NJSC 'Kazakh National Research Technical University named after K.I. Satbayev'
Mining and Metallurgical Institute. O. A. Baikonurov
Department of Metallurgical Processes, Heat Engineering and Technology of Special Materials
Institute of Information and Telecommunication Technologies
Department of "Automation and Control"

EDUCATIONAL PROGRAM

"NAME of the EDUCATIONAL PROGRAM"
(scientific and pedagogical direction (2 years)

Master of technical Sciences in the educational program " 7M07201- Automation and digitalization of metallurgical processes "

on the basis of the following specialties of the invalidated Classifier of specialties:
6M070900 - "Metallurgy" and
6M070200 - "Automation and Control"

1st edition
in accordance with the State Educational Standard of Higher Education 2018

Almaty 2019

САТБАЕВ УНИВЕРСИТЕТІ SATBAYEV UNIVERSITY

The program was developed and signed by the following parties:

On behalf of KazNRTU named after K.I. Satbayev:

1. Head of the department "MPHEaTSM" T.A. Chepushtanova
2. The head of "AaC" B.A. Suleimenov
3. Director of the mining and metallurgical Institute named after O. A. baykonurova Z.S. Abisheva
4. Director of the Institute of information and telecommunication technologies T.F. Umarov
5. Chairman of the educational and methodological group of the Department of AaC, doctor of technical Sciences, Professor B.A. Suleimenov

On behalf of employers:

Complex "Kazakhmys" LLP
processing of man-made raw materials
head of processing department,
doctor of technical Sciences. E.A. Ospanov

Co-Chair of the Advisory Board of IIaTT,
Chief Engineer of Haniuel-ASU LLP S.K. Abdygaliev

From a partner university:
Worcester Polytechnic Institute (USA) B. Mishra

K.I. Approved at the meeting of the Educational and Methodological Council of the Kazakh National Technical University named after Satpayev. Protocol №3 19.12.2018

Qualifications:
Level 7 National Qualifications Framework:
7M07 Engineering, manufacturing and construction industries
7M072 Production and processing industries (master):
Professional competence:

Organizational and production competence in the field of metallurgy. The master's degree has methods of control of specific technological processes of production and processing of metals; principles of creation of automated control systems for technological processes in metallurgy. Forms the requirements for mathematical models and technological processes of metallurgical facilities in control systems; uses the method of identification of the object of regulation. Has a method of using information technology in the creation of automation systems for metallurgical plants.

1 Brief description of the program

The purpose of the program is to master the basic, scientific foundations of the construction, maintenance and operation of automation systems for metallurgical processes; study and development of modern methodology, technology and tools related to the implementation, operation and modernization of databases as the basis for product life cycle management in relation to metallurgical processes; possession of basic knowledge of sustainable technologies for processing mineral raw materials; training undergraduates in basic and specialized disciplines with the achievement of relevant competencies.

2 Kinds of professional activity

Graduates of the Master's degree program can carry out the following types of professional activities: design and engineering, production and technology, organizational and management, research.

A distinctive feature of the master's program (1.5 years of study) is that the educational program provides basic, professional knowledge, skills and abilities in the metallurgical processing of mineral raw materials, as well as modern management systems; about modern methods and software for research and design of automation systems for technological processes; about modern technical means used in the automation of production processes.

The mission of the Master's degree program is to form students' professional competencies that allow graduates to successfully solve production and technological, organizational and managerial, project tasks in the field of automation and digitalization of metallurgical processes.

3. Objects of professional activity. The objects of professional activity of graduates are enrichment factories, enterprises of ferrous and non-ferrous metallurgy, chemical, mining, chemical and machine-building industries, industry research and design institutes, factory laboratories, higher and secondary vocational educational institutions, government authorities and organizations of various organizational and legal forms.

Types and subjects of professional activity.

The subjects of professional activity are technological automated control systems, digital technologies and techniques, quality control of final products, automation and digitalization of the processing of raw materials and the production of metal products with increased consumer properties.

Economic activities: automation and digitalization of mineral processing processes, production of metals from ores and technogenic raw materials.

Education level code - 07 Engineering, manufacturing and construction industries, 7 Engineering sciences and technologies, 7M072 - Manufacturing and manufacturing industries.

2 PASSPORT OF THE EDUCATIONAL PROGRAM

Scope and content of the program

The term of study in the master's program is determined by the amount of acquired academic credits Upon mastering the established amount of academic credits and achieving the expected learning outcomes for obtaining a master's degree, the master's educational program is considered fully mastered. In the master's program (1.5 years of study) at least 92 academic credits for the entire period of study, including all types of educational and scientific activities of the master's student.

The planning of the content of education, the method of organizing and conducting the educational process is carried out by the university and the scientific organization independently on the basis of the credit technology of education.

Master's program of 1.5 years of study implements educational programs of postgraduate education for the training of scientific personnel for universities and scientific organizations.

The content of the Master's degree program consists of:

1) theoretical training, including the study of cycles of basic and major disciplines;

2) practical training of undergraduates: various types of practices, scientific or professional internships;

3) research work, including the implementation of a master's thesis - for a specialized master's degree

4) final certification.

The content of the educational program includes the following modules: general education, general engineering, engineering and technical and professional modules.

The educational program includes the following stages of preparation of undergraduates: English (professional), history and philosophy of science, management of educational and organizational activities (pedagogy of higher school + psychology of management); theory and calculations of metallurgical thermodynamics and kinetics; MES-systems; digital control systems; microprocessor control systems of technological processes; diagnostics and reliability of automation systems; special chapters of heat exchange of metallurgical processes; modern management theory; waste management of the metallurgical industry; sustainable pyro - and hydrometallurgical technologies for processing mineral raw materials. Optimal control systems (with AI elements). Reliability of the control system and its elements. Resource and energy saving in metallurgy. Automation of design of control systems. Distributed control systems. Methods of analysis of metallurgical processes and metallurgical products. Design of automation systems. Numerical control systems for robots. Possibility to choose disciplines from the Satbayev University elective courses catalog.

The objectives of the educational program *are:*

1. Competence of graduates in the automation and digitalization of metallurgical processes to increase the productivity of technologies and improve the quality of products.

2. Competence of graduates in the implementation of the development and implementation of technological processes for the processing of mineral, natural and technogenic raw materials;

3. Competence of graduates in assessing innovative and technological risks when introducing new digital technologies;

4. Competence of graduates in the digitalization system of metallurgical industries. Acquisition of competencies in production management at all stages of the product life cycle;

The Master of Engineering Science in Industrial Process Automation must solve the following tasks in accordance with the types of professional activity:

in the field of production and technological activities:

- to be a leading engineer, a leading specialist of a production unit for operation, maintenance, repair and adjustment of technical means of automated control systems for production processes in various industries, including metallurgy;

in the field of organizational and management activities:

- be the head of the department for the maintenance and repair of elements, devices for automated control systems of production processes in various industries, including metallurgy;

in the field of experimental research:

- to be a leading specialist in experimental research of objects of industrial production automation, including in metallurgy;

in the field of research activities:

- to be a researcher in a scientific laboratory for the research and development of modern automated control systems for production processes in various industries, including metallurgy;
- to be a teacher of a bachelor's degree in special disciplines in the field of automation of production processes in metallurgy;

in the field of design and engineering activities:

- to be a leading engineer or chief engineer of a project for the development and design of automated control systems for production processes in various industries, including metallurgy.

Requirements for applicants

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 the admission of citizens to the magistracy is established in accordance with the "Standard rules for admission to training in educational organizations that implement 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, on a competitive basis, in accordance with the state educational order, free postgraduate education, if they receive education of this level for the first time.

