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

SPACE FLIGHT MECHANICS
(name of discipline/module)

Recommended for the field of study/specialty:

27.03.04 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):

DATA SCIENCE AND SPACE SYSTEMS
(name (profile/specialization) of the educational institution of higher education)

2025

1. THE GOAL OF MASTERING THE DISCIPLINE

The discipline "Space Flight Mechanics" is part of the bachelor's program "Data Science and Space Systems" in the direction 27.03.04 "Control in Technical Systems" and is studied in 3, 4, 5, 6, 7 semesters of the 2, 3, 4 years. The discipline is implemented by the Department of Mechanics and Control Processes. The discipline consists of 12 sections and 56 topics and is aimed at studying the theoretical foundations of space flight mechanics, forecasting the motion of spacecraft, maneuvering theory, trajectory measurements and interplanetary flights. Particular attention is paid to the analysis of methods for solving typical problems and analyzing the area of their application in professional activities.

The purpose of mastering the discipline is to develop fundamental knowledge and skills in applying methods of space flight mechanics to solve problems in astronautics, which are necessary for professional activity and mastering subsequent disciplines.

2. REQUIREMENTS TO THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the discipline "Space Flight Mechanics" 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-1	Able to analyze the tasks of professional activity based on provisions, laws and methods in the field of natural sciences and mathematics	GPC-1.1 Possesses basic knowledge obtained in the field of mathematical and (or) natural sciences; GPC-1.2 Knows how to use them in professional activities; GPC-1.3 Has the skills to select methods for solving problems of professional activity based on theoretical knowledge;
GPC-11	Able to understand the principles of operation of modern information technologies and use them to solve problems of professional activity	GPC-11.1 Knows digital methods and technologies used in professional activities; GPC-11.2 Able to apply digital methods and technologies in professional activities to study and model objects of professional activity, analyze data, and present information; GPC-11.3 Confidently uses digital methods and technologies in professional activities (in the field of control in technical systems) for: studying and modeling objects of professional activity, data analysis, presentation of information;
GPC-2	Able to formulate tasks of professional activity based on knowledge, specialized sections of mathematical and natural science disciplines (modules)	GPC-2.1 Has mastered mathematical methods, programming fundamentals and specialized programming systems for implementing algorithms for solving applied problems; GPC-2.2 Able to select and adapt mathematical methods and software to solve practical problems; GPC-2.3 Possesses skills in developing and implementing algorithms for solving applied problems in the field of professional activity;
GPC-3	Able to use fundamental knowledge to solve basic control problems in technical systems in order to improve in professional activities	GPC-3.1 Knows the theoretical foundations and principles of mathematical modeling; GPC-3.2 Able to develop and use methods of mathematical modeling, information technologies to solve problems of applied mathematics; GPC-3.3 Possesses practical skills in solving problems of applied mathematics, methods of mathematical modeling, information technologies and the basics of their use in professional activities, skills of professional thinking and an arsenal of methods and approaches necessary for the adequate use of methods of modern mathematics in theoretical and applied problems;

Cipher	Competence	Indicators of Competence Achievement (within the framework of this discipline)
GPC-6	Capable of developing and using algorithms and programs, modern information technologies, methods and means of control, diagnostics and control, suitable for practical application in the field of his professional activity	GPC-6.1 Knows the basic algorithms and programs, modern information technologies, methods and means of control, diagnostics and control, suitable for practical application in the field of his professional activity; GPC-6.2 Able to apply algorithms and programs, modern information technologies, methods and means of control, diagnostics and control, suitable for practical application in the field of his professional activity; GPC-6.3 Confidently uses algorithms and programs, modern information technologies, methods and means of control, diagnostics and control, suitable for practical application in the field of his/her professional activity;
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;
PC-2	Capable of participating in the development of schematic documentation for the flight control system of launch vehicles and spacecraft, in the preparation of publications based on the results of research and development	PC-2.1 Knows the basic approaches to the development of mathematical models of units, functional modules and devices for flight control systems of launch vehicles and spacecraft; PC-2.2 Able to compile analytical reviews and scientific and technical reports based on the results of research and development; PC-2.3 Has skills in designing functional units and blocks of flight control systems for launch vehicles and spacecraft;
PC-4	Able to formulate, analyze and solve engineering problems in the field of ballistics, motion mechanics and spacecraft motion control based on professional knowledge	PC-4.1 Knows the basic concepts and basic algorithms for solving problems in the field of ballistics, motion mechanics and motion control based on automated and automatic systems; PC-4.2 Able to solve engineering problems of an analytical nature in the field of ballistics, motion mechanics and control of spacecraft motion based on professional knowledge; PC-4.3 Possesses the skills to use mathematical methods for processing information obtained as a result of experimental research, the basic methods of analyzing the mechanics of motion and controlling the motion of spacecraft based on standard methods and software packages;

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

Discipline "Space Flight Mechanics" 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 "Space Flight Mechanics".

