Federal State Autonomous Educational Institution of Higher Education
"Russian Peoples' Friendship University named after Patrice Lumumba"

Academy of Engineering
(name of the main educational unit (POU) - developer of the EP HE)

COURSE SYLLABUS

Advanced Methods of Space Flight Mechanics
(name of discipline/module)

Recommended by the Didactic Council for the Education Field of:

27.04.04 CONTROL IN TECHNICAL SYSTEMS
(code and name of the area of training/specialty)

The discipline is mastered as part of the implementation of the main professional educational program of higher education (EP HE):

DATA SCIENCE AND SPACE ENGINEERING
(name (profile/specialization) EP HE)

2024

1. GOAL OF DISCIPLINE MASTERING

The discipline “Advanced Methods of Space Flight Mechanics” is included in the master’s program “Data Science and Space Engineering” in the direction 27.04.04 “Control in Technical Systems” and is studied in the 2nd semester of the 1st year. The discipline is implemented by the Department of Mechanics and Control Processes. The discipline consists of 2 sections and 5 topics and is aimed at studying methods for solving design problems of forming and calculating the movement of spacecraft, orbital structures for various purposes, solving specific engineering problems related to launch, maneuvering in orbit, using mathematical modeling methods in solving assigned problems using modern computer tools.

The purpose of mastering the discipline is to obtain knowledge, abilities, skills and experience in the field of designing space satellite systems for various purposes, maneuvering spacecraft in orbit, methods for their calculation and optimization, characterizing the stages of developing 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 “Advanced Methods of Space Flight Mechanics” is aimed at developing the following competencies (parts of competencies) in students:

Table 2.1. List of competencies formed in students when mastering the discipline (results of mastering the discipline)

Cipher	Competence	Indicators of Competency Achievement (within 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, regulations 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 Possesses tools for analyzing management problems in technical systems.;
GPC-10	Able to manage the development of methodological and regulatory documents, technical documentation in the field of automation of technological processes and production, including 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 Possesses 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	Able to independently solve 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 solve control problems in technical systems;; GPC-3.3 Knows methods for solving control problems in technical systems based on the latest achievements of science and technology.;
GPC-7	Able to make an informed choice, develop and implement in practice circuit design, systems engineering and hardware and 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 Able to develop hardware and software solutions for automation and control systems;; GPC-7.3 Masters approaches for making an informed choice and implementing in practice circuit design, system engineering and hardware and software solutions for automation and control systems.;

Cipher	Competence	Indicators of Competency Achievement (within this discipline)
PC-1	Able to formulate goals and objectives of scientific research in the field of aerospace systems control, select methods and means for solving professional problems	PC-1.1 Knows 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 purpose and objectives of scientific research in the professional field;; PC-1.3 Knows techniques for formulating the goals and objectives of scientific research, knows how to choose methods and means of solving problems of professional activity.;
PC-2	Able to apply modern theoretical and experimental methods for developing mathematical models of studied objects and processes in the field of aerospace systems control	PC-2.1 Knows modern theoretical and experimental methods used to develop mathematical models of studied objects and processes of professional activity;; PC-2.2 Able to determine the effectiveness of the methods used for the development of mathematical models of the objects and processes under study;; PC-2.3 Masters modern theoretical and experimental methods for developing mathematical models of objects and processes of professional activity in the field of training.;

3. PLACE OF DISCIPLINE IN THE STRUCTURE OF HE EP

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 educational program of higher education, students also master other disciplines and/or practices that contribute to achieving the planned results of mastering the discipline “Advanced Methods of Space Flight Mechanics”

Table 3.1. List of components of EP HE that contribute to achieving the planned results of mastering the discipline

Cipher	Name of competency	Previous disciplines/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 practice / Pre-graduate practice; Geoinformation Systems and Applications;
GPC-3	Able to independently solve 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 practice / Pre-graduate practice; Dynamics and Control of Space Systems;
GPC-7	Able to make an informed choice, develop and implement in practice circuit design, systems engineering and hardware and software solutions for automation and control systems		Research work / Scientific research work; Dynamics and Control of Space Systems; Undergraduate practice / Pre-graduate practice;
GPC-10	Able to manage the development of methodological and	History and Methodology of Science;	Research work / Scientific research work;

Cipher	Name of competency	Previous disciplines/modules, practices*	Subsequent disciplines/modules, practices*
	regulatory documents, technical documentation in the field of automation of technological processes and production, including the life cycle of products and their quality		Undergraduate practice / Pre-graduate practice;
PC-1	Able to formulate goals and objectives of scientific research in the field of aerospace systems control, select methods and means for solving professional problems		*Artificial Neural Networks (Reinforcement Learning)***; Research work / Scientific research work; Undergraduate practice / Pre-graduate practice;
PC-2	Able to apply modern theoretical and experimental methods for developing mathematical models of studied objects and processes in the field of aerospace systems control	History and Methodology of Science; Virtual Reality and Computer Vision; Information Technology in Mathematical Modeling;	*Research work / Scientific research work; Undergraduate practice / Pre-graduate practice; Dynamics and Control of Space Systems; Artificial Neural Networks (Reinforcement Learning)**; Geoinformation Systems and Applications;*

