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

DYNAMICS AND CONTROL OF SPACE SYSTEMS

(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)

2026

1. THE GOAL OF MASTERING THE DISCIPLINE

The course "Dynamics and Control of Space Systems" is part of the Master's program "Space mission and system design" in the 01.04.02 "Applied Mathematics and Informatics" major and is studied in semesters 3 and 4 of the second year. The course is offered by the Department of Mechanics and Control Processes. It consists of two sections and seven topics and focuses on developing practical skills in solving design problems related to the formation and calculation of the motion of spacecraft and orbital structures for various purposes, solving specific engineering problems related to orbital launch and maneuvering, and applying mathematical modeling methods to solve these problems using modern computer tools.

The purpose of mastering the discipline is to acquire knowledge, skills, abilities and experience in the field of designing space satellite systems for various purposes, maneuvering spacecraft in orbit, methods of their calculation and optimization, characterizing the stages of the formation of competencies and ensuring the achievement of the planned results of mastering the educational program.

2. REQUIREMENTS FOR THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the discipline "Dynamics and Control of Space Systems" 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-1	Capable of carrying out a critical analysis of problematic situations based on a systems approach and developing an action strategy	UC-1.1 Analyzes the task, identifying its basic components; UC-1.2 Searches for information to solve a given problem using various types of queries, suggests options for solving the problem, and analyzes the possible consequences of their use; UC-1.3 Analyzes ways of solving problems of ideological, moral and personal nature based on the use of basic philosophical ideas and categories in their historical development and socio-cultural context.
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.
GPC-2	Capable of improving and implementing new mathematical methods for solving applied problems	GPC-2.1 Uses the results of applied mathematics to master and adapt new methods for solving problems in the area of professional interests; GPC-2.2 Implements and improves new methods for solving applied problems in the field of professional activity; GPC-2.3 Conducts a qualitative and quantitative analysis of the obtained solution in order to construct an optimal option.
GPC-3	Able to develop mathematical models and analyze them when solving problems in the field of professional activity	GPC-3.1 Develops mathematical models in the field of applied mathematics and computer science; GPC-3.2 Analyzes mathematical models for solving applied problems of professional activity; GPC-3.3 Develops and analyzes new mathematical models for solving applied problems of professional activity in the field of applied mathematics and computer science.
PC-1	Able to formulate goals and objectives of scientific research	PC-1.1 Possesses fundamental knowledge obtained in the field of mathematical and (or) natural sciences, programming and infor-

Cipher	Competence	Indicators of Competency Achievement (within this discipline)
	in the field of applied mathematics and computer science, computer technology and modern programming technologies, and select methods and means for solving problems	mation 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 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 EDUCATIONAL INSTITUTION

Course "Dynamics and Control of Space Systems" 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 "Dynamics and Control of Space 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; Aerospace Systems; Project "Drone Systems Engineering. Part 1"; *Applied Mechanics and Engineering***; *Systems Engineering***;	
UC-1	Capable of carrying out a critical analysis of problematic situations based on a	Practical Training in Receiving Remote Sensing Data from Satellites and its Interpretation (online from	

Cipher	Name of competence	Previous courses/modules, practical training*	Subsequent disciplines/modules, practices*
	systems approach and developing an action strategy	RUDN Mission Control Center) / Research; Databases; Advanced Methods of Remote Sensing and Geoinformation Systems; Structures & Materials Modeling; Project "Drone Systems Engineering. Part 1"; *Machine Learning and Big Data Mining***; *From Data Acquisition to Data Treatment***;	
GPC-2	Capable of improving and implementing new mathematical methods for solving applied problems	Aerospace Systems; Structures & Materials Modeling;	
GPC-3	Able to develop mathematical models and analyze them when solving problems in the field of professional activity	Programming; Aerospace Systems; Structures & Materials Modeling; Project "Drone Systems Engineering. Part 1";	
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	Practical Training in Receiving Remote Sensing Data from Satellites and its Interpretation (online from RUDN Mission Control Center) / Research; Programming; Databases; Advanced Methods of Remote Sensing and Geoinformation Systems; *Machine Learning and Big Data Mining***; *From Data Acquisition to Data Treatment***; *Applied Mechanics and Engineering***; *Systems Engineering***; *Virtual Reality and Computer Vision***; *Modeling and Validation***;	
PC-3	Capable of participating in scientific research and development of design solutions in the field of ballistics, dynamics and flight control of spacecraft	Practical Training in Receiving Remote Sensing Data from Satellites and its Interpretation (online from RUDN Mission Control Center) / Research; Aerospace Systems; Structures & Materials Modeling; Project "Drone Systems Engineering. Part 1"; *Applied Mechanics and Engineering***; *Systems Engineering***;	
PC-5	Capable of analyzing, including in English, methods	English Language; Aerospace Systems;	

