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" (profile direction (1.5 years)

Master of engineering and technology in the educational program " 7M07208 - 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 training undergraduates: English (professional), project management (Management + Management Psychology), modern local automation and control systems, the use of mechatronic systems in production, technical thermodynamics, physicochemical and thermodynamic processes in metallurgy, powder metallurgy, processes and devices, technological measurements in continuous production, technical measuring instruments in discrete production, automation of technical systems, metallurgical units, calculations and structures, waste-free technologies, corrosion and protection of structures in the metallurgical industry, sustainable pyro- and hydrometallurgical technologies for the processing of mineral raw materials , refining in metallurgy of radioactive and precious metals, automated technological complexes of continuous production, robotic technological complexes in discrete production. Ability to choose disciplines from the catalog of elective disciplines of Satbayev University.

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 1.5 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: 1.5 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						
	LNG205	Foreign language (professional)	BD HC	5	3	0/0/3			Automation of technical systems	PD HC	5	3	1/1/1	
	MNG230	Project Management (Management + Management Psychology)	BD HC	3	2	1/0/1			Metallurgical units, calculations and structures	PD HC	5	3	2/0/1	
		Modern local automation and control systems	BD CC	4	2	1/0/1			Rational use of natural and technogenic raw materials	PD CC	5	3	2/1/0	
		Application of mechatronic systems in production							Corrosion and protection of structures in the metallurgical industry					
		Technical thermodynamics	BD CC	5	3	2/0/1			Fundamentals of Powder Metallurgy	PD CC	5	3	2/0/1	
		Physicochemical and thermodynamic processes in metallurgy							Technologies and equipment in uranium production				2/0/1	

		Fundamentals of pyro and hydrometallurgical processes	PD CC	5	3	2/1/0			Automated technological complexes of continuous production	PD CC	5	3	2/0/1	
		Processes and devices							Robotic technological complexes in discrete production					
		Process measurements in continuous production	PD CC	5	3	2/0/1		AAP207	Experimental research work of a master student	ER WM	6	4		
		Technical measuring instruments												
	AAP207	Experimental research work of a master student	ER WM	6	4									
		Total:		**33**	**20**				**Total:**		**31**	**19**		
2	**3 semester**													
	AAP207	Experimental research master's work	ER WM	6	4									
	AAP209	Internship	PD	1	6									
	ECA203	Registration and defense of a master's thesis (RaDMT)	FE	1	7									
		Total		**28**	**17**									
		Total		**92**	**56**									

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 – 3 (0/0/3)
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 message 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 various business situations using appropriate business vocabulary and grammatical structures - in pairs and groups discussions, meetings and negotiations.

Project Management (Management + Management Psychology)
CODE – MNG230
CREDIT – 2 (1/0/1)
PRE-REQUISIT –

PURPOSE AND OBJECTIVES OF THE COURSE
The aim of teaching the discipline "Project Management" is to master the methodology of project management in various fields of activity, to foster a culture adequate to modern project management and information technologies, to create conditions for the introduction of new information technologies in the implementation of projects. The course is based on international guidelines for project management (Project Management Body of Knowledge).

SHORT DESCRIPTION OF THE COURSE
The content of the discipline is aimed at studying modern concepts, methods, project management tools in order to apply them in further practical activities of a specialist to solve problems of planning and executing projects.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
Be able to: prepare documents for the initialization phase of a project, such as a feasibility study, project charter, etc .; develop and analyze documents related to the planning of project activities, apply various methods of decision support; promptly monitor the execution of work and track deadlines; select personnel, resolve contradictions between team members; manage the risks arising from the implementation of projects.
Knowledge gained during the course: Modern standards in the area of project management and their characteristics; PMI approach to project management; Investment planning; Accounting for project risks; Methods for optimizing the use of available resources; Ways to resolve conflict situations; Analysis of actual indicators for timely adjustment of work progress.
Skills: project management in accordance with modern project management requirements; apply in the process of project management software MS Project.

Modern local automation and control systemsCODE – AUT
CREDIT – 3 (1/1/1)
PRE-REQUISIT – AUT111

PURPOSE AND OBJECTIVES OF THE COURSE

The purpose of the discipline

Training of specialists who are proficient in the methods of modern theory of automatic control, capable of independently solving theoretical and applied problems for the creation of modern automatic control systems

Discipline objectives

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. The properties of linear and nonlinear systems and methods of their study are considered from a unified position of the state space method. Basic information about systems with variable structure, modal control, identification, adaptation and optimization in control systems is given.

