Mining and Metallurgical Institute named after O.A. Baikonurov
Department of "Materials Science, Nanotechnology and Engineering Physics"

EDUCATIONAL PROGRAM
6B07109 "Engineering physics and Materials Science"

Code and classification of the field of education: **6B07 "Engineering, manufacturing and construction industries"**
Code and classification of training directions: **6B071 "Engineering and Engineering Trades"**
Group of educational programs: **B061 "Materials Science and Technology"**
Level based on NQF: 6
Level based on IQF: **6**
Study period: 4 years
Amount of credits: **240**

Almaty 2024

NON-PROFIT JOINT STOCK COMPANY "K.I. SATPAYEV KAZAKH NATIONAL RESEARCH TECHNICAL UNIVERSITY"

The educational program 6B07109 "Engineering physics and materials science" was approved at a meeting of the Academic Council of KazNTU named after K.I.Satpayev.

Protocol No. 12, 22.04.2024 was reviewed and recommended for approval at the meeting of K.I. Satbayev KazNRTU Educational and Methodological Council.

Protocol No. 19.04.2024.

Full name	Academic degree/ academic title	Position	Workplace
Chairman of the Academic Committee:			
Mutushev A.	PhD	General Director	Scientific Production and Technical Center "ZHALYN"
Academic committee members:			
Kudaibergenov K.	PhD	Head of Department	Non-profit Joint Stock Company "Kazakh National Research Technical University named after K.I. Satpayev"
Smagulov D.	Doctor of Technical Sciences	Professor	Non-profit Joint Stock Company "Kazakh National Research Technical University named after K.I. Satpayev"
Nazhipkyzy M.	PhD in Chemistry	Associate Professor	Non-profit Joint Stock Company "Kazakh National Research Technical University named after K.I. Satpayev"
Kemelbekova A.	PhD in material science	Teacher	Non-profit Joint Stock Company "Kazakh National Research Technical University named after K.I. Satpayev»
Yetish T.	PhD student	Assistant	Non-profit Joint Stock Company "Kazakh National Research Technical University named after K.I. Satpayev»
Abay A.		Student	Non-profit Joint Stock Company "Kazakh National Research Technical University named after K.I. Satpayev»

F Kazntu 703-05 Educational program

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List of abbreviations and designations

Abbreviation		Full name
Ts	–	Teaching staff
EP	–	Educational program
OR	–	Registrar's Office
WC	–	Working Curriculum EP

1. Description of educational program

Educational program 6B07109 "Engineering Physics and Materials Science" - is the first level of qualification of the three-level system of higher education, which lays the foundation for subsequent master's programs, and then doctoral programs.

The program is aimed at training specialists of a wide profile of activity. Necessary basic knowledge and skills in the field of engineering and technology will allow future specialists to easily fit into the working process of almost any industry. The educational program lays scientific foundations in the field of materials science, nanotechnology, nuclear technology, space technology, semiconductor electronics. Specialists are trained in research, development, creation and operation of new materials, technologies, devices and appliances. The work of specialists consists in creation, improvement, operation and repair of devices and appliances, creation and research of new materials, as well as their development and implementation of technologies by branches of application.

Graduates, having received the degree "Bachelor of Engineering and Technology" in the educational program 6B07109 "Engineering Physics and Materials Science", have the following opportunities:

- to start labor activity as line personnel in small and large production enterprises; in military-industrial complex; in governmental and non-governmental institutions in the sphere of industry, energy, education; in research and design institutes and laboratories; in companies and firms related to supply, adjustment and maintenance of equipment and technologies.

- to improve qualification in a master's program of higher education in the received or related specialty on a grant or paid basis.

The following is meant as line personnel: an engineer-physicist in all branches of production; an engineering researcher in design organizations, institutions, institutes, universities; a pedagogical employee; a technical specialist, technical consultant in the fields of activity; an engineer-technician, engineer-technologist in the field of materials science (materials scientist, metal scientist); a research engineer; an electronic engineer, etc. The following is also meant as line personnel.

2. Purpose and objectives of educational program

Purpose of EP: The purpose of the educational program is to provide fundamental and practical training for students to solve scientific and engineering problems in various fields of technical physics and materials science, as well as to develop students' skills in engineering analysis and design.

