Ministry of Science and Higher Education of the Republic of Kazakhstan

NLC «Karagandy University of the name of Academician E. A. Buketov»

«AGREED»
Director of the Chemical and Metallurgical Institute
named after Zh. Abishev, Karaganda
_____ S.O. Baysanov
«___»_____2023 y.

«APPROVED»
Chairman of the Board – Rector
Karaganda University
named after academician E.A. Buketov
_____ N.O. Dulatbekov
«___»_____2023 y.

EDUCATIONAL PROGRAM

8D05302- Physics

Level: doctorate PhD

Karaganda

2023 y.

The educational program in the direction of preparation «8D05302-Physics» was developed on the basis of:

– The Law of the Republic of Kazakhstan dated July 27, 2007 No. 319-III "On Education" (with amendments and additions as of March 31, 2021)

– State compulsory standard of higher education of August 31, 2018, № 604 (with amendments and additions as of 05.05.2020, № 182).

– State compulsory standard of postgraduate education dated August 31, 2018, № 604

– National qualifications framework of March 16, 2016 by the Republican tripartite commission on social partnership and regulation of social and labor relations.

– Order of the Ministry of Education and Science of the Republic of Kazakhstan «On approval of the Rules for organizing the educational process on credit technology» dated October 2, 2018, № 152 (with amendments and additions dated October 12, 2018, № 563)

– Classifier of areas of training with higher and postgraduate education from 03.09.2020, №1.

Content:

Passport of the educational program

Code and name of the educational program: 8D05 Natural sciences, mathematics and statistics

Code and classification of the field of education, areas of training: 8D053 Physical sciences

Group of educational programs

Volume of credits: 180 academic credits.

Form of education: full-time form

Language of education: kazakh, russian, foreign languages.

Degree awarded: Doctor of Philosophy PhD/ according to the educational program "8D05302-Physics".

Type of EP: the current EP.

Level according to the ISCE: Level 8.

Level according to the NCF: Level 8.

Level according to the IQF: Level 8.

Distinctive features of the EP: no.

The number of the appendix to the license for the direction of training: State license of the Ministry of Education and Science of the Republic of Kazakhstan KZ83LAA00018495, date of issue: 28 July's 2020 y.

The name of the accreditation body and the validity period of the accreditation EP: IQAA, SA No. 0113/4, date of issue: May 29, 2017 y., validity period: May 27, 2022 y.

The purpose of the EP: Preparation of Doctors of Philosophy (PhD), able to effectively carry out the professional activities of a teacher in the field of natural sciences and a researcher who has the competence to conduct research in physics.

Qualification characteristics of the graduate

List of graduate positions: The graduate of the doctoral program is awarded the degree of "Doctor of Philosophy (PhD) in the educational program «8D05302-Physics». A graduate can hold the following positions: teacher, senior lecturer, associate professor, professor at universities, researcher, leading researcher, teaching assistant, head of an organization, head of a structural unit, deputy head of a structural unit.

Scope and objects of professional activity of the graduate: The sphere of professional activity of graduates of this educational program «8D05302-Physics» are:

– fields of science and technology, including research, development, creation and operation of new materials, technologies, devices and devices.

The objects of professional activity of doctoral students in the educational program «8D05302-Physics» are:

- for scientific and pedagogical training – research institutes, research centers, research laboratories, design and design bureaus, firms and companies, higher education institutions, state educational institutions and educational enterprises, as well as non-governmental educational organizations, ministries, public administration bodies of the relevant profile, organizations of the higher and secondary special education system education.

Types of professional activity of the graduate: educational (pedagogical); experimental research; organizational management; training; educating; methodical; social and communicative.

Functions of the graduate's professional activity

– educational;
– research;
– formulation of the task and plan of scientific research in the field of physics on the basis of bibliographic work with the use of modern information technologies;
– performing physico-mathematical, physico-chemical modeling and optimization of object parameters using developed and available research and design tools, including standard and specialized application software packages;
– implementation of adjustment, adjustment and experimental verification of physical devices, systems and complexes;
– design and construction of various types of systems, blocks and nodes of justifications;
– educating;
– methodical;
– social and communicative.