At the "entrance", a master's student must have all the prerequisites necessary for mastering the corresponding educational master's program. The list of required prerequisites is determined by the higher education institution independently.

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

3 Requirements for completing studies and obtaining a diploma

Awarded degree / qualifications: The graduate of this educational program is awarded the academic degree "Master of Engineering and Technology" in the direction of "Metallurgy and Mineral Processing".

A graduate who has mastered the master's program must have the following general professional competencies:

– the ability to independently acquire, comprehend, structure and use new knowledge and skills in professional activities, develop their innovative abilities;

– the ability to independently formulate research goals, establish a sequence for solving professional problems;

– the ability to apply in practice the knowledge of fundamental and applied disciplines that determine the focus (profile) of the master's program;

– the ability to professionally choose and creatively use modern scientific and technical equipment for solving scientific and practical problems;

– the ability to critically analyze, represent, defend, discuss and disseminate the results of their professional activities.

A graduate who has mastered the master's program must have professional competencies corresponding to the types of professional activity that the master's program is focused on:

research activities:

– the ability to independently conduct scientific experiments and research in the professional field, generalize and analyze experimental information, draw conclusions, formulate conclusions and recommendations;

- the ability to create and explore models of the studied objects based on the use of in-depth theoretical and practical knowledge in the field of metallurgy;
- *research and production activities:*
- the ability to independently carry out production, research and production, laboratory and interpretation work in solving practical problems;
- the ability to professionally operate modern laboratory equipment and instruments in the field of the mastered master's program;
- the ability to use modern methods of processing and interpreting complex information to solve production problems;
- *project activity:*
- readiness to design complex research and development work in solving professional problems;
- *organizational and management activities:*
- the willingness to use the practical skills of organizing and managing research and development work in solving professional problems;
- readiness for the practical use of regulatory documents in the planning and organization of scientific and industrial work;

When developing a master's program, all general cultural and general professional competencies, as well as professional competencies related to those types of professional activities that the master's program is focused on, are included in the set of required results of mastering the master's program.

4 Working curriculum of the educational program

4.1. Training period 2 years

Educational program "Automation and digitalization of metallurgical processes"
on the basis of the following specialties of the invalidated Classifier of specialties: 6M070900 - "Metallurgy" and 6M070200 - "Automation and Control"
enrollment for the 2019 - 2020 academic year

Academic degree: master of engineering and technology
Duration of study: 2 years

Year of study	CODE	Name of the discipline	Component	CREDITS		Lk/lb/pr	PRE-REQUISIT	CODE	Name of the discipline	Component	CREDITS		Lk/lb/pr	PRE-REQUISIT
				ECTS	RK						ECTS	RK		
1	1 semester							2 semester						
		Foreign language (professional)	BD HC	5	3	0/0/3			Microprocessor-based process control systems	BD CC	5	3	1/1/1	
		History and philosophy of science	BD HC	4	2	1/0/1			Diagnostics and reliability of automation systems					
		Pedagogy of higher education	BD HC	4	2	1/0/1			Special chapters of heat exchange of metallurgical processes	BD CC	5	3	2/1/0	
		Psychology of management	BD HC	4	2	1/0/1			Modern management theory	PD HC	5	2	2/0/1	
		Theory and calculations of metallurgical thermodynamics and kinetics	BD CC	5	3	2/0/1			Waste management of the metallurgical industry	PD CC	4	2	2/0/1	
									Treatment of waste water of metallurgical enterprises					
		MES systems	PD HC	5	3	2/0/1			Sustainable pyro - and hydrometallurgical technologies for processing mineral raw materials	PD CC	4	2	2/0/1	
		Digital control systems							Refining in the metallurgy of radioactive and precious metals					

		Teaching practice	BD HC	3	3				Research work of a master's student	RWMS	7	2		
		Total:		**30**	**18**				**Total:**		**30**	**15**		
2	**3 semester**							**4 semester**						
		Optimal control systems (with AI elements)	PD CC	5	3	2/0/1			Research work of a master's student	RWMS	9	2		
		Reliability of the control system and its elements							Research practice	PD	9	2		
		Technologies for processing uranium-containing raw materials	PD CC	5	3	2/0/1			Registration and defense of a master's thesis (RaDMT)	FE	12	3		
		Resource and energy saving in metallurgy												
		Automation of the design of managed systems	PD CC	4	2	1/1/1								
		Distributed control systems												
		Theory and technology of obtaining nano-structural materials	PD CC	4	2	2/1/0								
		Methods and means of analysis of metallurgical processes and metallurgical products												
		Design of automation systems	PD CC	4	2	1/1/1								
		Numerical control systems for robots												
		Research work of a master's student	RW MS	8	2									
		Total:		**30**	**14**				**Total:**		**30**	**7**		
									Total:		**120**	**73**		

6 Descriptors of the level and amount of knowledge, abilities, skills and competencies

The requirements for the level of preparation of a master's student are determined on the basis of the Dublin descriptors of the second level of higher education (master's) and reflect the acquired competencies, expressed in the achieved learning outcomes.

Learning outcomes are formulated both at the level of the entire educational program of the master's program, and at the level of individual modules or academic discipline.

Descriptors reflect learning outcomes that characterize the student's abilities:

1) demonstrate developing knowledge and understanding in the studied field of metallurgy, based on advanced knowledge of automation and digitalization of metallurgical processes, when developing and / or applying ideas in the context of research;

2) apply at a professional level their knowledge, understanding and ability to solve problems in a new environment, in a broader interdisciplinary context;

3) collect and interpret information to form judgments, taking into account social, ethical and scientific considerations;

4) clearly and unambiguously communicate information, ideas, conclusions, problems and solutions, both to specialists and non-specialists;

5) learning skills necessary for self-continued further education in the studied area of automation and digitalization of metallurgical processes.

7 Completion Competencies

6.1 Requirements for key competencies of graduates of a specialized magistracy must:

1) have an idea:

– on the role of science and education in public life;

– about modern trends in the development of scientific knowledge;

– on topical methodological and philosophical problems of natural sciences;

– about the professional competence of a higher school teacher;

– about the contradictions and socio-economic consequences of globalization processes;

– about the latest discoveries in the chosen field of activity, the prospects for their use for the construction of technical systems and devices;

– about mathematical and physical modeling of systems in the field of technology and equipment development;

– on design and development, research, inventive, innovative activities in the field of automation and digitalization of metallurgical processes;

– on the possibilities of advanced scientific methods and technical means, to use them at the level required in the study of mining and processing and metallurgical

processes and equipment.

2) know:

–current state and prospects of technical and technological development of automation and digitalization of metallurgical processes;

–the goals and objectives of a specialist in the field of automation and digitalization of metallurgical processes for the development and implementation of the latest science-intensive production technologies;

–research methods for metallurgical processes, equipment operation;

–basic requirements for technical documentation, materials and products;

–rules and regulations of labor protection, issues of environmental safety of technological processes;

–methods of synthesis of automated control systems for metallurgical technological and production processes;

–modern trends in the development of technical means and systems for the automation of industrial metallurgical processes;

–standards, methodological and regulatory materials accompanying the operation, installation, commissioning and design of automated production process control systems;

3) be able to:

– to develop technological processes for obtaining conditioned concentrates from ore, as well as metals from concentrates, processing of metals and alloys, diagrams of enrichment and metallurgical processes, to justify operating parameters and indicators;

- draw up a business plan for a technological project;

- to develop and research mathematical models and automation systems of production processes using modern software products;

- to develop algorithmic and software for micro-processor systems for the automation of production processes;

– process data using planning techniques, regression and correlation analysis, digitalization methods;

– to carry out activities for the organization of production in accordance with regulatory documents;

– use the knowledge gained for the original development and application of ideas in the context of scientific research;

– critically analyze existing concepts, theories and approaches to the analysis of processes and phenomena;

– integrate knowledge gained in different disciplines to solve research problems in new unfamiliar conditions;

– make judgments and decisions based on incomplete or limited information by integrating knowledge;

– apply interactive teaching methods;

– carry out information-analytical and information-bibliographic work with the involvement of modern information technologies;

– to think creatively and be creative in solving new problems and situations;

– be fluent in a foreign language at a professional level, allowing for scientific research and teaching of special disciplines in universities;

– summarize the results of research and analytical work in the form of a dissertation, scientific article, report, analytical note, etc.;

4) have skills:

–organization of work on the development, installation, commissioning and operation of tools and systems for automating production processes;

–organization of work on the collection, storage and processing of information used in the field of professional activity.

