers mainly in an external mode. One part of a thesis can be, for instance, a teaching text or a book of mathematical problems, including a methodological commentary and analysis of difficult issues. Everything has to be based on the students own teaching experience.

Ph.D. studies in General problems of mathematics and information science are aimed at secondary teachers who graduate with mathematics or information science as a teaching subject and at university teachers who teach mathematics or information science or didactics of these subjects. For admission to the study of the first area (Elementary mathematics) at least three–years of teaching experience is required. The second area (History) is also aimed at people who graduated with pure mathematics or information science. For the third area (Teaching) at least three–years of teaching experience is required. Only when a thesis concerns the teaching of information science can exception be allowed. The mode of study will be mainly through distance learning.

For admission to the studies in General questions of mathematics and information science the fol1owing requirements are required: a deeper knowledge of the whole of secondary mathematics and basic mathematical university courses; of general knowledge of the history of mathematics; good knowledge of the teaching of problem solving at the secondary level, an interest in this field. The entrance examination also contains a language exam English is the preferred language at MFF UK.

An individual study plan is prepared for each student. It contains the common elements of all three areas, deeper studies in the chosen area and a section directly connected with the proposed thesis topic.

Ph.D. studies are realized mainly in the form of a controlled study of the recommended literature and involvement in the work of seminars. After ea.ch school year the work of the doctoral students is evaluated.

The study is completed by the writing and defending of a doctoral thesis and the examination. Requirements for this exam are given individually, the main emphasis being put on the quality of the thesis.

I. Requirements

I.1. Mathematics/Computer Science

Broader and deeper knowledge than at the state exam for intending teachers at the Faculty of Mathematics and Physics of Charles University is expected. The candidate has to prove understanding of the subject on both the secondary school and the university level. Also the orientation in the present textbooks is required.

I.2. History of Mathematics and Computer Science

It is supposed that the students understand the mathematical background of the historical topics. Except the general orientation some deeper knowledge is supposed at the fields which are immediately related to the work. The objective is not a detailed knowledge of the history of mathematics but approximate idea on the development of mathematics/computer science and the basic orientation in the evolution of some its part. The instructor and the examiners define 300 pages of special text of reading at least.

I.3. Teaching of Mathematics

It is supposed that the student is informed on classical and modern teaching methods and that he/she is able to apply them on a particular theme. The methodology of problem solving and the knowledge of corresponding literature are required on a good level. The instructor and the examiners define 150 pages of special text of reading at least.

I.4. Specialization

According to the subject of the dissertation the instructor and the examiners will define some additional parts of literature in one of the preceding themes (Mathematics/Computer Science, History of Mathematics and Computer Science, Teaching of Mathematics) of at least 100 pages of the text.

I.5. Extension of the scope, cultivation

A deep interest in the field is supposed including regular following of literature in all three above mentioned areas. Student is supposed to master the way of creating references and the use of abstracting journals/data basis. Computer literacy is automatically supposed.

The doctor exam is crowning the process of the study and it is a shell of the exams and required sums of credits of the compulsory and also extended programme of the study. The studying literature to the exam is formed by the literature to the partial exams and by the extension concerning the theme of the dissertation.

Recommended Literature

Anglin, W. S., Lambek, J.: **The Heritage of Thales.** *Springer–Verlag, New York, 1995.*

Anglin, W. S.: **Mathematics — A Concise History and Philosophy.** *Springer–Verlag, New York, 1994.*

Bečvář, J. a kol.: **Matematika ve středověké Evropě. Dějiny matematiky 19.** *Prometheus, Praha, 2001.*

Bečvář, J., Bečvářová, M., Vymazalová, H.: **Matematika ve starověku. Egypt a Mezopotámie. Dějiny matematiky 23.** *Prometheus, Praha, 2003.*

Bečvář, J., Fuchs, E. (ed.): **Člověk — Umění — Matematika. Dějiny matematiky 4.** *(Čižmár: Vznik a vývoj algebrickej geometrie, Hejný: Objevování neeukleidovské geometrie, Veselý: O některých důležitých řadách), Prometheus, Praha, 1996, str. 73–126, 137–154.*

Bečvář, J., Fuchs, E. (ed.): **Historie matematiky I. Dějiny matematiky 1.** *(Fuchs: Přehled vývoje matematiky, Bečvář: Hrdinský věk řecké matematiky, Fuchs: Od měření obsahů a objemů k infinitesimálnímu počtu, Šimša: Archimé-*

dova statika v geometrii, Fuchs: Co ještě nevíme o prvočíslech, Šimša: Eukleidův důkaz nekonečnosti množiny všech prvočísel), JČMF, Brno, 1994, str. 4–169.

