



**SATBAYEV  
UNIVERSITY**

**Mining and Metallurgical Institute named after O.A. Baikonurov  
Department of Metallurgy and Mineral Processing**

## **EDUCATIONAL PROGRAM**

### **8D07201 - Mineral processing**

Code and classification of the field of education:	8D07 – Engineering, manufacturing and construction industries
Code and classification of training areas:	8D072 – Manufacturing and processing industries
Group of educational programs:	D118 – Mineral processing
The level of the NRK:	Level 8 – Postgraduate education (programs leading to the academic degree of Doctor of Philosophy (PhD) and doctors in the profile and/or practical experience)
ORC Level:	Level 8 – Knowledge at the most advanced level in the field of science and professional activity. Use specialized knowledge for critical analysis, evaluation and synthesis of new complex ideas that are at the cutting edge of this field. Evaluation and selection of information necessary for the development of activities. Expand or rethink existing knowledge and/or professional practice within a specific field or at the intersection of fields. Demonstrate the ability of sustained interest in developing new ideas or processes and a high level of understanding of learning processes. Methodological knowledge in the field of innovation and professional activity
Duration of training:	3 years
Volume of loans:	180

**Almaty, 2022**

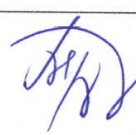
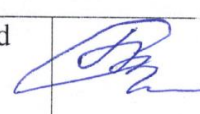
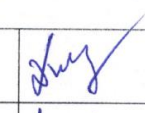
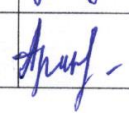

The educational program "8D07201 – Mineral enrichment" was approved at a meeting of the Academic Council of KazNTU named after K.I. Satpayev.

Protocol no. 13 from " 28 " 04 2022 y.

Reviewed and recommended for approval at a meeting of the Educational and Methodological Council of Kazntu named after K.I.Satpayev.

Protocol no. 7 from " 26 " 04 2022 y.

The educational program "8D07201 – Mineral enrichment" was developed by the academic committee in the direction of "Manufacturing and processing industries"

Full name	Academic degree/ academic title	Post	Place of work	Signature
<b>Chairman of the Academic Committee:</b>				
Barmenshinova M.B.	Candidate of Technical Sciences	Head of the Department of Metallurgy and mineral processing	KazNTU named after K.I. Satpayev	
<b>Teaching staff:</b>				
Dyussenova S.D.	PhD doctor	Assistant Professor	KazNTU named after K.I. Satpayev	
<b>Employers:</b>				
Jetybaeva U.K.	-	Chief metallurgist	LLP «KAZ Minerals»	
Arinov A.K.	-	General manager	Goldstone Minerals LLP	
<b>Students</b>				
Turymbai N.D.	-	4 <sup>th</sup> year student	KazNTU named after K.I. Satpayev	

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### List of abbreviations and designations

**NAO "Kazakh National Research Technical University named after K.I.Satpayev"** – NAO KazNITU named after K.I.Satpayev;

**SES** – The State compulsory standard of education of the Republic of Kazakhstan;

**MES RK** – Ministry of Education and Science of the Republic of Kazakhstan;

**OP** – educational program;

**SRO** – independent work of a student (student, undergraduate, doctoral student);

**SROP** – independent work of the student with the teacher (independent work of the student (master's student, doctoral student) with the teacher);

**RUP** – working curriculum;

**CAD** – catalog of elective disciplines;

**VK** – university component;

**KV** – component of choice;

**NRK** – National Qualifications Framework;

**ORC** – Industry qualifications framework;

**RO** – learning outcomes;

**CC** – key competencies.

## 1. Description of the educational program

The educational program for the preparation of a Doctor of Philosophy (PhD) has a scientific and pedagogical orientation and assumes fundamental educational, methodological and research training and in-depth study of disciplines in the relevant fields of sciences for the system of higher and postgraduate education and the scientific sphere.

The educational program for the preparation of a doctor in the profile involves fundamental educational, methodological and research training and in-depth study of disciplines in the relevant areas of science for the branches of the national economy, the social sphere: education, medicine, law, art, economics, business administration and in the field of national security and military affairs.

The educational programs of doctoral studies in terms of professional training are developed on the basis of studying the experience of foreign universities and research centers that implement accredited training programs for PhD doctors or doctors in the profile.