Tasks of EP:

1) knowledge and understanding of scientific and mathematical principles underlying various specializations in engineering physics and materials science;

2) ability to apply the acquired knowledge to set, formulate and solve applied scientific problems in engineering physics using recognized methods;

3) ability to apply the acquired knowledge to analyze technical systems, processes and methods related to different specializations in engineering physics and materials science, including the use of modeling methods;

4) understanding of engineering systems design methodologies and the ability to apply them;

5) ability to find the necessary literature, use databases and other sources of information;

6) ability to analyze, plan and conduct necessary research, interpret the obtained data and draw conclusions;

7) Ability to select and use appropriate equipment, tools and techniques;

8) Work effectively both individually and as a member of a team;

9) exhibit project management and business awareness, knowledge and understanding of the impact of risks and changing conditions;

10) recognize the need and have the ability to learn and develop skills independently throughout life;

11) understand health, safety, legal and liability issues in engineering, understanding the impact of engineering decisions on the social context and environment:

12) follow the code of professional ethics

3. Requirements for evaluating the educational program learning outcomes

Learning outcomes include knowledge, skills and competencies and are defined both for the educational program as a whole and for its individual modules, disciplines or assignments.

The main task at this stage is to select methods and assessment tools for all types of control, which can be used to most effectively assess the achievement of the planned learning outcomes of the discipline.

4. Passport of educational program

4.1. General information

№	Field name	Comments
1	Code and classification of the field of education	6B07 "Engineering, manufacturing and construction industries"
2	Code and classification of training directions	6B071 "Engineering and engineering trades"
3	Educational program group	B061 "Material Science and Technology"
4	Educational program name	6B07109 "Engineering Physics and Materials Science".
5	Short description of educational program	The educational program 6B07109 "Engineering Physics and Materials Science" is the first level of qualification of the three-level system of higher education
6	Purpose of EP	The purpose of the educational program is to provide fundamental and practical training for students to solve scientific and engineering problems in various fields of technical physics and materials science, as well as to develop students' skills in engineering analysis and design.
7	Type of EP	New
8	The level based on NQF	6
9	The level based on IQF	6
10	Distinctive features of EP	Double diploma EP
11	List of competencies of educational program	KK1. Communicativeness KK2. Basic literacy in Natural science disciplines KK3. General engineering competences KK4.Professional competencies KK5. Engineering-computer competencies KK6.Engineering-working competencies KK7. Socio-economic competences KK8. Special-professional competences
12	Learning outcomes of educational program	LO1 to substantiate the choice of experimental methods for studying systems with micro- and nano-sizes;

		LO2 plan the organization and conduct of an experiment to obtain materials with special physical and chemical properties (porous nanostructures, magnetic nanomaterials, nanobiomaterials); LO 3 Integrate knowledge in professional activities and have the competence to argue their ideas when making decisions in the field of engineering and technology; LO 4 explain the specifics of the functional purpose of equipment in the field of materials science and the possibility of its digitalization; LO 5 apply physical and chemical methods for obtaining nano-objects and their composites for solving applied problems, as well as methods for describing structures, structures, composition, morphologies; LO 6 to study the current trends in advanced materials science for further scientific and pedagogical activities; LO 7 choose the best methods for solving the problems of materials science, nanoproduction, processing and modification of materials; LO 8 to model and evaluate the forecast of product quality by the parameters of the technological process in order to optimize it in accordance with the type of product obtained;; LO 9 investigate the structure of the material by conducting a physical experiment using laboratory equipment and modern scientific equipment;
13	Education form	Full - time
14	Period of training	4
15	Amount of credits	240
16	Languages of instruction	Kazakh, Russian
17	Academic degree awarded	Bachelor of Engineering and Technology
18	Developer(s) and authors	Mutushev A. Kudaibergenov K. Smagulov D. Nazhipkyzy M. Kemelbekova A. Yetish T. Abay A.

