1. OPTIONAL COMPONENTS OF THE CYCLE OF CORE COURSES

Optional component 1

Course: **Planning and organization of scientific research**
Intensity of the Course: 5 academic credits
Module Code: IMPF-2
Module Name: Innovative methods and technologies in teaching physics
Prerequisites: Fundamentals of scientific research

Purpose: formation of a system of basic knowledge and skills for the organization and conduct of scientific research in future specialists. Systematization, expansion and consolidation of professional knowledge, formation of undergraduates skills in conducting independent scientific work, research and experimentation.

Short Description: The discipline “Planning and organization of scientific research” considers the features of the development of science in the twenty-first century: priority areas of science in the Republic of Kazakhstan and abroad (in Japan, Europe, USA, China, Russia and other countries), planning and organization of scientific research, and processing of experimental data

Learning Outcomes in EP (LOP):

LOP 4 – Plans and conducts analytical and numerical calculations, theoretical and experimental problems, scientific work in the field of theoretical, experimental and applied physics;

LOP 7 – Develops physical, mathematical, computer models of the studied phenomena and processes;

LOP 8 – Formulates the acquired knowledge and skills in the field of physics in his further professional activity.

Learning Outcomes in Course (LOC):

LOC 1 –Understands the role of scientific research in the development of the individual and the organization of education;

LOC 2 – Knows the principles and laws of methodology and technology for conducting scientific research and scientific forums;

LOC 3 – conducts research work in the organization of education;

LOC 4 – writes and presents scientific publications on the topic of scientific research.

LOC 5 – adapts innovative technologies, methods and tools, principles and patterns in selected areas of biology and teaching natural science subjects.

LOC 6 – projects methodological achievements and current problems of biology using modern methods of scientific research, processing and interpretation of experimental data.

Post requisites: CRD 7203 Commercialization of research and development

Optional component 1

Course: **Physics of open nonlinear systems**
Intensity of the Course: 5 academic credits
Module Code: IMPF-2
Module Name: Innovative methods and technologies in teaching physics
Prerequisites: Fundamentals of scientific research

Purpose: The formation of a complex of knowledge of the basic laws on the subject of the philosophical questions of physics and physics of open systems, the ability to apply these laws to solve practical problems and possessions of typical methods for calculating the parameters of the physics of open systems.

Short Description: The discipline considers the types, forms and organization of assessment of learning outcomes, the nature, functions and requirements for monitoring the quality of training. The types, methods of control, modern means of assessing learning outcomes are considered. They study the rating control system as an integral part of the educational process, the conditions for organizing a rating system of assessment and its advantages, and the design stages of a rating control system

Learning Outcomes in EP (LOP):

LOP 6 – Processes information using modern programs, tools and methods of computer and information technologies;

LOP 7 – Develops physical, mathematical, computer models of the studied phenomena and processes;

LOP 8 – Formulates the acquired knowledge and skills in the field of physics in his further professional activity.

Learning Outcomes in Course (LOC):

LOC 1 – use the basic laws of the physics of open systems to calculate physical parameters;

LOC 2 – owns the skills of independent work with educational and scientific literature;

LOC 3 – has skills in working with measuring instruments, laboratory research equipment.

Post requisites: RP Research practice.

Optional component 2

Course: **Computer technologies in science and education**

Intensity of the Course: 5 academic credits

Module Code: IMPF-2

Module Name: Innovative methods and technologies in teaching physics

Prerequisites: Modeling of physical processes

Purpose: formation of information and communication and technological competence of the future specialist, determining his readiness and ability to solve research tasks on the basis and with the use of modern information technologies.

Short Description: In the discipline "Computer technologies in education and science" undergraduates will gain knowledge and practical skills in using modern information and computer technologies as a tool for solving high-level scientific and educational problems in the field of fundamental and applied physics, network and multimedia technologies in education and science; master the methods of solving special problems using computer and multimedia technologies in professional pedagogical and scientific activities in the field of physics. Computer technology in research and development, teaching activities. Software in professional activities. Computer technologies for data analysis and interpretation. Network and multimedia technologies in scientific research and educational activities. Automate data processing in Office. Planning computer experiments. Computer graphics in scientific research. Hypermedia and multimedia systems. Computer decision support systems. Computer technology in the informatization of the educational process. Distance learning, technology and tools. Video conferencing.