The content of the educational program of the profile doctoral program is determined by the university independently.

The main criterion for the completion of the educational process for the preparation of doctors of philosophy (PhD) (doctors in the profile) is the development of at least 180 academic credits by a doctoral student, including all types of educational and scientific activities.

The duration of doctoral studies is determined by the amount of academic credits mastered. Upon mastering the established amount of academic credits and achieving the expected learning outcomes for obtaining a Doctor of Philosophy (PhD) degree or by profile, the educational program of the doctoral program is considered fully mastered.

The training of personnel in doctoral studies is carried out on the basis of master's degree educational programs in two directions:

- 1) scientific and pedagogical with a training period of at least 2 years;
- 2) profile with a training period of at least 1 year.

The content of the doctoral program consists of:

- 1) theoretical training, including the study of cycles of basic and core disciplines;
- 2) practical training of doctoral students: various types of practices, scientific or professional internships;
- 3) research work, including the execution and defense of a PhD thesis;
- 4) final certification.

The educational program includes the following stages of doctoral students' preparation: research methods, academic writing, current trends in the development of the theory and technology of enrichment production, theory and technology of selective disintegration of mineral raw materials, methods for optimizing design solutions of mining and processing complexes, conditioning of circulating and wastewater treatment of enrichment production, theory and technology of bio

hydrometallurgical processing of hard-to-enrich raw materials, nanotechnology mineral and non-traditional raw materials.

The ability to choose disciplines from the catalog of elective disciplines of Satbayev University.

*Types of research activities:* conducting experimental studies of processes, aggregates and products; application of methods of planning experiments and statistical data processing; application of methods of mathematical modeling of processes; performing literary and patent search, preparation of reports, reviews, conclusions, participation in the implementation of technological processes for obtaining conditioned concentrates; develops technological processes for obtaining enrichment products from raw materials; calculates the main and selects auxiliary equipment, develops and researches mathematical models of enrichment processes.

*Objects of professional activity.*

*The objects of professional activity of graduates* are processing plants, enterprises, chemical, mining, chemical and machine-building industries, branch research and design institutes, factory laboratories, higher educational institutions, consulting companies, scientific, innovation centers, banks.

## 2. The purpose and objectives of the educational program

### **The purpose of EP «8D07201 – mineral processing»:**

– training of highly qualified specialists with core competencies in the field of solving organizational and production tasks in the implementation of innovative projects in the field of mineral and man-made raw materials enrichment; formation of personnel for the innovative economy of mineral enrichment, covering modern energy-saving technologies, project activities, innovative solutions, entrepreneurship in the high-tech sphere.

**The objectives** of the EP «8D07201 – mineral processing» are:

- training of professionals in analytical, consulting and research activities;
- independent conduct of research, R&D, any project activity in the field of enrichment; compliance with international engineering qualifications;
- training of specialists for the implementation of pedagogical activities in universities in the profile;
- retraining and advanced training of specialists and managers;
- the graduate must master the basic laws of economic development; factors affecting the technical and economic efficiency of production; knowledge of sociology and psychology in the management of the enterprise; the ability to qualitatively and quantitatively substantiate management decisions.
- assessment of innovation and technological risks in the introduction of new technologies;
- competence in the marketing of high-tech technologies;
- development of personal scientific and metric indicators of graduates;
- foreign internship.

### **3. Requirements for applicants**

Persons with a master's degree and work experience of at least 1 (one) year are admitted to doctoral studies.

Admission to the number of doctoral students is carried out by the admissions committees of universities and scientific organizations based on the results of the entrance exam for groups of doctoral degree programs and a certificate confirming foreign language proficiency in accordance with the pan-European competencies (standards) of foreign language proficiency.

When enrolling in universities, doctoral students independently choose an educational program from the corresponding group of educational programs.

The enrollment of persons for the targeted training of Doctors of Philosophy (PhD) under the state educational order is carried out on a competitive basis.

The procedure for admission of citizens to doctoral studies is established in accordance with the "Standard rules for admission to study in educational organizations implementing educational programs of postgraduate education."

The formation of a contingent of doctoral students 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 doctoral student must have all the prerequisites necessary for mastering the relevant professional doctoral curriculum. The list of necessary prerequisites is determined by the higher educational institution independently.

