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:

27.04.04 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):

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

2025

1. THE GOAL OF MASTERING THE DISCIPLINE

The discipline "Dynamics and Control of Space Systems" is part of the master's program "Artificial Intelligence, Machine Learning and Space Sciences" in the direction 27.04.04 "Control in Technical Systems" and is studied in the 3rd semester of the 2nd year. The discipline is implemented by the Department of Mechanics and Control Processes. The discipline consists of 2 sections and 7 topics and is aimed at studying and acquiring practical skills in solving design problems of forming and calculating the motion of spacecraft, orbital structures for various purposes, solving specific engineering problems related to launching, maneuvering in orbit, applying mathematical modeling methods in solving the tasks using modern computer tools.

The purpose of mastering the discipline is to obtain 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 formation of competencies and ensuring the achievement of the planned results of mastering the educational program.

2. REQUIREMENTS TO THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the discipline "Dynamics and control of space systems" 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 control problems in technical systems and justify methods for solving them	GPC-2.1 Knows the basic methods of solving control problems in technical systems; GPC-2.2 Able to justify methods for solving control problems in technical systems; GPC-2.3 Proficient in methods of setting control problems in technical systems.
GPC-3	Capable of independently solving control problems in technical systems based on the latest achievements of science and technology	GPC-3.1 Knows the basic approaches to solving control problems in technical systems; GPC-3.2 Able to apply basic approaches based on the latest achievements of science and technology to solving control problems in technical systems; GPC-3.3 Has mastered methods for solving control problems in technical systems based on the latest achievements of science and technology.
GPC-4	Capable of assessing the effectiveness of the results of developing control systems using mathematical methods	GPC-4.1 Knows the basic mathematical methods used to evaluate the effectiveness of the results of control systems; GPC-4.2 Able to apply mathematical methods to evaluate the effectiveness of the results of control systems; GPC-4.3 Proficient in methods for assessing the effectiveness of management systems.
GPC-5	Capable of conducting patent research, determining forms and methods of legal protection and defense of rights to the results of intellectual activity, managing rights to them to solve problems in the development of science, engineering and technology	GPC-5.1 Knows the methods and approaches to conducting patent research, forms and methods of legal protection and defense of rights to the results of intellectual activity; GPC-5.2 Able to manage rights to the results of intellectual activity to solve problems in the field of development of science, engineering and technology; GPC-5.3 Has knowledge of methods and approaches to conducting patent research, knows methods of legal protection and defense of rights to the results of intellectual activity.;
GPC-7	Capable of making informed choices, developing and implementing in practice circuit,	GPC-7.1 Able to develop and implement in practice circuit and system engineering solutions for automation and control systems;

Cipher	Competence	Indicators of Competence Achievement (within the framework of this discipline)
	system engineering and hardware-software solutions for automation and control systems	GPC-7.2 Can develop hardware and software solutions for automation and control systems; GPC-7.3 Possesses 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 on existing facilities with processing of results based on information technologies 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 perform 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 the objects under study 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 mastered modern theoretical and experimental methods for developing mathematical models of objects and processes of professional activity in the field of study.;
PC-4	Capable of participating in scientific research and development of design solutions in the field of ballistics, dynamics and flight control of spacecraft	PC-4.1 Familiar with the basic methods and approaches used to solve problems in the field of artificial intelligence and robotic systems; PC-4.2 Has knowledge of methods for solving professional problems in the field of artificial intelligence and robotic systems; PC-4.3 Able to apply mathematical methods and modern information technologies when conducting scientific research.;

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

Discipline "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, practices*	Subsequent disciplines/modules, practices*
GPC-2	Able to formulate control problems in technical systems and justify methods for solving them	Virtual Reality and Computer Vision; Numerical Methods for Solving Mathematical Modeling Problems; Information Technology in Mathematical Modeling; Programming Technology;	Undergraduate Training;
GPC-3	Capable of independently solving control problems in technical systems based on the latest achievements of science and technology	Virtual Reality and Computer Vision; Advanced Methods of Space Flight Mechanics; Programming Technology;	Undergraduate Training;