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 ways of applying theoretical principles 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:

- carry out an analysis of control objects with the identification of the features necessary to determine the class of tasks to be solved and the choice of methods for managing it;
- to practically solve the problems of constructing algorithms for identification, adaptation and optimal control, depending on the changing parameters of the production process;
- to implement the assigned tasks in modern computer control systems in industry.

Application of mechatronic systems in production
CODE – AUT
CREDIT – 3 (2/0/1)
PRE-REQUISIT – AUT

PURPOSE AND OBJECTIVES OF THE COURSE
The purpose of the discipline
Training of highly qualified personnel who know the basics of the dynamics of the process of controlling robots in the robotization of production processes, in particular those who know mathematical methods for describing the kinematics of an industrial robot manipulator, methods of programmed control of robots, describing the dynamics of manipulation robots, methods and algorithms for controlling industrial robots.

Discipline objectives
Methods and algorithms for the matrix description of the kinematics of manipulation robots, the solution of direct and inverse kinematics problems, the synthesis of program trajectories by the degrees of mobility of the robot, the description of the dynamics of the robot's drive system, the description of the dynamics of the robot manipulator. Models and control algorithms for an industrial robot as part of robotic systems.

SHORT DESCRIPTION OF THE COURSE
The content of the discipline "Dynamics of Robot Control" includes the study of mathematical approaches of cyclic, positional and contour control of industrial robots, models and algorithms for kinematic and dynamic analysis of industrial robots, studies of the kinematics and dynamics of the manipulator and the drive system of an industrial robot.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of studying the discipline, you should know:
- mathematical models and methods of adaptive control according to the learning model;
- mathematical models and methods of adaptive control according to the reference model;
- mathematical methods and models of adaptive control with a self-adjusting controller;
- mathematical models and algorithms for choosing a model of a commercially available industrial robot when building robotic systems;
- mathematical models and algorithms for force-moment sensing of industrial robots;
- mathematical models and algorithms for the development of algorithms for adaptive control of an industrial robot as part of a robotic system.
As a result of studying the discipline should be able to:

- to analyze technological operations with the identification of parameters requiring adaptive approaches to the control of a robotic system;
- it is reasonable to choose the structure of the algorithm for adaptive control of the drives of the degrees of manipulator mobility, depending on the changing parameters of the production process;
- it is reasonable to choose the type of model and algorithm of force-moment sensing of industrial robots;
- to analyze the composition and structure of information-sensor systems to adapt the robot to the operating conditions.

Technical thermodynamics
CODE – MET
CREDIT – 3 (2/0/1)
PRE-REQUISIT – физика

PURPOSE AND OBJECTIVES OF THE COURSE
To give students knowledge about the basic laws of thermodynamics, considering the laws of the mutual transformation of heat into work and establishing the relationship between thermal, mechanical and chemical processes that take place in heat and refrigeration machines, studies the processes occurring in gases and vapors, and also the properties of these bodies under various physical conditions.
Course objectives:
• transfer basic theoretical knowledge of the course;
• help students gain the skills to perform practical thermodynamic calculations;

SHORT DESCRIPTION OF THE COURSE
Thermodynamic system, process and equilibrium. Ideal gases. Properties of ideal gases. Real gases. Properties of real gases. The first law of thermodynamics. Reversible and irreversible processes. Enthalpy. Heat capacity. Thermodynamic processes. The second law of thermodynamics. Carnot cycles. Carnot's theorem. Maximum work. Exergy. Water vapor. Basic concepts and definitions. Basic parameters and diagrams of water vapor. Thermodynamic processes of changes in the state of water vapor. Throttling of gases and vapors. Choke Van der Waals gas. Inversion curve. Gas mixing.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of mastering the discipline, students should
To complete the main tasks of the discipline is getting students
1) knowledge:
- about thermodynamic parameters of state and thermodynamic systems;
- about the basic laws of ideal and real gases, heat capacity of gases;
- about the first and second laws of thermodynamics;
2) skills:
- to analyze the basic laws of thermodynamics;
- determine thermodynamic processes;
- mastering the skills for solving problems, considering the laws of the mutual transformation of heat into work, as well as establishing the relationship between thermal, mechanical and chemical processes that occur in heat and refrigeration machines.

