Institute of Automation and Information Technology
Department of Higher Mathematics and Modeling

EDUCATIONAL PROGRAM

7M06105 - CYBERNETICS AND ARTIFICIAL INTELLIGENCE

(specialized direction – 2 years)

Code and Classification of Education Area: 7M06
Information and Communication Technology
Code and classification of areas of training: 7M061
Information and Communication Technologies
Group of educational programs: M094
Information Technology
NRC level: 7M
OPC level: 7
Study period: 2 years
Credit volume: 120

Almaty 2024

Educational program 7M06105 – «Cybernetics and Artificial Intelligence» approved at the meeting of the Academic Council of KazNRTU named after K.I. Satpayev.
Protocol No.12 of "22" April 2024 year.

Considered and recommended for approval at the meeting of the Educational-Methodical Council of KazNRTU named after K.I. Satpayev.
Protocol No. 6 of "19" April 2024 year.

Educational program 7M06105 – «Cybernetics and Artificial Intelligence» developed by the academic committee for the direction 7M061 "Information and communication technologies".

Name and surname.	Degree Academic title	Position	Place of work	Sign
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List of abbreviations and designations

EP - educational program,
LO - learning outcomes,
DG - Digital modeling,
IEP - individual educational plan

1. Description of the educational program

The educational program (EP) of higher professional education ensures the implementation of the state educational standard, taking into account the type of higher educational institution, educational needs and requests of students and includes a working curriculum, syllabuses (working programs of training courses), disciplines (modules) and other materials that ensure the quality of training of students.

The main idea of the educational program is to implement a continuous process of training a new generation of professional personnel capable of working to transform the new scientific potential of Kazakhstan from raw materials to innovation through the development and implementation of sustainable trends in the field of digital service and operational services.

The uniqueness of the EP "Cybernetics and Artificial Intelligence" is determined by the competencies that a master's student who has completed his education under this program possesses.

2. Goal and objectives of the educational program

Purpose of the EP: The goal of the educational program is to teach master's students basic and specialized disciplines with the achievement of relevant competencies. The goal of the educational program is the targeted training of specialists with valuable knowledge of the technologies of the future - artificial intelligence technologies, which will distinguish them favorably in the international IT services market. They will study the main methods of artificial intelligence using simple, "tangible" examples and show the mathematical basis of machine learning and artificial intelligence. The main task of this area is to model intellectual activity using computers.

Upon completion of the course, graduates will learn working machine learning algorithms to apply them to their tasks (theoretical or applied). The educational program involves mastering fundamental knowledge in mathematics and artificial intelligence. Graduates will have the opportunity to master almost all the skills necessary in the field of Data Science, Data Engineering, Quantitative Analysis (in Python and R languages).

The special feature of this master's program is the preparation of graduates capable of carrying out the following types of professional activities:

- production;
- organizational and managerial;
- production and technological.

Objects of professional activity.

Graduates of the program can realize themselves in the following types of professional activity:

secondary specialized educational institutions;

manufacturing enterprises;

professional activity in the field of computer programming; - specialist, leading specialist, leading engineer, programmer engineer in organizational and managerial organizations;

in design organizations as a developer of mathematical and computer models, mathematician-programmer;

Tasks of the OP:

Task 1: Study of the basics of constructing artificial intelligence systems, the features of their organization, functioning, life cycle, directions of development of artificial intelligence, development of students' competencies in designing and using modern intelligent systems in professional activities.

Task 2: Training highly qualified personnel capable of developing both computer and mathematical models for various applications in the context of the formation and development of the digital economy.

Task 3: Readiness of specialists to search for and obtain new information necessary for solving professional problems in the field of cybernetics and artificial intelligence.

Task 4: Prepare a product of human intellectual activity, study its structure, and strive to reproduce this product using modern technology.

Task 5: Readiness of specialists for self-training and continuous professional development throughout the entire period of their professional activity.

