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**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

SYSTEMS ENGINEERING

(name of discipline/module)

Recommended for the field of study/specialty:

01.04.02 APPLIED MATHEMATICS AND INFORMATICS

(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):

SPACE MISSION AND SYSTEM DESIGN

(name (profile/specialization) of the educational institution of higher education)

1. THE GOAL OF MASTERING THE DISCIPLINE

The course "Systems Engineering" is part of the Master's program "Space mission and system design" in the major 01.04.02 "Applied Mathematics and Informatics" and is studied in the first semester of the first year. The course is offered by the department of the Partner University. It consists of three sections and 12 topics and focuses on studying the fundamental principles of integrated systems design from a holistic perspective, analyzing the main methods for solving typical problems, and familiarizing students with the scope of their application in professional activities. The course involves viewing the system problem space in its entirety, from the initial concept throughout the lifecycle to retirement.

The goal of mastering the discipline is the formation of fundamental knowledge and skills in the application of problem solving methods necessary for professional activity, increasing the general level of literacy of students on basic systems and systems engineering concepts and terms; introduce systems engineering as a problem solving process / approach, project decision support, and its relationship to program life cycle.

2. REQUIREMENTS FOR THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the discipline "Systems Engineering" 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)
UC-2	Capable of managing a project at all stages of its life cycle	UC-2.1 Formulates a problem, the solution of which is directly related to the achievement of the project goal, defines the connections between the tasks set; UC-2.2 Within the framework of the assigned tasks, determines the available resources and limitations, current legal norms, and optimizes the ways of solving problems; UC-2.3 Monitors the progress of the project, adjusts the schedule in accordance with the monitoring results.
PC-1	Able to formulate goals and objectives of scientific research in the field of applied mathematics and computer science, computer technology and modern programming technologies, and select methods and means for solving problems	PC-1.1 Possesses fundamental knowledge obtained in the field of mathematical and (or) natural sciences, programming and information technology; PC-1.2 Able to find, formulate and solve standard problems in his own research activities in the field of applied mathematics and computer science, computer technology and modern programming technologies; PC-1.3 Has practical experience in research activities in the field of applied mathematics and computer science, computer engineering and modern programming technologies.;
PC-3	Capable of participating in scientific research and development of design solutions in the field of ballistics, dynamics and flight control of spacecraft	PC-3.1 Knows the basic mathematical methods and modern tools in the field of ballistic design of space complexes and systems; PC-3.2 Possesses basic knowledge of standards, norms and rules for developing design solutions in the field of ballistics, dynamics and flight control of spacecraft; PC-3.3 Able to apply mathematical methods and modern information technologies in conducting scientific research and developing design solutions in the field of ballistics, dynamics and flight control of spacecraft.
PC-5	Capable of analyzing, including in English, methods for studying ballistic and dynamic characteristics when modeling spacecraft flight trajectories	PC-5.1 Knows proven and applied methods, including those from English-language sources, for studying ballistic and dynamic characteristics when modeling spacecraft flight trajectories; PC-5.2 Able to develop and modernize methods for studying ballistic and dynamic characteristics when modeling spacecraft

Cipher	Competence	Indicators of Competency Achievement (within this discipline)
		flight trajectories; PC-5.3 Has mastered methods and approaches to studying ballistic and dynamic characteristics when modeling spacecraft flight trajectories.

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

Discipline "Design of engineering systems" 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 "Design of engineering systems."

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*
UC-2	Capable of managing a project at all stages of its life cycle		Practical Training in Receiving Remote Sensing Data from Satellites and its Interpretation (online from RUDN Mission Control Center) / Research; Pre-Graduation Internship in Industry; Aerospace Systems; System Design; Dynamics and Control of Space Systems; Project "Drone Systems Engineering. Part 1"; Project "Drone Systems Engineering. Part 2";
PC-1	Able to formulate goals and objectives of scientific research in the field of applied mathematics and computer science, computer technology and modern programming technologies, and select methods and means for solving problems		Pre-Graduation Internship in Industry; Practical Training in Receiving Remote Sensing Data from Satellites and its Interpretation (online from RUDN Mission Control Center) / Research; Practical Training and Research in Dynamics and Control of Space Systems (online from RUDN Mission Control Center) / Research work; Technological Training; Advanced Methods of Remote Sensing and Geoinformation Systems; System Design; Dynamics and Control of Space Systems;

Cipher	Name of competence	Previous courses/modules, practical training*	Subsequent disciplines/modules, practices*
PC-3	Capable of participating in scientific research and development of design solutions in the field of ballistics, dynamics and flight control of spacecraft		Pre-Graduation Internship in Industry; Practical Training in Receiving Remote Sensing Data from Satellites and its Interpretation (online from RUDN Mission Control Center) / Research; Practical Training and Research in Dynamics and Control of Space Systems (online from RUDN Mission Control Center) / Research work; Technological Training; Aerospace Systems; Structures & Materials Modeling; System Design; On-board Energy; Dynamics and Control of Space Systems; Project "Drone Systems Engineering. Part 1"; Project "Drone Systems Engineering. Part 2";
PC-5	Capable of analyzing, including in English, methods for studying ballistic and dynamic characteristics when modeling spacecraft flight trajectories		Pre-Graduation Internship in Industry; Practical Training in Receiving Remote Sensing Data from Satellites and its Interpretation (online from RUDN Mission Control Center) / Research; Practical Training and Research in Dynamics and Control of Space Systems (online from RUDN Mission Control Center) / Research work; Technological Training; Aerospace Systems; Structures & Materials Modeling; System Design; On-board Energy; Dynamics and Control of Space Systems; Advanced Methods of Remote Sensing and Geoinformation Systems;