Formulation of learning outcomes based on competencies

Type of competencies	Learning outcomes code	Learning result (according to Bloom's taxonomy)
1. Behavioral skills and personal qualities: (Softskills)	LO 1	He is fluent in the compilation and execution of scientific documentation (scientific reports, articles in refereed journals, reports, reviews, abstracts, annotations), bibliography and references, uses the skills of business communication, working with electronic databases in the field of professional and corporate ethics.
	LO 2	Demonstrates relevant knowledge of the methodology of scientific and pedagogical research, contributing to the implementation of the main directions of educational policy. He has the skills to analyze methodological problems that arise when solving research and practical problems.
	LO 3	Evaluates, interprets the results of optical studies of nanostructures and nanomaterials in accordance with their electronic and band structure. Selects methods of microscopic examination of nanostructures and nanomaterials depending on their physical properties.
	LO 4	Use the knowledge gained in the implementation of the sample preparation procedure for measurements, performed with microscopic and optical methods. To be able to interpret and give an explanation of the results obtained in the study.
2. Professional competencies: (Hardskills)	LO 5	Classifies the main types of nanomaterials and compares their physical properties. Defines methods for obtaining nanomaterials with desired properties.
	LO 6	Apply the acquired knowledge to the organization of the experiment and work on modern analytical equipment in the study of nanomaterials with desired properties. Compares the properties of functional nanomaterials and applies them to create a variety of devices in nano- and molecular electronics, photonics, photovoltaics, sensors, etc.
	LO 7	Demonstrates knowledge of the principles of interaction of electromagnetic radiation with nanoscale objects. Uses theoretical models and experimental methods to organize experiments and analyze data on the occurrence of photoinduced processes in nanostructures.
	LO 8	Analyzes and predicts the physicochemical properties of the synthesized nanostructures and nanomaterials used for the generation, transformation and detection of electromagnetic radiation. Develops and uses nanostructures with specified optical characteristics for photonics, optical technologies and photoelectronics.
	LO 9	Possess knowledge for studying the properties of surface and localized plasmons, as well as methods for creating and controlling plasmon excitations. Using the knowledge gained to organize the experiment and work on modern analytical equipment when studying the interaction of light with plasmon nanoobjects;
	LO 10	To be able to use the knowledge in the development of methods for obtaining plasmon nanostructures. Know the areas of application of plasmon materials and be able to create elements and devices using the plasmon effect.
	LO 11	Interprets knowledge of experimental and theoretical questions about the features of the molecular and electronic structure, as well as physicochemical processes in carbon nanostructures. Develops methods for the synthesis of carbon nanostructures and composite materials based on them.
	LO 12	Demonstrates knowledge of modern analytical techniques for organizing experiments and studying the physicochemical properties of carbon nanomaterials. Explains the theoretical sequence of actions in physical processes and interprets the experimental results obtained in the modeling and study of carbon structures. Uses the acquired knowledge in the development of new functional nanoelements using nanostructures.

Determination of modules of disciplines in accordance with the results of training

Learning outcomes code	Name of module	Name of discipline	Volume (ECTS)
LO 1	Methodological basics of research	Academic writing	5
LO 2		Methods of scientific research	5
LO 5 LO 6	Research methods	Functional nanomaterials: preparation, properties, application	5
LO 5		Teaching practice	10
LO 6		Research practice	10
LO 7 LO 8	Nanomaterials	Photonics of nanostructures	5
LO 3 LO 4		Optical and microscopic methods of nanostructures and nanomaterials research	
LO 9 LO 10		Nanoplasmonics	5
LO 11 LO 12		Carbon nanostructures	
LO 11 LO 12	Research work by a doctoral candidate	Research work of a doctoral candiate, including internships and doctoral thesis	123
	Final assessment	Writing and defending doctoral thesis	12