Learning Outcomes in EP (LOP):

LOP 4 – Plans and conducts analytical and numerical calculations, theoretical and experimental problems, scientific work in the field of theoretical, experimental and applied physics;

LOP 6 – Processes information using modern programs, tools and methods of computer and information technologies;

LOP 7 – Develops physical, mathematical, computer models of the studied phenomena and processes.

Learning Outcomes in Course (LOC):

LOC 1 – fundamentals and history of the formation and development of the use of computer technology in science and education;

LOC 2 – to use methodological knowledge in the field of information technology in solving problems of their application in the field of science and education;

LOC 3 – have the skills to develop system project solutions for using computer technologies in science and education.

Post requisites: MBMPh 7203 Modern biophysics and medical physics

Optional component 2

Course: **Selected chapters of thermo physics**

Intensity of the Course: 5 academic credits

Module Code: IMPF-2

Module Name: Innovative methods and technologies in teaching physics

Prerequisites: General physics

Purpose: to acquaint students with the main problems of modern thermal physics, with the thermophysical processes of special production and to prepare students for the study of special courses, the calculation of projects and the implementation of individual special practical work.

Short Description: Thermodynamics: mixtures of working fluids, heat capacity, laws of thermodynamics, thermodynamic processes and cycles, real gases and vapors, thermodynamics of flows, thermodynamic analysis of heat engineering devices, phase transitions, chemical thermodynamics. Cycles of heat power plants. Heat transfer theory: heat conduction, convection, radiation, heat transfer, heat transfer intensification. The basics of mass transfer. Heat and mass transfer devices. Basics of calculating heat exchangers. Fuel and combustion basics. Heat generating devices, refrigeration and cryogenic equipment. The use of heat in the industry. Environmental protection. The basics of energy conservation. Secondary energy resources. The main directions of energy saving

Learning Outcomes in EP (LOP):

LOP 4 – Plans and conducts analytical and numerical calculations, theoretical and experimental problems, scientific work in the field of theoretical, experimental and applied physics;

LOP 7 – Develops physical, mathematical, computer models of the studied phenomena and processes;

LOP 8 – Formulates the acquired knowledge and skills in the field of physics in his further professional activity.

Learning Outcomes in Course (LOC):

LOC1 – Knows selected chapters of Thermophysics and laws of thermodynamics;

LOC 2 – Calculates the equation of processes, equations of state, energy characteristics, the content of work and heat during heat transfer;

LOC 3 – Determines the thermophysical properties of various substances and the energy characteristics of thermodynamic processes;

LOC 4 – defines the place of Thermophysics in the technique of modern physics.

Post requisites: RP Research practice

Optional component 3

Course: **Fundamentals of relativity theory**

Intensity of the Course: 5 academic credits

Module Code: IMPF-2

Module Name: Innovative methods and technologies in teaching physics

Prerequisites: Electrodynamics and AST

Purpose: Formation of a clear understanding of the basic concepts and basic methods of the theory of relativity among undergraduates.

Short Description: The course discusses: Galileo's Principle of Relativity. Principles of the theory of relativity. Space, time coordinates, and the Lorentz transformation. General tensor analysis. The principle of equivalence. Relativistic law of addition of velocities. Body weight in one hundred. The connection of general relativity with Riemann geometry. Einstein's theory of gravity. The physical foundations of the general theory of relativity and its consequences.

Learning Outcomes in EP (LOP):

LOP 4 – Plans and conducts analytical and numerical calculations, theoretical and experimental problems, scientific work in the field of theoretical, experimental and applied physics;

LOP 8 – Formulates the acquired knowledge and skills in the field of physics in his further professional activity.

Learning Outcomes in Course (LOC):

LOC 1. To get a general idea of the discipline" fundamentals of relativity", learn to study basic concepts and basic methods;

LOC 2. Learn the basic methods and principles used in general relativity.

Post requisites: PP Pedagogical practice.

Optional component 3

Course: **Numerical methods in physics**

Intensity of the Course: 5 academic credits

Module Code: IMPF-2

Module Name: Innovative methods and technologies in teaching physics

Prerequisites: Introduction to numerical methods in physics

Aim of the course: formation of systematic knowledge in the field of numerical methods for solving problems of mathematical analysis, algebra and mathematical physics on a computer.