–professional communication and intercultural communication;

–oratory, correct and logical formulation of your thoughts in oral and written form;

–expanding and deepening the knowledge necessary for daily professional activities and continuing education in doctoral studies.

5) be competent:

–in the field of research methodology;

–in the field of scientific activity in higher educational institutions;

–in matters of modern educational technologies;

–in the implementation of scientific projects and research in the professional field;

–in ways to ensure constant updating of knowledge, expansion of professional skills and abilities.

B - Basic knowledge, abilities and skills

B1 - Know the psychology of management;

B 2 - Ability to independently apply methods and means of knowledge, learning and self-control to acquire new knowledge and skills, including in new areas that are not directly related to the field of activity.

B 3 - To know the state, Russian and one of the most common foreign languages in the industry at a level that ensures human communication.

B4 - To be able to use fundamental general engineering knowledge, the ability to practically use the foundations and methods of mathematics, physics and chemistry in their professional activities.

B5 - Proficiency in professional terminology and the ability to work with educational and scientific materials in the specialty in the original in a foreign language. Ability to be logically correct, reasoned and clearly build oral and written speech.

B6 - General engineering skills.

B7 - Possession of fundamental knowledge of metallurgy and automation and digitalization of metallurgical processes;

B8 - Basic knowledge of waste management, metal recycling.

B9 - Possession of modern and promising technologies of metallurgical production.

B10 - Know and own the main business processes in an industrial enterprise.

B11 - Ability to work using modern techniques and technologies.

P - Professional competencies:

P1 - a wide range of theoretical and practical knowledge in the professional field;

P2 - able to analyze technological lines of metallurgical processes.

P3 - ready to install, adjust and operate production systems for metallurgical processes;

P4 - is ready to participate in the development and design of new technologies and production lines for obtaining finished metal-containing products.

P5 - Have the skills of drawing up an apparatus and technological scheme

P6 - a wide range of theoretical and practical knowledge in the professional field;

P7 - able to analyze electrical and wiring diagrams of automation systems or robotization of production processes.

P8 - ready to install, commission and operate automation systems for production processes;

P9 - ready to participate in the development, digitalization and design of new automation and robotization systems.

P10 - Ability to apply knowledge, abilities, skills, mastered in the process of training in the educational program of the magistracy.

O - Human, socio-ethical competences

O1 - is able to freely use English as a means of business communication, a source of new knowledge in the field of automation or robotization of production processes. I am ready to use English in professional activities in the field of automation and digitalization of metallurgical processes;

O2 - able to fluently speak the Kazakh (Russian) language as a means of business communication, a source of new knowledge in the field of automation or robotization of production processes. I am ready to use the Kazakh (Russian) language in professional activities in the field of automation and digitalization of metallurgical processes;

O3 - know and apply in work and life the foundations of applied ethics and ethics of business communication;

O4 - know and apply the basic concepts of professional ethics;

O5 - to know and solve the problems of human influence on the environment.

C - Special and managerial competences

C1 - independent management and control of the processes of labor and educational activity within the framework of the strategy, policy and goals of the

organization, discussion of problems, reasoning of conclusions and competent handling of information;

C2 - to be a specialist in experimental research of metallurgical objects;

C3 - to be a researcher, a specialist in scientific research of objects of automation and digitalization of metallurgical processes;

C3 - to be an engineer for the development, automation and digitalization and design of metallurgical workshops, production lines.

6.2 Requirements for the research work of the undergraduate:

1) corresponds to the profile of the master's educational program, according to which the master's thesis is performed and defended;

2) is relevant and contains scientific novelty and practical significance;

3) is based on modern theoretical, methodological and technological achievements of science and practice;

4) carried out using modern scientific research methods;

5) contains research (methodological, practical) sections on the main protected provisions;

6) based on international best practices in the relevant field of knowledge.

6.3 Requirements for organizing practices:

The educational program of the profile magistracy includes industrial practice (3 semester).

8 ECTS Diploma Supplement

The application was developed according to the standards of the European Commission, Council of Europe and UNESCO / CEPES. This document is for academic recognition only and is not an official proof of education. Not valid without a university degree. The purpose of completing the European Annex is to provide sufficient information about the holder of the diploma, the qualification obtained, the level of this qualification, the content of the study program, the results, the functional purpose of the qualification, as well as information about the national education system. The application model that will be used to translate grades uses the European Credit Transfer or Transfer System (ECTS).

The European Diploma Supplement provides an opportunity to continue education at foreign universities, as well as to confirm national higher education for foreign employers. When going abroad for professional recognition, additional legalization of the educational diploma is required. The European Diploma Supplement is completed in English upon individual request and is issued free of charge.

Master, level 7 of the national qualifications framework with the right to hold the following positions: Technical Director, Development Director, Chief Mechanic, Chief Power Engineer at the enterprises of the mining and metallurgical industry, according to the Sectoral Qualifications Framework "Mining and Metallurgical Industry" dated

August 16, 2016 No. 1 Association of legal entities "Republican Association of Mining and Metallurgical Enterprises".

Foreign language (professional)
CODE – LNG205
CREDIT – 6
PRE-REQUISIT – Academic English, Business English, IELTS 5.0-5.5

PURPOSE AND OBJECTIVES OF THE COURSE
The aim of the course is to develop students' knowledge of the English language for their ongoing academic research and improve their performance in the field of project management.

SHORT DESCRIPTION OF THE COURSE
The course is aimed at building vocabulary and grammar for effective communication in the field of project management and improving reading, writing, listening and speaking skills at the "Intermediate" level. Students are expected to develop their Business English vocabulary and learn grammatical structures that are often used in a management context. The course consists of 6 modules. The 3rd module of the course ends with an intermediate test, and the 6th module is followed by a test at the end of the course. The course ends with a final exam. Master students also need to study independently (MIS). MIS is an independent work of undergraduates under the guidance of a teacher.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
Upon successful completion of the course, students are expected to be able to recognize the main idea and message as well as specific details while listening to monologues, dialogues and group discussions in the context of business and management; understand written and spoken English on topics related to management; write management texts (reports, letters, emails, minutes of meetings) following a generally accepted structure with a higher degree of grammatical accuracy and using business words and phrases, talk about different business situations using appropriate business vocabulary and grammatical structures - in pairs and groups discussions, meetings and negotiations.