Matrix of achievability of learning outcomes

№	Name of discipline	Brief description of the discipline	Number of credits	Generated learning outcomes (codes)											
				LO 1	LO 2	LO 3	LO 4	LO 5	LO 6	LO 7	LO 8	LO 9	LO 10	LO 11	LO 12
Cycle of basic disciplines University component															
D1	Academic writing	The discipline is studied in order to form competencies related to analytical research and textual activities; skills of analytical-synthetic, critical and pragmatic thinking. In the process of studying the discipline, the types, methods and ethical principles of writing scientific texts, the principles of constructing a scientific text and preparing it for publication, the design of a bibliographic list, the basic rules for quoting scientific literature, the types of annotations and the features of their compilation, reviewing a scientific text are considered.	5	+											
D2	Methods of scientific research	The discipline is studied in order to form the skills of doctoral students to carry out independent research activities; the use of scientific research methods to achieve the objectives set in the dissertation research; the use of methods of processing empirical data on the topic of their dissertation research.	5		+										
D3	Teaching practice	The purpose of pedagogical practice is the formation of professional competencies among doctoral students that ensure readiness for pedagogical activity in universities, the design of the educational process in accordance with the profile of training and conducting certain types of training sessions using innovative educational technologies.	10					+							
Cycle of basic disciplines Component of choice															
D4	Optical and microscopic methods of nanostructures and nanomaterials research	The aim of the discipline: to form knowledge on optical and microscopic methods for studying nanostructures and nanomaterials. The methods of research of nano-objects are considered. Microscopic methods. Transmission electron microscopy. Scanning microscopy. Atomic force	5			+	+								

		microscopy. Scanning tunneling microscopy. Optical microscopy of the near field. Spectroscopic methods. Electron absorption spectroscopy. Luminescent spectroscopy. Spectroscopy of light scattering.														
	Photonics of nanostructures	It is studied in order to form knowledge about the generation, transmission and use of light by nanostructures and nanomaterials, the optical properties of nanomaterials, the processes of absorption, reflection and scattering of light. The discipline allows you to improve your skills in the research of photostimulated processes in nanostructures.								+	+				
Cycle of profile disciplines University component																
D5	Functional nanomaterials: preparation, properties, application	The aim of the discipline: studying of the structure and physical properties, as well as mastering of the methods of obtaining nanomaterials with desired properties. The properties of nanostructures and methods for their preparation are considered. Classification of methods for the synthesis of functional nanomaterials. The use of functional nanomaterials: nanomechanisms and nanodevices, sensors, nanoelectronics, nanobiomaterials, nanomedicine.	5					+	+						
D6	Research practice	The purpose of the research practice is for doctoral students to study the latest theoretical, methodological and technological achievements of domestic and foreign science, as well as to consolidate practical skills in applying modern methods of scientific research, processing and interpretation of experimental data in dissertation research.	10						+						
Cycle of profile disciplines Component of choice																
D7	Carbon nanostructures	The aim of the discipline: the formation of knowledge about the features of molecular and electronic structure, as well as methods of synthesis, analysis and using of carbon nanostructures. Types, structure and physico-chemical properties of carbon nanostructures. Synthesis methods and their study. Composite materials based on carbon nanostructures. Prospects for the use and modern use of carbon	5												+	+

		nanomaterials.														
	Nanoplasmonics	The aim of the discipline: obtaining knowledge of the properties of surface and localized plasmons, as well as methods for creating and controlling plasmon excitations. Electromagnetic properties of metals, types of plasmons, methods of their excitation, and features of the plasmon effect on electronic processes in molecular media are considered. The methods for the synthesis of plasmon materials and areas of their application are considered.											+	+		
Including an internship and a doctoral dissertation																
D8	Research work of a doctoral student, including internships and master	The purpose of the doctoral student's research work is to form the level of knowledge, skills and abilities necessary for the implementation of professional activity and to prepare for the defense of a doctoral dissertation. It includes conducting independent scientific research, foreign scientific internship, preparation of scientific publications, execution of a doctoral dissertation.	123												+	+

Coordination of the planned learning outcomes with the methods of teaching and evaluation within the module