Short Description: The course "Numerical methods in physics" is aimed at mastering knowledge and practical skills on the formulation of a physical problem and finding the most effective numerical solution to this problem. The following topics will be studied in this course: Numerical methods in physics: basic concepts, problem statement. Approximation of functions. Interpolation of functions. Selection of empirical formulas. Linear and quadratic interpolation. Approximation of functions. Approximation of functions. Least square method. Methods of numerical integration. Methods of rectangles, trapezoid. The Simpson Method. Monte Carlo Method. Numerical solution of various integral and differential equations describing a physical phenomenon or process.

Learning Outcomes in EP (LOP):

LOP 4 – Plans and conducts analytical and numerical calculations, theoretical and experimental problems, scientific work in the field of theoretical, experimental and applied physics.

LOP 6 – Processes information using modern programs, tools and methods of computer and information technologies;

LOP 7 – Develops physical, mathematical, computer models of the studied phenomena and processes;

Learning Outcomes in Course (LOC):

LOC 1 – technologies for applying computational methods to solve specific problems from various fields of mathematics and its applications;

LOC 2 – skills of practical evaluation of the accuracy of results obtained in the course of solving certain computational problems, based on the approximation theory;

LOC 3 – the main methods of using computational methods in solving various problems of professional activity.

Post requisites: not

2. OPTIONAL COMPONENTS OF THE CYCLE OF MAJOR COURSES

Optional component 1

Course: **Astrophysics and cosmology**

Intensity of the Course: 5 academic credits
Module Code: SGSF-3
Module Name: Special chapters of modern physics
Prerequisites: Astronomy

Aim of the course: The goals of mastering the discipline of Astrophysics and Cosmology by undergraduates are: - formation of ideas about the structure and composition of the world around us: from the Solar System to the observable boundary of the Universe.

Short Description: The course covers: Physical laws in astrophysics. The connection of astrophysics and physics. Tasks of astrophysics. The solar system. The interstellar medium. The internal structure of stars. The state of matter in stars. The evolution of stars. The structure of the Galaxy. Elements of cosmology. The structure of the universe. Classification of galaxies. Clusters of galaxies. Active galaxies and quasars. Observational cosmology: Hubble's law. Large-scale structure of the universe. Acceleration in the expansion of the universe.

Learning Outcomes in EP (LOP):

LOP 3 – Applies modern teaching methods and techniques, technology in its pedagogical activity;

LOP 6 – Processes information using modern programs, tools and methods of computer and information technologies;

LOP 8 – Formulates the acquired knowledge and skills in the field of physics in his further professional activity.

Learning Outcomes in Course (LOC):

LOC 1 – applies the acquired knowledge in his research work;

LOC 2 – defines the goals and objectives of scientific research;

LOC 3 – organizes the search for information, data collection; draws up results; works with literature; compiles the results of research work; plans, prepares and conducts presentations.

Post requisites: MAC 7302 Modern astrophysics and cosmology

Optional component 1

Course: **Additional chapters of theoretical physics**
Intensity of the Course: 5 academic credits
Module Code: SGSF-3
Module Name: Special chapters of modern physics
Prerequisites: Classical Mechanics, Electrodynamics and SRT

Purpose: The goals of mastering the discipline "Additional chapters of theoretical physics" are to study additional chapters of theoretical mechanics and continuum mechanics, continuum electrodynamics and quantum mechanics, the material of which is necessary for students to perform bachelor's graduation works in theoretical physics.

Short Description: In this discipline, undergraduates will study the mathematical apparatus of the heads of modern theoretical physics, solve theoretical problems of analytics and numerically, model phenomena and processes, including on a computer. The following additional chapters of theoretical physics will be studied during the development of this discipline: mechanics of continuous media; conservation laws: energies, masses, momentum, angular momentum; hydrodynamics; hydroaerodynamics; chaos theory; perturbation theory

Learning Outcomes in EP (LOP):

LOP 4 – Plans and conducts analytical and numerical calculations, theoretical and experimental problems, scientific work in the field of theoretical, experimental and applied physics.

LOP 5 – Implements experiments of varying complexity in the field of physics on test equipment, instruments and installations;

LOP 7 – Develops physical, mathematical, computer models of the studied phenomena and processes.

Learning Outcomes in Course (LOC):

LOC 1 - material of those additional chapters of theoretical physics that will be presented in the course of training;

LOC 2 - use this knowledge to solve problems in continuum mechanics, continuum electrodynamics, and quantum mechanics;

LOC 3- skills for solving problems of theoretical physics that are close to those considered in the course of teaching this discipline.

