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

EDUCATIONAL PROGRAM
6B06103 «Mathematical and computer modeling»

Code and classification of the field of education:
6B06 «Information and Communication Technologies»
Code and classification of training directions:
6B061 «Information and Communication Technologies»
Group of educational programs: **B057 «Information technologies»**
Level on NQF: **6**
Level on IQF: **6**
Period of study: **2 years**
Volume of the credits: **120**

Almaty 2025

NCJS "KAZAKH NATIONAL RESEARCH TECHNICAL UNIVERSITY"
named after K.I. SATPAEV"

Educational program 6B06103 «Mathematical and computer modeling» was approved at the meeting of K.I. Satbayev KazNRTU Academic Council
Protocol No. 10 of 06.03.2025 year.

Was reviewed and recommended for approval at the meeting of K.I. Satbayev KazNRTU Educational and Methodological Council
Protocol No. 3 of 20.12.2024 year.

Educational program 6B06103 «Mathematical and computer modeling»
was developed by Academic committee based on direction «Information technologies».

Full name	Academic degree/ academic title	Position	Workplace	Signature
Chairman of the Academic Committee:				
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F KazNRTU 703-05 Educational program

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List of abbreviations and designations

EP – educational program
BC – basic competencies
PC – professional competencies
LO – Learning outcomes
MOOC – massive open online courses
NQF – National Qualifications Framework
IQF – Industry Qualifications Framework

1. Description of the educational program

The educational program 6B06103 "Mathematical and computer modeling" is aimed at teaching students general education, basic and specialized disciplines with the achievement of appropriate competencies.

The OP is based on the state educational standard for higher professional education; on the professional standard.

The educational program is designed to train specialists in the field of mathematical and computer modeling of various processes and complex systems, to master competitive knowledge and the opportunity to apply it to create new methods and knowledge in mathematical and computer modeling of three-dimensional objects, and to solve applied problems arising in physics, chemistry, biology, economics, etc. Specialists will also be able to simulate various tasks arising in theoretical computer science.

The content of the disciplines of the educational program has been developed taking into account the relevant educational programs of the world's leading universities, the international classifier of professional activity in the field of information and communication technologies.

Graduates of the educational program 6B06103 "Mathematical and computer modeling" are focused on the formulation of a mathematical problem, model construction and implementation through computer technology, as well as the application of acquired knowledge in the analysis of various problems arising in the field of physics, economics, finance, biology, computer science and engineering.

The educational program ensures the application of an individual approach to students, the transformation of professional competencies from professional standards and qualification standards into learning outcomes. Student–centered learning is provided - the principle of education, which assumes a shift in emphasis in the educational process from teaching (as the main role of the teaching staff in the "translation" of knowledge) to teaching (as an active educational activity of the student).

In case of successful completion of the full bachelor's degree course, the graduate is awarded a bachelor's degree in information and communication technologies according to the educational program 6B06103 "Mathematical and computer Modeling".

2. Purpose and objectives of educational program

The purpose of the OP: The curriculum program is created with the focus on training competitive professionals in computer science and information technologies, which will possess the valuable knowledge in such future technologies as artificial intelligence and hence will be distinguished on the international IT market.

As a result of completing their studies, graduates will be able to work as specialists in the field of technologies for building and researching mathematical models of a wide variety of systems and processes that allow them to predict the evolution of the systems under study, and thereby verify the correctness of decisions made.

Tasks of the OP:

 training of a competitive generation of technical specialists in the field of mathematical and computer modeling for the labor market, proactive, able to work in a team, possessing high personal and professional competencies;

 integration of educational and scientific activities;

Establishing partnerships with leading universities in the near and far abroad in order to improve the quality of education;

expansion of relations with customers of educational services, employers in order to determine the quality requirements for training specialists, conducting courses, seminars, master classes, internships, production practices.

The content of the educational program 6B06103 "Mathematical and computer modeling" is implemented in accordance with the credit technology of education and is carried out in the state, Russian and English languages.