Physicochemical and thermodynamic processes in metallurgy
CODE – MET
CREDIT – 3 (2/0/1)
PRE-REQUISIT – физика, химия

PURPOSE AND OBJECTIVES OF THE COURSE
The objectives of teaching the discipline are the acquisition of knowledge by undergraduates about the theoretical foundations of metallurgical processes, performing thermodynamic calculations of metallurgical processes, predicting the indicators of certain specific processes of processing ore and technogenic raw materials, studying physical and chemical processes during the processing of various mineral raw materials.
Course objectives:
• transfer basic theoretical knowledge of the course;
• help students acquire skills in performing practical thermodynamic calculations, analyzing reaction mechanisms in metallurgical processes.

SHORT DESCRIPTION OF THE COURSE
Thermodynamic functions. The laws of chemical thermodynamics. Thermodynamic potentials. Standard free energy. Thermodynamics of solutions. Raoul's laws. Methods for determining thermodynamic quantities. Fundamentals of thermochemical calculations. Hess's law. Kirchhoff's equation. Thermodynamics of oxide systems. Thermodynamic analysis of Me-S-O systems. Thermodynamics of exchange hydrometallurgical reactions. Thermodynamics of oxidative hydrometallurgical reactions. Construction and analysis of “Potential-pH” diagrams. Thermodynamics of autoclave processes. Thermodynamics of sorption and extraction processes.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of mastering the discipline, students should to fulfill the main tasks of the discipline is getting students
- knowledge about the principles and possibilities of thermodynamic calculations of metallurgical processes;
- the ability to apply these methods in solving practical problems and to correctly choose and use one or another calculation method to solve specific problems.

Powder Metallurgy Basics
CODE – MET
CREDIT – 3 (2/0/1)
PRE-REQUISIT – Theory of metallurgical processes, Physical chemistry, Physics, disciplines on metal technology

PURPOSE AND OBJECTIVES OF THE COURSE
Purpose of the course: Formation of systematized knowledge, abilities and skills in methods of obtaining powder metals and alloys and application for obtaining products with special properties.
Course objectives:
• to transfer basic theoretical information on the course "Fundamentals of powder metallurgy" with the formation of an integral system of knowledge in this area;
• to form students' skills of analytical thinking on the choice of the method of obtaining powder metals and alloys.
SHORT DESCRIPTION COURSE
The course "Fundamentals of Powder Metallurgy" examines the basics of technology for producing powder metals and alloys. As part of the course, a special place is occupied by methods of studying the properties of powder metals and alloys, methods of quality control of the products obtained from them and the use of metal and alloy powders to obtain products with special properties from them.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of mastering the discipline, students should
1) know: the main methods and features of the technology for producing powder metals and alloys; main types of equipment for the production of powder metals and alloys; information on the properties of powder metals and alloys and methods of quality control of the resulting products;
2) be able to: solve technological and thermodynamic problems by methods of obtaining powder metals and alloys; substantiate the choice and efficiency of the technological scheme for obtaining a specific powder metal or alloy; 3) possess the skills: comparative analysis of methods for obtaining powder metals and alloys; analysis of the reasons for possible defects in the production of powder metals and alloys, as well as the development of ways to prevent it during the technological process.

Processes and devices
CODE –
CREDIT – 3 (2/0/1)
PRE-REQUISIT –

PURPOSE AND OBJECTIVES OF THE COURSE
The purpose of the course: the acquisition of knowledge by students in the field of mechanical, hydromechanical, thermal, refrigeration and mass transfer processes and familiarization with the designs of technological devices and equipment ...
Course objectives:
• transfer basic theoretical knowledge of the course;
• help students acquire skills in performing practical work;
• familiarize with basic technological schemes, principles of equipment operation, methods of calculation and selection of technological parameters, areas of application of basic technological processes and equipment.
SHORT DESCRIPTION OF THE COURSE
The course studies mechanical, hydromechanical, thermal and mass transfer processes; presents the design and calculation of technological devices and equipment (pumps, compressors, filters, sedimentation tanks and thickeners, centrifuges, hydrocyclones; heat exchangers, evaporators apparatus, condensers, refrigeration units; crushers, mills, screens, classificators, batchers, mixers; extractors, rectification columns, adsorbers, absorbers, dryers, crystallizers). An analysis is given of the techno-logical processes associated with the transfer of mass and heat in technological systems
.
KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of mastering the discipline, students should
1) know:
• principles of hardware and technological design of basic and auxiliary technological processes and operations for obtaining technological materials;
2) be able to:
• analyze technological processes associated with the transfer of mass and heat in technological systems, including those involving moving phases;
• compile heat and material balances of technological units and calculate their basic dimensions;
3) own skills:
• methods of calculation and selection of technological parameters,
• comparative analysis of the main technological processes and equipment.

