Mining and Metallurgical Institute named after O.A. Baikonurov

Department of "Materials Science, Nanotechnology and Engineering Physics"

EDUCATIONAL PROGRAM
7M07103 "Engineering physics and Materials Science"

Code and classification of the field of education:
7M07 "Engineering, manufacturing and construction industries"
Code and classification of training directions:
7M071 "Engineering and Engineering Trades"
Group of educational programs:
M101 "Materials Science and Technology"

Level based on NQF: 7
Level based on IQF: **7**
Study period: 2years
Amount of credits: **120**

Almaty 2024

The educational program 7M07103 "Engineering physics and materials science" was approved at a meeting of the Academic Council of KazNTU named after K.I.Satpayev.

*Protocol No. 1*2, 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

Table of contents

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

The main objectives of the educational program are:

- to provide scientific training of undergraduates for their successful solution of scientific and engineering problems of an interdisciplinary nature;
- develop the skills of scientific analysis, staging and conducting scientific research, including as a team member;
- develop skills in the possession and application of scientific research methods, technologies for obtaining and processing materials for a specific purpose;
- to develop ideas about professional and ethical responsibility, the ability to independently study and improve their qualifications during their lifetime for a successful career in scientific, scientific and industrial organizations and educational institutions engaged in solving scientific and technical problems. The program is aimed at the following types of professional activity:

experimental research; design
and analytical; production
and technological; scientific
and pedagogical.

The objects of professional activity of the Master of Technical Sciences are:

employees of national companies, research centers, business structures, public administration of industry and committees on science and technology; teachers in higher educational institutions.

2. Purpose and objectives of educational program

Purpose of EP: The main purpose of the educational program is to provide scientific training for undergraduates to successfully solve scientific and engineering problems of an interdisciplinary nature, to develop the skills of scientific analysis, formulation and conduct of scientific research, to teach the skills of possession and application of scientific research methods, technologies for obtaining and processing materials for a specific purpose.

Tasks of EP:

The objectives of the educational program are consistent with the types of future professional activity and are as follows:

in the field of experimental research activities:

- analysis of the task of research in a given field based on the selection and study of literary and patent sources;
- diagnostics of the state and dynamics of objects of activity (materials, technological processes, equipment in various industries using the necessary tools and methods of analysis);
- study of the structure and properties of technical materials, their improvement and creation of new materials and technological processes for their manufacture;
- construction of mathematical models, computer modeling to solve the problem;
- carrying out measurements and research in the development of new materials and technologies according to a given methodology with the choice of modern technical means and computer processing of the results; - in the field of design and analytical activities:
- formulation of the objective and objectives of the project (program) with the given criteria, target functions, constraints, building the structure of their relationships, identifying priorities for solving problems;
- development of generalized solutions to problems, analysis of these options, forecasting of consequences, finding compromise solutions in conditions of multi-criteria, uncertainty, planning and implementation of projects;
- development of production equipment projects taking into account mechanical, technological, design, operational, ergonomic, aesthetic and economic parameters;
- the use of information technology to select the necessary materials and equipment in the manufacture of finished products;
- in the field of production and technological activities:
- conducting physical and experimental studies using modern methods of measuring and processing the results obtained;
- introduction of technological processes of production, quality control of

elements and assemblies for various purposes; calculation of production rates, technological standards for material consumption, selection of standard equipment, preliminary assessment of the economic efficiency of the selected materials;

- efficient use of materials and equipment, selection and calculation of technological process parameters for the preparation of finished products;
- quality control of materials and technologies;
- in the field of scientific and pedagogical activity:

ensuring high-quality transfer of skills and knowledge and the ability to work with staff during their training.

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 tasks.

The main task at this stage is to select assessment methods and tools for all types of control, with the help of which it is possible to most effectively assess the achievement of planned learning outcomes at the discipline level.

The previous level of education of applicants is higher professional education (bachelor's degree). The applicant must have a diploma of the established sample and confirm the level of knowledge of the English language with a certificate or diplomas of the established sample.