4.2. Relationship between the achievability of the formed learning outcomes based on educational program and academic disciplines

№	Discipline name	Short description of discipline	Amount of credits	Generated learning outcomes (codes)								
				PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CYCLE OF BASIC DISCIPLINES University component												
1	Fundamentals of anti-corruption culture and law	The course introduces students to the improvement of socio-economic relations of Kazakhstan society, psychological features of corrupt behavior. Special attention is paid to the formation of an anti-corruption culture, legal responsibility for acts of corruption in various spheres. The purpose of studying the discipline «Fundamentals of anti-corruption culture and law» is to increase public and individual legal awareness and legal culture of students, as well as the formation of a knowledge system and a civic position on combating corruption as an antisocial phenomenon. Expected results: to realize the values of moral consciousness and follow moral norms in everyday practice; to work on improving the level of moral and legal culture; to use spiritual and moral mechanisms to prevent corruption.	5	v		v					
2	Fundamentals of scientific research methods	The purpose of the discipline "Fundamentals of research methods" is the formation of students' skills and abilities in the field of methodology of scientific knowledge. Brief description of the discipline. Methodological foundations of scientific knowledge. The concept of scientific knowledge. Methods of theoretical and empirical research. Choice of the direction of scientific research. Stages of research work. Research topic and its relevance. Classification, types and tasks of the experiment. Metrological support of experimental studies. Computational experiment. Methods for processing the results of the experiment. Formulation of research results. Presentation of research work.	5	v							

		tasks of the experiment. Metrological support of experimental studies. Computational experiment. Methods for processing the results of the experiment. Formulation of research results. Presentation of research work.									
3	Fundamentals of economics and entrepreneurship	Discipline studies the foundations of economics and entrepreneurial activity from the point of view of science and law; features, problematic aspects and development prospects; the theory and practice of entrepreneurship as a system of economic and organizational relations of business structures; The readiness of entrepreneurs for innovative susceptibility. The discipline reveals the content of entrepreneurial activity, the stages of career, qualities, competencies and responsibility of the entrepreneur, theoretical and practical business planning and economic examination of business ideas, as well as the analysis of the risks of innovative development, the introduction of new technologies and technological solutions.	5	**v**							
4	Ecology and life safety	The discipline studies the tasks of ecology as a science, environmental terms, the laws of the functioning of natural systems and aspects of environmental safety in the conditions of labor activity. Monitoring of the environment and management in the field of its safety. Sources of pollution of atmospheric air, surface, groundwater, soil and ways to solve environmental problems; life safety in the technosphere; natural and man-made emergencies	5	**v**							
5	Introduction to nanomaterials	To form the ability to describe and evaluate the principles and physico-chemical effects underlying nanotechnology. The training course forms the theoretical basis for understanding the fundamental laws of nanotechnology and quantum-dimensional effects implemented in nanoobjects and nanomaterials. The content of the discipline is aimed at describing the properties of nanoparticles, nanostructures and nanomaterials. Zero-dimensional one- and two-dimensional nanostructured materials are considered. The	5		**v**						

		issues of synthesis of nanomaterials, methods of research of nanostructures and nanomaterials, the most important areas of application of nanomaterials are highlighted.									
6	Defects in the Crystal Structure of Materials	The discipline considers the laws of crystallography, qualitative and quantitative description of structures, establishes the relationship between structure and material properties. The course deals with the theory of defects, the structure of real materials, the essence of such processes as aging, hardening, diffusion.	5			v					
7	Alloy steels and alloys. Cast iron.	The purpose of the discipline is the study of steel, cast iron and alloys for its intended purpose. The course covers: steels for springs and springs, for ball bearings, hardened steels, martensitic - aging steels, as well as alloys based on non-ferrous metals intended for especially critical parts and mechanisms, classification of cast irons: white, gray, high-strength, malleable.	5			v					
8	Mathematics I	The course is devoted to the study of the basic concepts of higher mathematics and its applications. The main provisions of the discipline are applied in the teaching of all general education engineering and special disciplines taught by graduate departments. The course sections include elements of linear algebra and analytical geometry, an introduction to analysis, differential calculation of functions of one and several variables. Methods for solving systems of equations, problems of using vector calculations in solving problems of geometry, mechanics, and physics are considered. Analytical geometry on a plane and space, differential calculation of functions of one variable, derivatives and differentials, study of the behavior of functions, derivative and gradient in direction, extremum of a function of several variables.	5				v				
9	Mathematics II	The discipline is a continuation of Mathematics I. sections of the course include integral calculus of a function of one variable and several variables, series theory. Indefinite integrals, their properties and methods of their calculation. Certain integrals and their application. Incorrect integrals. Numerical series theory, functional series theory, Taylor and	5			v					