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-6	Capable of developing and using algorithms and	Computer Science and Programming;	Undergraduate Training;

Cipher	Name of competence	Previous courses/modules, practices*	Subsequent disciplines/modules, practices*
	programs, modern information technologies, methods and means of control, diagnostics and control, suitable for practical application in the field of his professional activity		
GPC-1	Able to analyze the tasks of professional activity based on provisions, laws and methods in the field of natural sciences and mathematics	Mathematical analysis; Algebra and Geometry; Physics;	Technological Training; Undergraduate Training;
GPC-2	Able to formulate tasks of professional activity based on knowledge, specialized sections of mathematical and natural science disciplines (modules)	Mathematical analysis; Algebra and Geometry;	Technological Training; Undergraduate Training;
GPC-3	Able to use fundamental knowledge to solve basic control problems in technical systems in order to improve in professional activities	Mathematical analysis; Algebra and Geometry;	Technological Training; Undergraduate Training;
GPC-11	Able to understand the principles of operation of modern information technologies and use them to solve problems of professional activity		Undergraduate Training; Technological Training;
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;	Technological Training; Undergraduate Training;
PC-2	Capable of participating in the development of schematic documentation for the flight control system of launch vehicles and spacecraft, in the preparation of publications based on the results of research and development		Undergraduate Training;
PC-4	Able to formulate, analyze and solve engineering problems in the field of ballistics, motion mechanics and spacecraft motion control based on professional knowledge		Technological Training; 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 “Space Flight Mechanics” course is 24 credits.

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	**4**	**5**	**6**	**7**
Contact work, academic hours	*411*		*36*	*51*	*108*	*108*	*108*
Lectures (LC)	160		18	34	36	36	36
Laboratory work (LW)	125		0	17	36	36	36
Practical/seminar classes (SC)	126		18	0	36	36	36
Independent work of students, academic hours	*363*		*36*	*57*	*108*	*45*	*117*
Control (exam/test with assessment), academic hours	*90*		*0*	*0*	*36*	*27*	*27*
General complexity of the discipline	**ac.h.**	***864***	*72*	*108*	*252*	*180*	*252*
	credit.ed.	***24***	*2*	*3*	*7*	*5*	*7*

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	Introduction	1.1	Space flight mechanics in the structure of scientific and technical knowledge. Structure of the discipline. Application areas of space flight mechanics methods	OK
		1.2	Dynamics of bodies of variable mass. Law of universal gravitation. Fundamental laws of mechanics.	LC, SC
		1.3	Spherical trigonometry	LC, SC
Section 2	Undisturbed motion of a spacecraft	2.1	Basic concepts and definitions. Equations of motion in a gravitational field	OK
		2.2	Integrals of the equations of unperturbed motion	LC, SC
		2.3	Trajectory equation. Orbit types. Geometric characteristics of orbits	LC, SC
		2.4	Kinematic parameters of movement	OK
		2.5	Kepler's equation	LC, LW, SC
		2.6	Determination of Keplerian orbital elements from initial conditions of motion	LW, SC
		2.7	Determination of kinematic parameters of motion by Keplerian orbital elements	LW, SC
		2.8	Spacecraft flight path	LC, LW, SC
		2.9	Determination of Keplerian orbital elements from two positions of the spacecraft	LC, LW, SC
Section 3	Disturbed motion of the center of mass of a spacecraft	3.1	General characteristics of disturbances and basic methods of studying disturbed motion	OK
		3.2	Osculating Elements Method	OK
		3.3	Analysis of perturbed motion in near-circular orbits	LC, LW, SC
		3.4	The influence of the non-centrality of the Earth's gravitational field	LW, SC
		3.5	The influence of the Earth's atmosphere	LW, SC
		3.6	The influence of gravity of celestial bodies	LW, SC
		3.7	Effect of light pressure	LW, SC
Section 4	Dynamics of spacecraft motion relative to the center of mass	4.1	Moments of forces acting on a spacecraft	OK
		4.2	Differential equations of rotational motion of a spacecraft	OK
		4.3	Poisson's Kinematic Relations. Energy Integral	LC, SC
		4.4	Energy integral. Relative equilibrium of a spacecraft. Stability of equilibrium	LC, LW, SC
		4.5	Boundaries of oscillations. Conditions of non-inversion	LC, LW, SC
		4.6	Methods of orientation and stabilization of spacecraft	LC, LW, SC
Section 5	Orbital maneuvers in the central gravitational field	5.1	Basic principles of the theory of maneuvers	OK
		5.2	Transition maneuvers	LC, LW, SC
		5.3	Meeting in coplanar orbits	LC, LW, SC
		5.4	Encounter in non-coplanar orbits	LC, LW, SC
		5.5	Numerical methods for optimization and increasing the accuracy of maneuver parameters	LC, LW, SC
		5.6	Maneuvering with an engine having limited constant thrust	LC, LW, SC