Learning outcomes	Planned learning outcomes for the module	Teaching methods	Assessment methods
LO 1	He is fluent in the compilation and execution of scientific documentation (scientific reports, articles in refereed journals, reports, reviews, abstracts, annotations), bibliography and references, uses the skills of business communication, working with electronic databases in the field of professional and corporate ethics.	Interactive lecture, case-methods, round table, analysis of publications, demonstration of speech	Writing an essay
LO 2	Demonstrates relevant knowledge of the methodology of scientific and pedagogical research, contributing to the implementation of the main directions of educational policy. He has the skills to analyze methodological problems that arise when solving research and practical problems.	Interactive lecture, experimental works intended for scientific research	Colloquium, test
LO 3	Evaluates, interprets the results of optical studies of nanostructures and nanomaterials in accordance with their electronic and band structure. Selects methods of microscopic examination of nanostructures and nanomaterials depending on their physical properties.	Project training, analysis of conducted experiments, interpretation of results	Colloquium, test
LO 4	Use the knowledge gained in the implementation of the sample preparation procedure for measurements, performed with microscopic and optical methods. To be able to interpret and give an explanation of the results obtained in the study.	Interactive lecture, discussion, analysis of scientific literature, presentation of reports	Presentation
LO 5	Classifies the main types of nanomaterials and compares their physical properties. Defines methods for obtaining nanomaterials with desired properties.	Interactive lecture, discussion, analysis of scientific literature, presentation of reports	Colloquium, test
LO 6	Apply the acquired knowledge to the organization of the experiment and work on modern analytical equipment in the study of nanomaterials with desired properties. Compares the properties of functional nanomaterials and applies them to create a variety of devices in nano- and molecular electronics, photonics, photovoltaics, sensors, etc.	Interactive lecture, discussion, analysis of scientific literature, presentation of reports	Colloquium, test
LO 7	Demonstrates knowledge of the principles of interaction of electromagnetic radiation with nanoscale objects. Uses theoretical models and experimental methods to organize experiments and analyze data on the occurrence of photoinduced processes in nanostructures.	Analysis of scientific literature, presentation of reports	Written work
LO 8	Analyzes and predicts the physicochemical properties of the synthesized nanostructures and nanomaterials used for the generation, transformation and detection of electromagnetic radiation. Develops and uses nanostructures with specified optical characteristics for photonics, optical technologies and photoelectronics.	Interactive lecture, discussion, analysis of scientific literature, presentation of reports	Project preparation
LO 9	Possess knowledge for studying the properties of surface and	Analysis of conducted experiments,	Written work

	localized plasmons, as well as methods for creating and controlling plasmon excitations. Using the knowledge gained to organize the experiment and work on modern analytical equipment when studying the interaction of light with plasmon nanoobjects;	analysis of scientific literature, presentation of reports	
LO 10	To be able to use the knowledge in the development of methods for obtaining plasmon nanostructures. Know the areas of application of plasmon materials and be able to create elements and devices using the plasmon effect.	Interactive lecture, discussion, analysis of scientific literature, presentation of reports	Colloquium, test
LO 11	Interprets knowledge of experimental and theoretical questions about the features of the molecular and electronic structure, as well as physicochemical processes in carbon nanostructures. Develops methods for the synthesis of carbon nanostructures and composite materials based on them.	Analysis of scientific literature, presentation of reports	Written work
LO 12	Demonstrates knowledge of modern analytical techniques for organizing experiments and studying the physicochemical properties of carbon nanomaterials. Explains the theoretical sequence of actions in physical processes and interprets the experimental results obtained in the modeling and study of carbon structures. Uses the acquired knowledge in the development of new functional nanoelements using nanostructures.	Interactive lecture, discussion, analysis of scientific literature, presentation of reports	Colloquium, test

