Federal state autonomous educational institution of higher education
“People’s Friendship University of Russia”, RUDN University
Faculty of Science

ANNOTATION OF THE ACADEMIC DISCIPLINE

Educational Program 03.06.01 Physics and Astronomy (specialization Theoretical Physics)

Course Title	**Methodology of scientific research**
Course Scope	**3 credits (108 hours)**
COURSE SUMMARY	
Course Units (Topics)	**Course Units (Topics) Outline**
Analogy and its role in science	Analogy as one of the important methods of cognition in science. Classification of physical quantities and kinematic analogies (vectors and tensors). Inductive and deductive methods of research. Intuition and hypothesis in theoretical physics.
Symmetry principles	Symmetry principle of P. Curie and its consequences. E. Noether theorem and conservation laws. Stability principle as a basis for the theory of measurements.
Optics-mechanics analogy	Quantum mechanics and optics-mechanics analogy. Charge independence of nuclear forces and gauge invariance of interactions as checking principle for physical models.
History and methodology of physics	Mechanics of Newton as a basis for physical world picture. Lagrangian and Hamiltonian formalisms. Electrodynamics of Maxwell and Faraday. Electromagnetic origin of light. Wave and corpuscular optics. Relativistic mechanics. Special theory of relativity. Molecular physics and kinetic theory of heat. Quantum thermodynamics. Planck’s law. Irreversibility in statistical physics. Atomic hypothesis. Wave – particle dualism. Quantum mechanics as a basis of a new physical world picture. Quantum gravity.

Developers:

Professor of the

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ANNOTATION OF THE ACADEMIC DISCIPLINE

Educational Program 03.06.01 Physics and Astronomy (specialization Theoretical Physics)

Course Title	**Condensed Matter Physics**
Course Scope	**3 credits (108 hours)**
COURSE SUMMARY	
Course Units (Topics)	**Course Units (Topics) Outline**
General concepts and methods of condensed matter physics	Main dynamic and thermodynamic parameters of state for the matter. Gaseous state, electrically neutral states and plasmas. Condensed state: liquid, solid, intermediate states. Quantum effects in condensed matter physics. Order parameters and quasi-particles.
Electric properties of condensed matter	Electric properties of crystals. Quasi-classical theory of metals: Drude, Lorentz, Sommerfeld. Quantum states of electrons in crystals. Adiabatic and self-consistent approximations. Approximation of slightly bound electrons. Kronig – Penny problem, periodicity in crystals. Bloch functions and Brillouin zones. Approximation of strongly bound electrons. Wannier functions. Metals, semiconductors and dielectrics. Fermi surface.
Electron-phonon interaction and superconductivity	Electron-phonon interaction. Cooper phenomenon. Bardeen – Cooper – Schrieffer – Bogoliubov theory of superconductivity. Low-dimensional matter: strings and films. Graphene. Quantum points and wires. Quantum Hall effect. Polaritons and plasmons in metals.
Magnetic properties of condensed matter	Weak and strong magnetics. Landau levels. Ferro-magnetics, antiferro-magnetics, ferri-magnetics. Magnetocaloric effect and its applications. Spin-waves, magnons. Surface properties of solids. Thermo-electron and photo-electron emission. Photo-conductivity. Amorphous solids, glasses. Polymers, bio-polymers.

Developers:

Professor of the

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Faculty of Science

ANNOTATION OF THE ACADEMIC DISCIPLINE

Educational Program 03.06.01 Physics and Astronomy (specialization Theoretical Physics)

Course Title	**Foreign Language**
Course Scope	**5 credits (180 hours)**
COURSE SUMMARY	
Course Units (Topics)	**Course Units (Topics) Outline**
The main principles of scientific reviews	Phrases-clichés. Bibliography lists. Reference styles. Scientific vocabulary. Typical fields of research. Motivation of the paper. Theoretical hypothesis and its experimental verification. Plan of future research. Unsolved problems. Conclusion.
Professional fields of research	Particle physics. Nuclear physics. Physical units of measurement. Statistical terminology. Symmetry principles. Typical mathematical constructions.
Useful advices for authors	Author’s translation and editing. The translation of “professional translator”. Mathematical clichés. Terms as objects and concepts. Introductory expressions.
Collection of typical errors	Misuse of articles and words “it”, “which”, “whose” and “that”. How to represent lectures and reports.

