Federal State Autonomous Educational Institution of Higher Education
"Peoples' Friendship University of Russia named after Patrice Lumumba"

Academy of Engineering
(name of the main educational unit (MEU) that developed the educational program of higher education)

WORKING PROGRAM OF THE DISCIPLINE

INFORMATION TECHNOLOGY IN MATHEMATICAL MODELING
(name of discipline/module)

Recommended for the field of study/specialty:

27.04.04 CONTROL IN TECHNICAL SYSTEMS
(code and name of the training area/specialty)

The discipline is mastered within the framework of the implementation of the main professional educational program of higher education (EP HE):

AIML and Space Sciences / ARTIFICIAL INTELLIGENCE, MACHINE LEARNING AND SPACE SCIENCES
(name (profile/specialization) of the educational institution of higher education)

2025

1. THE GOAL OF MASTERING THE DISCIPLINE

The course "Information Technology in Mathematical Modelling" is part of the Master's program "Artificial Intelligence, Machine Learning and Space Sciences" in the direction 27.04.04 "Control in Technical Systems" and is studied in the 1st semester of the 1st year. The course is implemented by the Department of Mechanics and Control Processes. The course consists of 6 sections and 27 topics and is aimed at studying the fundamental principles of modeling physical processes and phenomena, computational methods used in solving physical problems and in processing experimental data; methods for optimal implementation of an experiment on a computer, estimates of the error of the result of the calculations; analysis of the main methods for solving typical problems and familiarization with the area of their application in professional activities.

The purpose of mastering the discipline is to develop fundamental knowledge and skills in applying methods for solving problems necessary for professional activities, practical skills in programming basic mathematical algorithms used in modeling physical phenomena, and to improve the general level of digital literacy of students.

2. REQUIREMENTS TO THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the discipline " Information Technology in Mathematical Modelling " is aimed at developing the following competencies (parts of competencies) in students:

Table 2.1. List of competencies developed in students while mastering the discipline (results of mastering the discipline)

Cipher	Competence	Indicators of Competence Achievement (within the framework of this discipline)
UC-7	Able to search for the necessary sources of information and data, perceive, analyze, remember and transmit information using digital means, as well as using algorithms when working with data obtained from various sources in order to effectively use the information received to solve problems; evaluate information, its reliability, build logical conclusions based on incoming information and data	UC-7.1 Searches for the necessary sources of information and data, perceives, analyzes, remembers and transmits information using digital means, as well as using algorithms when working with data obtained from various sources in order to effectively use the information obtained to solve problems; UC-7.2 Conducts an assessment of information, its reliability, builds logical conclusions based on incoming information and data; UC-7.3 Has mastered modern digital technologies, methods of searching, processing, analyzing, storing and presenting information (in the field of management in technical systems) in the context of the digital economy and modern corporate information culture.;
GPC-1	Able to analyze and identify the natural scientific essence of control problems in technical systems based on provisions, laws and methods in the field of natural sciences and mathematics	OPC-1.1 Knows the basic laws, provisions and methods in the field of natural sciences and mathematics; OPC-1.2 Able to identify the natural scientific essence of control problems in technical systems, guided by the laws and methods of natural sciences and mathematics; GPC-1.3 Has command of tools for analyzing control problems in technical systems.
GPC-2	Able to formulate control problems in technical systems and justify methods for solving them	GPC-2.1 Knows the basic methods of solving control problems in technical systems; GPC-2.2 Able to justify methods for solving control problems in technical systems; GPC-2.3 Proficient in methods of setting control problems in technical systems.
PC-2	Able to apply modern theoretical and experimental methods for developing mathematical models of objects and processes under study in the field of aerospace systems management	PC-2.1 Knows modern theoretical and experimental methods used to develop mathematical models of the objects under study and processes of professional activity; PC-2.2 Able to determine the effectiveness of the methods used to develop mathematical models of the objects and processes under study;

Cipher	Competence	Indicators of Competence Achievement (within the framework of this discipline)
		PC-2.3 Has mastered modern theoretical and experimental methods for developing mathematical models of objects and processes of professional activity in the field of study.;

3. PLACE OF THE DISCIPLINE IN THE STRUCTURE OF THE EDUCATIONAL EDUCATIONAL EDUCATION

Discipline " Information Technology in Mathematical Modelling " refers to the mandatory part of block 1 “Disciplines (modules)” of the educational program of higher education.