Post requisites: QThSS 6304 Quantum theory of solid state

Optional component 2

Course: **Fundamentals of Materials science and Nanotechnology**

Intensity of the Course: 5 academic credits

Module Code: SGSF-3

Module Name: Special chapters of modern physics

Prerequisites: Solid body physics

Purpose: The purpose of the discipline "Fundamentals of Materials Science and Nanotechnology" is to familiarize with the features of the properties of materials in the nanostructured state, methods of their preparation and research, the formation of ideas about modern achievements in the field of nanotechnology and the prospects for their practical use.

Short Description: The course covers: Fundamental physico-chemical foundations of nanotechnology. Basic concepts and definitions of nanosystem sciences and nanotechnology. Features of physical interactions on nanoscales. Methods of obtaining nanomaterials. Research methods and diagnostics of nanoobjects and nanosystems. Quantum mechanics of nanosystems. Structure of porous and nanodisperse systems. Fundamental mechanisms of formation of nanodisperse systems. Composite nanomaterials. Basic approaches to the synthesis of nanomaterials.

Learning Outcomes in EP (LOP):

LOP 3 – Applies modern teaching methods and techniques, technology in its pedagogical activity;

LOP 4 – Plans and conducts analytical and numerical calculations, theoretical and experimental problems, scientific work in the field of theoretical, experimental and applied physics.

LOP 8 – Formulates the acquired knowledge and skills in the field of physics in his further professional activity.

Learning Outcomes in Course (LOC):

LOC 1 – obtains knowledge about the physical effects inherent in materials in the nanostructured state;

LOC 2 – obtains fundamental knowledge about the methods of obtaining and diagnosing nanomaterials.

Post requisites: PP Pedagogical practice.

Optional component 2

Course: **Introduction to theory gravity**

Intensity of the Course: 5 academic credits

Module Code: SGSF-3

Module Name: Special chapters of modern physics

Prerequisites: Electrodynamics and SRT

Purpose: To provide knowledge of the basic equations of the theory of gravity, the main phenomena described by the theory of gravity, possession of accurate and approximate methods for solving gravitational equations, the ability to obtain and analyze the basic solutions in the theory of gravity.

Short Description: In the course, undergraduates will familiarize themselves with the mathematical foundations and physical principles of the theory of gravity: Newtonian theory of gravity, special relativity, tensors in Minkowski space, elements of Riemannian geometry, Einstein's theory of gravity, alternative and modified theories of gravity

Learning Outcomes in EP (LOP):

LOP 4 – Plans and conducts analytical and numerical calculations, theoretical and experimental problems, scientific work in the field of theoretical, experimental and applied physics.

LOP 6 – Processes information using modern programs, tools and methods of computer and information technologies;

LOP 7 – Develops physical, mathematical, computer models of the studied phenomena and processes.

Learning Outcomes in Course (LOC):

LOC 1 – Know the basic equations of the theory of gravity, the basic solutions of the theory of gravity, the observed effects arising from the properties of the basic solutions of the theory of gravity.

LOC 2 – Be able to obtain the basic solutions of the theory of gravity and analyze their physical consequences;

LOC 3 – Possess accurate and approximate methods of the theory of gravity.

Post requisites: RP Research practice.

Optional component 3

Course: **Alternative Energy Sources**

Intensity of the Course: 5 academic credits

Module Code: SGSF-3

Module Name: Special chapters of modern physics

Prerequisites: MPhTh 2204 Molecular physics and thermodynamics

Aim of the course: The purpose of training future Bachelors with alternative energy sources is to stimulate their activities for the development of this direction of technology and technology.

Short Description: During the course, the undergraduate studies the current state of the use of renewable energy resources, problems and prospects for the development of these areas of energy; principle of operation and design of the implementation of the main elements of energy conversion devices; technical and economic indicators of renewable and alternative energy source.

Learning Outcomes in EP (LOP):

LOP 3 – Applies modern teaching methods and techniques, technology in its pedagogical activity;

LOP 8 – Formulates the acquired knowledge and skills in the field of physics in his further professional activity.

Learning Outcomes in Course (LOC):

LOC 1 – have an understanding of the technical and economic indicators of renewable sources and their ecology

LOC 2 – know about calculation methods in the field of energy conservation

LOC 3 – know the technology of energy production based on renewable energy sources and the program for the development of non-traditional energy in Kazakhstan

LOC 4 – use modern achievements of science and technology.