		Macloren Series, application of series to approximate calculations.									
10	Metallography	The discipline studies the features of the alloying process, as well as the dependence of the operational and technological properties of alloys on their structure and phase composition. The course also discusses methods for analyzing the properties of materials, practical skills of metallographic research.	5							v	
11	Mechanical properties of materials	The discipline studies the mechanical properties of materials determined during cyclic, static and dynamic tests, methods for determining hardness, as well as types of deformation and destruction. The course examines the influence of thermal, thermochemical, thermomechanical treatments on the mechanical properties of materials and the main factors on which they depend.	6					v			
12	Fundamentals of materials science	The discipline studies the fundamentals of materials science, as well as various types of materials used in industry, information about their composition, structure, structure, basic physical properties, classification, marking of alloys and methods of influencing properties. The course also examines the basics of phase and structural changes in materials, the general patterns of structure formation during solidification, deformation and various types of material processing.	4				v				
13	Fundamentals of electricity and magnetism	The discipline studies the electric field in matter, the circulation theorem, the magnetic field in matter, electromagnetic induction, forces in a magnetic field, free oscillations, the method of complex amplitudes, Maxwell's equations, electromagnetic waves in waveguides. The course deals with theoretical reviews and methods for solving key problems that are important for understanding the principles of practical application of theoretical knowledge.	5						v		
14	Carbon materials	The purpose of the discipline is to form the ability to organize and evaluate the synthesis of carbon materials. The discipline is aimed at developing students' skills in creating carbon materials by various methods, such as sputtering,	5					v			

		deposition and sol-gel, etc. The course covers: the synthesis and structure of carbon nanostructures and the main stages that determine the process of creating carbon materials; methods for obtaining carbon nanomaterials; optimization of technological parameters and characteristics of carbon materials from the main technological parameters; methods for the production of nanocarbon materials.									
15	Physics	The course studies the basic physical phenomena and laws of classical and modern physics; methods of physical research; the influence of physics as a science on the development of technology; the relationship of physics with other sciences and its role in solving scientific and technical problems of the specialty. The course covers the following sections: mechanics, mechanical harmonic waves, fundamentals of molecular kinetic theory and thermodynamics, electrostatics, direct current, electromagnetism, geometric optics, wave properties of light, laws of thermal radiation, photoelectric effect.	5						v		
16	Crystal physics	The discipline studies the nomenclature and classification of point and space symmetry groups of crystals, Bravais lattices and syngonies, the basics of the symmetry analysis of tensors, new materials, such as crystals and fullerenes. The course discusses the basic concepts of crystal chemistry, the main types of defects in crystals and their influence on physical properties.	4				v				
17	Physics of metals. Physical properties of materials	The discipline studies the creation of new materials with better or fundamentally new physical, chemical and mechanical properties, as well as structural sensitivity of properties such as fracture resistance, ductility, toughness, hardness, electrical resistance, ferromagnetic properties and their dependence on crystal defects and texture. The course deals with some structurally insensitive properties such as density, elastic modulus, thermal expansion, melting point, thermal conductivity, specific heat, thermoelectric properties, paramagnetic and dynamite properties, reflectivity, radiation absorption.	5						v		
18	Physical chemistry	The course physical chemistry allows students to form the	5				v				

		ability to understand the physico-chemical essence of processes and use the basic laws of physical chemistry in complex production and technological activities. In the course of training, the student studies the laws of thermodynamics; basic equations of chemical thermodynamics; methods of thermodynamic description of chemical and phase equilibria in multicomponent systems; properties of solutions; fundamentals of electrochemistry; basic concepts, theories and laws of chemical kinetics and catalysis.									
19	lloy steels and alloys. Cast iron.	The purpose of the discipline is the study of steel, cast iron and alloys for its intended purpose. The course covers: steels for springs and springs, for ball bearings, hardened steels, martensitic - aging steels, as well as alloys based on non-ferrous metals intended for especially critical parts and mechanisms, classification of cast irons: white, gray, high-strength, malleable.	5					v			v
20	Graphene and materials based on it.	The discipline studies the technology of obtaining fundamental knowledge in the field of low-dimensional systems, the use of low-dimensional systems in the creation of new devices and nanotechnology materials, as well as the quantum-dimensional properties of nanocrystals, the energy of the surface of nanocrystals, free dangling bonds of atoms of a nanocrystal, the interfaces of a nanocrystal matrix, the mechanisms of low-temperature growth of nanocrystals and the production of graphene large area.	5						v		
21	Dielectric materials	The discipline studies the composition, physico-chemical properties of dielectric materials, with modern methods of obtaining and processing technologies of dielectric materials, the use of dielectric materials for various fields of engineering and technology.	6				v				
22	Computer Modeling in Materials Science (thermocalc)	The discipline studies the work on the ThermoCalc software, modeling of multiphase systems using this	5								