In the absence of the necessary prerequisites, the doctoral student is allowed to master them on a paid basis. In this case, doctoral studies begin after the doctoral student has fully mastered the prerequisites.

### **4. Requirements for completing studies and obtaining a diploma**

Persons who have mastered the educational program of doctoral studies and defended a doctoral dissertation, with a positive decision of the dissertation councils of a university with a special status or the Committee for Control in the Field of Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan, according to the results of the examination, are awarded the degree of Doctor of Philosophy (PhD) or doctor in profile and a state-issued diploma with an appendix (transcript).

Persons who have received a PhD degree, in order to deepen scientific knowledge, solve scientific and applied problems on a specialized topic, perform a postdoctoral program or conduct scientific research under the guidance of a leading scientist of the chosen university.

## **5. Requirements for the evaluation of learning outcomes of the educational program**

### **5.1 Requirements for the key competencies of doctoral graduates**

A doctoral student should have an idea of:

- the main stages of development and paradigm shift in the evolution of science;
- on the subject, ideological and methodological specifics of the natural (social, humanitarian, economic) sciences;
- about scientific schools of the relevant branch of knowledge, their theoretical and practical developments;
- about scientific concepts of world and Kazakh science in the relevant field;
- on the mechanism of implementation of scientific developments in practical activities;
- on the norms of interaction in the scientific community;
- about the pedagogical and scientific ethics of a research scientist;
- to know and understand:
  - current trends, trends and patterns of development of Russian science in the context of globalization and internationalization;
  - methodology of scientific knowledge;
  - achievements of world and Kazakh science in the relevant field;
  - to realize and accept the social responsibility of science and education;
  - perfect foreign language for scientific communication and international cooperation;
- be able to:
  - to organize, plan and implement the process of scientific research;
  - analyze, evaluate and compare various theoretical concepts in the field of research and draw conclusions;
  - analyze and process information from various sources;
  - conduct independent scientific research, characterized by academic integrity, based on modern theories and methods of analysis;
  - generate your own new scientific ideas, communicate your knowledge and ideas to the scientific community, expanding the boundaries of scientific knowledge;
  - to choose and effectively use modern research methodology;
  - plan and predict your further professional development;
- have skills:
  - critical analysis, evaluation and comparison of various scientific theories and ideas;
  - analytical and experimental scientific activities;
  - planning and forecasting of research results;
  - public speaking and public speaking at international scientific forums, conferences and seminars;
  - scientific writing and scientific communication;



- planning, coordination and implementation of scientific research processes;
  - a systematic understanding of the field of study and demonstrate the quality and effectiveness of the selected scientific methods;
  - participation in scientific events, fundamental scientific domestic and international projects;
  - leadership management and team management;
  - responsible and creative attitude to scientific and scientific-pedagogical activity;
  - conducting patent search and experience in the transfer of scientific information using modern information and innovative technologies;
  - protection of intellectual property rights to scientific discoveries and developments;
  - free communication in a foreign language;
- be competent:
- in the field of scientific and scientific-pedagogical activity in the conditions of rapid updating and growth of information flows;
  - in carrying out theoretical and experimental scientific research;
  - in the formulation and solution of theoretical and applied problems in scientific research;
  - to conduct a professional and comprehensive analysis of problems in the relevant field;
  - in matters of interpersonal communication and human resource management;
  - in matters of university training of specialists;
  - in the examination of scientific projects and research;
  - in ensuring continuous professional growth.

## **5.2 Requirements for the research of a student under the Doctor of Philosophy (PhD) program**

Requirements for the R&D of a student under the Doctor of Philosophy (PhD) program:

- 1) compliance with the main problems of the educational program of the doctoral program on which the doctoral dissertation is being defended;
- 2) relevant and contains scientific novelty and practical significance;
- 3) based on modern theoretical, methodological and technological achievements of science and practice;
- 4) is based on modern methods of data processing and interpretation using computer technology;
- 5) performed using modern methods of scientific research;
- 6) contains research (methodological, practical) sections on the main protected provisions.

### 5.3 Requirements for the organization of practices

The practice is conducted in order to form practical skills of scientific, scientific, pedagogical and professional activities.