Post requisites: RP Research practice.

Optional component 3

Course: **Modern physical experiment**

Intensity of the Course: 5 academic credits

Module Code: SGSF-3

Module Name: Special chapters of modern physics

Prerequisites: Physical experiment methods

Purpose: The course aims to familiarize undergraduates with the main ideas and methods of setting up new educational experiments in physics.

Short Description: Discipline "Modern physical experiment" is aimed at the study and application in a specific field of physics of modern methods of experimental research. In the discipline, undergraduates study the principles of work, the selection of the appropriate and the design of modern measuring instruments and physical equipment. Graduate students will master the practical skills of using mathematical and computer modeling of physical phenomena and processes, and representing them in the form of an experiment, including a virtual one. They will master the accompanying software of modern physical experiments, methods of visualizing physical experiments, modern methods of analytical and numerical calculation, design and analysis of physical experiments, methods of automation and optimization of experimental work in physics

Learning Outcomes in EP (LOP):

LOP 5 – Implements experiments of varying complexity in the field of physics on test equipment, instruments and installations;

LOP 6 – Processes information using modern programs, tools and methods of computer and information technologies.

LOP 7 – Develops physical, mathematical, computer models of the studied phenomena and processes.

Learning Outcomes in Course (LOC):

LOC 1 – to develop practical skills of undergraduates in solving experimental problems of physics

LOC 2 – to give undergraduates practical skills in the methodology of conducting a physical experiment

LOC 3 – teach the principles and laws of physics to solve both simple and non-generalized physical problems.

Post requisites: RP Research practice.

Optional component 4

Course: **Jet theory**

Intensity of the Course: 5 academic credits

Module Code: SGSF-3

Module Name: Special chapters of modern physics

Prerequisites: Mechanics.

Aim of the course: is mastering the theory of jets by undergraduates from the monograph of famous scientists (undergraduates G. Abramovich, L.A. Voulis, A.S. Ginevsky, G. Schlichting, L. Prandtl, L.G. Loytsyansky) and prepare as teachers, and scientists.

Short Description: «Jets theory» underlies all production technologies - jet movements, combustion processes in cement and open-hearth furnaces. The theory of jets was created on the basis of many experimental works. In the discipline "Theory of jets" - from a theoretical and experimental point of view, laminar and turbulent flows of viscous, incompressible fluids (plane, axisymmetric jets, semi-limited flows, free, flooded and radial jets) are considered.

Learning Outcomes in EP (LOP):

LOP 5 – Implements experiments of varying complexity in the field of physics on test equipment, instruments and installations;

LOP 6 – Processes information using modern programs, tools and methods of computer and information technologies.

LOP 7 – Develops physical, mathematical, computer models of the studied phenomena and processes.

Learning Outcomes in Course (LOC):

LOD 1 – Owns the fundamental laws of jet theory.

LOD 2 – exact solutions of the Navier-Stokes equations are obtained analytically for laminar jets.

LOD 3 – The obtained theoretical knowledge can be used in solving problems and conducting experiments.

Post requisites: RP Research practice.

Optional component 4

Course: **Fundamentals of aerohydrodynamics**

Intensity of the Course: 5 academic credits

Module Code: SGSF-3

Module Name: Special chapters of modern physics

Prerequisites: Mechanics.

Purpose: Introduction to the physical and mathematical formulation of problems describing the motion of a continuous medium, volume and surface forces acting in the earth's atmosphere, equations of motion of an ideal and viscous fluid.

Short Description: The discipline "Fundamentals of Aerohydrodynamics" is presented as part of theoretical physics. The following topics are considered in the discipline: Dynamics equations in the problems of incompressible and compressible, ideal and viscous liquids and gases under laminar and turbulent modes of motion. Laminar and turbulent boundary layers, the occurrence of turbulence. In the course of studying the course, students will master the skills of analyzing physical processes and methods of solving problems using the equations of aerohydrodynamics.

Learning Outcomes in EP (LOP):

LOP 4 – Plans and conducts analytical and numerical calculations, theoretical and experimental problems, scientific work in the field of theoretical, experimental and applied physics.

LOP 5 – Implements experiments of varying complexity in the field of physics on test equipment, instruments and installations;

LOP 8 – Formulates the acquired knowledge and skills in the field of physics in his further professional activity.

Learning Outcomes in Course (LOC):

LOD 1 –Knows the fundamental laws of liquids and gases. Laws of statics, kinematics, and dynamics of liquids and gases.