Developers:

<u>Professor of the</u>

<u>Institute of physical research and technology</u> ________ <u>Yu.P. Rybakov</u>
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Federal state autonomous educational institution of higher education
Peoples' Friendship University of Russia

Faculty of Humanities and Social Sciences

DISCIPLINE ANNOTATION

Education Programs in all fields of postgraduate study

Discipline	**History and Philosophy of Science**
Total	**4 credits (144 hours)**
Contents	
Units	Topics
The subject and basic concepts of modern philosophy of science	Philosophy of science as the study of general laws of scientific knowledge in its historical development and changing socio-cultural context. The evolution of approaches to the analysis of science. Logical and epistemological approach to the study of science. Positivist tradition in the philosophy of science. Expansion of the field of philosophical issues in the postpositivistic philosophy of science.
Science in the culture of modern civilization	Traditionalist and technogenic types of civilizational development and their basic values. The role of science in modern education and the formation of personality. Functions of science in society.
The genesis of science and the main stages of its historical evolution	The culture of the ancient polis and the formation of the first forms of theoretical science. Antique logic and mathematics. Western and Eastern medieval science. The formation of experimental science in the new European culture. Background of the experimental method and its connection with a mathematical description of nature. Formation of science as a professional activity. The genesis of disciplinary organized science. Formation of technical sciences. The formation of social and human sciences.
The structure of scientific knowledge	The variety of types of scientific knowledge. Empirical and theoretical levels, the criteria for their distinction. Features of the empirical and theoretical language of science. The structure of empirical knowledge. Experiment and observation. Empirical dependencies and empirical facts. The structure of theoretical knowledge. Primary theoretical models and laws. Developed theory. Theoretical models. Foundations of science. Ideals and norms of research. Scientific picture of the world. Philosophical foundations of science.
Dynamics of science	The interaction of the foundations of science and experience, the formation of a new discipline. Formation of primary theoretical models and laws. The role of analogies in the theoretical search. Procedures to substantiate theoretical knowledge. The relationship of the logic of discovery and logic of justification.. Formation of a developed scientific theory. Problem

	situations in science. The development of science under the influence of new theories.
Scientific traditions and scientific revolutions. Types of scientific rationality	The interaction of traditions and the emergence of new knowledge. Scientific revolution as the restructuring of the foundations of science. Problems of typology of scientific revolutions. Intra-disciplinary mechanisms of scientific revolutions. Global revolutions and types of scientific rationality. Historical change of types of scientific rationality: classical, non-classical, post-non-classical science.
Features of the modern stage of development of science. Prospects for scientific and technological progress	Modern processes of differentiation and integration of sciences. Global evolutionism as a synthesis of evolutionary and systemic approaches. New ethical problems of science at the end of XX century. The problem of humanitarian control in science and high technology. Environmental and socio-humanitarian expertise of scientific and technical projects. Scientism and anti-scientism. Science and parascience. The role of science in overcoming contemporary global crises.
Science as a social institution	Scientific communities and their historical types. Science schools. Scientific training. Historical development of the methods of transmitting scientific knowledge. Science and economics. Science and power. The problem of state regulation of science.
Modern philosophical problems of the branch of science	In the areas of training postgraduate students

Author:
Professor of the Ontology and Epistemology department — V.M. Naidysh

The Head of the Ontology and Epistemology department — V.N. Belov

The Head of the Social Philosophy department — M.L.Ivleva

Federal state autonomous educational institution of higher education
"People's Friendship University of Russia", RUDN University
Faculty of Science

ANNOTATION OF THE ACADEMIC DISCIPLINE

Educational Program 03.06.01 Physics and Astronomy (specialization Theoretical Physics)

Course title	**Physics of Nonlinear Processes**
Course Scope	**3 credits (108 hours)**
COURSE SUMMARY	
Course Units (Topics)	**Course Units (Topics) Outline**
Topological solitons: review of models	Topological solitons: review of models. Kinks, monopoles, and instantons. Many-dimensional solitons in chiral models. Hobart – Derrick theorem. Hopf invariant and topological charge of the degree type . Skyrme and Faddeev models. Methods of studying many-dimensional solitons. Coleman – Palais symmetry principle. Hadrons' structure and the problem of describing their basic states. Models of extended particles. Soliton models in particle physics and in condensed matter physics.
Many-dimensional solitons in chiral models	Topological solitons and their classification: chiral and Higgsian solitons. Simplest examples: kinks in Sine-Gordon and ϕ^4 - models. Anyons, lamps, vortices in (2 + 1) – dimensional solitonian models. Vortices of Nielsen – Olesen and Belavin – Polyakov. Anyons. Monopoles of 't Hooft – Polyakov, Bogomolnyi equations, BPS – monopoles. N-monopoles configurations and scattering of monopoles. Instantons in Euclidian model of Yang – Mills. Self-duality equations and their solutions. BPTSch-instantons. N-instantons solutions.
Methods of studying many-dimensional solitons	Topological solitons in the Skyrme model and its gauge generalizations. Torons in n-field Faddeev model and their relation to the theory of nodes and strings. Topological charges of chiral and Higgsian solitons and algorithms for searching their explicit forms. Hopf invariant and methods of its construction. Hobart – Derrick theorems and topological stability of solitons. Estimate for the energy functional from below through the Hopf invariant.

