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

Academy of Engineering
(name of the main educational unit (POU) - developer of the EP HE)

COURSE SYLLABUS

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

Recommended by Didactic Council for the Education Field of:

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

The discipline is mastered as part of the implementation of the main professional educational program of higher education:

DATA SCIENCE AND SPACE ENGINEERING
(name (profile/specialization) EP HE)

2024

1. GOAL OF DISCIPLINE MASTERING

The discipline “Information Technology in Mathematical Modeling” is included in the master’s program “Data Science and Space Engineering” in the direction of 27.04.04 “Control in Technical Systems” and is studied in the 1st semester of the 1st year. The discipline is implemented by the Department of Mechanics and Control Processes. The discipline 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 processing experimental data; methods for optimal implementation of an experiment on a computer, estimates of the error in the result of calculations; analysis of the basic methods for solving typical problems and familiarization with the scope of their application in professional activities.

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

2. REQUIREMENTS FOR THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the discipline “Information technologies in mathematical modeling” is aimed at developing the following competencies (parts of competencies) in students:

Table 2.1. List of competencies formed in students when mastering the discipline (results of mastering the discipline)

Cipher	Competence	Indicators of Competency Achievement (within this discipline)
GC-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 received 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	GC-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 received from various sources in order to effectively use the received information to solve problems;; GC-7.2 Evaluates information, its reliability, builds logical conclusions based on incoming information and data;; GC-7.3 Proficient in modern digital technologies, methods of searching, processing, analyzing, storing and presenting information (in the field of management in technical systems) in the conditions 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	GPC-1.1 Knows the basic laws, regulations and methods in the field of natural sciences and mathematics;; GPC-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 Possesses tools for analyzing management 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 for solving control problems in technical systems;; GPC-2.2 Able to justify methods for solving control problems in technical systems;; GPC-2.3 Knows 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 control	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 for the development of mathematical models of the objects and processes under study;;

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

3. PLACE OF DISCIPLINE IN THE STRUCTURE OF HE EP

Discipline "Information technologies in mathematical modeling" refers to the mandatory part of block 1 “Disciplines (modules)” of the educational program of higher education.

As part of the educational program of higher education, students also master other disciplines and/or practices that contribute to achieving the planned results of mastering the discipline “Information Technologies in Mathematical Modeling.”

Table 3.1. List of components of EP HE that contribute to achieving the planned results of mastering the discipline

Cipher	Name of competency	Previous disciplines/modules, practices*	Subsequent disciplines/modules, practices*
GC-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 received 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)***; Research work / Scientific research work; Undergraduate practice / Pre-graduate practice;
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		*Undergraduate practice / Pre-graduate practice; Advanced Methods of Space Flight Mechanics; Advanced Methods of Earth Remote Sensing; Geoinformation Systems and Applications;*
GPC-2	Able to formulate control problems in technical systems and justify methods for solving them		*Dynamics and Control of Space Systems; Undergraduate practice / Pre-graduate practice;*
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 control		*Research work / Scientific research work; Undergraduate practice / Pre-graduate practice; Dynamics and Control of Space Systems; Artificial Neural Networks (Deep Learning)**;

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

* - to be filled out in accordance with the competency matrix and SUP EP VO

** - elective disciplines/practices

4. SCOPE OF DISCIPLINE AND TYPES OF STUDY WORK

The total labor intensity of the "Information Technology in Mathematical Modeling" discipline is "3" credit units.

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

Type of educational work	**TOTAL,**ac.ch.		**Semester(s)**
			1
Contact work, ac.ch.	*34*		*34*
Lectures (LC)	17		17
Laboratory work (LR)	0		0
Practical/seminar sessions (SZ)	17		17
Independent work of students, ac.ch.	*47*		*47*
Control (exam/test with assessment), academic degree.	*27*		*27*
Total labor intensity of the discipline	**ac.ch.**	***108***	*108*
	credit units	***3***	*3*