The educational program of the doctoral program includes:

- 1) pedagogical and research practice – for students of the PhD program;
- 2) industrial practice – for students under the program of specialized doctoral studies.

During the period of pedagogical practice, doctoral students, if necessary, are involved in conducting classes in bachelor's and master's degrees.

The doctoral student's research practice is conducted in order to study the latest theoretical, methodological and technological achievements of domestic and foreign science, as well as to consolidate practical skills, apply modern research methods, process and interpret experimental data in dissertation research.

The doctoral student's industrial practice is carried out in order to consolidate the theoretical knowledge gained in the course of training and improve the professional level.

The content of research and production practices is determined by the topic of the doctoral dissertation.

## 6. Passport of the educational program

### 6.1. General information

№	Field name	Note
1	Code and classification of the field of education	8D07 - Engineering, manufacturing and construction industries
2	Code and classification of training areas	8D072 - Manufacturing and processing industries
3	Group of educational programs	D118 – Mineral processing
4	Name of the educational program	Mineral enrichment
5	Brief description of the educational program	The educational program "Metallurgy and Mineral Processing" includes fundamental, natural science, general engineering and professional training of bachelors in the field of secondary metallurgy and recycling of industrial and industrial waste in accordance with the development of science and technology, as well as the changing needs of the mining and metallurgical industry.
6	Purpose of the EP	training of highly qualified specialists with core competencies in the field of solving organizational and production tasks in the implementation of innovative projects in the field of mineral and man-made raw materials enrichment; formation of personnel for the innovative economy of mineral enrichment, covering modern energy-saving technologies, project activities, innovative solutions, entrepreneurship in the high-tech field
7	Type of EP	New
8	The level of the NRK	Level 8 – Postgraduate education (programs leading to the academic degree of Doctor of Philosophy (PhD) and doctors in the profile and/or practical experience)
9	ORC Level	Level 8 – Knowledge at the most advanced level in the field of science and professional activity. Use specialized knowledge for critical analysis, evaluation and synthesis of new complex ideas that are at the cutting edge of this field. Evaluation and selection of information necessary for the development of activities. Expand or rethink existing knowledge and/or professional practice within a specific field or at the intersection of fields. Demonstrate the ability of sustained interest in developing new ideas or processes and a high level of understanding of learning processes. Methodological knowledge in the field of innovation and professional activity
10	Distinctive features of the EP	No
11	List of competencies of the educational program:	See 4.2 Matrix of correlation of learning outcomes in the educational program as a whole with the competencies being formed
12	Learning outcomes of the educational program:	
13	Form of training	Full - time full

- |    |                           |                    |
|----|---------------------------|--------------------|
| 14 | Duration of training      | 3 years            |
| 15 | Volume of loans           | 180                |
| 16 | Languages of instruction  | Kazakh/Russian     |
| 17 | Academic degree awarded   | Doctor of PhD      |
| 18 | Developer(s) and authors: | Barmenshinova M.B. |

## 6.2. Matrix of correlation of learning outcomes in the educational program as a whole with the competencies being formed

Key competencies /Learning outcomes	LO1	LO2	LO3	LO4	LO5	LO6
KC1 Professional competencies			V	V	V	V
KC2 Research competencies			V	V	V	V
KC3 Research competencies	V	V				
KC4 Communication competencies	V	V			V	
KC5 Universal competencies		V				
KC6 Management competencies			V	V		
KC7 Cognitive competencies		V				V
KC8 Creative competencies	V				V	V
KC9 Information and communication competencies	V				V	

### 6.3. The relationship between the achievability of the formed learning outcomes according to the educational program and academic disciplines