* - 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 discipline "Design of engineering systems" is 6 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)
			1
<i>Contact work, academic hours</i>	20		20
Lectures (LC)	10		10
Laboratory work (LW)	0		0
Practical/seminar classes (SC)	10		10
<i>Independent work of students, academic hours</i>	160		160
<i>Control (exam/test with assessment), academic hours</i>	36		36
Total complexity of the discipline	academic hours	216	216
	credit	6	6

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	Introduction to Systems Engineering	1.1	Systems Engineering Overview	Definition and scope of systems engineering as an interdisciplinary field. Key principles: holistic approach, lifecycle orientation, stakeholder focus. The role of the systems engineer in complex projects. Comparison with traditional engineering disciplines. Core concepts: system boundary, interfaces, functions, requirements, and architecture.	LC, SC
		1.2	Life Cycle Stages	Overview of typical system life cycle stages: concept, development, production, utilisation, support, and retirement. Technical, business, and management activities at each stage. Entry and exit criteria for stage transitions. Importance of traceability and documentation across the lifecycle.	LC, SC
		1.3	Decision Making and Risk Assessment in Design and Model-Based System Engineering	Decision-making processes in systems engineering: trade-off studies, selection criteria, stakeholder alignment. Risk assessment: identification, analysis, evaluation, and mitigation of technical, schedule, and cost risks. Introduction to Model-Based Systems Engineering as an approach using digital models to support analysis, requirements, design, verification, and validation throughout the lifecycle.	LC, SC
Section 2	System Engineering Technical Processes: Down the Systems Vee	2.1	Business and Mission Analysis Process	Definition of business or mission problem or opportunity. Identification of constraints and assumptions. Definition of success criteria and measurable outcomes. Outputs: preliminary concept of operations, mission needs statement, and high-level stakeholder requirements.	LC, SC
		2.2	Stakeholder Needs and Requirements Definition Process	Identification of stakeholders and their needs. Elicitation techniques: interviews, workshops, document analysis. Transformation of stakeholder needs into structured stakeholder requirements. Validation of requirements against mission objectives. Management of requirements traceability and changes.	LC, SC
		2.3	Architecture Definition Process	Definition of system architecture as a framework describing structure, behavior, and interactions. Development of logical and physical architectures. Use of architecture frameworks. Identification of system functions and their allocation to physical components. Creation of architecture views.	LC, SC

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
		2.4	Interface Design and Definition	Identification of internal and external interfaces. Definition of interface requirements: mechanical, electrical, data, software, human. Interface control documentation and management. Interface compatibility and conflict resolution.	LC, SC
		2.5	System Definition Process	Refinement of architecture into detailed system design. Definition of system components, their functions and performance parameters. Establishment of traceability between requirements and design elements. Preparation of system specification documents.	LC, SC
Section 3	System Engineering Technical Processes: Up the Systems Vee	3.1	Design Definition Process	Detailed design of system components including hardware, software, human elements, facilities, and services. Application of design methods. Development of design documentation including drawings, models, and specifications. Design optimization and trade-off analysis. Design review and acceptance criteria.	LC, SC
		3.2	System Analysis Process and Implementation Process	System analysis: selection of analytical methods for performance, cost, schedule, and risk evaluation. Trade-off studies supporting design decisions. Implementation process: transformation of design into physical components. Production, coding, assembly, and procurement activities. Verification of implementation against design specifications.	LC, SC
		3.3	Integration, Verification, Transition, and Validation Processes	Integration: assembly of components into larger subsystems and the complete system. Verification: confirmation that the system meets specified requirements through inspection, analysis, demonstration, and testing. Transition: movement of system to operational environment. Validation: confirmation that the system meets stakeholder needs in operational environment.	LC, SC
		3.4	Operation, Maintenance, Disposal Process, Tailoring SE Processes	Operation: system use to deliver intended services. Maintenance: corrective and preventive actions to sustain system capability. Disposal: safe and environmentally responsible retirement of system at end of life. Tailoring: adaptation of systems engineering processes to project scale, domain, risk, and constraints while maintaining compliance with relevant standards.	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. Donella Meadows, "Thinking in Systems: A Primer", 2008.240 pages.
2. Hammond and Keeney, "Smart Choices: A Practical Guide to Making Better Decisions," 2015.256 pages.

Further reading:

1. Janine Benyus, "Biomimicry: Innovation Inspired by Nature", 1997/2002.308 pages
2. Peter Bernstein, "Against the Gods: The Remarkable Story of Risk", 1998.400 pages.

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 Yurayt <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 "Design of engineering systems".

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

DEVELOPER:

Associate Professor

Position, DEPARTMENT

Signature

Saltykova Olga
Alexandrovna

Surname I.O.

HEAD OF THE DEPARTMENT:

Position of the DEPARTMENT

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Professor

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Razumny Yuri Nikolaevich

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