5. CONTENT OF DISCIPLINE

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

Section number	Name of the discipline section	Contents of the section (topic)		Type of educational work*
Section 1	Interpolation and approximation.	1.1	Basic concepts of the theory of approximate computing	LC, NW
		1.2	Methods for approximate solution of computational problems	LC, NW
		1.3	Gauss method. Matrix inversion using the Gaussian method. Passing method	LC, NW
Section 2	Solving equations	2.1	Iterative methods for solving nonlinear equations. Newton's method	LC, NW
		2.2	Method of simple iteration and compression mappings. Interpolation and approximation by polynomials	LC, NW
		2.3	Statements of the simplest interpolation problems. Lagrange interpolation polynomial	LC, NW
		2.4	Newton's interpolation polynomial for unequal intervals	LC, NW
		2.5	Finite differences and Newton interpolation polynomials for equidistant nodes	LC, NW
Section 3	Solving systems of equations	3.1	Elements of numerical integration	LC, NW
		3.2	Newton-Cotes quadrature formulas and their special cases	LC, NW
		3.3	Quadrature formula of trapezoid. Geometric meaning of trapezoid	LC, NW
		3.4	Simpson's quadrature formula	LC, NW
Section 4	Solving differential equations	4.1	Elements of numerical solution of differential equations.	LC, NW
		4.2	Difference approximation of differential operators. First order accuracy method	LC, NW
		4.3	Methods for solving ordinary differential equations. Methods of second order accuracy	LC, NW
		4.4	Methods for solving ordinary differential equations. Methods of fourth order of accuracy	LC, NW
Section 5	Information models in physics	5.1	Boundary value problems. Variational-difference schemes for boundary value problems	LC, NW
		5.2	Grid approximation. Euler's method for a system of equations	LC, NW
		5.3	Error and stability of Euler's method. Elements of numerical differentiation	LC, NW
		5.4	Numerical differentiation formula for unequally spaced nodes	LC, NW
		5.5	Total error in numerical differentiation. Least square method	LC, NW
		5.6	Elements of Operations Research Theory	LC, NW
Section 6	Computer simulation concept	6.1	Mathematical programming. Elements of Linear Programming	LC, NW
		6.2	Canonical linear programming problem	LC, NW
		6.3	Geometric meaning of the system of linear inequalities. Geometric meaning of a two-dimensional linear programming problem	LC, NW
		6.4	The idea of the Simplex method. Simplex tables. Geometric characteristics in problems and methods of linear programming. Mutually dual linear programming problems	LC, NW
		6.5	Elements of nonlinear programming. Lagrange's Undetermined Multiplier Method	LC, NW

* - to be filled out only for full-time education: LC – lectures; LR – laboratory work; SZ – practical/seminar classes.

6. MATERIAL AND TECHNICAL SUPPORT OF DISCIPLINE

Table 6.1. Material and technical support of the discipline

Audience type	Auditorium equipment	Specialized educational/laboratory equipment, software and materials for mastering the discipline (if necessary)
Lecture	An auditorium for conducting lecture-type classes, equipped with a set of specialized furniture; board (screen) and technical means of multimedia presentations.	
Seminar	An auditorium for conducting seminar-type classes, group and individual consultations, ongoing monitoring and intermediate certification, equipped with a set of specialized furniture and technical means for multimedia presentations.	
For independent work	An auditorium for independent work by students (can be used for seminars and consultations), equipped with a set of specialized furniture and computers with access to EIOS.	

* - the audience for independent work of students is MANDATORY!

7. EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT OF DISCIPLINE

Main literature:

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

2. Amosov A.A., Dubinsky Yu.A., Kopchenova N.V. Computational methods for engineers."Moscow Energy Institute" 2003. − 595s

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

4. Gmurman V.E. Elements of approximate calculations.Higher school: 2005. − 93 p.

Additional literature:

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

2. Heerman D.V. Methods of computer experiment in theoretical physics. - M.: NaGCa, 1990.− 176 s.

Resources of the information and telecommunications network "Internet":

1. EBS of RUDN University and third-party EBS, to which university students have access based on concluded agreements

- Electronic library system of RUDN University - EBS RUDN Universityhttp://lib.rudn.ru/MegaPro/Web
- EBS "University Library Online"http://www.biblioclub.ru
- EBS Lawhttp://www.biblio-online.ru
- EBS "Student Consultant"www.studentlibrary.ru

- EBS “Trinity Bridge”

2. Databases and search engines

- electronic fund of legal and regulatory technical documentationhttp://docs.cntd.ru/
- Yandex search enginehttps://www.yandex.ru/
- search systemGoogle https://www.google.ru/
- abstract databaseSCOPUS http://www.elsevierscience.ru/products/scopus/

Educational and methodological materials for students’ independent work when mastering a discipline/module:*

1. A course of lectures on the discipline “Information technologies in mathematical modeling.”

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

8. ASSESSMENT MATERIALS AND POINT-RATING SYSTEM FOR ASSESSING THE LEVEL OF COMPETENCIES FOR A DISCIPLINE

Evaluation materials and point-rating system* for assessing the level of development of competencies (parts of competencies) based on the results of mastering the discipline“Information technologies in mathematical modeling” are presented in the Appendix to this Work Program of the discipline.

* - OM and BRS are formed on the basis of the requirements of the relevant local regulatory act of RUDN University.

DEVELOPER:

Assistant professor		Saltykova Olga Alexandrovna
Position	*Signature*	*Last name I.O.*

HEAD OF DEPARTMENT:

Head of the department		Razumny Yuri Nikolaevich
Position	*Signature*	*Last name I.O.*

HEAD OF EP HE:

Professor		Razumny Yuri Nikolaevich
Position	*Signature*	*Last name I.O.*