		program. The course examines various systems of alloys based on ferrous and non-ferrous metals in the ThermoCalc database.									
23	Structural materials	The purpose of the discipline is to acquire knowledge about the technological processes of manufacturing blanks and parts from metallic and non-metallic materials. Considered: Classification of structural materials. Properties of structural materials. The relationship of the composition, structure and properties of structural materials. Non-metallic structural materials. Methods of surface treatment. Metal-based composites. Ceramic-based composites. Polymer-based composites.	5			v					
24	Corrosion and protection of metal structures.	The discipline considers the improvement of methods for protecting metals from corrosion in all industries. The course examines various methods of protecting metal from corrosion, methods of surface treatment with polymers, bituminous coatings, nanomaterials to create surfaces with desired properties.	5					v			
25	Paints and varnishes materials	The purpose of the discipline is to form the ability to organize and evaluate the synthesis of paints and varnishes. The discipline is aimed at developing students' skills in applying paint and varnish in various branches of engineering and technology, as in the use of automotive operating materials, etc. The following are considered: the main stages that determine the process of applying paints and varnishes materials; according to the main properties, quality indicators and organization of rational use operational materials; methods of synthesis and research of paints and varnishes materials; optimization of technological parameters and characteristics of paints and varnishes materials from the main technological parameters; methods of production of paints and varnishes.	5							v	
26	Methods of obtaning and research of nanostructered materials	The discipline studies the basic concepts and definitions of nanosystems and nanotechnologies, the features of physical interactions at the nanoscale, methods for studying and diagnosing nanoobjects and nanosystems, the structure of the main classes of nanomaterials, and their properties.	5		v						

27	Methods of forming the surface nanostructures	The discipline studies the basic concepts, laws and methods of the main physical and chemical processes that underlie the various methods of nanotechnology and the features of thermodynamic and kinetic calculations of physical and chemical processes and the ability to use them in nanotechnology and nanotechnology.	5								
28	Microstructure of Organic Materials	The discipline studies the microstructure and properties of soft materials, including the molecular weight distribution of polymers, amorphous polymers, semi-crystalline polymers, copolymers, elastomers, biopolymers, soft tissues, bones, and cellular structure. The design and functions of implantable biomaterials are considered.	5								**v**
29	Perspective glasses and glass materials	The purpose of the discipline is to form the ability to organize the synthesis of glass and glass materials and evaluate the physicochemical processes of phase formation, the relationship between the structure and properties of silicate materials, technological features of production, patterns of changes in the properties of products in service. The discipline is aimed at developing doctoral students' skills in creating silicate materials by various methods, such as the method of molding ceramics, binders, glass materials and composites based on them, etc. Planning and organizing technological processes for the production of silicate materials, taking into account the quality of the feedstock and the requirements for the final product The following are considered: the main stages that determine the process of creating glass and glass materials; methods for the synthesis of glass and glass materials; optimization of technological parameters and characteristics of glass and glass materials from the main technological parameters; principles for selecting raw materials and technological solutions for obtaining products based on refractory non-metallic and silicate materials, taking into account the influence of climatic and natural conditions	5					**v**			
30	Polymeric materials and composites based on them	The discipline studies polymers, polymer blends and their miscibility, dynamic, mechanical behavior, the Boltzmann superposition principle, the final properties of polymers,	5							**v**	