3. Requirements for assessing the learning outcomes of the educational program

List of competencies
General competencies

A graduate who has completed a Master's degree program must have the following general professional competencies:

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

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

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

– the ability to professionally select and creatively use modern scientific and technical equipment to solve scientific and practical problems;

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

– skills in compiling and formatting scientific and technical documentation, scientific reports, reviews, reports and articles; – readiness to lead a team in the field of their professional activity, tolerantly perceiving social, ethnic,

religious and cultural differences; – readiness to communicate orally and in writing in a foreign language to solve professional problems.

Professional competencies

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

– production activity:

– the ability to independently carry out production, field, laboratory and interpretation work in solving practical problems; – the ability to professionally operate modern field and laboratory equipment and devices in the field of the master's program;

– the ability to use modern methods of processing and interpreting complex information to solve production problems; – project activities: – the ability to independently draw up and present projects for research and development and scientific production work;

– readiness to design complex research and development and production work when solving professional problems; – organizational and managerial activities: – readiness to use practical skills in organizing and managing research and development and production work when solving professional problems;

- readiness for the practical use of regulatory documents in planning and organizing scientific and production work;

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

Learning outcomes

LO 1 - to know and understand modern trends, directions and patterns of development of domestic science in the context of globalization and internationalization; methodology of scientific knowledge; achievements of world and Kazakhstani science in the relevant field; (to recognize and accept) the social responsibility of science and education; to be proficient in a foreign language for scientific communication and international cooperation;
LO 2 - be able to organize, plan and implement the process of scientific research; analyze, evaluate and compare various theoretical concepts in the field of research and draw conclusions; analyze and process information from various sources;
LO 3 - be able to conduct independent scientific research, characterized by academic integrity, based on modern theories and methods of analysis; generate their own new scientific ideas, communicate their knowledge and ideas to the scientific community, expanding the boundaries of scientific knowledge;
LO 4 - have skills in critical analysis, evaluation and comparison of various scientific theories and ideas; analytical and experimental scientific activity; planning and forecasting research results; oratory and public speaking at international scientific forums, conferences and seminars; scientific writing and

scientific communication; planning, coordination and implementation of scientific research processes;
LO 5 - have skills in systematic understanding of the field of study and demonstrate the quality and effectiveness of the selected scientific methods; participation in scientific events, fundamental scientific domestic and international projects; leadership management and team management; responsible and creative attitude to scientific and scientific-pedagogical activities;
LO 6 - be competent in the field of scientific and scientific-pedagogical activity in the conditions of rapid renewal and growth of information flows; in conducting theoretical and experimental scientific research; in setting and solving theoretical and applied problems in scientific research; in conducting professional and comprehensive analysis of problems in the relevant field.
LO 7 - be competent in matters of interpersonal communication and human resource management; in matters of university training of specialists; in conducting examinations of scientific projects and research; in ensuring continuous professional growth;
LO 8 - Know the formulation of problems of classification, clustering, forecasting, know the algorithms and methods of deep learning;
LO 9 - be able to work with architectures that include open deep learning libraries, draw correct conclusions from comparing the results of theory and experiment, identify practical problems for machine learning, and work with modern software packages for solving machine learning problems;
LO 10 - Be able to apply technologies for intelligent analysis of electronic data arrays to solve specific practical problems;
LO 11 - know the features of the architecture of graphic processors, the principles of organizing hybrid computing systems based on graphic processors, and classes of tasks suitable for efficient execution on graphic processors;
LO 12- be able to analyze the efficiency of task execution on a graphics processor and hybrid computing systems based on graphics processors, and perform program profiling;
LO 13- know the concept of stochastic analysis of systems and methods of stochastic modeling, the application of stochastic analysis in the development of mathematical models and the study of various systems and processes;
LO 14 - be able to develop mathematical models and apply them in scientific experiments using modern software, conduct theoretical and experimental studies of stochastic processes and systems;
LO 15- to master the methods of numerical stochastic modeling for conducting theoretical and experimental research, knowledge of stochastic analysis for evaluating the obtained research results;
LO 16- possess professional knowledge for the analysis and synthesis of physical information in the field of quantum computing, basic quantum algorithms, capabilities, methods and systems of computer technologies for physical theoretical and experimental research in this field, basic physical platforms for the implementation of quantum computing.