Bečvář, J., Fuchs, E. (ed.): **Historie matematiky II. Dějiny matematiky 7.** *(Bečvář: Hrdinský věk řecké matematiky II, Mačák: Poznámky k formování teorie pravděpodobnosti), Prometheus, Praha, 1997, str. 7–67.*

Bečvář, J., Fuchs, E. (ed.): **Matematika v 16. a 17. století. Dějiny matematiky 12.** *(Nádeník: Geometrie v 16. a 17. století, Bečvář: Algebra v 16. a 17. století, Mačák: Poznámky k formování kombinatoriky v 16. a 17. století, Šimša: Vývoj představ o reálných číslech), Prometheus, Praha, 1999, str. 109–282.*

Bečvář, J., Fuchs, E. (ed.): **Matematika v 19. století. Dějiny matematiky 3.** *(Schwabik: Několik postřehů k vývoji matematické analýzy v 19. století), Prometheus, Praha, 1996, str. 7–37.*

Bečvář, J., Fuchs, E. (ed.): **Matematika v proměnách věků. Dějiny matematiky 11.** *(Schwabik: Druhá krize matematiky), Prometheus, Praha, 1998, str. 7–60.*

Bečvář, J.: **Z historie lineární algebry. Dějiny matematiky 35.** *Matfyzpress, Praha, 2007.*

Bečvářová, M.: **Česká matematická komunita v letech 1848 až 1918. Dějiny matematiky 34.** *Matfyzpress, Praha, 2008.*

Cooke, R.: **The History of Mathematics, A Brief Course.** *Wiley Interscience, New York, 1997.*

Dieudonné, J. (ed.): **Abrégé d'histoire des mathématiques 1700–1900.** *Hermann, Paris, 1978; německy 1985.*

Edwards, C. H.: **The Historical Development of the Calculus.** *Springer–Verlag, New York, 1979.*

Eves, H. W.: **An Introduction to the History of Mathematics.** *5th ed. Saunders, Philadelphia, 1983.*

Folta, J. (ed.): **Filozofické a vývojové problémy matematiky.** *(Bečvář: Teorie algeber, Fuchs: Od úlohy o 36 důstojnících ke konečným geometriím a k blokovým schématům (z historie kombinatoriky), Štefl: Vznik a rozvoj nebeské mechaniky), JČSMF, Praha, 1988, str. 93–147, 173–186.*

Gericke, H.: **Mathematik in Antike, Orient und Abendland.** *Fourier Verlag, Wiesbaden, 2003.*

Hecht, T., Sklenáriková, Z.: **Metódy riešenia matematických úloh.** *SPN, Bratislava, 1992.*

Hejný, M.: **Teória vyučovania matematiky 2.** *SPN, Bratislava, 1990.*

Herman, J., Kučera, R., Šimša, J.: **Metody řešení matematických úloh I, II.** *Praha, 1990, MU Brno 1991; další vydání 1996, 1997.*

Chabert, J.–L.: **A History of Algorithms — From the Pebbe to the Microchip.** *Springer–Verlag, Berlin–Heidelberg, 1999.*

Juškevič, A. P.: **Dějiny matematiky ve středověku.** *Academia, Praha, 1977.*

Kline, M.: **Mathematical Thought from Ancient to Modern Times.** *Oxford University Press, Oxford, 1972.*

Komenský, J. A.: **Analytická didaktika.** *SN, Praha, 1947.*

Larson, L. C.: **Metódy riešenia matematických problémov.** *Alfa, Bratislava, 1990.*

