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Информация о владельце:
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Должность: Ректор
Дата подписания: 27.06.2025 11:10:45
Уникальный программный ключ:
ca953a0120d891083f939673078ef1a989dae18a

**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

ADVANCED METHODS OF SPACE FLIGHT MECHANICS

(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)

1. THE GOAL OF MASTERING THE DISCIPLINE

The course "Advanced Methods of Space Flight Mechanics" 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 2nd semester of the 1st year. The course is implemented by the Department of Mechanics and Control Processes. The course consists of 2 sections and 5 topics and is aimed at studying the methods for 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 problems 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 "Advanced Methods of 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 and identify the natural scientific essence of control problems in technical systems based on provisions, laws and methods in the field of natural sciences and mathematics	GPC-1.1 Knows the basic laws, provisions and methods in the field of natural sciences and mathematics; GPC-1.2 Able to identify the natural scientific essence of control problems in technical systems, guided by the laws and methods of natural sciences and mathematics; GPC-1.3 Has command of tools for analyzing control problems in technical systems.
GPC-10	Capable of managing the development of methodological and regulatory documents, technical documentation in the field of automation of technological processes and production, including on the life cycle of products and their quality	GPC-10.1 Familiar with the main approaches to the development of methodological and regulatory documents, technical documentation in the field of automation of technological processes and production; GPC-10.2 Has knowledge of approaches to managing the development of technical documentation and regulatory documents in the field of automation of technological processes and production, including the life cycle of products and their quality.;
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-7	Capable of making informed choices, developing and implementing in practice circuit, 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 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.;

Cipher	Competence	Indicators of Competence Achievement (within the framework of this discipline)
PC-1	Able to formulate goals and objectives of scientific research in the field of aerospace systems management, select methods and means for solving professional problems	PC-1.1 Knows the methods and means of solving scientific research problems in the field of artificial intelligence systems and robotic systems; PC-1.2 Able to formulate the goals and objectives of scientific research in the professional field; PC-1.3 Proficient in techniques for formulating the goals and objectives of scientific research, and knows how to select methods and means for solving problems of professional activity.;
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.;

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

Discipline " Advanced Methods of 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 " Advanced Methods of 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-1	Able to analyze and identify the natural scientific essence of control problems in technical systems based on provisions, laws and methods in the field of natural sciences and mathematics	Virtual Reality and Computer Vision; Numerical Methods for Solving Mathematical Modeling Problems; Information Technology in Mathematical Modeling; Programming Technology;	Undergraduate Training; Geoinformation Systems and Applications;
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; Programming Technology;	Research work / Scientific research work; Undergraduate Training; Dynamics and Control of Space Systems;
GPC-7	Capable of making informed choices, developing and implementing in practice circuit, system engineering and hardware-software solutions for automation and control systems		Research work / Scientific research work; Undergraduate Training; Dynamics and Control of Space Systems;
GPC-10	Capable of managing the development of methodological and	History and Methodology of Science;	Research work / Scientific research work; Undergraduate Training;

Cipher	Name of competence	Previous courses/modules, practices*	Subsequent disciplines/modules, practices*
	regulatory documents, technical documentation in the field of automation of technological processes and production, including on the life cycle of products and their quality		
PC-1	Able to formulate goals and objectives of scientific research in the field of aerospace systems management, select methods and means for solving professional problems		<i>Artificial Neural Networks (Reinforcement Learning)**;</i> Research work / Scientific research work; 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	History and Methodology of Science; Virtual Reality and Computer Vision; Information Technology in Mathematical Modeling;	<i>Research work / Scientific research work;</i> <i>Undergraduate Training;</i> <i>Dynamics and Control of Space Systems;</i> <i>Artificial Neural Networks (Reinforcement Learning)**;</i> <i>Geoinformation Systems and Applications;</i>

* - 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 course "Advanced Methods of Space Flight Mechanics" 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)
			2
<i>Contact work, academic hours</i>	72		72
Lectures (LC)	36		36
Laboratory work (LW)	0		0
Practical/seminar classes (SC)	36		36
<i>Independent work of students, academic hours</i>	189		189
<i>Control (exam/test with assessment), academic hours</i>	27		27
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 calculating the disturbed motion of spacecraft in the force field of several celestial bodies	1.1	The two-body problem. Kepler's empirical laws. First integrals of the Kepler problem. Phase portrait. Osculating elements. Equations of perturbed motion in occupied elements	LC, SC
		1.2	Three-body problem. Restricted circular three-body problem. Stability of libration points. Hill regions. Sitnikov problem. Earth's gravitational potential. Euler problem of two fixed attracting centers. Generalized problem of two fixed centers.	LC, SC
		1.3	N-body problem. Stability of the Solar System. Laplace's theorem. KAM theory. Research of Jacques Lascar.	LC, SC
Section 2	Motion of a rigid body in a central gravitational field	2.1	Satellite approximation. Limited statement of the problem of satellite motion. Relative equilibria. Leonov and the plug problem.	LC, SC
		2.2	The influence of light pressure on the motion of a spacecraft. Solar sail.	LC, 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.	
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: A.F. Mozhaisky Space 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.: Publishing group URSS, 2017. – 432 p.

Further reading:

1. Vlasov S.A., Kulvits A.V., Skripnikov A.N. Theory of spacecraft flight: textbook. – St. Petersburg: A.F. Mozhaisky 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.
- 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 Yurait <http://www.biblio-online.ru>
- Electronic Library System "Student Consultant" www.studentlibrary.ru
- EBS "Znaniy" <https://znaniy.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 "Modern methods of 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:

Professor		Baranov Andrey Anatolyevich
<i>Position, Department</i>	<i>Signature</i>	<i>Surname I.O.</i>

**HEAD OF THE
DEPARTMENT:**

Head of Department		Razumny Yuri Nikolaevich
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