The educational program will make it possible to implement the principles of the Bologna process. Based on the students' choice and independent planning of the sequence of studying disciplines, they independently form an individual study plan (IUP) for each semester according to the Working Curriculum and the Catalog of elective disciplines. The educational program has increased the volume of mathematical, natural science, basic and language disciplines.

The following disciplines are studied: "Information and communication Technologies", "Algorithmization and programming in Python", "Computer modeling of engineering problems", "Algorithms, data structures and programming", "Mathematical models in neural networks", "Mathematical and computer modeling of chemical, technological and physical processes", "Geometric modeling based on OpenGL", "Elements of Data Science", "Mathematics of Cryptography", "Advanced Machine Learning Algorithms", "Asymptotic optimal Control methods", etc.

Undergraduates practice in commercial, government and departmental structures. According to the academic mobility program, the best students have the opportunity to study at leading foreign universities in the relevant field.

3. Requirements for the evaluation of educational program learning outcomes

The educational program has been developed in accordance with the State Mandatory Standards of Higher and Postgraduate Education, approved by Order No. 2 of the Minister of Science and Higher Education of the Republic of Kazakhstan dated July 20, 2022 (registered in the Register of State Registration of Normative Legal Acts under No. 28916) and reflects the learning outcomes on the basis of which curricula are developed (working curricula, individual curricula of students) and working curricula in disciplines (syllabuses).

Mastering disciplines of at least 10% of the total volume of credits of the educational program using MOOC on the official platform https://polytechonline.kz/cabinet/login/index.php /, as well as through the study of disciplines through the international educational platform Coursera https://www.coursera.org /.

The assessment of learning outcomes is carried out according to the developed tasks within the framework of the educational program in accordance with the requirements of the state mandatory standard of higher and postgraduate education. When evaluating learning outcomes, uniform conditions and equal opportunities are created for students to demonstrate their knowledge, skills and abilities.

4. Passport of educational program

4.1. General information

№	Field name	Note
1	The code and classification of the field of education	6B06 "Information and communication technologies"
2	The code and classification of training areas	6B061 "Information and communication technologies"
3	Group of educational programs	B057 "Information technology"
4	Name of the educational program	6B06103 "Mathematical and computer modeling"
5	A brief description of the educational program	6B06103 "Mathematical and computer modeling" is aimed at teaching students general education, basic and specialized disciplines with the achievement of appropriate competencies. The OP is based on the state educational standard for higher professional education; on the professional standard. The educational program is designed to train specialists in the field of mathematical and computer modeling of various processes and complex systems, to master competitive knowledge and the opportunity to apply it to create new methods and knowledge in mathematical and computer modeling of three-dimensional objects, and to solve applied

		problems arising in physics, chemistry, biology, economics, etc. Specialists will also be able to simulate various tasks arising in theoretical computer science. The content of the disciplines of the educational program has been developed taking into account the relevant educational programs of the world's leading universities, the international classifier of professional activity in the field of information and communication technologies. Graduates of the educational program 6B06103 "Mathematical and computer modeling" are focused on the formulation of a mathematical problem, model construction and implementation through computer technology, as well as the application of acquired knowledge in the analysis of various problems arising in the field of physics, economics, finance, biology, computer science and engineering. The educational program ensures the application of an individual approach to students, the transformation of professional competencies from professional standards and qualification standards into learning outcomes. Student–centered learning is provided - the principle of education, which assumes a shift in emphasis in the educational process from teaching (as the main role of the teaching staff in the "translation" of knowledge) to teaching (as an active educational activity of the student).
6	The purpose of the Educational program	The purpose of the educational program is to purposefully train specialists with valuable knowledge of future technologies – artificial intelligence technologies that will favorably distinguish them in the international IT services market.
7	type of educational program	New
8	The level of the NQF	6
9	Level by IQA	6
10	Distinctive features of the Educational Program	No
11	The list of competencies of the educational program:	Basic competencies: - English language proficiency for: searching for scientific and technical information; working with scientific and technical literature; oral and written communication with a native speaker on a professional topic and in a real life situation. - Mastery of critical systems thinking, transdisciplinarity and cross-functionality. - Knowledge of ICT competencies, the ability to develop software using algorithmic languages. - Mastery of skills: self-study; deepening one's knowledge; being open to new information; systemic thinking and one's own judgment.