Learning strategy

The strategy of the educational program "Cybernetics and Artificial Intelligence" is aimed at training highly qualified specialists with fundamental knowledge in the fields of natural science,

engineering mechanics and computer modeling for work in the field of high technologies, taking into account modern trends in the development of science in general and mathematical modeling in particular. During the training, special attention is paid to mastering by master's students:

demonstrate developing knowledge and understanding in the area of cybernetics and artificial intelligence studied, based on advanced knowledge in that area, in developing and/or applying ideas in the context of research;

apply knowledge, understanding and abilities professionally to solve problems in a new environment, in a broader interdisciplinary context;

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

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

learning skills necessary for independent further study in the studied area of cybernetics of artificial intelligence.

To achieve these goals, the structure of classes in almost all specialized disciplines includes both laboratory and practical classes, i.e. students’ theoretical knowledge is firmly reinforced by the skills of their practical application.

During the course of graduates' dissertations under the educational program, the main focus is on instilling in graduates the skills to independently or in a team develop physical or virtual models of complex mechanical, physical and biochemical processes and phenomena, create computer codes or apply modern software for their research.

Possession of fundamental knowledge in various fields and computer modeling skills will allow graduates to relatively easily integrate into the work process of almost any industry and quickly master a wide range of new technologies.

4. Passport of the educational program

4.1 General information

№	Field name	Note
1	Code and classification of the field of education	7M06 Information and Communication Technology
2	Code and classification of training areas	7M061 Information and Communication Technology
3	Group of educational programs	M094 Information Technology
4	Name of educational program	7M06105- Cybernetics and Artificial Intelligence
5	Brief description of the educational program	The educational program (EP) of higher professional education ensures the implementation of the state educational standard, taking into account the type of higher educational institution, educational needs and requests of students and includes a working curriculum, syllabuses (working programs of training courses), disciplines (modules) and other materials that ensure the quality of training of students. The main idea of the educational program is to implement a continuous process of training a new generation of professional personnel capable of working to transform the new scientific potential of Kazakhstan from raw materials to innovation through the development and implementation of sustainable trends in the field of digital service and operational services. The uniqueness of the EP "Cybernetics and Artificial Intelligence" is determined by the competencies that a master's student who has completed his education under this program possesses.
6	Purpose of the EP	Purpose of the EP: The goal of the educational program is to teach master's students basic and specialized disciplines with the achievement of relevant competencies. The goal of the educational program is the targeted training of specialists with valuable knowledge of the technologies of the future - artificial intelligence technologies, which will distinguish them favorably in the international IT services market. They will study the main methods of artificial intelligence using simple, "tangible" examples and show the mathematical basis of machine learning and artificial intelligence. The main task of this area is to model intellectual activity using computers. Upon completion of the course, graduates will learn working machine learning algorithms to apply them to their tasks (theoretical or applied). The educational program involves mastering fundamental knowledge in mathematics and artificial

		intelligence. Graduates will have the opportunity to master almost all the skills necessary in the field of Data Science, Data Engineering, Quantitative Analysis (in Python and R languages).
7	Type of EP	Master's Degree
8	NRC level	7M
9	Level on OCR	7
10	Distinctive features of the EP	The peculiarity of this master's program is the preparation of graduates capable of carrying out the following types of professional activity: - production; - organizational and managerial; - production and technological.
11	List of competencies of the educational program:	General competencies A graduate who has completed a Master's degree program must have the following general professional competencies: - the ability to independently acquire, comprehend, structure and use new knowledge and skills in professional activities, and develop their innovative abilities; – the ability to independently formulate research goals, establish a sequence for solving professional problems; – the ability to apply in practice knowledge of fundamental and applied sections of disciplines that determine the focus (profile) of the master's program; – the ability to professionally select and creatively use modern scientific and technical equipment to solve scientific and practical problems; – the ability to critically analyze, present, defend, discuss and disseminate the results of their professional activities; – skills in compiling and formatting scientific and technical documentation, scientific reports, reviews, reports and articles; – readiness to lead a team in the field of their professional activity, tolerantly perceiving social, ethnic, religious and cultural differences; – readiness to communicate orally and in writing in a foreign language to solve professional problems. Professional competencies A graduate who has completed a master's degree program must have professional competencies corresponding to the types of professional activity that the master's degree program is focused on: – production activity: – the ability to independently carry out production, field, laboratory and interpretation work in solving practical problems; – the ability to professionally operate modern field and laboratory equipment and devices in the field of the master's program;