Cipher	Name of competence	Previous courses/modules, practical training*	Subsequent disciplines/modules, practices*
	for studying ballistic and dynamic characteristics when modeling spacecraft flight trajectories	Structures & Materials Modeling; *Applied Mechanics and Engineering***; *Systems Engineering***; Practical Training in Receiving Remote Sensing Data from Satellites and its Interpretation (online from RUDN Mission Control Center) / Research; Russian as a Foreign Language; 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 course “Dynamics and Control of Space Systems” is 10 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	**4**
Contact work, academic hours	*190*		*126*	*64*
Lectures (LC)	80		54	26
Laboratory work (LW)	30		18	12
Practical/seminar classes (SC)	80		54	26
Independent work of students, academic hours	*143*		*54*	*89*
Control (exam/test with assessment), academic hours	*27*		*0*	*27*
Total complexity of the discipline	**academic hours**	***360***	*180*	*180*
	credit	***10***	*5*	*5*

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	Methods for optimizing orbital structures of satellite systems	1.1	General principles of satellite system design. Methods for constructing systems for global, continuous coverage of Earth's regions. Ballistic design of systems for zonal, continuous coverage of the Earth's surface.	General principles of satellite system design: purpose, composition, structure, accuracy and performance requirements. Methods for constructing global continuous surveillance systems: low-orbit constellations, geostationary systems, Molniya orbits. Ballistic design of zonal continuous surveillance systems: selection of orbital parameters (altitude, inclination, eccentricity), determination of the number of satellites in the constellation, coverage area analysis.	LC, LW, SC
		1.2	Determining the time gap in observations by a single frontal group of the entire Earth's surface. Methods for constructing satellite systems for periodic coverage of the Earth's surface. Designing ballistic structures for systems for covering the entire Earth's surface with small gaps in observations. Designing systems for periodic coverage of a region on the Earth's surface. Ballistic design of probabilistic spacecraft systems.	Determining the time gap in observations by a single frontal group. Methods for constructing periodic surveillance systems: using multiple orbits, phase shifts. Constructing ballistic structures for global coverage with a given periodicity: optimizing satellite placement, taking into account the latitude belt.	LC, LW, SC
		1.3	Spacecraft communication systems. Satellite radio navigation systems. Design features of meteorological satellite systems. Design of space surveillance systems. Ballistic design of systems using ballistically coupled spacecraft groups.	Satellite communication systems: geostationary and low-orbit systems (Iridium, Globalstar, Starlink). Satellite radio navigation systems: GPS, GLONASS, Galileo, BeiDou – design principles, orbital structures. Features of meteorological satellite systems: geostationary (GOES, Meteosat) and polar-orbiting (NOAA, Meteor). Space surveillance systems: detection and tracking of space debris and hazardous objects. Ballistic design of systems with highly elliptical orbits.	LC, LW, SC
		1.4	Space tether systems. Orbital operation of tethered space objects. Space rendezvous using tether systems. A method for developing optimal controlled motion modes for tether systems when solving practical problems.	Space tether systems: purpose, design, and physical principles. Orbital operation of tethered objects: the dynamics of the satellite-tether-cargo system. Rendezvous using tether systems. Method for developing optimal controlled motion modes for tether systems: minimizing energy consumption and stabilization.	LC, LW, SC
Section 2	Numerical and analytical methods for optimizing or-	2.1	Equations of spacecraft motion during deviations from a reference circular orbit. Sin-	Equations of spacecraft motion during deviations from a reference circular orbit. Single-impulse maneuvers: changing the orbital	LC, LW, SC

