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

DISCRETE MATHEMATICS

(name of discipline/module)

Recommended for the field of study/specialty:

27.03.04 CONTROL IN TECHNICAL SYSTEMS

(code and name of the field of study/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)

2026

1. THE GOAL OF MASTERING THE DISCIPLINE

The "Discrete Mathematics" course is part of the "Data Science and Space Systems" bachelor's program, focusing on the 27.03.04 "Control in Technical Systems" program, and is taught in the third semester of the second year. The course is offered by the Department of Mechanics and Control Processes. It consists of three sections and 15 topics and focuses on the fundamentals of set theory, Boolean algebra, and graph theory. Particular attention is paid to the analysis of methods for solving typical problems and their application in professional activities.

The purpose of mastering the discipline is to improve the level of mathematical literacy, the formation of fundamental knowledge and skills in the application of methods of discrete mathematics, necessary for professional activity and the mastery of subsequent disciplines.

2. REQUIREMENTS FOR THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the discipline "Discrete Mathematics" 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 Competency Achievement (within this discipline)
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 INSTITUTION

Discipline "Discrete Mathematics" refers to the part formed by the participants of educational relations 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 "Discrete Mathematics".

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, practical training*	Subsequent disciplines/modules, practices*
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	Computer Science and Programming; Introduction to Computing Science;	Research work / Scientific research work; Technological Training; Undergraduate Training; Space Flight Mechanics; Numerical Methods; Automatic Control Theory; *Virtual and Augmented Reality Technology***;

Cipher	Name of competence	Previous courses/modules, practical training*	Subsequent disciplines/modules, practices*
			*Virtual and augmented reality technologies***; Computer Science and Programming; Optimal Control Methods; Analysis of Geoinformation Data;

* - filled in accordance with the competency matrix and the SUP EP HE
** - elective courses/practices

4. SCOPE OF THE DISCIPLINE AND TYPES OF EDUCATIONAL WORK

The total workload of the course "Discrete Mathematics" is 2 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,**academic hours		**Semester(s)**
			3
Contact work, academic hours	*36*		*36*
Lectures (LC)	18		18
Laboratory work (LW)	18		18
Practical/seminar classes (SC)	0		0
Independent work of students, academic hours	*27*		*27*
Control (exam/test with assessment), academic hours	*9*		*9*
Total complexity of the discipline	**academic hours**	***72***	*72*
	credit	***2***	*2*

The total workload of the course "Discrete Mathematics" is 2 credit units.

Table 4.2. Types of educational work by periods of mastering the educational program of higher education for full-time education.

Type of academic work	**TOTAL,**academic hours		**Semester(s)**
			3
Contact work, academic hours	*36*		*36*
Lectures (LC)	18		18
Laboratory work (LW)	18		18
Practical/seminar classes (SC)	0		0
Independent work of students, academic hours	*27*		*27*
Control (exam/test with assessment), academic hours	*9*		*9*
Total complexity of the discipline	**academic hours**	***72***	*72*
	credit	***2***	*2*

The total workload of the course "Discrete Mathematics" is 2 credit units.

Table 4.3. Types of educational work by periods of mastering the educational program of higher education for full-time education.

Type of academic work	**TOTAL,**academic hours		**Semester(s)**
			3
Contact work, academic hours	*36*		*36*
Lectures (LC)	18		18
Laboratory work (LW)	18		18
Practical/seminar classes (SC)	0		0
Independent work of students, academic hours	*27*		*27*
Control (exam/test with assessment), academic hours	*9*		*9*
Total complexity of the discipline	**academic hours**	***72***	*72*
	credit	***2***	*2*