№	Name of the discipline	Brief description of the discipline	Кол-во кредитов	Generated learning outcomes (codes)					
				LO1	LO2	LO3	LO4	LO5	LO6
Cycle of basic disciplines University component									
1	Methods of scientific research	The concept of science and scientific research, methods and methodology of scientific research, methods of collecting and processing scientific data, principles of organization of scientific research, methodological features of modern science, ways of development of science and scientific research, the role of technical sciences, computer science and engineering research in modern science, the structure of technical sciences, the use of general scientific, philosophical and special methods scientific research in theory and in practice.	5		V	V	V		
2	Academic writing	The course is aimed at developing academic writing skills and writing strategies for doctoral students in the field of engineering and natural sciences. The course focuses on the basics and general principles of academic writing for; writing effective sentences and paragraphs; using tenses in scientific literature, as well as styles and punctuation; writing abstracts, introductions, conclusions, discussions, conclusions, literature and resources used; quoting in the text; preventing plagiarism, and making presentations at a conference.	5	V	V	V			
Cycle of basic disciplines Elective component									
3	Current trends in the development of the theory and technology of enrichment production	The current state and trends in the development of the raw material base of metal production. Modern trends in the development of enrichment processes and enrichment engineering. Familiarization with the best samples of processing equipment of foreign companies, with new technological schemes of the processes of enrichment of ore and man-made raw materials containing gold, non-ferrous and ferrous, rare and rare earth metals. Analysis of the principles and patterns of the main processes in the enrichment of minerals with the use of new reagents, methods of analysis and methods of research.	5		V	V	V		
4	Theory and technology of selective disintegration of mineral raw materials	Basic concepts of the disintegration of heterogeneous materials. Models of the origin and growth of cracks. Energy aspects of destruction models. Uncontrolled and controlled factors of ore destruction. Methods and devices for studying the strength characteristics of ores and minerals. Dislocation structure of minerals and accretion boundaries. Comparison of particle strength and the spectrum of force effects in the mill. Disintegration of technogenic materials. Analysis of the causes of high energy consumption in grinding processes. Selective softening by physical influences. Destruction by thermal stresses and on the basis of wave processes (Snyder and Dean-Gross technologies, explosive rebounding), technologies of exposure to electric fields,	5			V	V	V	

		spontaneous disintegration of ores when exposed to surfactants. Principles of disintegration modeling. Analysis of the work of crushers and mills from the standpoint of selective destruction.								
<b>Cycle of profile disciplines</b> <b>Component of choice</b>										
5	Methods of optimization of design solutions of mining and processing complexes	Formalization of the task of making design decisions. An example of a decision-making model under uncertainty. Structure and formulation of optimization problems. Optimality conditions and types of computational optimization procedures. One-dimensional optimization methods (Golden Section method, Step-by-step method). Methods for finding the extremum of functions of many variables (Gradient and gradient-free methods). Conditional optimization methods (Method of penalty functions; Method of direct search with return; Method of possible directions; Search for the extremum of functions of many variables in the presence of connections). Linear programming problems. Variational problems and methods of their solution. Multi-criteria selection. Translating criteria into constraints. Weighting and combining criteria (Method of weighted sum of partial criteria; Multiplicative criterion; Methods for determining weighting coefficients). Methods of sequential optimization (The method of sequential concessions. The method of equality of particular criteria). A method for analyzing hierarchies. Pareto optimality (Pareto set construction methods. Methods of narrowing the Pareto set). Decision-making in conditions of risk and uncertainty (Building a "decision tree" and an outcome table; the "utility" function; Decision-making in conditions of uncertainty). Features of project decision-making. Basic concepts and methods of making a project decision.	5			V	V	V	V	
6	Conditioning of circulating and wastewater treatment of processing production	The composition of wastewater from processing plants. Mechanical wastewater treatment. Neutralization. Wastewater treatment from metal cations, arsenic and antimony, xanthogenates and dithiophosphates, cyanides and rhodanides, sulfides, phenols and cresols, from petroleum products. Coagulation and flocculation. Extraction wastewater treatment. Sorption wastewater treatment. Ion exchange wastewater treatment. Flotation wastewater treatment. Biotechnological methods of purification of industrial wastewater, soils from heavy non-ferrous metal ions with the disposal of industrial waste. Electrochemical methods and devices for neutralization and conditioning of cyanide-containing industrial solutions of MMC enterprises. Automatic control and management of the operation of treatment facilities and tailings dumps of mining and metallurgical enterprises. Methods of biotesting in the environmental monitoring system of mining and metallurgical enterprises. Disinfection of wastewater. Natural wastewater treatment in tailings dumps. Circulating water supply of processing plants. Concentration of reagents in recycled water. Conditioning of circulating water. Selection of the wastewater treatment scheme. Wastewater treatment schemes. The system of rationing of water consumption and sanitation is an important aspect of environmental protection activities. Mountain ecology and its impact on the	5		V	V	V	V		