History and philosophy of science
CODE – HUM201
CREDIT – 2 (1/0/1)
PRE-REQUISIT – HUM124

PURPOSE AND OBJECTIVES OF THE COURSE
To reveal the connection between philosophy and science, to highlight the philosophical problems of science and scientific knowledge, the main stages of the history of science, the leading concepts of the philosophy of science, modern problems of the development of scientific and technical reality

SHORT DESCRIPTION OF THE COURSE
The subject of the philosophy of science, science dynamics, the specifics of science, science and pradnya, the antiquity and the emergence of theoretical science, main stages of the historical development of science, characteristics of science, neklassicheskie and post-non-classical science, philosophy, mathematics, physics, engineering and technology, the specifics of engineering Sciences, ethics of science, social and moral responsibility of the scientist and engineer.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
Know and understand the philosophical questions of science, the main historical stages of development of science, leading to the concept of philosophy of science, to be able to critically evaluate and analyze scientific and philosophical problems, to understand the specifics of engineering science, possess the skills of analytical thinking and philosophical reflection, to be able to justify and defend its position, own techniques of discussion and dialogue, to master the skills of commutatively and creativity in their professional work.

Management of educational and organizational activities (higher school Pedagogy + Psychology of management)
CODE –
CREDIT – 2 (1/0/1)
PRE-REQUISIT –

PURPOSE AND OBJECTIVES OF THE COURSE
Study of the basic principles of organization management and educational activity management

SHORT DESCRIPTION OF THE COURSE
The content of the course is aimed at studying the basics of education management, management of global educational processes, analysis and selection of strategic initiatives, the project as a strategy for managing the development of an educational institution/organization. Also, undergraduates will study marketing of education, human resource management in educational organizations, information and communication technologies in the field of education and management of the educational process (on the example of higher education).

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of studying this course, the student should:
to know modern ideas about the role of pedagogical management in ensuring the competitiveness of the educational institutions/organisations; the content of the concept of "education management"; the main stages of the educational process; the main features of the marketing policy of the educational institution/organization; the main approaches used in the practice of human resources management educational institutions/organizations; role of information and communication technologies in education.
be able to navigate the main trends of modern scientific and technological development; use various resources and tools for managing the educational process; choose the most appropriate strategy for innovative development of an educational institution/organization; work with scientific, technical and economic literature on the organization, management and marketing of education.

Reliability of the control system and its elements
CODE – AUT215
CREDIT – 3 (2/0/1)
PRE-REQUISIT – AUT156

PURPOSE AND OBJECTIVES OF THE COURSE
Purpose of the discipline
Training of specialists to independently solve theoretical and applied problems related to the assessment, analysis and reliability of control systems and their elements.
Tasks of the discipline
Establishment of types of quantitative indicators of reliability of various elements of control systems, including software, technical and organizational support, development of methods of analytical assessment of reliability, calculation of reliability indicators based on test results and at the stages of development and operation.

SHORT DESCRIPTION OF THE COURSE
The course content includes the characteristics of qualitative and quantitative indicators of reliability of elements of control systems, their probabilistic and statistical evaluation of test results, study of the basic methods of calculation of reliability of renewable and non-repairable systems, analysis and selection of the multiplicity of backup.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of studying the discipline, you should know:
- properties and reliability indicators;
- quantitative indicators and mathematical models of reliability (reliability);
- basic methods of calculating reliability;
- types and plans of reliability tests.

As a result of studying the discipline should be able to:
- determine the quantitative characteristics of reliability;
- apply various calculation methods to determine the reliability of control systems and their elements;
- determine quantitative reliability indicators based on test results.

MES-systems
CODE – AUT216
CREDIT – 3 (2/0/1)
PRE-REQUISIT – AUT

PURPOSE AND OBJECTIVES OF THE COURSE
Classification of MES functions determines their clear orientation to achieving the set real goals of increasing production efficiency, taking into account the organizational structure of an industrial enterprise.

SHORT DESCRIPTION OF THE COURSE
Data collection and storage - Interaction of information subsystems in order to obtain, accumulate and transfer technological and control data circulating in the production environment of the enterprise. Product quality management-Analysis of product quality measurement data in real time based on information coming from the production level, ensuring proper quality control, identifying critical points and problems that require special attention.
Production process management - Monitoring of production processes, automatic adjustment or dialog support of operator's decisions. Maintenance and repair management-Management of maintenance, scheduled and operational repairs of equipment and tools to ensure their operational readiness.
Product history tracking-Visualization of information about the place and time of work for each product. Information may include reports on performers, technological routes, components, materials, batch and serial numbers, alterations made, current production conditions, etc. performance Analysis-Providing detailed reports on the actual results of production operations. Comparison of planned and actual indicators.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
Expected results: the Concept, architecture and technologies of development and design of the MES system in the creation of automation systems for production processes of enterprises with a continuous production cycle.

Digital control systems

CODE – AUT

CREDIT – 3 (2/0/1)

PRE-REQUISIT – AUT

PURPOSE AND OBJECTIVES OF THE COURSE

Purpose of the discipline

Training of highly qualified personnel who know basics of applications of digital control systems, in particular knowing the mathematical methods of the description of digital systems, analysis techniques in time and frequency domains, stability study of digital systems and analyze the quality of the regulatory process of digital systems.

Tasks of the discipline

Mathematical apparatus used to describe digital control systems, methods for determining the transfer function of the controller as part of a digital system, methods for investigating the stability and quality of control processes of linearized digital control systems, methods for constructing the frequency response characteristics of digital systems, methods for synthesizing digital controllers to ensure a given dynamics of the control process.

SHORT DESCRIPTION OF THE COURSE

The content of the discipline "Digital control systems" includes the study of the mathematical apparatus of the description of digital systems, the description of digital systems in the time and frequency domains, the synthesis of digital controllers in the automation of production processes.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE

As a result of studying the discipline, you should know:

- mathematical models and methods for describing digital control systems;
- methods for studying the stability of digital control systems;
- methods for assessing the quality of the process of regulating digital control systems;
- problem statements and methods of synthesis of digital controllers in the automation of production processes.

As a result of studying the discipline should be able to:

- perform analysis of technological processes for the generation of digital control systems;
- conduct a study of the stability of digital control systems;
- evaluate the quality of the digital control system regulation process;
- it is justified to choose the structure of the digital control algorithm for a technical or technological system, depending on the features of the production process.

Modern management theory
CODE – AUT201
CREDIT – 3 (1/1/1)
PRE-REQUISIT – AUT111

PURPOSE AND OBJECTIVES OF THE COURSE
Purpose of the discipline
Training of specialists who know the methods of modern automatic control theory, who are able to independently solve theoretical and applied problems of creating modern automatic control systems

Tasks of the discipline
Expanding and strengthening the knowledge of specialists in the field of automatic control theory, mastering modern methods of analysis and synthesis of control systems based on state space methods. Study of systems with variable structure, modal control methods, current identification, adaptation and optimal control.

SHORT DESCRIPTION OF THE COURSE
The content of the discipline includes the study of modern approaches to the analysis and synthesis of automatic control systems based on the "state space"methodology. Properties of linear and nonlinear systems and methods of their investigation are considered from the unified positions of the state space method. Basic information about systems with variable structure, modal control, identification, adaptation and optimization in control systems is provided.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of studying the discipline, you should know:
- basic concepts and principles of building automatic control systems for technical objects;
- methods and methods of applying theoretical provisions for the development of mathematical models, analysis and synthesis of modern automatic control systems for technical objects;
- prospects for the development and improvement of automatic control systems for technical objects based on the achievements of scientific and technological progress.

As a result of studying the discipline should be able to:
- perform an analysis of control objects with the identification of features necessary to determine the class of tasks to be solved and the choice of methods for managing them;
- practically solve the problems of constructing algorithms for identification, adaptation and optimal control, depending on the changing parameters of the production process;
- implement the tasks set in modern computer control systems in industry.