LOD 2 – Applies the basic laws of fluid mechanics.

LOD 3 – uses a mathematical analysis apparatus to calculate thermal characteristics in liquid and gaseous media

LOD 4 – Knows the principles and laws of methodology and technology of scientific research.

Post requisites: RP Research practice.

Optional component 5

Course: **Elementary particle physics**

Intensity of the Course: 6 academic credits

Module Code: SGSF-3

Module Name: Special chapters of modern physics

Prerequisites: Atomic physics, Introduction to elementary particles physics

Aim of the course: The purpose of studying the discipline is to form students' knowledge of the basic issues of theoretical physics.

Short Description: Elementary particle physics is a branch of theoretical physics, the study of which requires undergraduates to know all the previous sections of general and theoretical physics, since this discipline generalizes all the knowledge obtained in the previous sections of physics, it gives a generalized classification of elementary particles and fundamental interactions. Undergraduates will study the limits of applicability of the classical and quantum laws of physics, prospects, and interdisciplinary connections of particle physics. The elementary particles of matter are quarks and leptons. The natural system of units. Isospin. Bosons and fermions. P parity. C-parity. Particles and antiparticles. Weirdness. CP parity. CP violation. Enchanted quark. B-quark. B-quark mesons and baryons. Top quark. Naive quark model. Multiples of mesons in SU (2), SU (3) and SU (4). Vector and pseudoscalar mesons. Gell-Mann-Okubo mass formulas. Classification of baryons by multiplets. The expansion of the universe. Relict radiation. The chemical composition of the universe. Primary nucleosynthesis. Dark matter. Dark energy. Klein-Gordon equation. Dirac equation. Gauge Invariance Lagrangian QCD. Color charge. Discovery of gluons. Confinement. Quark vacuum condensate. Quark condensation and meson mixing. Scattering on a compound object. Deep inelastic scattering of leptons. Scaling. Parton model. Spin and parton charges. Weak interaction. V-A structure of weak interaction. Neutral currents. The basics of the standard electroweak model. Local gauge invariance for groups SU (2) xU (1). Higgs mechanism. Masses of fermions in the Standard Model. Neutrino oscillations

Learning Outcomes in EP (LOP):

LOP 4 – Plans and conducts analytical and numerical calculations, theoretical and experimental problems, scientific work in the field of theoretical, experimental and applied physics.

LOP 7 – Develops physical, mathematical, computer models of the studied phenomena and processes;

LOP 8 – Formulates the acquired knowledge and skills in the field of physics in his further professional activity.

Learning Outcomes in Course (LOC):

LOC 1 – to know the meaning of fundamental physical constants (the speed of light in vacuum, Planck's constant, the masses of quarks and leptons, the lifetime of elementary particles, etc.).

LOC 2 – be able to use key concepts, quantities, laws, principles, postulates of elementary particle physics to explain natural and man-made physical phenomena and processes;

LOC 3 – possess information about the achievements of Russian and foreign scientists at the level necessary to explain natural and man-made physical phenomena.

Post requisites: RP Research practice.

Optional component 5

Course: **High energy physics**

Intensity of the Course: 6 academic credits

Module Code: SGSF-3

Module Name: Special chapters of modern physics

Prerequisites: Theory of electromagnetic radiation

Purpose: «High energy physics» study of weak, electro-magnetic and strong (hadron) particle interaction processes at high energies, behavior of neutrino scattering cross sections, charged leptons with increasing energies, description of characteristics of inclusive reactions involving nucleons and mesons in the framework of phenomenological models that are used for calculating and modeling wide atmospheric showers generated by cosmic rays in the Earth's atmosphere and in astrophysical objects of interest as sources of high and ultrahigh energy cosmic radiation. As a result of studying the course, the graduate student acquires knowledge about the fundamental processes that form the basis of mechanisms for generating high-energy cosmic radiation - cosmic rays, gammaquants, and neutrinos.

Short Description: The discipline is devoted to studying the nature of the particles that make up matter and radiation. The presentation of this discipline begins with the classification of elementary particles, fields and interaction. In the future, the discipline gives knowledge in the following sections: conceptual mathematical apparatus: quantized fields, the standard model of particles and its extensions, such as Higgs bosons and others. Applications of high-energy physics to astrophysics, cosmology, and also to the theory of gravity.