Section number	Name of the discipline section	Section Contents (Topics)		Type of academic work*
Section 6	Coordinate systems	6.1	Celestial coordinate system. Heliocentric coordinate system	LC, SC
		6.2	Geocentric coordinate systems. Linked coordinate systems	LC, SC
		6.3	Transition between coordinate systems	LC, LW
Section 7	Time scales	7.1	Solar, stellar and atomic time	OK
		7.2	Dynamic and coordinated time	OK
		7.3	Transition between time scales	LC, LW, SC
Section 8	Methods for predicting the motion of a spacecraft	8.1	Forms of representation of the Earth's gravitational field	LC, LW, SC
		8.2	Mathematical modeling of disturbing forces	LC, LW, SC
		8.3	Analytical methods for predicting movement	LC, LW, SC
		8.4	Representation of the right-hand sides of the equations of motion as functions of orbital elements	LC, SC
		8.5	Numerical methods for motion prediction	LC, LW, SC
		8.6	Methods of the theory of special perturbations in problems of spacecraft dynamics	LC, SC
Section 9	Determination of spacecraft motion parameters based on trajectory measurements	9.1	Characteristics and classification of measurements. Transformation of measurement information.	LC, LW
		9.2	Lambert's problem	LC, SC
		9.3	Least squares method	LC, LW, SC
		9.4	Kalman filters	LC, LW, SC
Section 10	Dynamics of launching a spacecraft into near-earth orbit	10.1	Starting coordinate systems. Determining the optimal start time	LC, SC
		10.2	Rocket engines. Forces and moments acting on the launch vehicle	LC, SC
		10.3	Mathematical modeling of the launch vehicle motion	LC, LW, SC
Section 11	Dynamics of the descent of a spacecraft to Earth	11.1	General scheme of descent. Requirements for the descent trajectory	OK
		11.2	Mathematical modeling of the motion of a descent vehicle in the atmosphere	LC, LW, SC
Section 12	Interplanetary flights	12.1	Methods for calculating sections of interplanetary trajectories	OK
		12.2	Flight patterns of interplanetary vehicles. Launch windows.	OK
		12.3	Mathematical modeling of interplanetary spacecraft motion	LC, LW, SC
		12.4	Optimization of interplanetary trajectories	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 (15 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. 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. 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.

3. Baranov A.A. Maneuvering of spacecraft in the vicinity of a circular orbit. – M.: Publishing house “Sputnik+”, 2016 – 512 p.

4. 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.

5. N.M. Ivanov, L.N. Lysenko. Ballistics and navigation of spacecraft. - M.: Publishing house of Bauman Moscow State Technical University.N. E. Bauman, 2016 - 524 p.

Further reading:

1. DA Vallado. Fundamentals of Astrodynamics and Applications. 4th ed. - USA, Hawthorne: Microcosm Press, 2013 - 1135 p. ISBN 13: 9781881883180. ISBN 10: 1881883183

2. O. Montenbruck, E. Gill. Satellite Orbits: Models, Methods and Applications. - Germany, Berlin: Springer, 2000 - 371 p. ISBN 978-3-540-67280-7

3. C.V. Soloviev, E.V. Tarasov. Forecasting of interplanetary flights. - M: "Mashinostroenie", 1973 - 401 p.

4. M.B. BaLC, V.G. Demin, A.L. Kunitsyn. Collection of problems in celestial mechanics and cosmodynamics.M: “Science”, 1972 - 336 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 RUDNhttp://lib.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
- Electronic library system "Troitsky Bridge"

2. Databases and search engines

- electronic fund of legal and normative-technical documentationhttp://docs.cntd.ru/
- Yandex search enginehttps://www.yandex.ru/
- search engineGoogle https://www.google.ru/
- abstract databaseSCOPUS 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 "Space Flight Mechanics".

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

DEVELOPER:

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