Metropolis, N., Howlett, J., Rota, G.–C.: **A History of Computing in the Twentieth Century.** *Academic Press, New York, 1980.*
Nový, L. a kol.: **Dějiny exaktních věd v českých zemích.** *ČSAV, Praha 1961.*
Odvárko, O.: **Metody řešení matematických úloh.** *SPN, Praha, 1990.*
Pátý, L. (ed.): **Jubilejní almanach 1862–1987.** *JČSMF, Praha, 1987.*
Posejpal, V.: **Dějepis Jednoty Českých Mathematiků.** *JČM, Praha, 1912.*
Potůček, J.: **Vývoj vyučování matematice na českých středních školách v období 1900–1945, I, II.** *ZČU, Plzeň 1992, 1993.*
Pristley, W. M.: **Calculus: An Historical Approach.** *Springer–Verlag, New York, 1979.*
Scharlau, W., Opolka, H.: **From Fermat to Minkowski.** *Springer–Verlag, New York 1985; německy 1980.*
Scholz, E. (Hrsg.): **Geschichte der Algebra, Eine Einführung.** *Wissenschafts–Verlag, Mannheim–Wien-Zürich, 1990.*
Schwabik, Š., Šarmanová, P.: **Malý průvodce historií integrálu. Dějiny matematiky 6.** *Prometheus, Praha, 1996.*
Stillwell, J.: **Mathematics and Its History.** *2nd ed. Springer–Verlag, New York, 1989, 2002.*
Šedivý, J. (ed.): **Světonázorová výchova v matematice.** *(Štefl: Vývoj názorů na stavbu vesmíru od starověku po Galilea, Fuchs: Vznik a vývoj teorie množin. Třetí krize matematiky, Netuka, Schwabik: Vznik a vývoj matematické analýzy, Veselý: Sčítání divergentních řad, Bečvář: Soustavy lineárních rovnic a determinanty, Čižmár: Vývin geometrického myslenia v 19. storočí a na začiatku 20. storočia), JČSMF, Praha, 1987, str. 17–43, 80–156, 169–252.*
Veselý, F.: **100 let Jednoty československých matematiků a fyziků.** *SPN, Praha 1962.*
Vopěnka, P.: **Rozpravy s geometrií. Otevření neeukleidovských geometrických světů.** *Vesmír, Praha, 1995, str. 7–98.*
Waerden van der, B. L.: **A History of Algebra, From al–Khwárizmí to Emmy Noether.** *Springer–Verlag, Berlin, 1985.*
Williams, M. R.: **A History of Computing Technology.** *IEEE Computer Society Press, Los Alamitos, California, 1997.*

Cooperating Institutes

- Astronomical Institute of the ASCR, v.v.i.
  Fričova 298, 251 65 Ondřejov
  `http://www.asu.cas.cz/en/`

  4F1 Theoretical Physics, Astronomy and Astrophysics
  4F2 Physics of plasmas and ionized media
  4F12 Physics education and general problems of physics

- Czech Hydrometeorological Institute
  Na Šabatce 17, 143 06 Praha 4
  `http://www.chmu.cz/indexe.html`

  4F8 Meteorology and climatology

- Institute of Physics of the ASCR, v.v.i.
  Na Slovance 2, 182 21 Praha 8
  `http://www.fzu.cz/`

  4F1 Theoretical Physics, Astronomy and Astrophysics
  4F2 Physics of plasmas and ionized media
  4F3 Physics of condensed matter and materials research
  4F4 Biophysics, chemical and macromolecular physics
  4F5 Surface and interface physics
  4F6 Quantum optics and optoelectronics
  4F9 Subnuclear physics
  4F13 Physics of nanostructures

- Institute of Physiology of the ASCR, v.v.i.
  Vídeňská 1083, 142 20 Praha 4
  `http://www.biomed.cas.cz/fgu/en/index.php`

  4F4 Biophysics, chemical and macromolecular physics

- Institute of Geophysics of the ASCR, v.v.i.
  Boční II/1401, 141 31 Praha 4 - Spořilov
  `http://www.ig.cas.cz/en/welcome/`

  4F7 Geophysics

- Institute of Mathematics of the ASCR, v.v.i.
  Žitná 25, 115 67 Praha 1
  http://www.math.cas.cz