As part of the higher education program, students also master other disciplines and/or practices that contribute to the achievement of the planned results of mastering the discipline " Information Technology in Mathematical Modelling ".

Table 3.1. List of components of the educational program of higher education that contribute to the achievement of the planned results of mastering the discipline

Cipher	Name of competence	Previous courses/modules, practices*	Subsequent disciplines/modules, practices*
UC-7	Able to search for the necessary sources of information and data, perceive, analyze, remember and transmit information using digital means, as well as using algorithms when working with data obtained from various sources in order to effectively use the information received to solve problems; evaluate information, its reliability, build logical conclusions based on incoming information and data		*Artificial Neural Networks (Reinforcement Learning)***; *Artificial Neural Networks (Reinforcement Learning)***; Web application development and security; Undergraduate Training; Research work / Scientific research work;
GPC-1	Able to analyze and identify the natural scientific essence of control problems in technical systems based on provisions, laws and methods in the field of natural sciences and mathematics		*Advanced Methods of Space Flight Mechanics; Advanced Methods of Earth Remote Sensing; Geoinformation Systems and Applications; Undergraduate Training;*
GPC-2	Able to formulate control problems in technical systems and justify methods for solving them		*Undergraduate Training; Dynamics and Control of Space Systems;*
PC-2	Able to apply modern theoretical and experimental methods for developing mathematical models of objects and processes under study in the field of aerospace systems management		*Research work / Scientific research work; Undergraduate Training; Dynamics and Control of Space Systems; Artificial Neural Networks (Deep Learning)**; Artificial Neural Networks (Deep Learning)**;*

Cipher	Name of competence	Previous courses/modules, practices*	Subsequent disciplines/modules, practices*
			Advanced Methods of Space Flight Mechanics; *Artificial Neural Networks (Reinforcement Learning)**;* *Geoinformation Systems and Applications;*

* - filled in in accordance with the competency matrix and the SUP EP HE

** - elective disciplines/practices

4. SCOPE OF THE DISCIPLINE AND TYPES OF STUDY WORK

The total workload of the discipline “Information Technology in Mathematical Modelling” is “3” credit units.

Table 4.1. Types of educational work by periods of mastering the educational program of higher education for full-time education.

Type of academic work	**TOTAL,**ac.h.		**Semester(s)**
			1
Contact work, academic hours	*34*		*34*
Lectures (LC)	17		17
Laboratory work (LW)	0		0
Practical/seminar classes (SC)	17		17
Independent work of students, academic hours	*47*		*47*
Control (exam/test with assessment), academic hours	*27*		*27*
General complexity of the discipline	**ac.h.**	***108***	*108*
	credit.ed.	***3***	*3*