Cipher	Name of competence	Previous courses/modules, practices*	Subsequent disciplines/modules, practices*
		Research work / Scientific research work;	
GPC-4	Capable of assessing the effectiveness of the results of developing control systems using mathematical methods	History and Methodology of Science; Advanced Methods of Earth Remote Sensing;	Undergraduate Training;
GPC-5	Capable of conducting patent research, determining forms and methods of legal protection and defense of rights to the results of intellectual activity, managing rights to them to solve problems in the development of science, engineering and technology	Machine Learning and Big Data Mining; Research work / Scientific research work;	Undergraduate Training;
GPC-7	Capable of making informed choices, developing and implementing in practice circuit, system engineering and hardware-software solutions for automation and control systems	Advanced Methods of Space Flight Mechanics; Research work / Scientific research work;	Undergraduate Training;
GPC-9	Capable of developing methods and performing experiments on existing facilities with processing of results based on information technologies and technical means	Virtual Reality and Computer Vision;	Undergraduate Training;
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	Research work / Scientific research work; History and Methodology of Science; Virtual Reality and Computer Vision; *Artificial Neural Networks (Deep Learning)***; *Artificial Neural Networks (Deep Learning)***; Information Technology in Mathematical Modeling; Advanced Methods of Space Flight Mechanics;	Undergraduate Training;
PC-4	Capable of participating in scientific research and development of design solutions in the field of ballistics, dynamics and flight control of spacecraft	Research work / Scientific research work; History and Methodology of Science; Advanced Methods of Earth Remote Sensing;	Undergraduate Training;

* - 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 discipline "Dynamics and Control of Space Systems" is "8" 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,**ac.h.		**Semester(s)**
			3
Contact work, academic hours	*72*		*72*
Lectures (LC)	36		36
Laboratory work (LW)	0		0
Practical/seminar classes (SC)	36		36
Independent work of students, academic hours	*180*		*180*
Control (exam/test with assessment), academic hours	*36*		*36*
General complexity of the discipline	**ac.h.**	***288***	*288*
	credit.ed.	***8***	*8*

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	Methods for optimizing orbital structures of satellite systems	1.1	General principles of designing satellite systems. Methods of constructing systems for global continuous coverage of areas of the Earth. Ballistic design of systems for zonal continuous coverage of the Earth's surface.	LC, LW
		1.2	Determining the time of the gap in observation by one frontal group of the entire surface of the Earth. Methods of constructing satellite systems for periodic coverage of the Earth's surface. Construction of ballistic structures of systems for coverage of the entire surface of the Earth with small gaps in observation. Construction of systems for periodic coverage of an area on the Earth's surface. Ballistic design of probabilistic systems of spacecraft.	LC, LW
		1.3	Spacecraft communication systems. Satellite radio navigation systems. Features of construction of meteorological satellite systems. Construction of space surveillance systems. Ballistic design of systems using ballistically coupled groups of spacecraft.	LC, LW, SC
		1.4	Space tether systems. Orbital functioning of linked space objects. Rapprochement in space using tether systems. Method of forming optimal modes of controlled motion of tether systems when solving practical problems.	LC, LW
Section 2	Numerical and analytical methods for optimizing orbital maneuvers	2.1	Equations of motion of spacecraft in deviations from motion along a reference circular orbit. Single-impulse maneuvers. Changing the shape of the orbit as a result of applying a velocity impulse. Estimation of the magnitude of maneuvers, selection of the initial deviation along the orbit at the launch of the spacecraft. Necessary conditions for optimality. Main types of problems of optimal maneuvering of spacecraft	LC, LW
		2.2	Optimal Maneuvering in the Space Debris Problem. Spacecraft Evasion Maneuvers from Collision with Space Debris. Evaluation of Maneuvers Performed by an Active Space Object	LC, LW, SC
		2.3	Optimal maneuvering in the space servicing problem. Planning optimal servicing of a group of spacecraft located in non-coplanar orbits. Evaluation of maneuvers performed by active spacecraft when transferred to the vicinity of serviced objects	LC, LW, SC

* - 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 (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 work of students (can be used for conducting seminars and consultations), equipped with a 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. 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: VKA named after A.F. Mozhaisky, 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.: Publishing groupURSS, 2017. - 432 p.

Further reading:

1. Vlasov S.A., Kulvits A.V., Skripnikov A.N. Theory of spacecraft flight: 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 the mechanics of space flight.Special course. - M.: Moscow State University Publishing House, 2018. - 152 p.

4. Mechanical engineering. Encyclopedia. Editorial board: K.V. Frolov (chairman) and others. -M.: Mechanical engineering. Rocket and space technology. T.IV-22 / A.P. Adjian, E.L.

Akim, O.M. Alifanov and others; resp. ed. 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, Prince. 1. 2012. Section 2.5. Satellite systems. pp. 180-224

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

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 RUDN https://mega.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
- EBS "Znanium"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 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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