Microprocessor-based process control systems
CODE – AUT232
CREDIT – 3 (1/1/1)
PRE-REQUISITE – AUT243

PURPOSE AND OBJECTIVES OF THE COURSE
- formation of the bachelor's knowledge on the principles of building digital data processing tools, features of the organization of microprocessor devices and the use of microprocessors in control systems of technical objects and technological processes, as well as the formation of skills in designing control systems based on microcontrollers and the development of their application software

BRIEF DESCRIPTION OF THE COURSE
In this discipline the emphasis is placed on features of the item of program-logic controllers made by leading in the field of industrial automation firms, which can be used to build highly reliable systems of control and management of technological processes. It provides for the study of the use of the principles of organization and various classes of microprocessor systems, the acquisition of skills in programming embedded systems. A certain place is given to the design of hardware and software of microprocessor systems at the system, structural and logical stages of design, the method of selecting microprocessor kits, the features of developing and debugging hardware and software systems on cross-means and in resident mode. Microprocessor technology is widely used for control in production systems. The use of microprocessors in the management of distributed systems as a means of collecting and primary processing, transmission, transformation, as well as as regulators of technological processes has expanded the functionality of sensors, actuators, peripheral and terminal devices. This course covers issues that will give students the basics of knowledge and skills needed to solve industrial and scientific problems related to the choice of microprocessor control systems.

KNOWLEDGE, SKILLS AND ABILITIES AT THE END OF THE COURSE
KNOWLEDGE: in the field of architecture and programming of typical microprocessor systems; methods and tools for automated modeling and design of microprocessor control systems; in the field of nomenclature of families of controllers currently produced by suppliers and components for industrial automation systems.
SKILLS: design components included in the objects of technological control and control, including those based on microprocessor control systems; read and understand simple diagrams of typical electronic equipment on a digital integrated element base; select the necessary elements from reference information, in accordance with the operating conditions of the elements in the scheme.

SKILLS: working with tools and hardware for testing and debugging software of microprocessor systems in the implementation of ACS TP on their basis.

Design of automation systems
CODE – AUT
CREDIT – 3 (2/0/1)
PRE-REQUISITE – AUT

PURPOSE AND OBJECTIVES OF THE COURSE
The purpose of the course is to prepare specialists who possess theoretical devices that underlie the modern theory of designing automation systems, who are able to perform calculation and research work on the design and operation of control systems based on modern computer technology.
Tasks: in the course of the course, it is necessary to prepare students for work in the field of automation systems design, who possess the theoretical and practical foundations, basic principles and mathematical methods of system design, analysis and synthesis of automation systems based on modern methods.

BRIEF DESCRIPTION OF THE COURSE
The course covers the following methodologies:
– methods of automating the construction of mathematical models –
- methods of analysis and synthesis of systems using modern computer technology and automation;
– modern trends in the development of automation;
- regulatory documents, state standards for the design of automation systems;
- structure and purpose of the state system of devices; various structural and functional schemes of control systems; basic algorithms that ensure the operation of standard industrial regulators.

KNOWLEDGE, SKILLS AND ABILITIES AT THE END OF THE COURSE
In the learning process students should obtain theoretical knowledge and practical skills in the design of automation systems; possess the theoretical foundations, basic principles and mathematical methods of designing systems; to own methods of automating the construction of mathematical models, analysis and synthesis of systems using modern computer technology and automation research; to familiarize with trends in science and technology and their impact on automation; to study regulatory documents, state standards for the design of automation systems, the essence of the system approach in the design, the requirements for modern control systems; the structure and purpose of the state system of devices; various structural and functional schemes of control systems; the main algorithms that ensure the operation of standard industrial regulators; technical means of automation systems; modern technical and software tools of computer technology.

Numerical control systems for robots
CODE – AUT
CREDIT – 3 (2/0/1)
PRE-REQUISITE – AUT

PURPOSE AND OBJECTIVES OF THE COURSE
Purpose of the discipline
Training of highly qualified personnel who know the basics of developing algorithms and cyclograms for controlling robots, building cyclic, positional and contour systems for software control of robots, systems for numerical software control of machines and machines.
Tasks of the discipline
Methods of development of algorithms and cyclograms of robot control as part of a robotic system, development of cyclic, positional and contour systems of software control of robots, systems of numerical software control of machines, machines.
BRIEF DESCRIPTION OF THE COURSE
The content of the discipline "systems of numerical program control of robots" includes the study of mathematical methods of program control of robots, the basics of the development of algorithms and cyclograms of robot control. The structure, composition and purpose of elements of cyclic, positional and contour systems of program control of robots, systems of numerical program control of machines and machines are considered.
KNOWLEDGE, SKILLS AND ABILITIES AT THE END OF THE COURSE
As a result of studying the discipline, you should know:
- methods for developing algorithms and cyclograms for controlling robots as part of a robotic system;
- cyclic, position and contour of the system software is a software to control robots;
- architecture of software control systems for machines, machines and robots;
- electroautomatics of software control systems;
- basics of programming machine tools with numerical control.
As a result of studying the discipline should be able to:
- analyze the objects of robotization to select the required system of software control of robots and technological equipment;
- analyze the operation of electrical automation systems and form the required connections with the robot's software control system and technological equipment; - evaluate the quality of control of the robot's software control system and production processes;
- program numerical control systems for robots and production processes.

Diagnostics and reliability of automation systems
CODE – AUT205
CREDIT – 3 (2/0/1)
PRE-REQUISITE – AUT156

PURPOSE AND OBJECTIVES OF THE COURSE
Purpose of the discipline
Training of specialists to independently solve theoretical and applied problems related to the assessment, analysis, diagnostics and reliability of automation systems and other complex technical systems.
Tasks of the discipline
Establishment of types of quantitative reliability indicators, development of methods of analytical reliability assessment, calculation of reliability indicators based on test results and at the stages of development and operation, application of technical diagnostics methods in determining the location and cause of malfunctions of diagnostic objects.

BRIEF DESCRIPTION OF THE COURSE
The course content includes the characteristics of qualitative and quantitative indicators of reliability of technical systems, their probabilistic and statistical evaluation of test results, study of the basic methods of calculation of reliability of renewable and non-repairable systems, analysis and selection of a multiplicity of reserving, consideration of methods and models of technical diagnostics of automation systems.

KNOWLEDGE, SKILLS AND ABILITIES AT THE END OF THE COURSE
As a result of studying the discipline, you should know:
- properties and reliability indicators;
- quantitative indicators and mathematical models of reliability(reliability); basic methods of calculating reliability;
- types and plans of reliability tests;
- functions and features of the technical diagnostics system;
- basic methods of diagnostics of automation systems.
As a result of studying the discipline should be able to:
- determine the quantitative characteristics of reliability;
- apply various calculation methods in determining the reliability of complex systems; determine quantitative reliability indicators based on test results; practically implement technical diagnostics methods in assessing the functioning of automation systems.

Optimal control systems (with AI elements)
CODE – AUT
CREDIT – 3 (2/0/1)
PRE-REQUISITE – AUT

PURPOSE AND OBJECTIVES OF THE COURSE
Purpose of the discipline
Training of highly qualified personnel who know the basics of research and construction of optimal control systems based on the methods of classical variational calculus, in particular, who know the basics of program and stabilizing optimal control, elements of classical variational calculus, the basics of the Maxim principle and dynamic programming.
Tasks of the discipline
Methods of optimal control theory, elements of classical calculus of variations, fundamentals of the maximum principle and dynamic programming. Models and methods of program and stabilizing optimal control.

BRIEF DESCRIPTION OF THE COURSE
The content of the discipline "optimal control Systems" includes the study of mathematical methods of optimal control based on the classical calculus of variations, the basics of the maximum principle and the method of dynamic programming. Models and methods of program and stabilizing optimal control are considered. Separate sections are devoted to methods of synthesis of intellectual systems of optimum control.