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
	bital maneuvers		gle-impulse maneuvers. Orbital shape change due to the application of a velocity impulse. Estimating the magnitude of maneuvers, choosing the initial deviation along the orbit at spacecraft launch. Necessary optimality conditions. Main types of optimal spacecraft maneuvering problems.	shape and orientation. Estimating the characteristic velocity. Selecting the initial deviation to minimize costs.	
		2.2	Optimal maneuvering in the space debris problem. Spacecraft collision avoidance maneuvers against space debris. Evaluation of maneuvers performed by an active space object.	The space debris problem: sources, scale, and threats. Avoidance maneuvers: proximity detection, impulse calculation, and optimization of direction and magnitude. Maneuver evaluation: fuel consumption, execution accuracy.	LC, LW, SC
		2.3	Optimal maneuvering in space servicing. Planning optimal servicing for a constellation of spacecraft in non-coplanar orbits. Evaluation of maneuvers performed by active spacecraft when transferred to the vicinity of serviced objects.	Space servicing tasks: refueling, repairs, and deorbiting. Constellation servicing planning in non-coplanar orbits: optimization of rendezvous sequences, minimization of fuel consumption. Active spacecraft maneuver assessment: insertion accuracy, remaining fuel.	LC, LW, 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.	
Computer class	A computer room for conducting classes, group and individual consultations, ongoing monitoring and midterm assessment, equipped with personal computers (in the amount of ____ units), a board (screen) and technical means for multimedia presentations.	
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. Averkiev N.F., Vlasov S.A., Bogachev S.A., Zhatkin A.T., Kulvits A.V. Ballistic principles of designing launch vehicles and satellite systems: textbook. - St. Petersburg: A.F. Mozhaisky Air Defense Academy, 2017. - 300 p.

2. Baranov A.A. Maneuvering of spacecraft in the vicinity of a circular orbit. - M.: Publishing House "Sputnik+", 2016. - 512 p.

3. Bordovitsyna T.V., Avdyushev V.A. Theory of motion of artificial Earth satellites. Analytical and numerical methods: a tutorial. - Tomsk: Publishing house of Tomsk. University, 2007. - 178 p.

4. Beletsky V.V. Essays on the motion of cosmic bodies. Issue No. 4. - M.: URSS Publishing Group, 2017. - 432 p.

Further reading:

1. Vlasov S.A., Kulvits A.V., Skripnikov A.N. Spacecraft flight theory: textbook. - St. Petersburg: A.F. Mozhasky Space Academy, 2018. - 412 p.

2. Ivanov N.M., Lysenko L.N. Ballistics and navigation of spacecraft: textbook. 3rd edition. - M.: Drofa, 2016. - 528 p.

3. Sazonov V.V., Barbashova T.F. Lectures on space flight mechanics. Special course. - M.: Moscow State University Publishing House, 2018. - 152 p.

4. Mechanical Engineering. Encyclopedia. Editorial Board: K. V. Frolov (chairman) et al. - Moscow: Mechanical Engineering. Rocket and Space Technology. Vol. IV-22 / A. P. Adzhyan, E. L. Akim, O. M. Alifanov et al.; editors V. P. Legostaev, editors E. A. Akim, Yu. P. O. M. Alifanov, V. V. Vakhnichenko, G. N. Zaslavsky, A. A. Dyadkin, V. V. Ivashkin, B. I. Katorgin, Yu. N. Razumny, Yu. P. Ulybyshev, Book 1. 2012. Section 2.5. Satellite Systems. Pp.

5. Razumny Yu.N., Shkolnikov D.O. Basic integrals of unperturbed motion and the Kepler equation: a tutorial. - Moscow: Publishing house of Bauman Moscow State Technical University, 2011. - 38 p.

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 "Dynamics and control of space 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:

Professor		Baranov Andrey Anatolyevich
Position, DEPARTMENT	*Signature*	*Surname I.O.*

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