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

NUMERICAL METHODS
(name of discipline/module)

Recommended for the field of study/specialty:

27.03.04 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):

DATA SCIENCE AND SPACE SYSTEMS
(name (profile/specialization) of the educational institution of higher education)

2025

1. THE GOAL OF MASTERING THE DISCIPLINE

The discipline "Numerical Methods" is included in the bachelor's program "Data Science and Space Systems" in the direction 27.03.04 "Control in Technical Systems" and is studied in the 5th semester of the 3rd year. The discipline is implemented by the Department of Mechanics and Control Processes. The discipline consists of 10 sections and 65 topics and is aimed at studying classical algorithms for solving optimization problems, including the most effective and most important methods from a methodological point of view.

The purpose of mastering the discipline is to obtain the necessary knowledge for the implementation of numerical optimization methods in algorithmic programming languages

2. REQUIREMENTS TO THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the discipline "Numerical Methods" 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)
GPC-2	Able to formulate tasks of professional activity based on knowledge, specialized sections of mathematical and natural science disciplines (modules)	GPC-2.1 Has mastered mathematical methods, programming fundamentals and specialized programming systems for implementing algorithms for solving applied problems; GPC-2.2 Able to select and adapt mathematical methods and software to solve practical problems; GPC-2.3 Possesses skills in developing and implementing algorithms for solving applied problems in the field of professional activity;
GPC-3	Able to use fundamental knowledge to solve basic control problems in technical systems in order to improve in professional activities	GPC-3.1 Knows the theoretical foundations and principles of mathematical modeling; GPC-3.2 Able to develop and use methods of mathematical modeling, information technologies to solve problems of applied mathematics; GPC-3.3 Possesses practical skills in solving problems of applied mathematics, methods of mathematical modeling, information technologies and the basics of their use in professional activities, skills of professional thinking and an arsenal of methods and approaches necessary for the adequate use of methods of modern mathematics in theoretical and applied problems;
PC-1	Capable of collecting, processing and interpreting modern scientific research data necessary to draw conclusions on relevant scientific research, including Earth remote sensing data	PC-1.1 Knows modern methods of collecting, processing and interpreting data from modern scientific research necessary for drawing conclusions on relevant scientific research; PC-1.2 Able to apply modern methods and tools for processing and interpreting scientific research data; PC-1.3 Possesses the basic skills of collecting, processing and interpreting data from modern scientific research necessary for drawing conclusions on relevant scientific research;

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

Discipline "Numerical Methods" 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 "Numerical Methods".

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*
GPC-2	Able to formulate tasks of professional activity based on knowledge, specialized sections of mathematical and natural science disciplines (modules)	Mathematical analysis; Space Flight Mechanics; Algebra and Geometry; Analysis of Geoinformation Data;	Research work / Scientific research work; Technological Training; Undergraduate Training; Research Work; Space Flight Mechanics; Automatic Control Theory; Equations of mathematical physics; Analysis of Geoinformation Data;
GPC-3	Able to use fundamental knowledge to solve basic control problems in technical systems in order to improve in professional activities	Mathematical analysis; Space Flight Mechanics; Theoretical Mechanics; Algebra and Geometry; Theory of Probability and Mathematical Statistics; Differential equations; Complex analysis; Analysis of Geoinformation Data;	Space Flight Mechanics; Automatic Control Theory; Equations of mathematical physics; Optimal Control Methods; Analysis of Geoinformation Data; Research work / Scientific research work; Technological Training; Undergraduate Training;
PC-1	Capable of collecting, processing and interpreting modern scientific research data necessary to draw conclusions on relevant scientific research, including Earth remote sensing data	Space Flight Mechanics; Computer Science and Programming; *Discrete Mathematics***; *Discrete Mathematics***; Analysis of Geoinformation Data;	Research work / Scientific research work; Technological Training; Undergraduate Training; Space Flight Mechanics; Automatic Control Theory; *Virtual and Augmented Reality Technology***; *Virtual and augmented reality technologies***; Optimal Control Methods; Analysis of Geoinformation Data;

* - 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 "Numerical Methods" discipline is 4 credits.

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)**
			5
Contact work, academic hours	*54*		*54*
Lectures (LC)	18		18
Laboratory work (LW)	36		36
Practical/seminar classes (SC)	0		0
Independent work of students, academic hours	*90*		*90*
Control (exam/test with assessment), academic hours	*0*		*0*
General complexity of the discipline	**ac.h.**	***144***	*144*
	credit.ed.	***4***	*4*