KNOWLEDGE, SKILLS AND ABILITIES AT THE END OF THE COURSE
As a result of studying the discipline, you should know:
- mathematical models and methods for constructing optimal control systems based on elements of classical calculus of variations;
- mathematical models and methods of optimal control based on the maximum principle;
- mathematical models and optimal control methods based on the dynamic programming method;
- mathematical models and methods for constructing optimal control systems based on the method of analytical design of regulators;
- mathematical models and methods for constructing optimal control systems under random external influences;
- mathematical models and methods for constructing optimal control systems with incomplete information about the vector of state variables.
As a result of studying the discipline should be able to:
- perform analysis of technological processes for synthesis of optimal control systems;

- it is justified to choose the structure of the algorithm for optimal control of a technical or technological system, depending on the characteristics of the production process;
- it is justified to choose the type of model and algorithm (including intellectual ones) for optimal control of a technical or technological system.

Automation of control system design
CODE – AUT229
CREDIT – 3 (1/1/1)
PRE-REQUISITE – AUT131

PURPOSE AND OBJECTIVES OF THE COURSE
Purpose of the discipline
Training of specialists who know the theoretical foundations of control system design and methods of performing experimental and computational work on the creation and operation of automation systems based on modern software and hardware.

Tasks of the discipline
Mastering methods and algorithms for constructing mathematical models of objects and calculating modern automatic control systems, studying the basics of computer-aided design of automation systems with the choice of their technical and mathematical support.

BRIEF DESCRIPTION OF THE COURSE
The content of the discipline "automation of design of control systems" includes the study of methods of analysis and synthesis of control systems, the choice of structure and calculation of parameters of the control law. The procedures of analytical design of regulators, development of structural, functional and other automation schemes with the use of modern application software packages are considered.

KNOWLEDGE, SKILLS AND ABILITIES AT THE END OF THE COURSE
As a result of studying the discipline, you should know:
- methods of automating the construction of mathematical models, methods of analysis and synthesis of systems using modern software and hardware; modern packages of computer-aided design systems;
- regulatory documents, state standards for the design of automation systems;
As a result of studying the discipline should be able to:
- analyze technological processes to build a control system; it is justified to choose the structure of the method and control algorithm, depending on the characteristics of the production process;
- it is justified to choose software and technical means of the control system and use modern computer-aided design packages.

Distributed control systems
CODE – AUT
CREDIT – 3 (2/0/1)
PREREQUISIT – AUT

PURPOSE AND OBJECTIVES OF THE COURSE
The purpose of the discipline
Training of highly qualified personnel who know the basics of building distributed control systems in various industries, in particular those who know the methods of mathematical description of distributed control systems using partial differential equations, methods for studying stability and assessing the quality of the control process of distributed systems, the structure and composition of technical means of a distributed system management.
Discipline objectives
Methods and algorithms for constructing distributed control systems in various industries, methods of mathematical description, stability studies and quality assessment of the process of regulation of distributed control systems. Methods for developing the structure and composition of hardware, software modules and information support for distributed control systems.

BRIEF DESCRIPTION OF THE COURSE
The content of the discipline "Distributed control systems" includes the study of mathematical methods of description, the study of stability, assessment of the quality of the control process of distributed systems. The issues of choosing the structure and composition of hardware and software for distributed control systems are considered.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of studying the discipline, you should know:
- mathematical models and methods for describing distributed control systems;
- mathematical models and methods for studying the stability of distributed control systems;
- mathematical models and methods for assessing the quality of the control process of distributed control systems;
- Methods for choosing the composition and developing the structure of hardware and software for building distributed control systems.
As a result of studying the discipline should be able to:
- analyze technological processes to build distributed control systems;
- it is reasonable to choose the structure of the control algorithm for distributed control systems, depending on the characteristics of the production process;
- conduct research to determine the stability of the distributed control system and assess the quality of the distributed control system control process.

Theory and calculations of metallurgical thermodynamics and kinetics
CODE – MET
CREDIT – 3 (2/0/1)
PREREQUISIT - Physics 2

PURPOSE AND OBJECTIVES OF THE COURSE
Purpose of the course: Formation of students' systematic knowledge about the basic thermodynamic and kinetic processes of processing oxidized and sulfide mineral, as well as technogenic raw materials, about kinetics and thermodynamics in molten systems.
Objective of the course:
• mastering by students of the basic laws of thermodynamics, mechanism and kinetics of the main pyrometallurgical processes;
• obtaining skills for independent study of thermodynamic and kinetic patterns of pyrometallurgical processes;
• mastering the methods of solving problems in kinetics and thermodynamics of processes.
BRIEF DESCRIPTION OF THE COURSE
The processes occurring in metallurgical systems are considered from the standpoint of thermodynamics and kinetics. The characteristics of equilibrium and non-equilibrium processes and states of metallurgical systems are given; examples of calculating the equilibrium composition of gaseous atmospheres of metallurgical systems. Theoretical provisions and conclusions about the structure and properties of metal, oxide and sulfide systems: thermodynamics and kinetics of metallurgical processing of oxidized and sulfide mineral and technogenic raw materials; liquation and distillation processes of obtaining; methods of refining metals and on the main directions of development of theory and practice of extraction and refining of metals, taking into account the complex use of raw materials and modern environmental requirements.
KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of mastering the discipline, students should
1) know: about the thermodynamics of processes and kinetics of reactions, about the mechanisms and modes of reactions occurring in the metallurgical system;
2) be able to: perform thermodynamic calculations of sulfidation processes, oxidation processes, hydrometallurgy processes; perform kinetic calculations of reactions, calculate kinetic parameters of reactions, orders of reactions, activation energy, analyze the reaction mechanism.
3) own skills:
independent study of thermodynamic and kinetic regularities of pyro- and hydrometallurgical processes.

Special chapters of heat transfer in metallurgical processes
CODE – MET
CREDIT – 3 (2/1/0)
PREREQUISIT - Physics 2

PURPOSE AND OBJECTIVES OF THE COURSE
Purpose of the course: Theoretically and practically, to prepare students in the methods of obtaining, transforming, transferring and using heat to such an extent that they can choose and, if necessary, operate energy technology units (furnaces) in order to maximize the saving of thermal energy resources and materials, intensify and optimize technological processes.
Objective of the course:
Studying the theoretical foundations of the course and instilling practical skills in solving problems in accordance with the requirements of the qualification characteristics.
SHORT DESCRIPTION OF THE COURSE
Types of heat transfer. Thermal conductivity. Fourier's hypothesis. Thermal conductivity coefficient. Influence of various factors on the thermal conductivity coefficient. Stationary problems of heat conduction through a single-layer, flat, cylindrical and spherical wall. Thermal conductivity through a multilayer wall. Convection. The essence of convection. Convective heat flux. Factors determining the value of heat transfer coefficients by convection. Calculation of the heat transfer coefficient by convection using empirical formulas. Criteria of Nusselt, Reynolds, Grashof, Prandtl. Heat transfer by radiation. Basic concepts and laws. Heat transfer between surfaces in a radiant medium. Heat transfer by radiation between bodies arbitrarily located in space. Heat exchange by radiation in furnaces and combustion chambers. Complex heat transfer. Non-stationary heat conduction process. Methods for solving problems of unsteady heat conduction. The concept of a thin and massive body. The theory of heating thin and massive bodies.
KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of mastering the discipline, students should
1) know: the main provisions on fuel and the calculation of its combustion, the mechanics of gas movement in the furnace, the basic laws of heat propagation in continuous media, the properties of refractory materials, the work and designs of metallurgical furnaces;
2) be able to: calculate the main parameters of fuel combustion, pressure losses during the movement of gases in the gas duct system, select fans and smoke exhausters, heat consumption processes and heat losses in the furnace with the preparation of a heat balance, select refractory materials for the lining of a specific technological furnace using reference literature.
3) own skills:
Calculation of heat transfer, complex heat transfer.