Developers:

Developers:

Professor of the

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Specialty Supervisor:

Federal state autonomous educational institution of higher professional education
Peoples' Friendship University of Russia
Philological Faculty

DISCIPLINE ANNOTATION

Education Programs in all fields of postgraduate study

Discipline	***Pedagogy of Higher Education***
Total	**2 credits (72 hours)**
Contents	
Units	**Topics**
Unit I. **Pedagogy of higher education as a field of study and academic subject area.**	1. Pedagogy as a science, key concepts. Pedagogy of higher education in the system of pedagogical science. 2. Systems of higher education: comparative analyses. 3. Contemporary trends in higher education. Internationalization of higher education.
Unit 2. **Didactics of higher education.**	1. General aspects of didactic system. 2. Content of higher education (laws and regulations; main principles of selecting content). Curriculum and course syllabus. 3. Forms and methods of teaching. Lecture in modern higher education. Seminars, practical training, laboratory class. Project – working. 4. Students' individual work. 5. Interactive methods of teaching (discussions, case-study, training, professional simulation etc.). 6. ICT in modern higher education. 7. Monitoring and evaluation of academic performance. Point rating system.
Unit 3. **Educational environment of modern university.**	1. Faculty members' rights and responsibilities. Professional ethics. 2. Faculty interaction with students: case study. 3. Educational potential of extra-curricular activities.

Author:
Associate Professor of the
Psychology and Pedagogy Department ____________ O.K. Logvinova

The Head of the
Psychology and Pedagogy Department ____________ N.B. Karabushchenko

Federal state autonomous educational institution of higher education
“People’s Friendship University of Russia”, RUDN University
Faculty of Science

ANNOTATION OF THE ACADEMIC DISCIPLINE

Educational Program 03.06.01 Physics and Astronomy (specialization Theoretical Physics)

Course Title	**Quantum Field Theory**
Course Scope	**3 credits (108 hours)**
COURSE SUMMARY	
Course Units (Topics)	**Course Units (Topics) Outline**
Relativistic description of particles	Foundations of classical field theory. Variational principle. Structure of conserved quantities. Classical “displacement”, “rotation”, and “charge” theorems in Hamiltonian formalism. Methods of group theory in physics of particles. Infinitesimal method for constructing irreducible representations of Lie groups. Irreducible representations of rotation group, Lorentz group, and Poincaré group. The Dirac’s equation. Internal symmetry groups. Dynkin schemes and root diagrams. Principle of gauge symmetry. Higgs effect. Supersymmetry.
General theory of quantum fields	Dirac quantization rule. Canonical commutation relations. The second quantization method. Von Neumann’s theory of infinite tensor products of Hilbert spaces. Fock space. Foundations of generalized functions theory. Schwarz space and functionals in it. Tensor representation of operators in Fock space. Superselection rule. General principles of fields quantization. Schwinger – Feynman dynamical principle. Quantization of scalar field, massive vector field, and electromagnetic field. Quantization of spinor field.
Scattering matrix in quantum field theory	Scattering matrix in quantum field theory. Tomonaga – Schwinger equation and Dyson’s solution. *S*-matrix properties. Feynman’s rules in quantum electrodynamics. Calculation of the simplest effects. Estimation of radiation corrections. Heisenberg theorem on renormalizable field theories. Bogoliubov’s *R*-operation and elimination of divergences. Dyson and Schwinger equations for complete

	Green functions. Bethe – Salpeter equation. Axiomatic theory of *S*-matrix.

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ANNOTATION OF THE ACADEMIC DISCIPLINE

Educational Program 03.06.01 Physics and Astronomy (specialization Theoretical Physics)