The procedure for admission of citizens to the magistracy is established in accordance with the "Standard rules for admission to training in educational organizations implementing educational programs of postgraduate education". The formation of a contingent of undergraduates is carried out by placing a state educational order for the training of scientific and pedagogical personnel, as well as paying for training at the expense of citizens' own funds and other sources. The State provides citizens of the Republic of Kazakhstan with the right to receive free postgraduate education on a competitive basis in accordance with the state educational order, if they receive education of this level for the first time.

At the "entrance", a master's student must have all the prerequisites necessary to master the relevant master's degree program. The list of necessary prerequisites is determined by the higher educational institution independently.

In the absence of the necessary prerequisites, the undergraduate is allowed to master them on a paid basis.

4. Passport of educational program

4.1. General information

№	Field name	Comments
1	Code and classification of the field of education	7M07 "Engineering, manufacturing and construction industries"
2	Code and classification of training directions	7M071 "Engineering and engineering trades"
3	Educational program group	7M071 "Material Science and Technology"
4	Educational program name	7M07103 "Engineering Physics and Materials Science".
5	Short description of educational program	The main objectives of the educational program are to provide scientific training of undergraduates for their successful solution of scientific and engineering problems of an interdisciplinary nature
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	7
9	The level based on IQF	7
10	Distinctive features of EP	Two - degree 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	2
15	Amount of credits	120
16	Languages of instruction	Kazakh, Russian
17	Academic degree awarded	Master of Technical Sciences
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
1	Foreign language (professional)	The course is designed for undergraduates of technical specialties to improve and develop foreign language communication skills in professional and academic fields. The course introduces students to the general principles of professional and academic intercultural oral and written communication using modern pedagogical technologies.public discussions; interpret and present the results of scientific research in a foreign language.									
2	History and philosophy of science	The subject of philosophy of science, dynamics of science, specifics of science, science and pre-science, antiquity and the formation of theoretical science, the main stages of the historical development of science, features of classical science, non-classical and post-non-classical science, philosophy of mathematics, physics, engineering and technology, specifics of engineering sciences, ethics of science, social and moral responsibility of a scientist and engineer.									

3	Materials science and technologies of modern and promising materials	The course proposes the master students to estimate the results of the research and development projects and choose optimal decision in materials science and engineering to introduce novel materials and structures for structural and functional applications for different industries, including electronics and medicine, and technology of surface hardening and coating/ Master students learn how to provide research of physical, chemical, mechanical, technological and functional properties of - ceramic, metal and polymer materials of different application.									
4	Fundamentals of pedagogical activity	The course focuses on the approaches of giving classes. Master students learn how to choose the modern resources and methods of teaching based on the competence-oriented aims and outcomes of lessons as well as get the experience of elaboration of scenario of classes and guidelines allowing estimated the outcomes of the learning.									
5	Higher school pedagogy	Undergraduates will master the methodological and theoretical foundations of higher school pedagogy, plan and organize the processes of teaching and upbringing, master the communicative technologies of subject-subject interaction between a teacher and a master in the educational process of a university.									
6	Professional training in English	The course is focused on the experience of learning, analysis and presentation of									

		research results in English, as well as audio- and video-perception of English materials. Master students can translate texts from Russian to English and vice versa, as well as they know the terminology of English in the field of materials science and technologies.									
7	Professional training in English	The course is focused on the experience of learning, analysis and presentation of research results in English, as well as audio- and video-perception of English materials. Master students can translate texts from Russian to English and vice versa, as well as they know the terminology of English in the field of materials science and technologies.									
8	Psychology of communication	The course gives the conceptions and principals of human relations, interpersonal and group interaction. Students learn the knowledge which help them to build fruitful relations with persons from different groups and social structures, to reveal prejudice and discrimination behavior inside and outside, and to prevent and solve conflicts and overcome communicative barriers in different situations.									
9	Psychology of management	The discipline studies the modern role and content of psychological aspects in managerial activity. The improvement of the psychological literacy of the student in the process of implementing professional activities is considered. Self-improvement in the field of psychology and studying the									