		polymer rheology and processing, recycling, and the design and selection of polymer materials.									
31	Reactor Materials Science	The discipline studies the phenomenon of radiation and the effect on the materials of structures for reactors used in nuclear technology.The course examines the patterns of changes in structure, size, structural and phase qualities near exposure to radiation and ways to increase the stability of the qualities of the material.	6				v				
32	Structural materials	The purpose of the discipline is to acquire knowledge about the technological processes of manufacturing blanks and parts from metallic and non-metallic materials. Considered: Classification of structural materials. Properties of structural materials. The relationship of the composition, structure and properties of structural materials. Non-metallic structural materials. Methods of surface treatment. Metal-based composites. Ceramic-based composites. Polymer-based composites.	5					v			
33	Physics of Low-Dimensional Systems	The discipline studies the physics of low-dimensional systems, structures with quantum wells, quantum wires, quantum dots and superlattices. The course examines the study of electronic, photonic and phonon states in semiconductor nanostructures and the analysis of their physical properties.	6								v
34	Physics of Strength and Plasticity	The discipline studies the mechanical properties of materials, the analysis of the processes of deformation and destruction at different temperatures and conditions of a certain load. The course examines the methods of mechanical testing, factors affecting the structure and composition of materials, methods of mechanical testing, their features, methods of processing the results.	5					v			
35	Methods for studying the structure of material properties	The discipline studies materials for a number of branches of new technology with high physics-mechanical properties, requires a detailed study of their phase composition, structure and properties, using a variety of spectroscopic methods of physical materials science: measurement of	5								v

		quantitative metallography, X-ray diffraction analysis, electron microscopy, differential thermal analyzes , measurement of thermal and mechanical properties of materials, corrosion resistance and wear resistance.									
36	Nanomaterials and nanotechnologies in construction	The purpose of the discipline is to form the ability to organize and evaluate the methodology of the technical and economic assessment of the introduction of nanotechnology in construction . The discipline is aimed at developing the phenomenology of nanotechnology among students production of building materials skills of creating composite materials by various methods, as a method of researching processes nanostructuring in fine-grained concretes with the addition of nanoparticles of dioxide silicon, etc. The course covers: the main stages that determine the process of identification and the role of nanofillers in composition of fine-grained concretes; methods for the synthesis of various types of nanomaterials; optimization of technological parameters and characteristics of nanomaterials from the main technological parameters; methods for the production of various types of nanomaterials.	4						v		
37	Non Metallic Materials and Technologies	The discipline studies the regularities connecting chemical compositions, structures (structure) and properties of materials; patterns of change in the properties of materials in the process of manufacture and operation of products; methods of purposeful change of mechanical and decorative properties of materials; chemical composition and structure, properties and areas of application of the main types of non-metallic materials used for the production of industrial products.	6							v	
38	Semiconductor materials	The discipline studies the physical properties of semiconductor materials, the main physical problems of optoelectronic devices, the fundamentals of the technology for obtaining semiconductor materials and methods for determining their parameters, the principle of operation of devices based on semiconductor materials.	4							v	
39	Functional materials	The discipline studies the production of new materials with a controlled structure and properties, the change in the	5								v

		technical parameters of properties from external factors, as well as the influence of the chemical composition and various types of processing that affect the course of structural and phase transformations in the material. The course examines the physicochemical properties of various modern functional materials and their practical application.									
40	Chemical-thermal treatment of metals and alloys.	The discipline studies the theoretical foundations of the chemical-thermal treatment of materials and the technology of their surface hardening. The course discusses the optimal, economical modes of chemical-thermal treatment of metals for the synthesis of the required structure and properties of materials and choose the most effective methods of chemical-thermal treatment, as well as promising types of chemical-thermal treatment of materials to increase the strength, durability, reliability of products.	5								
41	Vacuum Technology	The discipline studies the technology of obtaining fundamental knowledge in the field of physics of low-dimensional systems, the use of low-dimensional systems in the creation of new devices and nanotechnology materials. The quantum-dimensional properties of nanocrystals, the energetics of the surface of nanocrystals, free dangling bonds of atoms of a nanocrystal, and interfaces of a nanocrystal matrix are considered.	4						**v**		
42	Probing methods on materials research	The discipline studies the surfaces of materials at the atomic level and gaining knowledge about the principles of operation of various types of scanning probe microscopes and their application to study the morphology and local properties of the surface of materials with nanometer spatial resolution.	6							**v**	
43	Material quality control	The discipline studies physical methods for studying the structure and properties of materials, as well as research methods on experimental devices, the main set of physical methods that allow measuring or calculating most of the known properties, characteristics and parameters of solids.	6								**v**
44	Methods for studying powder and composite materials	The discipline studies the mechanisms and patterns of creating powder and composite materials, technologies for obtaining powders in various ways. The course deals with	5		**v**			**v**			