  4F1 Theoretical Physics, Astronomy and Astrophysics
  4F11 Mathematical and computer modelling
  4I1 Theoretical Computer Science
  4I2 Software systems
  4I3 Mathematical linguistics
  4I4 Discrete models and algorithms
  4M1 Algebra, theory of numbers and mathematical logic
  4M2 Geometry, topology, global analysis and general structures
  4M3 Mathematical analysis
  4M4 Probability and mathematical statistics
  4M6 Scientific and technical calculations
  4M8 General problems of mathematics and computer science

- Institute of Microbiology of the ASCR, v.v.i.
  Vídeňská 1083, 142 20 Praha 4 - Krč
  http://www.biomed.cas.cz/mbu/en/index.php

  4F4 Biophysics, chemical and macromolecular physics

- Institute of Photonics and Electronics of the ASCR, v.v.i.
  Chaberská 57, 182 51 Praha 8
  http://www.ufe.cz/setlang.php?lang=en&ref=/

  4F3 Physics of condensed matter and materials research
  4F4 Biophysics, chemical and macromolecular physics
  4F5 Surface and interface physics
  4F6 Quantum optics and optoelectronics

- J. Heyrovsky Institute of Physical Chemistry of the ASCR, v.v.i.
  Dolejškova 2155/3, 182 23 Praha 8
  http://www.jh-inst.cas.cz/

  4F1 Theoretical Physics, Astronomy and Astrophysics
  4F2 Physics of plasmas and ionized media
  4F4 Biophysics, chemical and macromolecular physics
  4F5 Surface and interface physics

- Institute of Atmospheric Physics of the ASCR, v.v.i.
  Boční II/1401, 141 31 Praha 4
  http://www.ufa.cas.cz/

  4F2 Physics of plasmas and ionized media
  4F8 Meteorology and climatology

- Institute of Plasma Physics of the ASCR, v.v.i.
  Za Slovankou 1782/3, 182 00 Praha 8
  `http://www.ipp.cas.cz/`

  4F2 Physics of plasmas and ionized media

- Institute of Computer Science of the ASCR, v.v.i.
  Pod vodárenskou věží 2, 182 07 Praha 8
  `http://www.cs.cas.cz/`

  4I1 Theoretical Computer Science
  4I2 Software systems
  4M1 Algebra, theory of numbers and mathematical logic
  4M6 Scientific and technical calculations

- Nuclear Physics Institute of the ASCR, v.v.i.
  Husinec – Řež č. p. 130, PSČ 250 68
  `http://www.ujf.cas.cz/`

  4F1 Theoretical Physics, Astronomy and Astrophysics
  4F3 Physics of condensed matter and materials research
  4F9 Subnuclear physics
  4F10 Nuclear physics

- Institute of Macromolecular Chemistry of the ASCR, v.v.i.
  Heyrovského nám. 2, 162 06 Praha 6
  `http://www.imc.cas.cz/en/index.html`

  4F3 Physics of condensed matter and materials research
  4F4 Biophysics, chemical and macromolecular physics
  4F13 Physics of nanostructures

- Institute of Organic Chemistry and Biochemistry of the ASCR, v.v.i.
  Flemingovo nám. 2, 166 10 Praha 6
  `http://www.uochb.cas.cz/`

  4F4 Biophysics, chemical and macromolecular physics

- Institute of Rock Structure and Mechanics of the ASCR, v.v.i.
  V Holešovičkách 41, 182 09, Praha 8
  `http://www.irsm.cas.cz/?Lang=ENG&Menu=0,0,0,0`

  4F7 Geophysics

- Institute of Information Theory and Automation of the ASCR, v.v.i.
  Pod vodárenskou věží 4/1143, 182 08 Praha 8
  `http://www.utia.cas.cz`

  4I1 Theoretical Computer Science
  4I2 Software systems
  4M4 Probability and mathematical statistics
  4M5 Econometrics and operational research

- Institute of Thermomechanics of the ASCR, v.v.i.
  Dolejškova 1402/5, 182 00 Praha 8
  `http://www.it.cas.cz/?q=en/node`

  4F3 Physics of condensed matter and materials research
  4F8 Meteorology and climatology
  4F11 Mathematical and computer modelling
  4I1 Theoretical Computer Science
  4M6 Scientific and technical calculations