Process measurements in continuous production
CODE – AUT
CREDIT – 3 (1/1/1)
PRE-REQUISIT –

PURPOSE AND OBJECTIVES OF THE COURSE
The purpose of teaching the discipline is to teach students how to carry out measurements, control, diagnostics and other types of experiments with controlled accuracy, taking into account the requirements of metrology and standardization, and interpreting the results of the experiment..

SHORT DESCRIPTION OF THE COURSE
The basic component of all automated control systems for technological processes (APCS) is a system for automatic monitoring of the state of a production facility, which makes it possible to obtain measurement information about the values of the operating process variables - temperature, level and pressure of the medium in the unit, degree of loading, costs and compositions of raw products, etc. The classification of conversion methods and converters non-electrical and into electrical, specific types of measuring instruments used to measure technological parameters in various areas of production. The main characteristics of the measuring transducers are given, which determine their area of application, the conversion functions, and the conversion error is estimated.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
The tasks are to master the principles of operation, the main characteristics of measuring instruments, develop the ability to choose the right method and means for measuring physical quantities, assess the measurement errors, and process the measurement results.
As a result of studying the discipline, students should know:
- basics of metrology and classification of measuring instruments;
- basic methods of measuring technological variables;
- the principle of operation and the device for measuring technological variables;
- comparative characteristics of various measuring instruments;
- be able to choose measuring instruments necessary for information support of automation systems

Technical measuring instruments in discrete production
CODE – AUT
CREDIT – 3 (1/1/1)
PRE-REQUISIT –

PURPOSE AND OBJECTIVES OF THE COURSE
The purpose of teaching the discipline is to teach students how to carry out measurements, control, diagnostics and other types of experiments with controlled accuracy, taking into account the requirements of metrology and standardization, and interpreting the results of the experiment..

SHORT DESCRIPTION OF THE COURSE
The basic component of all automated control systems for technological processes (APCS) is a system for automatic monitoring of the state of a production facility, which makes it possible to obtain measurement information about the values of the operating process variables - temperature, level and pressure of the medium in the unit, degree of loading, costs and compositions of raw products, etc. The classification of conversion methods and converters non-electrical and into electrical, specific types of measuring instruments used to measure technological parameters in various areas of production. The main characteristics of the measuring transducers are given, which determine their area of application, the conversion functions, and the conversion error is estimated.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
The tasks are to master the principles of operation, the main characteristics of measuring instruments, develop the ability to choose the right method and means for measuring physical quantities, assess the measurement errors, and process the measurement results.

As a result of studying the discipline, students should know:
- basics of metrology and classification of measuring instruments;
- basic methods of measuring technological variables;
- the principle of operation and the device for measuring technological variables;
- comparative characteristics of various measuring instruments;
- be able to choose measuring instruments necessary for information support of automation systems

Metallurgical units, calculations and structures
CODE – MET
CREDIT – 3 (2/0/1)
PRE-REQUISIT – физика

PURPOSE AND OBJECTIVES OF THE COURSE
The purpose of the discipline is to form students' systematic knowledge about the classification and general characteristics of the operation of furnaces, metallurgical units, furnace construction, the course program provides for the study of elements and structures of a number of furnaces used in nonferrous and ferrous metallurgy.
The objectives of the course are: the acquisition by students of knowledge about the theory of metallurgical furnaces and practical calculations of thermal units, a positive result of trainings on 3D atlases of furnaces.