		composition and structure of management activities, both at the local level and abroad. The psychological feature of modern managers is considered.									
10	Modern methods of structural analysis in materials science	The course gives master students the information about methods, equipment and practical skills to determine chemical compositions and structure parameters for materials with the help of scanning and transmission electron microscopy, and phase composition and structure of materials be means of X-Ray analysis.									
11	Technologies of zero-dimensional nanoobjects	In the frame of the course master students get the practical skill of choosing the optimal technology of synthesizing nanopowders, nanoparticles and quantum dots depending on the initial requirements to the properties of zero-dimension objects. Master students also learn how to reveal basic features of nanoparticles properties from the bulk materials and get the experience of determining criteria to compare methods for nanopowders, nanoparticles and quantum dots synthesis in terms of the final requirements to the target products.									
12	Philosophical and methodological problems of science and technology	In the framework of the discipline master students acquire knowledge about criteria, norms and standards of scientific knowledge in professional activity. Also master students acquire experience in applying the basic provisions of the theory of argumentation in scientific research, knowledge about the value									

		systems of different social groups to organize professional interaction and knowledge about different forms of worldview to organize business communication.									
13	Intellectual property and research	Purpose: the goal is to train specialists who can effectively manage rights to the results of intellectual activity in the field of science, as well as ensure their legal protection and commercialization. Contents: analysis of legal protection of research and development results, methods of commercialization of scientific inventions, ethical and legal aspects of scientific activity in the context of IP.									
14	Materials science and technologies of advanced materials	The discipline studies the issues of structure formation, mechanisms for the manifestation of functional properties, manufacturing technology and the use of certain groups of modern and promising materials. The course describes new technologies for the manufacture of nanomaterials, materials from powders and nanopowders of metals, non-metals, and composites. The technologies for applying coatings and films, superhard materials and tools from them are described.					**v**				
15	Materials research methods	The purpose of the discipline is to form the ability to operate with various modern methods of studying substances, classify modern methods and techniques for studying the structure and elemental composition of materials according to			**v**						

		their purpose and technical characteristics. The discipline is aimed at studying the basic methods and techniques of studying the structure and elemental composition of materials and products based on them. The following methods are considered: transmission electron microscopy, X-ray diffraction analysis, electron microscopic methods, etc.									
16	The scientific basis and practice of application of nano	The course content includes the main methods of obtaining nanostructures that are used for coating. The course examines the analysis of various nanotechnological processes, which are based on the implementation of local atomic-molecular interactions that form nanoscale systems through self-assembly or self-organization of complex structures on the surface of the material.							**v**		
17	Modern problems of materials and process sciences	The discipline studies the current state of the science of materials and processes, which allows them to be used in materials science in studying the properties of modern materials, as well as the processes of improving the methods of their research and development. This discipline considers theoretical and experimental nuclear physics, nanomaterials and nanotechnologies, infrared methods for studying the structure of polymeric materials, advanced composite materials.									
18	Sustainable development strategies	The goal is to develop deep knowledge and competencies in the development									

		and implementation of sustainable development strategies at various levels. The content covers a wide range of topics, ranging from global environmental challenges such as climate change, biodiversity loss and natural resource depletion, to socio-economic aspects including inequality, health and education.									
19	Structure and properties of carbon nanomaterials	The purpose of the discipline is to form the ability to analyze the morphological diversity of carbon depending on its structure. The discipline is aimed at developing skills in the synthesis of carbon nanostructures. The following questions are considered: structure, nomenclature, synthesis, modification, growth mechanism, morphological features and properties of carbon nanomaterials and their practical application.	5				v				
20	Technological quality assurance of materials	This discipline studies the concepts of material quality. The course of the discipline also includes the analysis of the reasons for the decline in quality at different stages of the design of the technological process; methods of control (diagnostics) of the state of the material, its defectiveness associated with the violation of technological processes; methods for improving the quality of materials in the technological process of manufacturing parts and structures.	5					v			