		– the ability to use modern methods of processing and interpreting complex information to solve production problems; – project activities: – the ability to independently draw up and present projects for research and development and scientific production work; – readiness to design complex research and development and production work when solving professional problems; – organizational and managerial activities: – readiness to use practical skills in organizing and managing research and development and production work when solving professional problems; - readiness for the practical use of regulatory documents in planning and organizing scientific and production work; When developing a master's program, all general cultural and general professional competencies, as well as professional competencies related to the types of professional activity that the master's program is focused on, are included in the set of required results for mastering the master's program.
12	Learning outcomes of the educational program:	LO 1 - to know and understand modern trends, directions and patterns of development of domestic science in the context of globalization and internationalization; methodology of scientific knowledge; achievements of world and Kazakhstani science in the relevant field; (to recognize and accept) the social responsibility of science and education; to be proficient in a foreign language for scientific communication and international cooperation; LO 2 - be able to organize, plan and implement the process of scientific research; analyze, evaluate and compare various theoretical concepts in the field of research and draw conclusions; analyze and process information from various sources; LO 3 - be able to conduct independent scientific research, characterized by academic integrity, based on modern theories and methods of analysis; generate their own new scientific ideas, communicate their knowledge and ideas to the scientific community, expanding the boundaries of scientific knowledge; LO 4 - have skills in critical analysis, evaluation and comparison of various scientific theories and ideas; analytical and experimental scientific activity; planning and forecasting research results; oratory and public speaking at international scientific forums, conferences and seminars; scientific writing and scientific communication; planning, coordination and implementation of scientific research processes; LO 5 - have skills in systematic understanding of the field of study and demonstrate the quality and effectiveness of the selected scientific methods; participation in scientific events, fundamental scientific domestic and international projects; leadership management and team management; responsible and creative attitude to scientific and scientific-pedagogical activities; LO 6 - be competent in the field of scientific and scientific-pedagogical activity in the conditions of rapid renewal and

		growth of information flows; in conducting theoretical and experimental scientific research; in setting and solving theoretical and applied problems in scientific research; in conducting professional and comprehensive analysis of problems in the relevant field. LO 7 - be competent in matters of interpersonal communication and human resource management; in matters of university training of specialists; in conducting examinations of scientific projects and research; in ensuring continuous professional growth; LO 8 - Know the formulation of problems of classification, clustering, forecasting, know the algorithms and methods of deep learning; LO 9 - be able to work with architectures that include open deep learning libraries, draw correct conclusions from comparing the results of theory and experiment, identify practical problems for machine learning, and work with modern software packages for solving machine learning problems; LO 10 - Be able to apply technologies for intelligent analysis of electronic data arrays to solve specific practical problems; LO 11 - know the features of the architecture of graphic processors, the principles of organizing hybrid computing systems based on graphic processors, and classes of tasks suitable for efficient execution on graphic processors; LO 12- be able to analyze the efficiency of task execution on a graphics processor and hybrid computing systems based on graphics processors, and perform program profiling; LO 13- know the concept of stochastic analysis of systems and methods of stochastic modeling, the application of stochastic analysis in the development of mathematical models and the study of various systems and processes; LO 14 - be able to develop mathematical models and apply them in scientific experiments using modern software, conduct theoretical and experimental studies of stochastic processes and systems; LO 15- to master the methods of numerical stochastic modeling for conducting theoretical and experimental research, knowledge of stochastic analysis for evaluating the obtained research results; LO 16- possess professional knowledge for the analysis and synthesis of physical information in the field of quantum computing, basic quantum algorithms, capabilities, methods and systems of computer technologies for physical theoretical and experimental research in this field, basic physical platforms for the implementation of quantum computing.
13	Form of training	Full-time
14	Duration of training	2 years

15	Volume of credits	120
16	Languages of instruction	Kazakh, Russian, English
17	Academic degree	Master of Engineering and Technology
18	Developer(s) and authors:	Lukpanova L.H., Tulesheva G.A.