Criteria for assessing the achievability of learning outcomes

Codes of LO	Criteria
LO 1	**Knows:** methods of compilation and registration of scientific documentation (scientific reports, articles in peer-reviewed journals, reports, reviews, abstracts, annotations), bibliography and references
	Can: prepare and execute scientific and technical documentation, scientific reports, write articles, reviews, abstracts
	Owns: business communication skills, work with electronic databases in the field of professional and corporate ethics
LO 2	**Knows:** current methodologies of scientific and pedagogical research that contribute to the implementation of the main directions of educational policy
	Can: analyze the problems that arise when solving research and practical tasks
	Owns: Has the skills to analyze methodological problems that arise when solving research and practical tasks
LO 3	**Knows:** methods of optical and microscopic studies of nanostructures and nanomaterials
	Can: compare, interpret the results of optical studies of nanostructures and nanomaterials in accordance with their electronic and band structure; apply methods of microscopic examination of nanostructures and nanomaterials depending on their physical properties
	Owns: the main methods of research of nanostructures and nanomaterials in accordance with their electronic and band structure, methods of microscopic examination of nanostructures and nanomaterials depending on their physical properties
LO 4	**Knows:** procedures for sample preparation of samples for measurements by microscopic and optical research methods
	Can: to use the acquired knowledge in the implementation of the procedure of sample preparation of samples for measurements by microscopic and optical research methods, to interpret and explain the results obtained in the framework of the study
	Owns: theoretical and practical knowledge in the implementation of the procedure of sample preparation of samples for measurements by microscopic and optical research methods
LO 5	**Knows:** the main types of nanomaterials and their physical properties
	Can: apply knowledge in the development of methods for obtaining nanomaterials with specified properties
	Owns: methods of obtaining nanomaterials with specified properties
LO 6	**Knows:** principles of operation and expected results on modern analytical equipment in the study of nanomaterials with specified properties; fundamental principles of the properties of functional nanomaterials for the creation of various devices of nano- and molecular electronics, photonics, photovoltaics, sensors
	Can: to use the acquired knowledge for the organization of the experiment and work on modern analytical equipment in the study of nanomaterials with specified properties; to use the properties of functional nanomaterials to create a variety of devices of nano- and molecular electronics, photonics, photovoltaics, sensors, etc.
	Owns: skills of working on modern analytical equipment in the study of nanomaterials with specified properties; methods of obtaining functional nanomaterials for creating various devices of nano- and molecular electronics, photonics, photovoltaics, sensors, etc.
LO 7	**Knows:** on the peculiarities of the interaction of electromagnetic radiation with nanoscale objects, theoretical models and experimental methods for organizing experiments and analyzing data on the course of photoinduced processes in nanostructures.
	Can: to use theoretical models and experimental methods for organizing experiments and analyzing data on the course of photoinduced processes in nanostructures
	Owns: experimental methods for the organization of the experiment and analysis of data on the course of photoinduced processes in nanostructures
LO 8	**Knows:** research techniques, analysis and prediction of properties of nanostructures and nanomaterials used for generation, transformation and detection of electromagnetic radiation
	Can: develop and use nanostructures with specified optical characteristics for photonics, optical technologies and photoelectronics
	Owns: methods of analysis of the course of photoinduced processes in nanostructures and experimental methods for the organization of the experiment
LO 9	**Knows:** fundamentals of research on the properties of surface and localized plasmons, as well as methods for creating and controlling plasmon excitations
	Can: to use the acquired knowledge for the organization of the experiment and work on modern analytical equipment in the study of the interaction of light with plasmon nanoobjects
	Owns: experimental skills and work on modern analytical equipment in the study of the interaction of light with plasmonic nanoobjects

LO 10	**Knows:** areas of application of plasmon materials and how to create elements and devices using the plasmon effect
	Can: to use the acquired knowledge in the development of methods for obtaining plasmon nanostructures
	Owns: experimental skills and work on modern analytical equipment in the study of the interaction of light with plasmonic nanoobjects
LO 11	**Knows:** experimental and theoretical aspects of the features of molecular and electronic structure, as well as physico-chemical processes in carbon nanostructures
	Can: to develop methods for the synthesis of carbon nanostructures and composite materials based on them
	Owns: skills of experiment and work on modern analytical equipment in the study of carbon nanostructures and composite materials based on them
LO 12	**Knows:** physico-chemical properties of carbon nanostructures and composite materials based on them
	Can: The ability to theoretically explain and interpret experimental results obtained in the modeling and study of carbon structures, to use the knowledge gained in the development of new functional nanoelements using nanostructures
	Owns: skills of working with modern analytical techniques and equipment for the organization of experiments and research of physicochemical properties of carbon nanomaterials