Learning Outcomes in EP (LOP):

LOP 2 – Uses the theoretical and methodological foundations of the development of pedagogical and psychological science, teaching methods, management and development processes, the nature and content of psychological and pedagogical research in professional activities.

LOP 5 – Implements experiments of varying complexity in the field of physics on test equipment, instruments and installations;

LOP 6 – Processes information using modern programs, tools and methods of computer and information technologies.

Learning Outcomes in Course (LOC):

LOC 1 – the main regularities of processes that play a key role in the mechanisms of particle acceleration in astrophysical objects and generation of gamma radiation, high-and ultra-high-energy neutrinos, the main methods for describing the interaction in the physics of leptons and hadrons, and phenomenological models, principles and methods for detecting high-energy particles

LOC 2 – apply these principles and methods to solve specific problems of high-energy physics.

Post requisites: RP Research practice.

Optional component 6

Course: **Design and modeling of new materials**

Intensity of the Course: 6 academic credits

Module Code: SGSF-3

Module Name: Special chapters of modern physics

Prerequisites: Solid state physics

Purpose: Mastering by undergraduates theoretical and practical skills of quantum chemical computer modeling methods in the description, prediction and improvement of physical, including electronic, energy and perspective, etc. properties of functionally new materials in the framework of research and teaching activities.

Short Description: Quantum chemical modeling methods are one of the modern methods of describing, predicting, and evaluating atomic-molecular processes in condensed matter physics. Quantum chemical modeling uses experimental, empirical and semi-empirical research methods in describing the physical and chemical, electronic properties of multifunctional new materials. The discipline integrates theoretical and experimental knowledge in the disciplines of quantum physics, statistical physics, molecular mechanics, molecular dynamics, and numerical methods. The discipline examines the main approximations used in quantum mechanics (the Hartree-Fock method, one-electron approximation, multi-electron approximation, density functional theory (DFT)) and the theory of functionals. Practical classes are implemented by available programs implementing quantum chemical modeling methods, VASP, MOPAK, SAGE MD programs, and visualization of multicomponent systems by VESTA, Orign programs.

Learning Outcomes in EP (LOP):

LOP 4 – Plans and conducts analytical and numerical calculations, theoretical and experimental problems, scientific work in the field of theoretical, experimental and applied physics.

LOP 6 – Processes information using modern programs, tools and methods of computer and information technologies.

LOP 7 – Develops physical, mathematical, computer models of the studied phenomena and processes;

LOP 8 – Formulates the acquired knowledge and skills in the field of physics in his further professional activity.

Learning Outcomes in Course (LOC):

LOC 1 – Demonstrate theoretical and practical knowledge of quantum chemical modeling of electronic, energy and perspective, etc. properties of functionally new materials;

LOC 2 – Ability to analyze theoretical and experimental data, justify your choice of a way to solve a problem in the professional field, taking into account scientific, economic, environmental and other requirements;

LOC 3 – Ability to model and apply visualization methods of processes in polyatomic systems using the VASP program, skills of correct interpretation of the results of simulation calculations and computational methods for improving the studied properties of objects.

Post requisites: QChDMM 7302 Quantum-chemical design multifunctional materials

Optional component 6

Course: **Modern optics**

Intensity of the Course: 6 academic credits

Module Code: SGSF-3

Module Name: Special chapters of modern physics

Prerequisites: Beginning of modern physics

Aim of the course: the study of the laws of geometric and physical optics, the phenomenon of light propagation in various environments, the elements of the quantum nature of light; generalization of observations, practical experience and experiment for the formation of students' ideas about physical theory.

Short Description: The structure of holography. Methods and schemes of optical holography. The use of holography. Gas and ion lasers. Molecular and solid state semiconductor lasers. Features of the dynamic characteristics of lasers. Laser gyro. The main parameters and types of fibers. Chromatic dispersion and non-linear effects in fibers. Optical glasses for fiber optics. Achievements and prospects of integrated optics. The effective thickness of the waveguide. Integrated optical communication elements. Elements of connection between waveguides. Investigation of the parameters of optical waveguides. The basics of creating diffractive optical elements. Ways and methods of obtaining zoned plates with a complex profile of zones

Learning Outcomes in EP (LOP):

LOP 4 – Plans and conducts analytical and numerical calculations, theoretical and experimental problems, scientific work in the field of theoretical, experimental and applied physics.

LOP 7 – Develops physical, mathematical, computer models of the studied phenomena and processes;

LOP 8 – Formulates the acquired knowledge and skills in the field of physics in his further professional activity.