4.2 Interrelation of achievability of the learning outcomes of the educational program and academic disciplines

№	Name of discipline	Brief description of the discipline	Number of credits	Formable learning outcomes (codes)									
				LO1	LO2	LO3	LO4	LO5	LO6	LO7	LO8	LO9	LO10
Cycle of basic disciplines The university component													
1	Foreign language (professional)	Purpose: The course is designed for master's students of technical specialties to improve and develop foreign language communication skills in the professional and academic sphere. Contents: The course introduces students to the general principles of professional and academic intercultural oral and written communication using modern pedagogical technologies (round table, debates, discussions, analysis of professionally oriented cases, design).	5							V			

2	History and philosophy of science	Purpose: Subject of philosophy of science, dynamics of science, specifics of science, science and pre-science, antiquity and the formation of theoretical science. Contents: main stages of the historical development of science, features of classical science, non-classical and post-non-classical science, philosophy of mathematics, physics, engineering and technology, specifics of engineering sciences, ethics of science , social and moral responsibility of a scientist and engineer.	3								v		
3	Higher education pedagogy	Purpose: As part of the course, master's students will master the methodological and theoretical foundations of higher education pedagogy, learn to use modern pedagogical technologies, plan and organize teaching and educational processes. Contents: master communicative technologies of subject-subject interaction between a teacher and a master's student in the educational process of the university. Master's students will also study human resource management in educational	3								v		

		organizations (using the example of higher education).											
4	Psychology of management	Purpose: The discipline studies the modern role and content of psychological aspects in management activities. Contents: The improvement of the student's psychological literacy in the process of implementing professional activities is considered. Self-improves in the field of psychology and studies the composition and structure of management activities, both at the local level and abroad. The psychological peculiarities of modern managers are considered.	3								**v**		
Cycle of basic disciplines Optional component													

5	Data Mining	Purpose: study of modern methods and algorithms for visualization, systematization, research, analysis and forecasting of high-dimensional data, basic methods and algorithms of Data Mining and their comparative analysis. Contents: Development of practical skills in using basic methods and algorithms for data mining; ability to apply technologies for intelligent analysis of electronic data arrays to solve specific practical problems.	5		v							
6	Artificial neural networks	Purpose: The goal of mastering the discipline is to develop in students in the field of system analysis and management theoretical knowledge and practical skills in the use of neural networks to solve problems of classification, forecasting and management of objects of professional activity. Contents: Discusses the history of the development of artificial neural networks; main directions of use of artificial neural networks; types of neural networks.	5								v	

7	Quantum computing	Purpose: developing theoretical knowledge among undergraduates on the basic concepts and methods of the theory of quantum computing; development of skills and practical skills in constructing and analyzing quantum circuits, calculating probabilities in quantum measurements; study of quantum algorithms and quantum information protocols. Contents: The course examines the basic principles of the classical theory of computational complexity, the gate model of quantum computing, quantum computing algorithms based on the quantum Fourier transform.	5				**v**						
8	Machine learning methods	Purpose: to develop theoretical knowledge on the basics of machine learning for constructing formal mathematical models and interpreting modeling results; develop skills in the practical application of machine learning methods for constructing formal mathematical models and interpreting modeling results when solving applied problems in various applied areas.	5						**v**				

		Contents: Machine learning methods are a broad subsection of artificial intelligence that studies methods for constructing algorithms that can learn.											
9	Machine learning theory	Purpose: to create intelligent control systems, pattern recognition, forecasting in all spheres of human activity. Contents: In the course, students are introduced to the basics of machine learning: setting a learning problem, preparing data, principles of learning and decision-making, approaches to organizing training and validating results, methods and algorithms for classification and clustering of data. The theoretical foundations of machine learning are reinforced in practical classes and used during independent research.	5	v									