Graduate Model

Attributes of a doctoral graduate

- Deep professional knowledge in their field of study
- Interest in mastering trends in education and science
- Ability to collaborate in the professional community
- Independence in the search for opportunities for professional and personal development
- Sociability
- Tolerance and good manners
- Academic integrity
- Willingness to participate in solving state tasks and strategies of Kazakhstan

Types of competencies	Description of competencies
1. Behavioral skills and personal qualities: (Softskills)	He is fluent in the compilation and execution of scientific documentation (scientific reports, articles in refereed journals, reports, reviews, abstracts, annotations), bibliography and references, uses the skills of business communication, working with electronic databases in the field of professional and corporate ethics. Demonstrates relevant knowledge of the methodology of scientific and pedagogical research, contributing to the implementation of the main directions of educational policy. He has the skills to analyze methodological problems that arise when solving research and practical problems. The ability to compare and interpret the results of optical studies of nanostructures and nanomaterials in accordance with their electronic and band structure. To be able to choose the microscopic methods for nanostructures and nanomaterials studying depending on their physical properties. Use the knowledge gained in the implementation of the sample preparation procedure for measurements, performed with microscopic and optical methods. To be able to interpret and give an explanation of the results obtained in the study.
2. Professional competencies: (Hardskills)	Knowledge of the main types of nanomaterials and their physical properties. Development of methods for obtaining nanomaterials with desired properties. The use of the knowledge gained for the organization of the experiment and work on modern analytical equipment in the study of nanomaterials with predicted properties. The ability to use functional nanomaterials to create a variety of devices of nano- and molecular electronics, photonics, photovoltaics, sensorics, etc. Comprehensive knowledge of the features of the interaction of electromagnetic radiation with nanoscale objects. The use of theoretical models and experimental methods for organizing an experiment and analyzing the data obtained about photoinduced processes in nanostructures. Study, analysis and prediction of the properties of nanostructures and nanomaterials used to generate, transform and detect electromagnetic radiation; Ability to develop and use nanostructures with given optical characteristics for photonics, optical technologies and photoelectronics. Possess knowledge for studying the properties of surface and localized plasmons, as well as methods for creating and controlling plasmon excitations. Using the knowledge gained to organize the experiment and work on modern analytical equipment when studying the interaction of light with plasmon nanoobjects; To be able to use the knowledge in the development of methods for obtaining plasmon nanostructures. Know the areas of application of plasmon materials and be able to create elements and devices using the plasmon effect.

	Comprehensive knowledge of experimental and theoretical questions about the features of the molecular and electronic structure, as well as physicochemical processes in carbon nanostructures. Development of methods for the synthesis of carbon nanostructures and composite materials based on them. The use of modern analytical techniques for the organization of the experiment and the study of the physicochemical properties of carbon nanomaterials. The ability of theoretical explanation and interpretation of experimental results obtained in modeling and studying carbon structures. Use of the knowledge gained in the development of new functional nanoelements using nanostructures.

Developers:
Members of the working group:

Head of the Department of physics and Nanotechnology — G.S. Omarova

Research Professor of the Department of Physics and Nanotechnology — N.Kh.Ibraev

Associate Professor of the Department of Physics and Nanotechnology, PhD — T.M. Serikov

Doctoral student 3 years of study — A.E. Kanapina

The educational program was reviewed by the Faculty Council from 16.03.2023 Protocol No. 8
The educational program was reviewed at the meeting of the Academic Council from 28.04.2023 Protocol No. 5
The educational program was reviewed and approved at the meeting of the University Board from 30.05.2023 Protocol No. 12

Member of the Board – Vice-rector for academic affairs — **T.Z. Zhusipbek**

Director of the Department for Academic Work — **S.A. Smailova**

Dean of the faculty of physics and technology — **A.K. Zeinidenov**