		- The ability to be tolerant of another nationality, race, religion, culture; the ability to conduct an intercultural dialogue. - Possession of communication skills, the ability to cooperate and work in a team. - The ability to work in a mode of high uncertainty and rapid change of task conditions; to work with consumer requests. - Knowledge of a broad socio-social, political and professional outlook; the ability to use data from various sources and special literature, analyze and critically evaluate historical facts and events. - Knowledge of the basics of entrepreneurship and business economics, readiness for social mobility. Professional competencies - Possession of fundamental knowledge in mathematics, physics and scientific principles and the ability to use them in solving engineering problems. - The ability to independently develop adequate physical and mathematical models, computer modeling algorithms. - The ability to use mathematical and computer models of technological processes for independent research. - The ability to develop new mathematical models of information technology. The ability to work with high-tech laboratory and research equipment. Knowledge of algorithmic languages and programming technology using object-oriented programming of mathematical and numerical models of physical processes and engineering problems. Knowledge of mathematical modeling and machine learning methods and computer modeling skills to work as a designer in mechanical engineering, energy, transport, chemical production. – Knowledge of methodology: system analysis; design and decision-making in complex and professional situations; methods of communication and coordination of points of view; design and presentation of analytical and project documentation.

12	Learning outcomes of the educational program:	LO1: to know official etiquette and be able to use it; to know the basic regulatory framework of the state, the basic regulatory framework in the field of human and civil rights protection, etc., to know the basics of financial management, the quality management system; to be able to identify key issues of business strategies of the organization; to know the issues of financial mathematics in terms of certainty, as well as in uncertainty, optimal portfolio theory, including

		probability-theoretic methods and financial risks; possess the skills of: various methods of calculating interest, finding generalizing characteristics of payment flows, methods for determining the effectiveness of short-term instruments and long-term financial transactions, including industrial investments and bonds, analyzing, synthesizing and designing their theoretical knowledge to solve financial problems. LO2: to demonstrate the skills of managing R&D and production job using modern equipment, instruments, software and information technologies based on the principles of entrepreneurship and leadership, anti-corruption policy and life safety. LO3: have knowledge on research methodologies, communicative and human principles of life, and on project and human resource management models; be able to analyze technical documentation, extract from it the information necessary to solve the task. LO4: to defend and prove your own at assessment of innovative domestic or foreign experience at the formation of an original judgment on a professional problem and conduct ethical interpersonal communication with public speaking skills and the ability to work in a team. LO5: to know the theoretical foundations of human life safety in the environment, legal and regulatory and technical foundations of life safety; be able to use theoretical knowledge of the fundamentals and economics of environmental management in the analysis of sustainable development, competently present basic information in the field of ecology and environmental management. LO6: know the algorithms and how to represent them, main classes from the Python programming language class library for creating object-oriented applications; be able to use classes and modules from Python libraries; have the skills to develop console applications in the style of object-oriented programming, programming numerical methods for solving problems of linear algebra, differential equations, nonlinear equations and systems of equations. LO7: to know the main types of data structures used in solving problems, algorithms for processing information stored in various types of data structures; to apply data structures and algorithms for their processing in solving various problems. LO8: know the main types of linear integral equations of Fredholm, Volterra, equations with a weak singularity and problems leading to these integral equations; know the theory of groups, rings and fields; be able to apply in practice methods for solving integral equations in limited domains; understand and apply in practice the reduction of problems for ordinary differential equations and problems for equations of mathematical physics to integral equations and methods for solving them; be able to find, analyze and contextually process