SHORT DESCRIPTION OF THE COURSE
Classification of furnaces and operating modes. Heat engineering characteristics of the furnaces. Heat balance and fuel consumption. Refractory and heat-insulating materials, furnace building elements. Thermal insulation materials. Furnace building elements and materials. Utilization of secondary energy resources. Thermal engineering bases of various methods of waste gas heat recovery. Metallurgical furnaces. Fuel furnaces for ferrous metallurgy. Fuel furnaces for non-ferrous metallurgy. Ferrous metallurgy furnaces with heat generation due to the burnout of metal impurities. Non-ferrous metallurgy furnaces with full or partial use of the chemical energy of raw materials. Thermal and temperature modes of operation of the furnace for roasting sulphide concentrates in a fluidized bed. Thermal and temperature modes of operation of matte melting furnaces (autogenous processes). Electric ovens. Special ovens. Titanium furnaces.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of mastering the discipline, students must:
know: about the types of fuel and its combustion; on the classification of furnaces and modes of their operation; about the heat work of the furnaces; about materials and elements of furnaces;
be able to: classify furnaces by technological and design features; perform material and heat balances; calculate the furnace.
have skills: in the basics of oven theory; on the calculations of furnaces and graphic design of the corresponding calculations using the AutoCAD program, the use of 3D atlases of metallurgical furnaces.
have competencies: by choosing a heating unit; on the choice of materials for the construction of furnaces.

Rational use of natural and technogenic raw materials
CODE – MET
CREDIT – 3 (2/1/0)
PRE-REQUISIT – химия

PURPOSE AND OBJECTIVES OF THE COURSE
The purpose of the discipline is to contribute to the formation of a unified view of ensuring the basic laws of the rational interaction of society and nature, to promote understanding of the principles of the "Green Economy".

SHORT DESCRIPTION OF THE COURSE
Classification of mineral raw materials. Rational use of natural and technogenic raw materials. Waste-free technologies in metallurgy. Recycling and disposal of metallurgical waste. Greening technologies and waste-free production. Metallurgical technologies aimed at greening production. Recycling and disposal of industrial waste. Rationing of waste generation and limits for their disposal. Requirements for waste disposal facilities. Transportation of hazardous waste. Transboundary movement of waste.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of mastering the discipline, students must:
know: characteristics of raw materials and principles of its integrated use; physical and chemical foundations of raw materials processing in order to obtain marketable products.
be able to: apply the knowledge gained: to assess the impact of production on the components of the biosphere, on the disposal facilities of metallurgical waste; to address issues of limiting anthropogenic impact on the environment; to address issues of rational use of natural resources.

Corrosion and protection of structures in the metallurgical industry
CODE –
CREDIT – 3 (2/1/0)
PRE-REQUISIT –

PURPOSE AND OBJECTIVES OF THE COURSE
Purpose of the course: to teach informed choice, engineering assessment, application of methods of corrosion protection at the stage of design, manufacture and operation of structures in technological conditions.
Course objectives:
• transfer basic theoretical knowledge of the course;
• help students gain skills in laboratory work;
• teach to predict the corrosion resistance of metal structures in gas and liquid environments.
SHORT DESCRIPTION OF THE COURSE
The course provides theoretical laws and practice of chemical and electrochemical corrosion in relation to metal structures, taking into account: the fusion of cross-sections of various structures, streamlining, general layout and arrangement of structural elements. The article describes the effect of the structural form of elements on corrosion. Methods of application and installation of heat-shielding and insulating materials and other methods of corrosion protection, as well as examples of successful and unsuccessful design solutions are given.
KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of mastering the discipline, students should
1) know:
• basic laws and concepts of chemical and electrochemical corrosion;
• thermodynamics and kinetics of corrosion processes;
• basic methods of protection of metal structures from chemical and electrochemical corrosion;
2) be able to:
• to determine and calculate the probability and mechanism, the rate of corrosion of structures and metals in gaseous, liquid technological environments, to establish the influence of internal and external factors on it
• to evaluate the corrosion resistance of metallurgical structures by indicators and points;
3) own skills:
• the choice of the method of protection against corrosion, depending on the operating conditions and the purpose of the metal and structure;
• consideration of corrosion factors in the design of industrial metal structures