Learning Outcomes in Course (LOC):

LOC 1 – the basic physical concepts, quantities, their mathematical expressions and units of measurement; use basic physical devices, take measurements, process the results and evaluate them

LOC 2 – practically apply theoretical knowledge, methods of theoretical and experimental research in solving physical problems in optics

LOC 3 – the ability to use basic knowledge and information management skills to solve physical problems

Post requisites: RP Research practice.

Optional component 7

Course: **Condensed matter physics**

Intensity of the Course: 5 academic credits

Module Code: SGSF-3

Module Name: Special chapters of modern physics

Prerequisites: Atomic physics, nuclear physics.

Aim of the course: the acquisition by students of knowledge about the physical properties of crystalline solids, familiarization with the processes and phenomena occurring between atoms during condensation into a solid state.

Short Description: Since the theoretical and experimental apparatus of condensed matter physics is used in chemistry, materials science, engineering, nanotechnology, atomic physics, nuclear physics, and even in biophysics, this discipline is the most actively developing field of physics. Discipline gives undergraduates knowledge about a large number of interacting particles with strong bonds. Discipline is built in the following sequence of chapters of condensed matter physics: structural units of substances, physical and chemical foundations of particle bonds, interactions of particles, liquids and solids, various directions and applications of condensed matter physics. In turn, each of these chapters consists of many topics and subtopics that reveal the essence of modern condensed matter physics

Learning Outcomes in EP (LOP):

LOP 4 – Plans and conducts analytical and numerical calculations, theoretical and experimental problems, scientific work in the field of theoretical, experimental and applied physics.

LOP 7 – Develops physical, mathematical, computer models of the studied phenomena and processes;

LOP 8 – Formulates the acquired knowledge and skills in the field of physics in his further professional activity.

Learning Outcomes in Course (LOC):

LOC 1 - Knows the basics of the theory of the condensed state and the crystal lattice and its main sections, the history of its development and data related to the theory of modeling;

LOC 2 - Possess the skills of solving differential equations of the grid model and apply the basic basic methods of solving problems;

LOC 3 - Is able to see the difficulties that arise during liquid-crystal transitions, analyze and use various methodological techniques necessary for mastering the course material.

LOC 4 - A master's student knows what results should be achieved when studying the discipline and has knowledge in close contact with the results necessary for teaching physics to schoolchildren.

Post requisites: RP Research practice.

Optional component 7

Course: **Quantum theory of solid state**

Intensity of the Course: 6 academic credits

Module Code: SGSF-3

Module Name: Special chapters of modern physics

Prerequisites: AChThPh 5302 Additional chapters of theoretical physics

Aim of the course: is the formation of students' skills and abilities to use the fundamental laws, theories of classical and modern physics, as well as methods of physical research to solve theoretical and experimental-practical learning problems from various fields of physics;

Short Description: In the course of studying the discipline, an introduction to the theory of the solid state is considered: the Drude theory, energy zones, the Fermi-Dirac distribution. Model of free electrons. Models of Debye and Einstein. Quantization of collective excitations in a solid, the concept of quasiparticles. Phonons in covalent, molecular and ionic crystals. Plasma waves in solids. Plasmon Screening Spin waves. Magnons. Quantum size effects. Adrerson, Mott and Lifshitz models for amorphous condensed state. Modern applications of the quantum theory of the solid state in quantum electronics, photonics and spintronics. Quantum pits, wires and points

Learning Outcomes in EP (LOP):

LOP 4 – Plans and conducts analytical and numerical calculations, theoretical and experimental problems, scientific work in the field of theoretical, experimental and applied physics.

LOP 7 – Develops physical, mathematical, computer models of the studied phenomena and processes;

LOP 8 – Formulates the acquired knowledge and skills in the field of physics in his further professional activity.

Learning Outcomes in Course (LOC):

LOC 1 – independent search, analysis and selection of information, training in its use in practice, providing scientific, theoretical, methodological and practical application in teaching the discipline;

LOC 2 – problems of development of knowledge and creative abilities of students, formation of knowledge and skills of the future specialist of physics; knowledge of basic concepts of laws of basic laws of physics;

LOC 3 – generalization of formulas and their use in everyday practice; mastering innovative pedagogical technologies; preparation for innovative, search, cultural, educational, skills.

Post requisites: QFTh 7302 Quantum field theory