		scientific and technical information related to integral equations and methods for constructing their solutions; demonstrate the ability to analyze and synthesize applications of integral equations; be able to use abstract algebraic structures for specific calculations. LO9: to know the ways of defining curves, surfaces, three-dimensional geometric objects, the basic methods of their image in various environments, visualization methods for solving geometric and dynamic problems, classical methods used in geometric modeling; to possess mathematical apparatus, information and computer technologies necessary to solve the tasks; be able to create 3D models of objects. LO10: Have knowledge of the basics of information theory, architecture of computing systems, theory of algorithms and programming; apply the laws of algebra of logic; determine the types of graphs and give their characteristics; build the simplest automata; to know the basic concepts and techniques of discrete mathematics, logical operations, formulas of logic, laws of algebra of logic, basic classes of functions, completeness of a set of functions, basic concepts of set theory, set-theoretic operations and their connection with logical operations, predicate logic, binary relations and their types, elements of mapping theory and substitution algebra, method of mathematical induction, algorithmic enumeration of basic combinatorial objects, elements of automata theory. LO11: to know the basics of fundamental disciplines such as mathematics and physics, to be able to apply the main mathematical and physical theories to specific problems; to know the basics of information technologies and modern software tools for conducting engineering analysis, the principles of constructing computer models; to be able to apply the basic concepts and laws of mechanics, and the methods derived from these laws for studying the equilibrium and motion of a material point, a rigid body, and a mechanical system in professional activities. LO12: be able to build a mathematical model of a phenomenon or process; be able to use mathematical packages such as MatLab, MATHEMATICA to find, analyze and graphically represent solutions to mathematical models, know the basic capabilities of the SIMULINK mathematical modeling package, and computational error; to know numerical methods for solving problems of linear algebra, differential equations, methods for solving nonlinear equations and systems of equations. LO13: to know the basic mathematical concepts and methods necessary for developing the skills to solve problems in professional activities: methods of linear algebra and analytical geometry; differential calculus of single and multiple-variable functions; integral calculus of single and multiple-variable

		functions; methods of solving differential equations; basic methods of probability theory and mathematical statistics; optimization methods; problems of discrete, integer, nonlinear, and linear programming; methods of constructing an optimal plan. LO14: apply machine learning algorithms for data analysis and management, business process analysis, formation of technical requirements and specifications, TensorFlow library for image analysis; know modern programming languages, operating systems, database management systems, various software development technologies, modern methods of data storage, analysis, processing and interpretation, basic tools of artificial intelligence the main areas of application of artificial intelligence systems. LO15: know the basic concepts of cryptography; basic requirements for cryptographic protection systems; basic cryptographic protection algorithms; be able to formulate information security tasks; use modern information security tools; apply protection methodologies in the field of information security. LO16: know the architecture of multilayer unidirectional neural networks, methods and basic algorithms for their training; methods of collecting and preprocessing data used for training and testing; methods for evaluating the quality of neural network training; the structure of deep, hybrid and fuzzy neural networks; basic principles of designing data processing systems using artificial neural networks; be able to model single-layer and multi-layer unidirectional neural networks in the MATLAB environment/Neulal Networks Toolbox; solve typical data processing problems using neural network models (classification, recognition, forecasting); apply fuzzy and neural network models in applied tasks.
13	The form of education	Full-time
14	The duration of the training	2
15	Volume of loans	120
16	Languages of instruction	Kazakh, Russian, English
17	Academic degree awarded	Bachelor's Degree in Information and Communication Technology
18	Developers and authors:	Candidate of Physical and Mathematical Sciences Tulesheva G.A., Doctor of Physical and Mathematical Sciences Sakabekov A., senior lecturer Ergazina R.A.

4.2. Relationship between the achievability of the formed learning outcomes according to educational program and academic disciplines

№	Name of the discipline	A brief description of the discipline	Number of credits	Generated learning outcomes (codes)															
				LO1	LO2	LO3	LO4	LO5	LO6	LO7	LO8	LO9	LO10	LO11	LO12	LO13	LO14	LO15	LO16
The cycle of basic disciplines The university component																			
1	Applied Mechanics	Purpose: to master the basics of scientific knowledge in the field of solid mechanics by students and develop skills for their application in practical work in their specialty. Contents: Force vector and its components. Systems of forces. Methods for determining the movement of a point. The simplest motions of a rigid body. Plane motion of a rigid body. Complex point movement. Dynamics of a material point. Differential equations of motion of a material point. Dynamics of a system of material points. D'Alembert's principle for a material point.	5											v		v			
2	Calculations in algebraic structures	Purpose: to obtain basic knowledge of basic algebraic structures; to instill the ability to carry out proofs of basic statements, establish logical connections between concepts, apply the knowledge gained to solve problems related to applications of algebraic methods. Contents: commutative, associative distributive algebraic operations; definition of a group, rings; commutative ring, ring with one, properties	5								v								