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

PURPOSE AND OBJECTIVES OF THE COURSE
The aim of the course is to form students' systematic knowledge of 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".
SHORT DESCRIPTION OF THE COURSE
Sustainable pyrometallurgical technologies for processing mineral raw materials: energy saving in pyroprocesses, exothermic processes: suspended smelting for matte production, matte refining and converting processes to obtain blister copper, metallothermic 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

Refining in metallurgy of radioactive and precious metals
CODE – MET203
CREDIT – 3 (2/0/1)
PRE-REQUISIT – Теория металлургических процессов

PURPOSE AND OBJECTIVES OF THE COURSE
Purpose of the course: Formation of knowledge about the theoretical laws and practice of refining methods in the production of radioactive and noble metals.
Course objectives:
• help students acquire skills in performing practical work;
• to acquaint with the basic technological schemes of various purification methods in the production of radioactive and noble metals, their principles and capabilities, prospects and limitations.
SHORT 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

Automated technological complexes of continuous production
CODE – AUT
CREDIT – 3 (2/0/1)
PRE-REQUISIT – 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.
SHORT 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.

Robotic technological complexes in discrete production
CODE – AUT
CREDIT – 3 (2/0/1)
PRE-REQUISIT – AUT

PURPOSE AND OBJECTIVES OF THE COURSE
The 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 programmed control of robots, systems for numerical programmed control of machines and machines.
Discipline objectives
Methods for developing algorithms and cyclograms for controlling robots as part of a robotic system, developing cyclic, positional and contour systems for programmed control of robots, systems for numerical programmed control of machines, machines.
SHORT DESCRIPTION OF THE COURSE
The content of the discipline "Systems of numerical control of robots" includes the study of mathematical methods of programmed control of robots, the foundations of the development of algorithms and cyclograms of control of robots. The structure, composition and purpose of elements of cyclic, positional and contour systems of programmed control of robots, systems of numerical programmed control of machine tools, machines are considered.
KNOWLEDGE, ABILITY, SKILLS TO COMPLETE 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; cycle, positional and contour systems for programmed control of robots; architecture of software control systems for machine tools, machines and robots; electroautomatics of software control systems; fundamentals of programming machine tools with numerical control.
As a result of studying the discipline should be able to:
- analyze robotization objects to select the required programmed control system for robots and technological equipment;
- analyze the operation of electrical automation systems and form the required connections with the robot's programmed control system and technological equipment; - to assess the quality of control of the programmed control system for robots and production processes;
- to program systems for numerical control of robots and production processes.

Automation of technical systems
CODE – AUT
CREDIT – 3 (1/1/1)
PRE-REQUISIT – AUT243

PURPOSE AND OBJECTIVES OF THE COURSE

The purpose of the discipline is to train specialists who are able to quickly master modern information technologies and apply them to solve problems arising in the practice of developing and implementing design and technological projects at mechanical engineering enterprises.
The objectives of the course are to study the basic principles of building the architecture of automated systems for technological preparation of production (ASTPP), taking into account the development trends of modern industrial production and new information technologies.

SHORT DESCRIPTION OF THE COURSE
The methodological foundations of the construction of automated systems for technological preparation of production (ASTPP) are considered. The basic principles of building the architecture of the AMTPP are formulated, taking into account the development trends of modern industrial production and new information technologies intended for its automation. CAD and its structure. Introduction. General concepts of design. Structural CAD model. CAD subsystems. Types of collateral. Approaches to design. Organization of the design process. Systematic approach to design. Ways to reduce the design time for a complex technical system. Information Support. Mathematical software. CALS - technologies. Definition and purpose of CAD / CAE / CAM systems. CAD / CAE / CAM system levels. Modularity of CAD / CAE / CAM systems. Integration in CAD / CAE / CAM systems.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
Knowledge gained during the course:
- advanced domestic and foreign experience in the field of creating complex automated systems
-methodology, IPI / CALS standards, technical requirements for the product lifecycle support system
- the basic principles of building the architecture of ASTPP
-methods for constructing an object-oriented model of the CCI and its implementation by means of a PDM system
Skills and skills (professional, managerial, communicative) obtained during the course:
-create 3D models of parts, perform operational sketches for individual technological operations

-in an automated mode, create and issue sets of technological documentation
-in the environment of CAM systems to compose and execute control programs for CNC machines

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's 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 research by a master's student of one of the urgent problems of a particular 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 the master's student, carried out during the entire period of study of the 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 urgent 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	