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	Numerical methods of optimization	1.1	The concept of optimization	LC, LW
		1.2	Statement of the optimization problem	LC, LW
		1.3	Numerical approach to solving the optimization problem	LC, LW
Section 2	One-dimensional optimization methods	2.1	Swann's algorithm for finding the uncertainty interval	LC, LW
		2.2	One-dimensional optimization methods	LC, LW
		2.3	The bisection method	LC, LW
		2.4	Dichotomy method	LC, LW
		2.5	Golden section method	LC, LW
		2.6	Fibonacci Method	LC, LW
Section 3	Multidimensional optimization methods	3.1	Multidimensional optimization methods of zero order	LC, LW
		3.2	The Hooke–Jeeves configuration method	LC, LW
		3.3	Nelder-Mead deformable polyhedron method	LC, LW
		3.4	Rosenbrock's method	LC, LW
		3.5	Powell's conjugate direction method	LC, LW
		3.6	Random Search Methods	LC, LW
		3.7	Adaptive Random Search Method	LC, LW
		3.8	Random search method with backtracking on failure	LC, LW
		3.9	Best Sample Method	LC, LW
		3.10	Statistical gradient method	LC, LW
		3.11	Random Search Method with Directing Hypersquare	LC, LW
Section 4	Numerical methods of differentiation and integration	4.1	Numerical methods for approximate calculation of derivatives	LC, LW
		4.2	Difference formula for calculating the first partial derivative	LC, LW
		4.3	Difference formula for calculating the second derivative	LC, LW
		4.4	Numerical methods for solving ODEs	LC, LW
		4.5	Cauchy problem	LC, LW
		4.6	Numerical solution of the Cauchy problem	LC, LW
		4.7	Euler's method	LC, LW
		4.8	Improved Euler methods	LC, LW
Section 5	First order optimization methods	5.1	First order optimization methods	LC, LW
		5.2	Constant step gradient descent method	LC, LW
		5.3	Coordinate gradient descent method	LC, LW
		5.4	Steepest Gradient Descent Method	LC, LW
		5.5	Gauss-Seidel method	LC, LW
		5.6	Fletcher–Reeves method	LC, LW
Section 6	Second order optimization methods	6.1	Second order optimization methods	LC, LW
		6.2	Newton's method	LC, LW
		6.3	Newton–Raphson method	LC, LW
		6.4	Marquardt method	LC, LW
Section 7	Conditional Optimization Methods	7.1	Penalty function methods in conditional optimization	LC, LW
		7.2	Penalty function method (external penalty method)	LC, LW
		7.3	Barrier function method (internal penalty method)	LC, LW
		7.4	Combined penalty function method	LC, LW
Section 8	Linear programming problems	8.1	Statement of the linear programming problem	LC, LW
		8.2	Canonical form of writing a linear programming problem and methods of reduction to it	LC, LW

Section number	Name of the discipline section	Section Contents (Topics)		Type of academic work*
		8.3	Simplex method for solving linear programming problems	LC, LW
		8.4	An algorithm for obtaining an admissible initial basis when solving a linear programming problem using the simplex method	LC, LW
Section 9	Discrete optimization problems	9.1	Concept and class of discrete optimization problems	LC, LW
		9.2	Classical discrete optimization problems	LC, LW
		9.3	Methods for solving discrete optimization problems	LC, LW
		9.4	Heuristic algorithms	LC, LW
		9.5	Branch and Bound Method	LC, LW
		9.6	Dynamic programming method	LC, LW
Section 10	Modern metaheuristic algorithms for global optimization	10.1	Class of metaheuristic algorithms for global optimization	LC, LW
		10.2	Evolutionary and population optimization methods	LC, LW
		10.3	Evolutionary algorithms	LC, LW
		10.4	Genetic algorithm	LC, LW
		10.5	Crossover and mutation operations in genetic algorithm	LC, LW
		10.6	Population algorithms	LC, LW
		10.7	Particle swarm method	LC, LW
		10.8	Scheme of modification of a possible solution in the particle swarm method	LC, LW
		10.9	Bee algorithm	LC, LW
		10.10	Gray wolf algorithm	LC, LW
		10.11	Cat optimization algorithm	LC, LW
		10.12	A method inspired by bats	LC, LW
		10.13	Whale optimization algorithm	LC, LW

* - 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	An auditorium for conducting lecture-type classes, equipped with a set of specialized furniture; a board (screen) and technical means for multimedia presentations.	
Computer class	A computer room for conducting classes, group and individual consultations, ongoing monitoring and midterm assessment, equipped with personal computers (15 units), a board (screen) and technical means for multimedia presentations.	
For independent work	A classroom for independent work of students (can be used for conducting seminars and consultations), equipped with a	

Audience type	Equipping the auditorium	Specialized educational/laboratory equipment, software and materials for mastering the discipline (if necessary)
	set of specialized furniture and computers with access to the Electronic Information System.	

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

7. EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT OF THE DISCIPLINE

Main literature:

1. Attetkov A.V., GaLCin S.V., Zarubin V.S. Optimization methods.M.: Publishing house of Bauman Moscow State Technical University. 2001. 440 p.

2. Panteleev A.V., Letova T.A. Optimization methods in examples and problems.M.: Higher School. 2002. 544 p.

3. Kornienko V.P. Optimization methods.M.: Higher School. 2007. 664 p.

4. Sobol B.V., Meskhi B.Ch., Kanygin G.I. Optimization Methods. Workshop. Rostov-on-Don: Phoenix Publishing House.2009. 380 p.

Further reading:

1. Gladkov L.A., Kureichik V.V., Kureichik V.M. Genetic algorithms: M.: Fizmatlit, 2006.- 319 p.

2. Chernorutsky I.G. Optimization methods in control theory

3. Izmailov A.F., Solodov M.V. Numerical methods of optimization

4. Andreeva E.A., Tsiruleva V.M. Variational calculus and optimization methods

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 RUDNhttp://lib.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
- Electronic library system "Troitsky Bridge"

2. Databases and search engines

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

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

1. Lecture course on the subject "Numerical Methods".

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

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