		of a ring, the concept of zero divisors, isomorphism of rings, residue ring, definition of a field, properties of a field.																	
3	Theory of the function of a complex variable	Purpose: to familiarize students with the theoretical foundations of the discipline; to create conditions for the formation of logical and abstract thinking among students as the basis for their further effective learning. Contents: basic concepts of complex analysis, representation of functions by series, functional series, power series, Taylor series, Laurent series, singular points, deductions and their applications, Laplace transform, properties of Laplace transformations, some applications of operational calculus.	5														v		
4	Algorithms and data structures	Purpose: to gain knowledge about the basic theoretical concepts underlying the process of developing algorithms and data structures; to master the methods of developing and describing various algorithms related to data management. Contents: linear unidirectional list, linear lists with limited sets of operations, linear bidirectional list, trees, graphs, search in data structures, hashing, sorting problems (external and internal), algorithm development methods, combinatorial optimization problems.	5						v	v									

5	Probability theory	Purpose: to master the necessary mathematical apparatus, with the help of which theoretical and experimental models of objects of professional activity are developed and studied. Contents: algebra of random events, combinatorics formulas, classical definition of probability, total probability formula, Bayes formulas, Bernoulli scheme, local and integral Laplace formulas, discrete random variables, continuous random variables, integral and differential distribution functions, mathematical expectation and dispersion, covariance and correlation, linear regression equations	5														**v**			
6	Functional analysis	Purpose: to develop skills in analyzing functions in various spaces; to find the cardinality of a set, determine the norm and metric, orient in functional spaces, as well as prove theorems related to the studied topics. Contents: linear spaces equipped with metrics or norms, dual spaces, linear operators and their associated, self-adjoint operators in Hilbert spaces, elements of spectral theory, fixed point theorems and their applications.	5														**v**			
7	Math statistics	Purpose: to study the basic concepts of mathematical statistics, to master the patterns and methods of solving specific problems of mathematical statistics. Contents: General information about the	5														**v**			

		selective method. Empirical distribution function. Average values. Indicators of variation. Statistical estimates of distribution parameters. Methods for finding point estimates. The concept of interval estimation. Testing statistical hypotheses. Criterion $\chi 2$ and its application to testing hypotheses about the type of distribution.Testing hypotheses about the equality of the averages of two populations. Elements of correlation analysis. The correlation coefficient and its properties. Significance check and interval estimation of communication parameters. The correlation relation. Determination of parameters of nonlinear regression by the least squares method.																		
8	Geometric modeling in OpenGL	Purpose: to study the basics of geometric modeling, the principles of creating applied software in the field of graphic information processing; students acquire knowledge of modern methods for solving computational geometry problems and processing graphical information. Contents: geometric models, OpenGL architecture and syntax features, visualization of primitives, image visualization in OpenGL, transformation and projection matrices in OpenGL, images of curves and surfaces.	5									**v**							
The cycle of basic disciplines Component of choice																				

9	3D modeling	Purpose: to master the 3ds MAX graphics editor, with which you can model three-dimensional images of objects, as well as basic concepts of animation programs and fundamental tools. Contents: types of models, three-dimensional workspace, three-dimensional modeling editor, types of projections in 3ds MAX, world and object coordinate system, creation of the simplest three-dimensional scene, creation of stereometry shapes, grouping of objects, management of drawing and modification tools, materials and texturing, creation of simple models.	5										v							
	Numerical methods and programming	Purpose: o study the basic techniques of developing and applying in practice methods for solving various mathematical problems arising both in theory and in applications to various fields of mathematics, physics, mechanics, chemistry, etc. Contents: computational error; concepts of approximation, stability, convergence of the algorithm; methods of root localization; iterative methods for solving SLAE; interpolation; numerical differentiation, integration; numerical methods for solving the Cauchy problem for ODEs.							v						v					
	Mathematical statistics and stohastic processes	Purpose: to form students' knowledge about the construction and analysis of mathematical models that take into account														v				