Waste management in the metallurgical industry

CODE – MET

CREDIT – 3 (2/0/1)

PREREQUISIT - Physics 2

PURPOSE AND OBJECTIVES OF THE COURSE

The purpose of the course: Formation of knowledge in the field of management, enrichment and processing of metallurgical industry waste containing rare, non-ferrous and noble metals.

Course objectives:

- transfer basic theoretical knowledge of the course;
- help students acquire skills in performing practical work;
- to familiarize with the basic technological schemes of various methods of waste processing and disposal.

BRIEF DESCRIPTION OF THE COURSE.

System, hierarchy and the need to organize waste management in the metallurgical industry. Legislative consolidation of responsibility for waste management, prevention of waste generation, waste disposal until complete extraction of metals. Safe disposal of waste and priority of waste disposal over its disposal.

Disposal of waste without causing harm to public health and damage to the environment. Waste disposal at the expense of the manufacturer. Physicochemical, technological and environmental aspects of processing the most typical types of waste in the metallurgical industry. Sources of formation and classification of wastes, methods of transportation and enrichment. Features of technological schemes for processing metal-containing waste.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE

As a result of mastering the discipline, students should

1) know:

- stages of the waste technological cycle:
- principles of hardware and technological design of the main and auxiliary technological processes and operations for processing metal-containing waste;

2) be able to:

- choose and justify the scheme for processing specific types of metal-containing waste;
- apply methods for assessing the environmental and economic efficiency of the technologies being developed;

3) own skills:

- comparative analysis of sources of metal-containing waste generation;
- making managerial decisions when choosing a technology for complex processing of metal-containing waste.

Wastewater treatment of metallurgical enterprises
CODE – MET
CREDIT – 3 (2/0/1)
PREQUISIT - Chemistry

PURPOSE AND OBJECTIVES OF THE COURSE
Water purification and water treatment systems can be attributed to the most important component of metallurgy enterprises, since the reliability and efficiency of the existing equipment will directly depend on the quality of water. Otherwise, scale, iron oxide deposits, corrosion and other unpleasant phenomena appear that lead to losses. The course is devoted to these problems.
The objectives of the course are to study wastewater treatment methods, water treatment and water treatment systems.
BRIEF DESCRIPTION OF THE COURSE
The course includes wastewater treatment methods, the concept of environmental safety of the metallurgical industry. Wastewater generation problem. Mechanical method and reagent chemical treatment for industrial wastewater treatment. Reagent-free methods: electrochemical, electroionite, the use of ion-exchange resins, ozonation. Mechanical cleaning methods to separate insoluble, suspended impurities of various sizes. Devices for mechanical cleaning: grates, drum screens, settling tanks, filters, sand traps, oil traps, grease traps, etc. Basic equipment for mechanical wastewater treatment. The use of hydrocyclones. Chemical, physicochemical and biological treatment.
KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of mastering the discipline, students should
1) know:
- modern methods of wastewater treatment at metallurgical enterprises;
- efficient and economical processes for wastewater treatment.
2) be able to:
- distinguish between methods for wastewater treatment
3) have the skills: design of water treatment and water treatment systems for metallurgical enterprises.

Sustainable pyro- and hydrometallurgical technologies for mineral processing
CODE – MET
CREDIT – 3 (2/0/1)
PREREQUISIT - chemistry

PURPOSE AND OBJECTIVES OF THE COURSE
The aim of the course is to form students' systematized knowledge about sustainable pyro- and hydrometallurgical technologies for processing mineral raw materials. The objectives of the course are to define in the minds of students modern, promising metallurgical technologies of the "green economy".
BRIEF DESCRIPTION OF THE COURSE
Sustainable pyrometallurgical technologies for processing mineral raw materials: energy saving in pyro-processes, exothermic processes: suspended smelting for matte production, matte refining and converting processes to obtain blister copper, metal-thermal processes. Sustainable hydrometallurgical technologies for the processing of mineral raw materials: the influence of diffusion spread on the dissolution potential in mineral raw material leaching systems; underground leaching of rare earth elements; the kinetics of lime dissolution during the neutralization of acidic water drainage; heap leaching of large particles; "Urban" extraction and processing of electronic scrap. Hydrometallurgical technologies for extracting valuable raw materials, for example, leaching a valuable component (Ni, Cd, Co, Zn or Li) from spent batteries, extracting rare earth elements from crystal luminophores, luminescent light sources, PGMs from used catalysts, leaching Cu, Au from electronic printed boards. Recovery of metals from secondary sources, especially the enrichment of certain elements from enriched solutions containing several types of metals, and the development of cost-effective processes. Development of selective enrichment methods - effective and relatively small scale, especially in the field of ion exchange and selective deposition. Extraction of metals from low-grade ores. Heap leaching, liquid extraction. Ionic. Technical and economic (environmental) research. Biohydrometallurgy.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
Upon completion of the course, students gain knowledge about the laws, pyro- and hydrometallurgical processes; on the ways to intensify them, methods of critical analysis of the current level of technology; the ability to select and substantiate the pyro- and hydrometallurgical technology for processing specific metallurgical raw materials and its hardware design; propose ways to improve and create new effective pyro- and hydrometallurgical technologies.

Technologies for processing uranium-containing raw materials
CODE – MET
CREDIT – 3 (2/0/1)
PREREQUISIT –

PURPOSE AND OBJECTIVES OF THE COURSE
The purpose of teaching the discipline "Technology of uranium solutions processing" is to provide masters with a systematic knowledge of the processing technology of uranium solutions, formed during underground borehole leaching of uranium (ISL); on the properties and characteristics of precipitators, ion-exchange resins and uranium extractants from solutions; on kinetics and thermodynamics, mechanisms of chemical reactions in the hydrometallurgical technology of natural uranium processing.
BRIEF DESCRIPTION OF THE COURSE
General technological scheme of uranium ore hydrometallurgical processing. Interaction of leaching reagents with uranium ores, qualitative and quantitative composition of uranium solutions. Ion exchange theory. Processing of uranium solutions using cation and anion exchangers. Methods for the desorption of uranium from ion exchangers. Causes of poisoning and destruction of ion exchange resin. Equipment for ion exchange processes. Processing of uranium solutions using alkylamines. Processing of uranium solutions using neutral extractants. Equipment for extraction processes. Technological aspects of the deposition process. Deposition of uranium from sulfuric acid solutions. Precipitation of uranium from carbonate solutions. Electrochemical deposition of uranium from solution.
KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of mastering the discipline, students should
1) know: about the technology of processing uranium solutions formed during underground borehole leaching of uranium (ISL); on the properties and characteristics of precipitators, ion-exchange resins and uranium extractants from solutions; on kinetics and thermodynamics, mechanisms of chemical reactions in the hydrometallurgical technology of natural uranium processing.
2) Skills and skills acquired during the course:
to evaluate the content of uranium and impurities in the productive solution formed during underground borehole leaching using sulfuric acid and carbonate solutions; calculate the amount of chemical reagents required to obtain solutions with a given uranium concentration; perform calculations to find the quantities of reagents; calculate the parameters and select the equipment used in the technology of processing uranium solutions; choose the optimal technological, operational, economic and safe parameters for the processing of uranium solutions.