10	Python for deep machine learning	Purpose: The goals of mastering the discipline are to familiarize themselves with modern approaches to the construction, training and use of recognition and classification systems based on machine learning methods and to develop professional competencies among undergraduates. Contents: The content of the discipline is aimed at mastering algorithms and methods of deep learning - a special section in machine learning; developing skills and abilities in solving practical problems using deep learning methods.	5			v							
Cycle of major disciplines Higher education component													
11	Additional questions of the theory of stochastic processes	Purpose: The purpose of the study: to develop masters' theoretical knowledge and practical skills on stochastic differential systems and methods for their modeling, as well as the application of this knowledge in solving problems in research and production processes. Contents: At the end of the course, the student must know	5					v					

		the methods of stochastic modeling, be able to apply stochastic analysis in the development of mathematical models, and the study of systems and processes.											
12	Interfaces for multi-core systems	Purpose: to develop masters' theoretical knowledge and practical skills in the use of modern computing systems and software to solve a wide range of problems in various fields. Contents: The course examines the architecture features of GPUs, the principles of organizing hybrid computing systems based on GPUs, and classes of tasks suitable for efficient execution on GPUs.	5					v					
13	Mathematical statistics and stochastic processes	Purpose: The course studies the patterns of random phenomena, a probabilistic approach to constructing mathematical models of real events and processes in various classes of random functions, formulation and solution of emerging mathematical problems. Contents: The formal mathematical apparatus of the theory of probability and random processes, the possibility of its	5										v

		use in the process of further education, the application of methods of the theory of probability and stochastic processes for the analysis of problems in various subject areas are also considered.											
14	Parallel Computing	Purpose: The purpose of the course is to acquire knowledge and skills in the basics of parallel programming and parallel data processing using computer tools. Contents: teach methods of parallel information processing and presentation of parallel algorithms; familiarizing students with computer architecture; to form means of specification of parallel processes; teach parallel programming languages; master methods of automatic parallelization of sequential algorithms.	5						**v**				

15	Applied Information Theory	Purpose: Purpose of mastering: developing ideas about information theory as a universal language of science, a means of modeling phenomena and processes, ideas and methods of coding and cryptography Contents: development of logical thinking, spatial imagination, algorithmic culture, critical thinking at the level necessary for future professional activity, for continuing education and self-education; mastery of theoretical knowledge and skills necessary in everyday life for the study of related disciplines of the professional cycle.	5	v									
Cycle of core disciplines Optional component													

16	Modern issues in the theory of partial differential equations	Purpose: Purpose of development: to study modern methods for constructing and analyzing mathematical models that arise when solving natural science problems, as well as modern methods for developing and implementing algorithms for solving them. Contents: The course examines the equations of transport, heat, waves, Laplace and their fundamental solutions, energy methods; nonlinear PDE of the first order; theory for linear PDEs; second order elliptic equations; theory of nonlinear PDEs; nonvariational methods; Hamilton-Jacobi equations.	5			v							
17	Partial differential equations on complex sets	Purpose: The course is based on the theory of ordinary and partial differential equations and mathematical analysis. Contents: Some modern principles for modeling mechanical systems consisting of a finite number of elements of different dimensions. Some methods of theoretical study of differential equations describing processes in layered media and methods of numerical analysis	5										v

		are presented. As a result of this course, students should gain some experience in modeling and investigating some complex mechanical systems.											
18	Machine Learning & Deep Learning	Purpose: The course focuses on deep learning models. As a field within machine learning, deep learning models illustrate the quantitative-qualitative transition. Contents: New models and their properties require separate study and practice in tuning the metaparameters of such models. This course covers the basics of deep learning, neural networks, convolutional networks, RNN, LSTM, Adam, Dropout, BatchNorm, Xavier/He initialization.	5									**v**	

6. Additional educational programs (Minor)

Name of additional educational programs (Minor) with disciplines	Total number of credits	Recommended semesters of study	Documents on the results of the development additional educational programs (Minor)