Course Title	**Scientific Seminar**
Course Scope	**8 credits (288 hours)**
COURSE SUMMARY	
Course Units (Topics)	**Course Units (Topics) Outline**
Theory of nuclei and particles	Part I. Foundations of nuclei theory. Types of particles and nuclei interactions. Main properties of nuclei. Nuclei models. The origin of nuclear forces. Deuteron. Nuclear reactions. Decays of nuclei. Charge symmetry of strong interactions. Part II. Relativistic theory of particles scattering. The Dirac's equation. Spin in Dirac theory. Polarization density matrix. Relativistic theory of quantum transitions. Feynman diagrams. Decay probabilities and effective sections of scattering. Methods for calculating matrix elements. Cartan's mapping. Relativistic theory of scattering. Mott and Rosenbluth formulae.Pions scattering. Scattering of polarized electrons.
Group theory of nuclei and particles	Part III. Classification of particles. Historical introduction. Group theory approach to particles classification. Unitary groups. Masses relations. Spin effects estimation in quark models. Supersymmetry. Part IV. Weak interaction. Pauli hypothesis on neutrino. Fermi theory of beta-decays. Structure of matrix elements. Fermi and Gamov – Teller selection rules. Five variants of weak interaction. Neutrino physics. Lepton numbers. Neutrino mass and neutrinos oscillations. Neutrino in astrophysics.
Electro-weak interactions of particles	Part I. Current – current theory of weak interactions. Weinberg's classification of currents. Conservation of vector current and partial conservation of axial-vector current. Fermi theory of beta-decay. General form of current – current Lagrangian of weak interaction. Creation of *V-A* theory of beta-

	decay and its generalization to other processes. Weak form-factors. Non-renormalizability of theory with intermediate vector boson.
Gauge invariance in particle physics	Part II. Gauge models. Principle of gauge invariance. Local *SU*(2)-symmetry. Yang – Mills fields. T'Hooft – Polyakov monopole. Asymptotic freedom. Spontaneous symmetry breaking. Higgs fields and Goldstone theorem. Weinberg – Salam model of unitary electro-weak interaction. Intermediate vector bosons. Main principles of quantum chromodynamics. Grand unification of interactions. Supersymmetry.
Structure of elementary particles	Composite models of particles. The simplest models of atomic nuclei. Nuclear form-factors. Phenomenological description of elementary particles structure. Mott and Rosenbluth formulae. Hofstadter experiments on determination of proton structure. Nonlinear models in physics of fields and particles. Composite models, quarks, gluons. Color. Grand unification.
Quarks theory	First composite models of particles. Symmetry between leptons and quarks. Lie algebras and groups. Unitary symmetries. Quark constituents in hadrons. Masses relations. Parton model. Color. Weinberg – Salam model of electroweak interaction of leptons. Foundations of quantum chromodynamics. Problem of quarks confinement.

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ANNOTATION OF THE ACADEMIC DISCIPLINE

Educational Program 03.06.01 Physics and Astronomy (specialization Theoretical Physics)

Course Title	**Theoretical Physics**
Course Scope	**3 credits (108 hours)**
COURSE SUMMARY	
Course Units (Topics)	**Course Units (Topics) Outline**
General concepts of coherent states	Main points in representations of coherent states. 1/*N*-decomposition and quasi-classical approximation for description of quantum extended objects. Weyl displacement operator. Bargmann – Segal – Fock holomorphic representation.
Quantum Optics and Lasers	Quantum optics. Glauber – Arecchi photon detector model. Glauber laser model. Generalized coherent states and theory of Lie groups.
Spin Coherent States in Ferromagnetics	Spin coherent states and their application for description of localized excitations in ferromagnetics. Landau – Lifshitz equation.

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ANNOTATION OF THE ACADEMIC DISCIPLINE

Educational Program 03.06.01 Physics and Astronomy (specialization Theoretical Physics)

Course Title	**Pedagogical practice**
Course Scope	**24 credits (864 hours)**
COURSE SUMMARY	
Course Units (Topics)	**Course Units (Topics) Outline**
Planning lectures and seminars on theoretical physics	The goal of pedagogical practice is accomplishing the abilities in teaching the courses from the cycle "Theoretical physics" including theoretical mechanics, electrodynamics, quantum theory and statistical physics. Acquiring the experience in preparing the seminar problems, acquaintance with the typical pedagogical approaches in analyzing the solutions to the physical problems.
Preparing presentations of lectures	Acquired professional competences: ability to change its professional activity depending on interests of the pupils; ability to plan the seminars or labs according to the content of the training plan. Preparing presentations of lectures and reports.

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ANNOTATION OF THE ACADEMIC DISCIPLINE

Educational Program 03.06.01 Physics and Astronomy (specialization Theoretical Physics)

Course Title	**Scientific practice**
Course Scope	**179 credits (6444 hours)**
COURSE SUMMARY	
Course Units (Topics)	**Course Units (Topics) Outline**
Planning scientific publications	The goal of scientific practice is accomplishing of the practical knowledge and abilities in future professional activity of theoretical physicist including the experience in proper scientific work, in preparing the talks at scientific conferences.
Studying mathematical methods in theoretical physics	Acquired competences: free usage of the professional knowledge in computer technologies; ability to use recent achievements in modern physics; ability to put scientific problems.

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