21	High technologies: from research to business	In the frame of the course master students learn how to plan small enterprises aimed at the highly technological products. Master students can reveal the technological problem in the stage of elaboration and application of new materials noting the market requirements and find the best delivers of the equipment, raw materials. They can also form the list of documents needed to start business on the Russia territory taking into account occupational risks of used materials and the application of the final products.	3								
22	Probe methods of diagnostics of the structure and properties of nanomaterials	Master students can investigate the composition and structure of substances, taking into account the specifics of nanoscale materials, using modern equipment and software devices, evaluate the morphology and surface structure of materials, process data obtained using various types scanning probe microscopy, and apply knowledge of the specifics of various techniques to assess the topography of nanostructured materials.	6								
23	Composite materials with desired properties	The purpose of the disciplines is the wide possibilities of research and evaluation of the synthesis of composite materials. The discipline is aimed at developing the skills of masters in creating composite materials, such as electroforming, 3D printing, etc. The main stages that reach the process of creating composite materials are considered; methods for the	5								

		synthesis of fibrous forms of nanomaterials; optimization of technological parameters and characterization of composite materials from the main technological parameters; production of continuous nanoscale cargoes.									
24	Materials for 3D technology	The discipline studies the methods of obtaining and using composite and powder materials, as well as the presentation of the mechanism and patterns of materials for 3D modeling, their advantages, disadvantages and main areas of application.	5								
25	Multiphase structures and methods for calculating phase diagrams	The discipline studies the creation of new materials with the required level of properties, based on the calculation of phase diagrams. Calculation methods for constructing state diagrams using computer technology and studying the thermodynamic and physical properties of alloys are considered.	5								
26	Modeling of nanomaterials	This course is a professional orientation course for master's degree students in materials. Through this course, students can understand the most basic knowledge of numerical modeling in the process of material processing, master the concept of material modeling and numerical simulation, and have the basic ability of material research test design and numerical simulation	6								
27	Research work in the semester	Selection and study of literature. Preliminary statement of the problem. Search for solution methods, justification	6								

		of the chosen method and research technique. Description of the object under study. The choice of the method of solving the problem and its implementation. Planning and conducting preliminary experiments and tests in the field of processing of mineral and man-made raw materials. Processing and analysis of the results of experiments and tests, including using modern computer programs. registration of the results of scientific research in the form of scientific articles, reports, patents. Preparation of the report.									
28	New functional materials	The discipline studies the formation of scientific basic knowledge among undergraduates aimed at improving traditional and developing new functional materials and coatings with various properties, such as superhydrophobic, anti-icing, as well as technologies for their production with the required level of quality and properties.	5								
29	The main directions of development of materials science	The course systematizes the knowledge about the history of nanomaterials research with a global perspective. Master's students analyze current trends in nanotechnology development with respect to the application of metallic, ceramic and polymeric nanomaterials for high-tech industries (nuclear industry, electronics, aerospace engineering, chemical industry, mechanical engineering, laser engineering, security systems, biomedicine) using	3								

		international and Russian information and publishing resources, activities of leading international scientific organizations, professional and scientific societies in the field of materials science and nanomaterials.									
30	Powder consolidation processes: regularities and efficiency criteria	In the frame of course master students get principals of modelling processes of pressing powders, learn methods of complex optimization of pressing modes, and choose optimal modes of pressing powders depending on the external energetic impact and target functional characteristics of sintered articles.	3								
31	Dimensional effects in nanomaterials	In this course master students get the experience of choosing nanomaterials depending on the desirable mechanical and physico-chemical properties, can reveal the relations between materials compositions, structure and mechanical properties, know the features of nanosized state and apply modern methods to analyze mechanical, physical and surface parameters of nanoobjects.	3								
32	Technologies for manufacturing products from bulk nanomaterials	The purpose of the course is to introduce master students to traditional and unique methods for production of nanoceramics After completing the course students will be able to produce and analyze some nanoceramic materials using hot pressing, to produce and analyze nanostructured materials using spark plasma sintering, and to calculate the parameters of some molds for powder compaction.	3								