		environment. Assessment of the impact of the mining and metallurgical complex on the environment. Development of certification of the environmental management system at industrial enterprises.							
7	Theory and technologies of biohydrometallurgical processing of difficult-to-enrich raw materials	The current state of hydrometallurgical processes and equipment. Theoretical foundations and technologies for the use of microorganisms in the leaching of metals, schemes for processing concentrates. The use of microorganisms for wastewater treatment, the experience of domestic and foreign enterprises. Trends in the development of biohydrometallurgy of processing metals from uranium-containing, gold-containing and polymetallic ores, in the production of materials with increased added value, including the production of nanoscale materials. Economic and environmental aspects of the application of biohydrometallurgical processing of difficult-to-enrich raw materials.	5				V	V	V
8	Nanotechnologies of mineral and non-traditional raw materials	Physico-chemical fundamentals of nanotechnology. The dimensional effect of different nature and ways of their practical use in various nanostructures and products. Modern methods of obtaining, research and determination of properties of nanomaterials. The main directions of nanotechnology and nanotechnology development are: physical nanomaterial science and nanomechanics, nanoelectronics and nanobiotechnology. Examples of specific developments brought to industrial production. Modern concepts of electrical, magnetic, thermal, optical, diffusion, chemical and mechanical properties of nanomaterials. The dependence of these properties on the structure of the material and the geometric dimensions of the nanoparticles. Issues of storage and transportation of nanomaterials. For the first time in the course, liquid systems containing nanostructured components and nanoprocesses occurring in it, manifested in flotation systems, are considered. Nanoassociates and nanodispersions of flotation systems are systematized. The influence of physicochemical and structural changes in interphase nanoassociates on the flotation properties of flotation system components is given.	5			V	V	V	

## 6.4. Information about modules/disciplines

№	Name of the discipline	Brief description of the discipline (30-50 words)	Number of credits	Formed competencies (codes)
<b>Cycle of basic disciplines University component</b>				
1	Methods of scientific research	The concept of science and scientific research, methods and methodology of scientific research, methods of collecting and processing scientific data, principles of organization of scientific research, methodological features of modern science, ways of development of science and scientific research, the role of technical sciences, computer science and engineering research in modern science, the structure of technical sciences, the use of general scientific, philosophical and special methods scientific research in theory and in practice.	5	KC1, KC2, KC4, KC3, KC7, KC9
2	Academic writing	The course is aimed at developing academic writing skills and writing strategies for doctoral students in the field of engineering and natural sciences. The course focuses on the basics and general principles of academic writing for; writing effective sentences and paragraphs; using tenses in scientific literature, as well as styles and punctuation; writing abstracts, introductions, conclusions, discussions, conclusions, literature and resources used; quoting in the text; preventing plagiarism, and making presentations at a conference.	5	KC2, KC4, KC5, KC6, KC8
<b>Basic disciplines Component of choice</b>				
3	Current trends in the development of the theory and technology of enrichment production	The current state and trends in the development of the raw material base of metal production. Modern trends in the development of enrichment processes and enrichment engineering. Familiarization with the best samples of processing equipment of foreign companies, with new technological schemes of the processes of enrichment of ore and man-made raw materials containing gold, non-ferrous and ferrous, rare and rare earth metals. Analysis of the principles and patterns of the main processes in the enrichment of minerals with the use of new reagents, methods of analysis and methods of research.	5	KC1, KC2, KC3, KC7, KC8
4	Theory and technology of selective disintegration of mineral raw materials	Basic concepts of the disintegration of heterogeneous materials. Models of the origin and growth of cracks. Energy aspects of destruction models. Uncontrolled and controlled factors of ore destruction. Methods and devices for studying the strength characteristics of ores and minerals. Dislocation structure of minerals and accretion boundaries. Comparison of particle strength and the spectrum of force effects in the mill. Disintegration of technogenic materials. Analysis of the causes of high	5	KC1, KC2, KC3, KC7



