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

OPERATIONS RESEARCH AND OPTIMIZATION TECHNIQUES
(name of discipline/module)

Recommended for the field of study/specialty:

27.04.04 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):

Artificial Intelligence, Machine Learning, and Space Science
(name (profile/specialization) of the educational institution of higher education)

2026

1. THE GOAL OF MASTERING THE DISCIPLINE

The course "Operations Research and Optimization Techniques" is part of the Master's program "Artificial Intelligence, Machine Learning, and Space Sciences" in the 27.04.04 "Control in Technical Systems" program and is studied in the second semester of the first year. The course is offered by the department of the Partner University. It consists of 6 sections and 15 topics and is aimed at studying an information-based approach to data models; modern decision-making technologies, systems and situation analysis; mastering the fundamental concepts, methods, specific application areas, and methods for using them as a ready-made practical tool in the design and development of systems, mathematical data processing, algorithm construction, and the organization of computational processes on computer equipment; and developing the necessary moral, ethical, and professional qualities of developers and users of information systems.

The purpose of this course is to develop students' theoretical knowledge and practical skills in matters related to management decision-making; to master modern mathematical methods of analysis and scientific forecasting; and to teach students how to apply models and methods of operations research in the process of preparing and making management decisions.

2. REQUIREMENTS FOR THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the discipline "Methods of Operations Research and Optimization" 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)
GPC-7	Capable of making informed choices, developing and implementing in practice circuit design, system engineering and hardware-software solutions for automation and control systems	GPC-7.1 Able to develop and implement in practice circuit and system engineering solutions for automation and control systems; GPC-7.2 Able to develop hardware and software solutions for automation and control systems; GPC-7.3 Has knowledge of approaches for making a well-founded choice and implementing in practice circuit, system engineering and hardware-software solutions for automation and control systems;
GPC-9	Capable of developing methods and performing experiments at existing facilities with processing of results based on information technology and technical means	GPC-9.1 Possesses modern information technologies and technical means for conducting experiments at operating facilities; GPC-9.2 Has skills in developing methods and conducting experiments at existing facilities; GPC-9.3 Has the skills to develop methods and conduct experiments at existing facilities with processing of results using information technology;
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 studied objects 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; PC-2.3 Has a command of 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 INSTITUTION

Course "Methods of Operations Research and Optimization" 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 "Methods of Operations Research and Optimization".

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***
GPC-7	Capable of making informed choices, developing and implementing in practice circuit design, system engineering and hardware-software solutions for automation and control systems		Undergraduate practice / Pre-graduation practice;
GPC-9	Capable of developing methods and performing experiments at existing facilities with processing of results based on information technology and technical means	Introduction to Geospatial Technology;	Undergraduate practice / Pre-graduation practice; Dynamics and Control of Space Systems; Geoinformation Systems and Applications;
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	Mathematics for Spatial Sciences;	Undergraduate practice / Pre-graduation practice; Research Work; Dynamics and Control of Space Systems; *Artificial Neural Networks (Deep Learning)***; *Artificial Neural Networks (Deep Learning)***; Advanced Methods of Space Flight Mechanics; *Artificial Neural Networks (Reinforcement Learning)***;

* - 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 “Methods of Operations Research and Optimization” is 4 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)**
			2
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	*83*		*83*
Control (exam/test with assessment), academic hours	*27*		*27*
Total complexity of the discipline	**academic hours**	***144***	*144*
	credit	***4***	*4*

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	Basics of Linear Programming	1.1	Basic concepts of operations research. Forms for writing linear programming problems.	The subject and objectives of operations research. Stages of solving optimization problems.	LC, SC
		1.2	Graphical method for solving linear programming problems	Geometric interpretation of a linear programming problem with two variables. Construction of a feasible region (polyhedron). Determining the direction of the objective function gradient. Finding the optimal point by moving the level line. Special cases: alternative optimum, unbounded objective function, empty feasible region.	LC, SC
		1.3	Basic concepts of operations research.	The concept of a mathematical model of an operation. Forms of linear programming problems: general, standard, and canonical. Objective function and constraint system. Feasible and optimal solutions.	LC, SC
Section 2	Applied optimization methods for solving linear programming problems	2.1	Simplex method	A simplex method algorithm for solving linear programming problems in canonical form. Initial feasible basis solution. Simplex tables. Rules for selecting the resolving column (input variable) and resolving row (output variable). Optimality criterion. Degeneracy, unboundedness, and non-existence of a solution criteria. Modifications of the simplex method.	LC, SC
		2.2	Duality in linear programming	The concept of a dual problem. Construction of a dual problem to the original (primary) problem in symmetric and asymmetric forms. Fundamental duality theorems: the relationship between optimal solutions to the primary and dual problems. Economic interpretation of dual variables (shadow prices, objectively determined valuations).	LC, SC
		2.3	Stability analysis of the optimal solution	Study of the sensitivity of the optimal solution to changes in model parameters. Analysis of the impact of changes in the objective function coefficients. Analysis of the impact of changes in the right-hand sides of constraints (resources). Determination of stability intervals for the coefficients. The range of resource changes within which the structure of the optimal solution is preserved.	LC, SC
		2.4	Linear programming transportation problem	Statement of the transportation problem: minimizing the cost of transporting a homogeneous cargo from suppliers to consumers. Balance condition (closed model). Open model and its reduction to	LC, SC