5. CONTENT OF THE DISCIPLINE

Table 5.1. Contents of the discipline (module) by types of academic work

Section number	Name of the discipline section	Section Contents (Topics)		Type of academic work*
Section 1	Interpolation and approximation.	1.1	Basic concepts of the theory of approximate calculations	LC, SC
		1.2	Methods of approximate solution of computational problems	LC, SC
		1.3	Gauss Method. Matrix Inversion by Gauss Method. Sweep Method	LC, SC
Section 2	Solving equations	2.1	Iterative methods for solving nonlinear equations. Newton's method	LC, SC
		2.2	Simple iteration and contraction mapping method. Interpolation and polynomial approximation	LC, SC
		2.3	Statements of the simplest interpolation problems. Lagrange interpolation polynomial	LC, SC
		2.4	Newton's interpolation polynomial for unequal intervals	LC, SC
		2.5	Finite differences and Newton interpolation polynomials for equidistant nodes	LC, SC
Section 3	Solving systems of equations	3.1	Elements of numerical integration	LC, SC
		3.2	Newton-Cotes quadrature formulas and their special cases	LC, SC
		3.3	Quadrature formula of trapezoid. Geometric meaning of trapezoid	LC, SC
		3.4	Simpson's quadrature formula	LC, SC
Section 4	Solution of differential equations	4.1	Elements of numerical solution of differential equations.	LC, SC
		4.2	Difference approximation of differential operators. First-order accuracy method	LC, SC
		4.3	Methods for solving ordinary differential equations. Second-order methods of accuracy	LC, SC
		4.4	Methods for solving ordinary differential equations. Fourth-order methods of accuracy	LC, SC
Section 5	Information models in physics	5.1	Boundary value problems. Variational-difference schemes for boundary value problems	LC, SC
		5.2	Grid approximation. Euler's method for a system of equations	LC, SC
		5.3	Error and stability of Euler's method. Elements of numerical differentiation	LC, SC
		5.4	Formula for numerical differentiation for unequal nodes	LC, SC
		5.5	Total Error in Numerical Differentiation. Least Squares Method	LC, SC
		5.6	Elements of Operations Research Theory	LC, SC
Section 6	The concept of computer modeling	6.1	Mathematical programming. Elements of linear programming	LC, SC
		6.2	Canonical linear programming problem	LC, SC
		6.3	Geometrical meaning of the system of linear inequalities. Geometrical meaning of the two-dimensional linear programming problem	LC, SC
		6.4	The idea of the Simplex method. Simplex tables. Geometric characteristics in problems and methods of linear programming. Mutually dual problems of linear programming	LC, SC
		6.5	Elements of Nonlinear Programming. Method of Uncertain Lagrange Multipliers	LC, SC

* - filled in only for FULL-TIME education: LC – lectures; LW – laboratory work; SC – practical/seminar classes.

6. LOGISTIC AND TECHNICAL SUPPORT OF DISCIPLINE

Table 6.1. Material and technical support of the discipline

Audience type	Equipping the auditorium	Specialized educational/laboratory equipment, software and materials for mastering the discipline (if necessary)
Lecture		
Seminar		
For independent work		

* - the audience for independent work of students MUST be indicated!

7. EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT OF THE DISCIPLINE

Main literature:

1. Ilyina V.A. Silaev P.K. Numerical methods for theoretical physicists (part 1,2) RHD, 2003, 2004.

2. Amosov A.A., Dubinsky Yu.A., Kopchenova N.V. Computational methods for engineers."Moscow Power Engineering Institute" 2003. - 595 p.

3. Malinetsky G.G. Mathematical foundations of synergetics. Chaos, structures, computational experiment Edition 4 Series: Synergetics: from the past to the future" Editorial URSS 2005.- 312s.

4. Gmurman V.E. Elements of approximate calculations.Higher School: 2005. - 93 p.

Further reading:

1. Fedorenko R.P. Introduction to Computational Physics. - M.: Publishing house Mosk. Phys.-Techn. Institute, 1994.- 528 pp.

2. Heerman D.V. Methods of computer experiment in theoretical physics. - M.: NaUCa, 1990.- 176 pp.

3. Bursian E.V. Physics. 100 tasks for solution on the computer. - St. Petersburg: MiM, 1997.

4. Tyurin Yu.N. Data analysis on a computer / Yu.N. Tyurin, A.A. Makarov. - M.: Finance and Statistics, 1995.

Resources of the information and telecommunications network "Internet":

1. RUDN University EBS and third-party EBSs to which university students have access on the basis of concluded agreements
   - Electronic library system of RUDN - ELS RUDN https://mega.rudn.ru/MegaPro/Web
   - Electronic library system "University library online"http://www.biblioclub.ru
   - EBS Yuraithttp://www.biblio-online.ru
   - Electronic Library System "Student Consultant" www.studentlibrary.ru
   - EBS "Znanium"https://znanium.ru/
2. Databases and search engines
   - Sage https://journals.sagepub.com/
   - Springer Nature Link https://link.springer.com/
   - Wiley Journal Database https://onlinelibrary.wiley.com/
   - Scientometric database Lens.org https://www.lens.org

Educational and methodological materials for independent work of students in mastering a discipline/module:*

1. Lecture course on the subject "Information technologies in mathematical modeling".

* - all educational and methodological materials for independent work of students are posted in accordance with the current procedure on the discipline page in TUIS!

DEVELOPER:

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