		energy consumption in grinding processes. Selective softening by physical influences. Destruction by thermal stresses and on the basis of wave processes (Snyder and Dean-Gross technologies, explosive rebounding), technologies of exposure to electric fields, spontaneous disintegration of ores when exposed to surfactants. Principles of disintegration modeling. Analysis of the work of crushers and mills from the standpoint of selective destruction.		
<b>Cycle of profile disciplines</b> <b>Component of choice</b>				
5	Methods of optimization of design solutions of mining and processing complexes	Formalization of the task of making design decisions. An example of a decision-making model under uncertainty. Structure and formulation of optimization problems. Optimality conditions and types of computational optimization procedures. One-dimensional optimization methods (Golden Section method, Step-by-step method). Methods for finding the extremum of functions of many variables (Gradient and gradient-free methods). Conditional optimization methods (Method of penalty functions; Method of direct search with return; Method of possible directions; Search for the extremum of functions of many variables in the presence of connections). Linear programming problems. Variational problems and methods of their solution. Multi-criteria selection. Translating criteria into constraints. Weighting and combining criteria (Method of weighted sum of partial criteria; Multiplicative criterion; Methods for determining weighting coefficients). Methods of sequential optimization (The method of sequential concessions. The method of equality of particular criteria). A method for analyzing hierarchies. Pareto optimality (Pareto set construction methods. Methods of narrowing the Pareto set). Decision-making in conditions of risk and uncertainty (Building a "decision tree" and an outcome table; the "utility" function; Decision-making in conditions of uncertainty). Features of project decision-making. Basic concepts and methods of making a project decision.	5	KC1, KC2, KC4, KC6, KC8
6	Conditioning of circulating and wastewater treatment of processing production	The composition of wastewater from processing plants. Mechanical wastewater treatment. Neutralization. Wastewater treatment from metal cations, arsenic and antimony, xanthogenates and dithiophosphates, cyanides and rhodanides, sulfides, phenols and cresols, from petroleum products. Coagulation and flocculation. Extraction wastewater treatment. Sorption wastewater treatment. Ion exchange wastewater treatment. Flotation wastewater treatment. Biotechnological methods of purification of industrial wastewater, soils from heavy non-ferrous metal ions with the	5	KC1, KC2, KC3, KC9

		disposal of industrial waste. Electrochemical methods and devices for neutralization and conditioning of cyanide-containing industrial solutions of MMC enterprises. Automatic control and management of the operation of treatment facilities and tailings dumps of mining and metallurgical enterprises. Methods of biotesting in the environmental monitoring system of mining and metallurgical enterprises. Disinfection of wastewater. Natural wastewater treatment in tailings dumps. Circulating water supply of processing plants. Concentration of reagents in recycled water. Conditioning of circulating water. Selection of the wastewater treatment scheme. Wastewater treatment schemes. The system of rationing of water consumption and sanitation is an important aspect of environmental protection activities. Mountain ecology and its impact on the environment. Assessment of the impact of the mining and metallurgical complex on the environment. Development of certification of the environmental management system at industrial enterprises.		
7	Theory and technologies of biohydrometallurgical processing of difficult-to-enrich raw materials	The current state of hydrometallurgical processes and equipment. Theoretical foundations and technologies for the use of microorganisms in the leaching of metals, schemes for processing concentrates. The use of microorganisms for wastewater treatment, the experience of domestic and foreign enterprises. Trends in the development of biohydrometallurgy of processing metals from uranium-containing, gold-containing and polymetallic ores, in the production of materials with increased added value, including the production of nanoscale materials. Economic and environmental aspects of the application of biohydrometallurgical processing of difficult-to-enrich raw materials.	5	KC1, KC2, KC3, KC7
8	Nanotechnologies of mineral and non-traditional raw materials	Physico-chemical fundamentals of nanotechnology. Dimensional effects of various nature and ways of their practical use in various nanostructures and products. Modern methods of obtaining, researching and determining the properties of nanomaterials. The main directions of nanotechnology and the development of nanotechnology are: the science of physical nanomaterials and nanomechanics, nanoelectronics and nanobiotechnology. Examples of specific developments brought to industrial production. Modern concepts of electrical, magnetic, thermal, optical, diffusion, chemical and mechanical properties of nanomaterials. The dependence of these properties on the structure of the material and the geometric dimensions of the nanoparticles is shown. Issues of storage and transportation of nanomaterials. For the first time, the	5	KC2, KC7, KC8, KC9

		course examines liquid systems containing nanostructured components and the nanoprocesses occurring in them, manifested in flotation systems. Nanoassociates and nanodispersions of flotation systems are systematized. The influence of physicochemical and structural changes in interfacial nanoassociates on the flotation properties of the components of the flotation system is given.		
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## 7. Curriculum of the educational program



MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN  
KAZAKH NATIONAL RESEARCH TECHNICAL UNIVERSITY named after K. SATPAYEV



APPROVED  
Chairman of the Management Board  
Rector of KazNRTU named after K. Satpayev  
M.M. Begentaev  
2022 y.