		random factors, to give a modern understanding of the methods of stochastic mathematics used for analysis and mathematical modeling. Contents: systems of random variables, random processes, Markov chains, Pearson and Kolmogorov agreement criteria, regression and correlation analysis, time series, queuing systems.																	
10	Applied Logic	Purpose: to develop an understanding of the logical structure of computer programs, to introduce specifications of responsive information systems into languages. Contents: logical programs, unification, unification algorithm; resolution method, conclusion; semantics: erbran interpretations, many program solutions, completeness of the resolution method; algorithmic properties of the smallest Erbran model; the problem of negation: lists, structures; language and semantics: temporal propositional calculus; correctness theorem; theorems on deduction, on substitution; language and semantics of temporal predicate logic.	5										v						
	Calculus of variations and optimal control	Purpose: to study the basic principles of formulation and research of extreme problems of mathematical modeling and mathematical physics, as well as methods for solving typical problems of calculus of variations and optimal control.														v			

		Contents: classical calculus of variations, integral calculus of variations, differentiation of maps, smooth problems with constraints in the form of equalities and inequalities, optimization in infinite-dimensional spaces, Pontryagin maximum principle, Bellman dynamic programming.																			
The cycle of core disciplines The university component																					
11	Partial differential equations	Purpose: to get acquainted with the classification of partial differential equations and their physical interpretation, to study the formulations of boundary value problems for these equations and ways to solve the tasks set. Contents: classification of partial differential equations of the 2nd order, the theorem on reduction to the canonical form of a quasi-linear partial differential equation of the 2nd order, the theory of hyperbolic equations, the theory of elliptic equations, the theory of parabolic equations.	6														**v**			
12	Machine learning methods	Purpose: to teach students the theoretical and practical rules of machine learning, the skills of applying machine learning methods and models. Contents: structure of the field of machine learning, linear regression problems with one variable, gradient descent method, multidimensional linear regression, logistic regression, systematization methods, training of neural	6															**v**		**v**

		networks, machine learning experience, linear regression with regularization, unsupervised learning, dimensionality reduction, analysis of the main components, anomaly detection.																		
13	Mathematical models in neural networks	Purpose: to master the theoretical and practical foundations of neural network models by students; to study the methods of designing and training neural networks; to build neural network mathematical models and analyze their functioning. Contents: the structure and properties of an artificial neuron, the basic concepts of artificial neural networks, artificial neural networks simulating the properties of natural neural networks, the use of artificial neural networks, the use of fuzzy and neural networks, the use of fuzzy and neural network models in applied tasks, the design of models of fuzzy and neural network technologies.	5															**v**		**v**
14	Optimization and control	Purpose: students gain knowledge about modern methods of solving mathematical optimization problems; formation of optimization thinking; development of mathematical and algorithmic intuition in solving problems encountered in practice. Contents: problem statement and data analysis, linear programming, simplex method, dual problem, mathematical model of the transport problem, methods of constructing an optimal plan, method of potentials, networks, integer programming,	5														**v**			

		binary programming, elements of game theory, nonlinear optimization, gradient descent.																	
15	Applied Analysis	Purpose: to teach students to choose the most effective ways to solve problems using numerical methods used in practice, and to compile its algorithms. Contents: error analysis, iteration method for a fixed point, methods for solving nonlinear equations and systems of equations, Raphson-Newton method, Jacobi and Gauss-Seidel methods, interpolation, least squares method, interpolation with splines, numerical differentiation, numerical integration, Cauchy problem for ordinary differential equations, boundary value problem, run-through method.	6													**v**			
16	Artificial intelligence	Purpose: to form systematic knowledge about modern computer science methods; to expand and deepen the concepts of artificial intelligence; to develop abstract thinking, spatial representations, computational, algorithmic cultures and general mathematical and information culture.. Contents: the main directions of research in the field of artificial intelligence (AI), genetic algorithms, instrumental computer tools for the development of AI systems, the basics of the theory of knowledge representation, the basics of the theory of neural and random networks, the	4															**v**		