5. CONTENT OF THE DISCIPLINE

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

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
Section 1	Set theory	1.1	Basic concepts. Set operations and their properties. Venn diagrams. Binary relations and equivalence relations.	The concept of a set, element, and subset. Methods for defining sets. Operations: union, intersection, difference, complement, symmetric difference. Properties of operations: commutativity, associativity, distributivity, absorption laws, and De Morgan's law. Venn diagrams as a graphic way to illustrate relationships between sets. Binary relations: definition and methods of definition. Equivalence relations: reflexivity, symmetry, transitivity. Equivalence classes and set partitioning.	LC, LW
		1.2	Mappings, properties of mappings. Product of mappings, inverse mapping. Permutations of nth order	The concept of a mapping (function) from one set to another. Properties: injectivity (differentiality), surjectivity (mapping onto), bijectivity (one-to-one correspondence). Composition (product) of mappings. Inverse mapping for a bijection. Permutation of a finite set as a bijective mapping onto itself. Concept of permutation order, cycles, transpositions. Parity of a permutation, sign of a permutation.	LC, LW
		1.3	Algebraic laws. Internal law of composition. Generalized associativity. External law of composition.	The concept of algebraic structure. The internal law of composition (binary operation) on a set. Algebraic laws: associativity, commutativity, distributivity. Generalized associativity: the ability to uniquely calculate the result for any number of operands during an associative operation. Neutral and inverse elements. The external law of composition: multiplication of the elements of a set by the elements of another set (for example, multiplication of a vector by a number).	OK
Section 2	Propositional logic	2.1	Statements and logical connectives. Truth tables. Conditional statements.	The concept of a proposition as an assertion that can be true or false. Logical connectives (operations): negation, conjunction (logical "and"), disjunction (logical "or"), implication (the "if...then" condition), equivalence. Truth tables as a way of determining the truth of complex propositions based on the truth of simpler ones. Conditional propositions: direct, inverse, opposite, and contrapositive implication.	LC, LW
		2.2	Equivalent statements. Laws of propositional logic	The concept of logical equivalence. Fundamental laws of propositional logic: laws of idempotence, commutativity, associativity, distributivity, De Morgan's laws, the law of double negation, ab-	LC, LW

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
				sorption laws, laws of excluded middle, and contradiction. Using laws to simplify logical expressions.	
		2.3	Axiomatic Systems: Inferences and Proofs. Completeness in Propositional Logic	The concept of an axiomatic system: axioms and rules of inference. Correct inferences (modus ponens, modus tollens, etc.). Proof as a sequence of formulas, each of which is an axiom or is derived from the rules of inference from the preceding ones. The concept of completeness of a logical system: any tautology can be proven within a given axiomatics.	LC, LW
		2.4	Karnaugh Maps. Switching Circuits	Karnaugh maps as a graphical method for minimizing Boolean functions. Constructing maps for 2, 3, and 4 variables. Rules for gluing cells. Covering units with a minimum number of rectangles. Switching circuits (relay circuits, logic gates) as a technical implementation of Boolean functions. Series and parallel connection of contacts.	LC, LW
		2.5	Predicate calculus	Extension of propositional logic: introduction of predicates (statements about the properties of objects and the relationships between them). Quantifiers: the universal quantifier ("for all") and the existential quantifier ("exists"). Variables and subject areas. Formulas of predicate logic. Rules for negating quantifiers. Examples of formalizing propositions in natural language using predicates and quantifiers.	LC, LW
		2.6	Fundamentals of proof theory. Mathematical induction	The concept of proof in mathematics. Direct and indirect proofs (proof by contradiction). The method of mathematical induction as a method for proving statements that depend on a natural number. The basis of induction (testing for the initial value). The inductive step (proof of a step from n to n + 1). Application examples.	LC, LW
Section 3	Graph theory	3.1	Basic Concepts. Methods for Specifying Graphs. Incidence and Adjacency Matrices	Graph definition: vertices and edges. Undirected and directed graphs. Methods of graph definition: listing vertices and edges, graphical, matrix. Adjacency matrix: a square matrix indicating the presence of an edge between vertices. Incidence matrix: a rectangular matrix indicating the relationship between vertices and edges (which edge is incident to which vertex).	LC, LW
		3.2	Paths and Cycles. Graph Connectivity. Euler Paths and Cycles	The concepts of route, path, simple path, cycle, and simple cycle. Graph connectivity: connected and disconnected graphs, connected components. Eulerian path and Eulerian cycle: a path (cycle) that traverses each edge of the graph exactly once. Criterion for the	LC, LW