CURRICULUM  
of Educational Program on enrollment for 2022-2023 academic year

Educational program 8D07201 - "Mineral processing"  
Group of educational programs D118 - "Mineral processing"

Form of study: full-time		Duration of study: 3 year													
Discipline code	Name of disciplines	Cycle	Total amount in credits	Total hours	Classroom amount lec/lab/pr	SIS (including TSIS) in hours	Form of control	Allocation of face-to-face training based on courses and semesters							
								1 course	2 course	3 course	1 semester	2 semester	3 semester	4 semester	5 semester
CYCLE OF BASIC DISCIPLINES (BD)															
M-1. Module of basic training (university component)															
MET322	Scientific research methods	BD UC	5	150	2/0/1	105	E	5							
LANG305	Academic writing	BD UC	5	150	0/0/3	105	E	5							
component of choice															
MET319	Modern trends in the development of the theory and technology of enrichment production	BD CCH	5	150	2/0/1	105	E	5							
MET320	Theory and technology of selective disintegration of mineral raw materials														
CYCLE OF PROFILE DISCIPLINES (PD)															
M-2. Module of professional activity (component of choice)															
MET317	Methods of optimization of design solutions of mining and processing complexes	PD, CCH	5	150	2/0/1	105	E	5							
MET316	Air conditioning recycling and wastewater treatment and mineral processing														
MET318	Theory and technology of bihydrometallurgical processing of refractory raw materials	PD, CCH	5	150	2/0/1	105	E	5							
MET315	Nanotechnology of mineral and non-traditional raw materials														
M-3. Practice-oriented module															
AAP350	Pedagogical practice	BD UC	10						10						
AAP355	Research practice	PD UC	10							10					
M-4. Experimental research module															
AAP336	Research work of a doctoral candidate, including internships and completion of a doctoral dissertation	RWDS UC	5					5							
AAP347	Research work of a doctoral candidate, including internships and completion of a doctoral dissertation	RWDS UC	40						20	20					
AAP356	Research work of a doctoral candidate, including internships and completion of a doctoral dissertation	RWDS UC	60									30	30		
AAP348	Research work of a doctoral candidate, including internships and completion of a doctoral dissertation	RWDS UC	18												18
M-5. Module of final attestation															
ECA303	Writing and defending a doctoral dissertation	FA	12												12
Total based on UNIVERSITY:										30	30	30	30	30	30

Number of credits for the entire period of study				
Cycle code	Cycles of disciplines	Credits		
		university component (UC)	component of choice (CCH)	Total
BD	Cycle of basic disciplines	20	5	25
PD	Cycle of profile disciplines	10	10	20
	<b>Total for theoretical training:</b>	<b>0</b>	<b>30</b>	<b>45</b>
	RWDS			123
FA	Final attestation	12		12
	<b>TOTAL:</b>	<b>12</b>	<b>30</b>	<b>180</b>

Decision of the Academic Council of KazNRTU named after K. Satpayev. Protocol № 13, "28" 04/2022.

Decision of the Educational and Methodological Council of KazNRTU named after K. Satpayev. Protocol № 7, "26" 04/22.

Decision of the Academic Council of MaMI named after O. Baikonurov. Protocol № 5, "20" 12/2021 y.

Vice-Rector for Academic Affairs

Director of the Mining and Metallurgical Institute named after O. A. Baikonurov

Head of department "Metallurgy and mineral processing"

Representative of the employers' council of the LLP "KAZ Minerals"

B.A. Zhaatikov

K.B. Rysbekov

M.B. Barmenshinova

U.K. Jetybaeva

**CHANGE REGISTRATION SHEET**

Sequence number of the change	Section, paragraph of the document	Type of change (replace, cancel, add)	Number and date of notification	The change has been made	
				Date	Surname and initials, signature, position