33	The surface structure engineering	The course considers developments in the theory of friction and wear, plasma technologies for surface treatment, ion technology, laser processing, new methods of surface analysis, in particular, developments in the design of nanostructured coatings on the surface of steel.	5								
34	Innovation in material science	The discipline studies trends and innovative technologies in the field of materials science. Advanced technologies for designing the structure of materials with desired properties, new technologies for creating modern materials in the field of renewable energy sources, water purification processes, heat and power engineering are considered.	5								
35	The study of functional materials by electron and probe microscopy	The discipline studies the study of functional materials by probe methods, the basic physical principles of probe methods for the study of materials. The course covers aspects of the effective and adequate use of various types of electron microscopes, probing methods for studying functional materials, creating a modern element base that will contribute to gaining knowledge about the structure, phase and chemical composition in the practice of solving various problems of materials science and technical physics.	5								
36	Methodology for materials selection and technology	The discipline studies the methodology of material selection, which affects the quality, reliability and performance of the part. The main material	5								

		characteristics and application features for various equipment and structures are considered, as well as the choice of advanced materials to increase the life cycle and improve the performance of the part.									
37	Methods for obtaining functional materials and nanostructures	The discipline considers the main methods for obtaining nanosystems and functional materials, the features of physical interactions at the nanoscale, methods for studying and diagnosing nanoobjects and nanosystems, the structure of the main classes of nanomaterials, their properties, production methods, and the most important applications.	5								
38	Methods for calculating phase transformations and structural analysis of materials	The discipline studies the fundamentals of the theory of alloys of phase transformations occurring in materials, the patterns of formation of the phase composition and structure of alloys depending on their chemical composition, temperature, pressure, as well as processing modes, and theoretical methods for calculating phase equilibria and predicting state diagrams of multicomponent metal systems.	5								
39	Methods of testing the performance characteristics of nanomaterials	The course gives the bases and methods of fast analysis of thermal and corrosive stability of materials. Students use the equipment and can determine electrochemical and thermal properties of materials by means of gravimetry, dilatometry and microscopy. Special	6								

		attention is given to the study of sintering ceramic and composite materials.									
40	Nanomaterials and nanotechnologies in industry	The purpose of mastering the discipline is the formation of theoretical and practical knowledge about the basic physical and chemical processes in nanostructured materials, the properties of functional nanomaterials and the use of nanotechnologies and nanomaterials in industry. The discipline is aimed at studying the synthesis of low-dimensional systems in powder metallurgy and the creation of functional nanomaterials based on them used in industry. Their classification, methods and technologies for obtaining nanomaterials, structural features and properties, as well as the study of the formation of nanostructures are considered.	5								
41	Nanomaterials and the environment: application and risk assessment	The goal of the course gives the information about sources, fate and toxicity of engineered micro- and nanoparticles released into atmosphere, hydrosphere, lithosphere, and biosphere. Master students can use diffraction, spectroscopic and microscopic methods to learn physical, physico-chemical and biological properties of nanoparticles, as well as they know the environmental impact of nanoparticles, forecast the fate of airborne nanoparticles in human body, and choose the personal protective equipment.	6								

42	Advanced materials processing technologies	The discipline studies advanced materials processing technologies used in modern production. Processes such as thermomechanical and thermochemical processing are considered, and the processes of surface treatment of metals for protection against wear and corrosion of metals are studied.	5								
43	Destruction and reliability assessment of materials	The discipline studies the issues of destruction of materials associated with the formation of crack propagation conditions (type of stressed and deformed state of the initial material, structural inhomogeneity in the crack zone, dislocation mechanism of crack initiation and propagation), which contributes to the formation of the basic concepts of the theory of reliability and durability of materials, taking into account their specifics. Within the framework of the course, the basic concepts of the theory of reliability are studied, the fundamental provisions of the method of limit states are given, and the nature of the calculated coefficients is shown with the position of the theory of probability and the theory of reliability.	5								
44	Modern technologies of surface hardening	Through the study of the course, students can master the enhanced mechanism of enhancers in composite materials, understand the structure, organization and performance characteristics of different properties of enhanced body materials, master the surface treatment	6								

		process of various enhancer materials and understand their applications.									
45	Technologies for the production of powder composite materials	In the frame of the course students learn the classification and labelling composite powder materials and fields of their application as well as their get the skills to determine dispersion composition by different methods, morphology, density, etc. They synthesize powders and articles depending on their application and target properties including economical viewpoint.	6								
46	Functional problems of materials science	The content of the course includes the formation of in-depth theoretical knowledge in the field of materials science, ideas about modern topical problems and methods for solving them, as well as the ability to independently set tasks for solving functional problems and ways to solve them by studying the characteristics, properties and structure of materials.									