		the relationship of technological parameters with the structure and properties of materials, types of various metallic and non-metallic powders, their technological properties and methods for their evaluation.									
45	Methods for producing powder materials	The discipline studies the main methods of manufacturing powders, such as physical-mechanical and chemical-metallurgical methods, mechanisms and patterns of synthesis of composite and powder materials with special properties, methods for forming metal powders, and preparing powder mixtures.	5				**v**			**v**	
46	Methods for calculating phase diagrams	The discipline studies the control of the phase composition, structure and properties of alloys necessary for further theoretical and experimental research, various phase transitions in liquid and solid metals and alloys. The course also discusses theoretical studies of phase equilibria in multicomponent metallic systems.	5					**v**			
47	Microstructure of Inorganic Materials	The discipline studies the relationship between structure and properties in metallic and ceramic materials. Crystal structures of important metal and ceramic elements, alloys and compounds. Binary and ternary phase diagrams for known systems will be presented. Microstructural features to be considered include grain size and distribution, multiphase microstructures, and defects. Examples of important metal and ceramic systems for structural, electrical, optical and magnetic applications will be given.	5						**v**		
48	Nanomaterials in electronics	The discipline studies the technology and application of low-dimensional systems in the creation of new devices and materials, strong nonlinear interaction of electromagnetic radiation with the 2D electronic subsystem of graphene, as well as broadband absorption of graphene from UV to far terahertz IR radiation, direct electric currents in graphene and non-threshold amplification of surface acoustic waves.	5								**v**
49	Scientific basis for material selection	The discipline studies the main ways of choosing materials depending on the technological purpose. The course discusses the system layout in the study of materials by analysis and synthesis, the use of materials depending on their mechanical properties and methods for determining the	5						**v**		

		quality of materials at the level of their applied use.									
50	Fundamentals of laser ablation	The discipline studies the technology of pulsed laser deposition, high-power laser pulses for melting, evaporation and ionization of material from the target surface, the creation of a short-term, intense glowing plasma plume.	4						v		
51	Fundamentals of technological processes for the production of nanomaterials	The discipline studies technological processes in the manufacture of nanomaterials, their structure, structure and properties. Thermal, chemical-thermal treatment that affects the structure and properties of the material is considered. Modern technological processes for the production of nanomaterials are being studied.	5						v		
52	Advanced materials	The discipline studies special functional, physical, mechanical and operational properties based on non-traditional materials and high-tech technologies for their manufacture. The course examines the main types of advanced materials, their physical and chemical properties, theoretical principles based on the creation of materials with special physical, mechanical and operational properties and their manufacturing technology.	5						v		
53	X-ray diffraction and electron microscopic analysis	The discipline studies the theoretical foundations of X-ray diffraction analysis, methods for evaluating the specific surface area, including direct microscopic or electron microscopic analysis. Also discussed are methods based on the measurement of permeability, X-ray methods of structural analysis, the introduction of structural analysis data for the conclusion of structural analysis problems.	5					v			
54	Technologies of obtaining nanomaterials and nanosystems	The discipline studies the physicochemical foundations of the synthesis of nanoclusters and nanomaterials, chemical and physical methods for the synthesis of nanoparticles and nanomaterials, methods of controlled growth to obtain nanoparticles of the required size and shape, methods for the deposition of films and coatings, and also studies the self-organization of nanoparticles in films and bulk structures.	5						v		

55	Physicochemical principles of coating	TThe discipline studies the theory of electrochemical technology of coating deposition and surface treatment, the application of metallic and non-metallic coatings, as well as the mechanism of coating formation and technological features of various coating methods. The course also discusses the formation of the surface and methods of its preparation for coating.	4	**v**							
56	Technologies of obtaining nanomaterials and nanosystems	The discipline studies the physicochemical foundations of the synthesis of nanoclusters and nanomaterials, chemical and physical methods for the synthesis of nanoparticles and nanomaterials, methods of controlled growth to obtain nanoparticles of the required size and shape, methods for the deposition of films and coatings, and also studies the self-organization of nanoparticles in films and bulk structures.	5		v			v			