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
				a closed one. Methods for constructing the initial baseline plan: northwest corner method, minimum cost method. Potential method for finding the optimal solution. Distribution method. The problem of degeneracy in the transportation problem.	
Section 3	Integer programming	3.1	Gomori's cutting methods	Statement of an integer linear programming problem. Gomory's cutting (cutting plane) methods for fully and partially integer problems. Algorithm for constructing additional constraints (cuts). Solution process: sequential addition of constraints until an integer optimal solution is obtained.	LC, SC
		3.2	Reducing a matrix game to a linear programming problem	The relationship between matrix game theory and linear programming. Transition from finding the optimal mixed strategy in a zero-sum game to solving a pair of dual linear programming problems. Interpretation of variables and constraints. Application of the simplex method to finding the value of the game and optimal strategies for players.	LC, SC
Section 4	Matrix game theory	4.1	Basic concepts of matrix game theory	The subject and objectives of game theory. Classification of games: antagonistic (zero-sum) and non-antagonistic, cooperative and non-cooperative. Matrix games as a model of conflict between two players with opposing interests. Payoff matrix. The concept of pure strategy. Lower and upper price of the game. Minimax principle. Saddle point. The concept of mixed strategy. Active and passive strategies.	LC, SC
		4.2	Reducing a matrix game to a linear programming problem	Justification of the transition from a zero-sum antagonist matrix game to a pair of dual linear programming problems. Construction of an objective function and a system of constraints for the maximizing and minimizing players. Interpretation of the problem variables as normalized probabilities of choosing pure strategies. Determining the value of the game and optimal mixed strategies for solving a linear programming problem. Application of the simplex method to the analysis of high-dimensional game models.	LC, SC
Section 5	Dynamic programming	5.1	Statement of the dynamic programming problem	Basic concepts of dynamic programming. Multi-step decision processes. Bellman's optimality principle. Key elements of the model: stages (steps), system states, control variables, transition function, optimality criterion. Forward and backward fit.	LC, SC
		5.2	Functional method	Derivation and application of Bellman functional equations to dynamic programming problems. Sequential optimization at each	LC, SC

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
				step. Resource allocation problem, equipment replacement problem, inventory control problem. Computational scheme of the method.	
Section 6	Nonlinear programming	6.1	Lagrange multiplier method	Statement of the constrained optimization problem under equality constraints. The Lagrange multiplier method: constructing the Lagrange function. Necessary optimality conditions (Kuhn-Tucker theorem). Calculation of partial derivatives and solution of a system of equations. Economic interpretation of Lagrange multipliers.	LC, SC
		6.2	Quadratic programming	Statement of the quadratic programming problem: quadratic objective function with linear constraints. Convexity conditions (definite sign of the quadratic matrix). Solution methods: gradient methods, Wolfe's method (reduction to a linear programming problem). Application of quadratic programming in portfolio analysis and regression analysis.	LC, SC

* - 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.	
Seminar	An auditorium for conducting seminar-type classes, group and individual consultations, ongoing monitoring and midterm assessment, equipped with a set of specialized furniture 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. Kulkarni AJ, Satapathy SC (ed.). Optimization in machine learning and applications. – Heidelberg: Springer, 2020. –P. 51-68.
2. Sra S., Nowozin S., Wright S. J. (ed.).Optimization for machine learning. – MIT press, 2011.

Further reading:

1. Haidar AD Operations research and optimization techniques //Construction Program Management–Decision Making and Optimization Techniques. – Cham: Springer International Publishing, 2015. – pp. 131-157.
2. Lan G. First-order and stochastic optimization methods for machine learning. – Cham: Springer, 2020. – T. 1.

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
   - RUDN University Electronic Library System – RUDN University Electronic Library System https://mega.rudn.ru/MegaPro/Web
   - Electronic Library System "University Library Online" http://www.biblioclub.ru
   - EBS "Urayt" http://www.biblio-online.ru
   - Electronic Library System "Student Consultant" www.studentlibrary.ru
   - EBS “Knowledge” 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 "Methods of operations research and optimization".

* - 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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