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
				existence of an Eulerian cycle (all vertices have even degree). The Königsberg Bridges Problem.	
		3.3	Directed and weighted graphs	Directed graph (digraph): edges have directions (arcs). Concepts of in-degree and out-degree. Connectivity in oriented graphs (weak, strong, one-way). Weighted graph: each edge (or arc) is assigned a numerical value (weight, cost, length). Examples: road map, connection diagram.	OK
		3.4	Hypercubes and Gray code	Hypercube as a special type of graph. n-dimensional hypercube: vertices are binary vectors of length n, edges connect vertices that differ in exactly one coordinate. Properties of hypercubes. Gray code: an ordering of binary vectors such that adjacent vectors differ in exactly one bit. Relationship with hypercube traversal. Applications of Gray code (e.g., in analog-to-digital converters).	LC, LW
		3.5	Breadth-first and depth-first traversal of a graph, recovering the path with the least number of intermediaries	Graph traversal algorithms. Depth-first search: recursive or stack-based depth-divide along edges. Breadth-first search: layer-by-layer propagation from the starting node using a queue. Using breadth-first search to find the shortest path in an unweighted graph (based on the number of edges). Recovering a path with the fewest intermediaries.	LC, LW
		3.6	Finding the shortest path, Dijkstra's algorithm	The problem of finding the shortest path in a weighted graph with non-negative weights. Dijkstra's algorithm: supports a set of visited vertices, distances from the start, and a priority queue. Step-by-step description of the algorithm. Recovering the shortest path. Examples of application in navigation and network routing.	LC, LW

* - to be completed 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 for the discipline

Audience type	Equipment of the auditorium	Specialized educational/laboratory equipment, software and materials for mastering the discipline (if necessary)
Lecture	A lecture hall equipped with specialized furniture, a whiteboard (screen), and multimedia presentation equipment.	Projector
Computer class	A computer room for conducting classes, group and individual consultations, ongoing monitoring and midterm assessment, equipped with personal computers (14 in total), a board (screen) and technical means for multimedia presentations.	
For independent work	A classroom for independent student work (can be used for seminars and consultations), equipped with a set of specialized furniture and computers with access to the Electronic Information System.	

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

7. EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT OF THE DISCIPLINE

Main literature:

1. Anderson, D.A. Discrete Mathematics and Combinatorics. : Translated from English – Moscow: Williams Publishing House. 2004. - 960 p.

2. Erusalimskii Ya. M. Discrete Mathematics. Theory and Practical Training [Electronic resource]: textbook. - St. Petersburg: Lan, 2018. - 476 p.

3. Melikhov, A.N. Oriented graphs and finite automata. – Moscow: Nauka, 1971. – 416 p.

Further reading:

1. Shevelev Yu. P. Discrete Mathematics [Electronic resource]: study guide. - St. Petersburg: Lan, 2019. - 592 p.

2. Gavrilov G.P., Sapozhenko A.A. Problems and exercises in the course of discrete mathematics. – Moscow: Nauka Publishing House, 2009 – 416 p. – ISBN 978-5-9221-0477-7

Resources of the information and telecommunications network "Internet":

1. RUDN University Electronic Library System and third-party electronic library systems to which university students have access based on concluded agreements
   - Electronic library system of RUDN - ELS RUDN http://lib.rudn.ru/MegaPro/Web
   - Electronic Library System "University Library Online" http://www.biblioclub.ru
   - EBS Yurayt http://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 regulatory documentation http://docs.cntd.ru/

- Yandex search engine https://www.yandex.ru/
- Google search engine https://www.google.ru/
- SCOPUS abstract database 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 "Discrete Mathematics".

* - all teaching 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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