		concept of an expert system, the task of pattern recognition.																	
17	Linear programming	Purpose: to form students' knowledge of the basic concepts, definitions and statements of linear programming, skills in applying this theory to solve practical problems. Teaching students to apply linear programming methods and models in the process of preparing and making managerial decisions. Contents: methods for solving linear programming problems, graphical method for solving LP problems, simplex method, artificial basis method. duality in LP, transport task, method of potentials.	6													**v**			
18	Mathematical and computer modeling of chemical-technological and physical processes	Purpose: to form students' theoretical knowledge, practical skills and abilities in the application of modern methods of mathematical and computer modeling of chemical, technological and physical processes. Contents: general principles of modeling, deterministic mathematical models of chemical technological processes, experimental statistical methods for constructing mathematical models, basic methods for finding patterns and relationships between the studied objects, the use of universal software packages and analytical platforms for data analysis.	6										**v**	**v**	**v**			

19	Industrial practice II	Purpose: to develop students' skills in building and researching mathematical models of various systems and processes; skills in mathematical description, aggregation and decomposition of the studied systems; skills in setting practical tasks, self-study of mathematical models of systems and processes; skills in constructing and implementing algorithms for solving specific engineering and applied problems to obtain numerical results of model research with required accuracy; gain practical experience of participating in the development of software requirements and in software design using specialized software packages.	3	v	v	v	v	v	v	v									
The cycle of core disciplines Component of choice																			
20	Optimization methods	Purpose: to study the basics of the theory of mathematical methods for finding optimal solutions in problems of mathematical programming, calculus of variations and optimal control. Contents: linear programming problem, canonical type of linear programming problem, graphical solution under given constraints, dual problem, simplex method, transport problem, minimum element method, potential method, Pareto set, methods for finding optimal solutions under	5													v			

		uncertainty, methods for solving problems in game theory.																	
	Asymptotic expansions and averaging	Purpose: to introduce the main types of asymptotic methods used in solving low-parametric algebraic and ordinary differential equations. Contents: dimension analysis, calibration functions, asymptotic sequences and series, solution of algebraic equations, application of asymptotic classification to the calculation of integrals, self-moving oscillatory systems, weakly nonlinear oscillatory systems of general form, 2nd-order differential equations with a small parameter by a higher-order derivative.													v			
21	Advanced machine learning algorithms	Purpose: to familiarize with modern approaches to the construction, training and use of recognition and classification systems based on machine learning methods and deep learning neural networks. Contents: adaptive linear neurons, training models based on decision trees, algorithms for sequential feature selection, data compression using dimensionality reduction, implementation of a multilayer artificial neural network, deep convolutional neural networks, recurrent neural networks.	5														v		v

	Elements of Data Science	Objective: to form students' holistic understanding of the problems arising in the field of working with data and their solution, taking into account various conditions. Content: data processing tasks, end-to-end Big Data technologies, quantitative and qualitative data processing methods, intelligent data processing methods, Data Mining tasks, fuzzy data, text, image, sound analysis technologies; big data processing technologies, technology for obtaining, presenting and processing knowledge.													v		v
22	Mathematics of cryptography	Purpose: to study the mathematical foundations of cryptography, to teach the student information security methods and their use in the field of information security. Contents: cryptology, cryptography, cryptanalysis, encryption, durability, security, imitability, authenticity, modern cryptographic methods of information protection, encryption, mathematical foundations of algorithms of asymmetric cryptosystems, mathematical foundations of algorithms of symmetric cryptosystems, methods research of cryptographic algorithms, models of encryption systems, mathematical foundations of electronic digital signature algorithms, cryptographic key management, steganography.	5								v					v		

	Encryption algorithms and computer security tools	The purpose of mastering the discipline is to study modern concepts of computer security, application in ensuring the protection of information, the safe use of software in computing systems. To teach the student the methods of information security, their use in the field of information protection. The objective of the course is to present the theory of information security, the practice of applying cryptographic algorithms.																		