Resource and energy saving in metallurgy
CODE – MET
CREDIT – 3 (2/0/1)
PREQUISIT - Chemistry

PURPOSE AND OBJECTIVES OF THE COURSE
Purpose of the course: Formation of systematized knowledge, skills and abilities to assess opportunities, methods and techniques of resource and energy conservation in metallurgical production.
Course objectives:
• to transfer the basic theoretical knowledge on the course "Resource and energy saving in metallurgy";
• to form students' skills of analytical thinking in analyzing data on raw materials, energy and other resources in the metallurgical industry;
• to form a system of students' knowledge about the methods and technological methods of resource and energy saving in metallurgical production.
SHORT DESCRIPTION COURSE
The course "Resource and Energy Saving in Metallurgy" examines the basic concepts and methods in saving fuel, energy and resources. As part of the course, a special place is occupied by modern resource and energy saving and waste-free technologies and directions of energy and resource conservation in extractive and processing metallurgy.
KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of mastering the discipline, students should
1) know:
• terms, directions, technologies and features of resource and energy saving in the metallurgical industry;
• Methods for processing waste and secondary raw materials in metallurgy;
2) be able to:
• solve technological problems associated with energy and resource conservation and regulation in extractive and processing metallurgy;
• solve situational tasks related to the identification of tasks and prospects for energy and resource conservation in metallurgy;
3) own skills:
• analysis of data on raw materials, energy and other resources in the metallurgical industry and methods of saving them;
• selection of the optimal production organization system to ensure measures for resource and energy saving.

Theory and technology of obtaining nano-structural materials
CODE – MET
CREDIT – 3 (2/1/0)
PREQUISIT –

PURPOSE AND OBJECTIVES OF THE COURSE
This special course is aimed at a consistent presentation of the physical foundations of obtaining nanomaterials, as well as methods for studying nanoscale objects. The expediency of reading this special course is due to the fact that these materials have very diverse and interesting properties, they clearly express unique physical phenomena caused by electronic processes in condensed media. Nanostructured materials and devices based on them are currently the most developed, both theoretically and experimentally, the field of solid state physics. This special course allows you to significantly expand and deepen your knowledge in the field of nanostructured objects.
BRIEF DESCRIPTION OF THE COURSE
Development of the physical foundations of nanotechnology. Priority areas of nanotechnology. Varieties of nanomaterials: consolidated nanomaterials, nanosemiconductors, nanopolymers, nanobiomaterials, fullerenes and tubular nanostructures, catalysts, nanoporous materials and supramolecular structures. Nanoparticles (nanopowders). Science of small objects (nanoscience). Natural boundaries of development of existing microelectronics. Quantum holes, wires and points. Powder technology. Condensation method (Glater method). High energy grinding. Mechanochemical synthesis. Plasma chemical synthesis. Synthesis under conditions of ultrasonic exposure. Electric explosion of wires. Consolidation methods. Electric discharge sintering. Severe plastic deformation (high pressure torsion, equal channel angular pressing). Nanomaterials with special physical properties: magnetic nanomaterials, conductive nanomaterials and insulators, nanostructured semiconductor materials (emitters, transistors, switches). Nanomaterials for nuclear power. Nanomaterials for medicine and biology. Micro- and nanoelectromechanical systems: creation of ultra-small copies of known macro-objects; development of fundamentally new designs that have no traditional analogues.
KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of mastering the discipline, students should
1) know: the physical foundations of obtaining nanoscale materials and methods of their research.
2) be able to analyze and formulate certain conclusions on certain phenomena in the production of nanostructured materials.
3) have the skills to identify nanostructured materials, analyze using nanostructured materials.

Methods and tools for the analysis of metallurgical processes and metallurgical products

CODE – MET

CREDIT – 3 (2/1/0)

PREREQUISIT - physics, chemistry

PURPOSE AND OBJECTIVES OF THE COURSE

Purpose of the course: Formation of knowledge in the field of analysis and control of metallurgical processes (MP) and their products, mastering modern methods of measuring the main parameters of MP.

Course objectives: to transfer basic theoretical knowledge of the course; help students gain skills in laboratory work; to acquaint with the basic technological schemes of various methods and means of analysis of MP.

BRIEF DESCRIPTION OF THE COURSE

The course provides basic information about the current state and development of methods of analysis of MP; on the principles of operation and devices for monitoring the most important parameters of metallurgical processes (temperature, viscosity, density, surface tension of melts, pressure, level, flow rate, composition and structure of the substance); on the control and measuring devices installed on the MP units. Methods for measuring electrical conductivity, vapor pressure of metals and their compounds are considered; methods for studying the equilibrium of chemical reactions in metallurgical systems. Along with the theoretical foundations of methods of analysis, a description of installations and devices used for research in laboratory and industrial conditions is given.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE

As a result of mastering the discipline, students should

1) know:

• methods for measuring technological variables of metallurgical processes;

• principles of operation and arrangement of technical means of control of the most important technological parameters of MP and metallurgical products;

2) be able to:

• to apply the methods of analysis of metallurgical processes and metallurgical products to the specific conditions of the practice of metallurgical plants and plants;

• use control and measuring equipment;

3) own skills:

• verification and recalibration of MP instrumentation;

• making management decisions in the analysis of small businesses and metallurgical products.

Refining in metallurgy of radioactive and precious metals
CODE – MET203
CREDIT – 3 (2/0/1)
PREQUISIT - Theory of metallurgical processes

PURPOSE AND OBJECTIVES OF THE COURSE

Purpose of the course: Formation of knowledge about theoretical laws and practice of refining methods in the production of radioactive and precious metals.

Course objectives:

• transfer basic theoretical knowledge of the course;
• help students acquire skills in performing practical work;
• to acquaint with the basic technological schemes of various methods of purification in the production of radioactive and noble metals, their principles and capabilities, prospects and limitations.

BRIEF DESCRIPTION OF THE COURSE

The course provides theoretical patterns and practice of the main processes of refining radioactive metals (uranium, thorium and plutonium), technology and instrumentation: precipitation and extraction methods of purification in uranium technology; uranium oxide refining; purification of thorium compounds (method of fractional neutralization, method of precipitation of hydrated thorium sulfate, method of oxalate purification and extraction purification); precipitation technology for the separation and purification of uranium and plutonium, extraction schemes for the separation and purification of uranium and plutonium with organic solvents; dry technology for separation and purification of uranium and plutonium. The course also studies the refining of noble metals: gold, silver (chlorine process, electrolysis refining, acid refining methods) and platinum group metals - processing of placer platinum, dissolving and finishing solutions, processing mother liquors, obtaining rhodium and iridium, osmium and ruthenium.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE

As a result of mastering the discipline, students should

1) know:

• principles of instrumental and technological design of the main and auxiliary technological processes and operations for the refining of radioactive and noble metals;

2) be able to:

• choose and justify the refining scheme for a specific radioactive or noble metal;
• compile material balances of refining apparatus;

3) own skills:

• comparative analysis of various methods of refining;
• application of refining methods in solving practical problems.

Master's thesis defense
CODE
CREDIT – 7

The purpose of the master's thesis is:
demonstration of the level of research qualifications of a master student, the ability to independently conduct scientific research, test the ability to solve technical, technical and practical problems, knowledge of the most common methods and techniques for their solution.

SHORT DESCRIPTION
A master's thesis is a final qualifying work, which is a generalization of the results of an independent study by a master student of one of the topical problems of a specific specialty of the corresponding branch of science, which has an internal unity and reflects the course and results of the development of the chosen topic.
Master's thesis is the result of the research / experimental research work of a master's student, carried out during the entire period of study of a master's student.
The defense of a master's thesis is the final stage of the master's preparation. A master's thesis must meet the following requirements:
- research should be carried out in the work or actual problems in the field of automation and digitalization of metallurgical processes should be solved;
- decisions must be scientifically grounded and reliable, have internal unity;
- the thesis should be written individually.

Content