* - to be filled out in accordance with the competency matrix and SUP EP VO

** - elective disciplines/practices

4. SCOPE OF DISCIPLINE AND TYPES OF STUDY WORK

The total labor intensity of the "Advanced Methods of Space Flight Mechanics" discipline is "8" credit units.

Table 4.1. Types of educational work by periods of mastering the educational program of higher education for full-time study.

Type of educational work	**TOTAL,**ac.ch.		**Semester(s)**
			2
Contact work, ac.ch.	*36*		*36*
Lectures (LC)	18		18
Laboratory work (LR)	0		0
Practical/seminar sessions (SZ)	18		18
Independent work of students, ac.ch.	*225*		*225*
Control (exam/test with assessment), academic degree.	*27*		*27*
Total labor intensity of the discipline	**ac.ch.**	***288***	*288*
	credit units	***8***	*8*

5. CONTENT OF DISCIPLINE

Table 5.1. Contents of the discipline (module) by type of academic work

Section number	Name of the discipline section	Contents of the section (topic)		Type of educational work*
Section 1	Methods for calculating the perturbed motion of spacecraft in the force field of several celestial bodies	1.1	Two body problem. Kepler's empirical laws. First integrals of the Kepler problem. Phase portrait. Osculating elements. Equations of perturbed motion in occupying elements	LC, NW
		1.2	Three body problem. Restricted circular three-body problem. Stability of libration points. Hill areas. Sitnikov's problem. Earth's gravitational potential. Euler's problem about two fixed attracting centers. Generalized problem of two fixed centers.	LC, NW
		1.3	Problem N bodies. Stability of the Solar System. Laplace's theorem. KAM theory. Research by Jacques Lascar.	LC, NW
Section 2	Movement of a rigid body in a central gravitational field	2.1	Satellite proximity. Restricted formulation of the problem of satellite motion. Relative equilibria. The problem about Leonov and the stub.	LC, NW
		2.2	The influence of light pressure on the motion of a spacecraft. Solar sail.	LC, NW

* - to be filled out only for full-time education: LC – lectures; LR – laboratory work; SZ – practical/seminar classes.

6. MATERIAL AND TECHNICAL SUPPORT OF DISCIPLINE

Table 6.1. Material and technical support of the discipline

Audience type	Auditorium equipment	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; board (screen) and technical means of multimedia presentations.	
Seminar	An auditorium for conducting seminar-type classes, group and individual consultations, ongoing monitoring and intermediate certification, equipped with a set of specialized furniture and technical means for multimedia presentations.	
For independent work	An auditorium for independent work by students (can be used for seminars and consultations), equipped with a set of specialized furniture and computers with access to EIOS.	

* - the audience for independent work of students is MANDATORY!

7. EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT OF DISCIPLINE

Main literature:

1. Averkiev N.F., Vlasov S.A., Bogachev S.A., Zhatkin A.T., Kulvits A.V. Ballistic fundamentals of designing launch vehicles and satellite systems: textbook. – St. Petersburg: VKA named after A.F. Mozhaisky, 2017. – 300 p.

2. Baranov A.A. Maneuvering 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: textbook. – Tomsk: Publishing house Tom. Univ., 2007. – 178 p.

4. Beletsky V.V. Essays on the movement of cosmic bodies. Issue No. 4. – M.: Publishing GroupURSS, 2017. – 432 p.

Additional literature:

1. Vlasov S.A., Kulvits A.V., Skripnikov A.N. Theory of spacecraft flight: textbook. – St. Petersburg: VKA named after A.F. Mozhasky, 2018. – 412 p.

2. Ivanov N.M., Lysenko L.N. Ballistics and navigation of spacecraft: textbook.3rd edition. – M.: Bustard, 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 advice: K.V. Frolov (prev.), etc. -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. EBS of RUDN University and third-party EBS, to which university students have access based on concluded agreements

- Electronic library system of RUDN University - EBS RUDN Universityhttp://lib.rudn.ru/MegaPro/Web
- EBS "University Library Online"http://www.biblioclub.ru
- EBS Lawhttp://www.biblio-online.ru
- EBS "Student Consultant"www.studentlibrary.ru
- EBS "Trinity Bridge"

2. Databases and search engines

- electronic fund of legal and regulatory technical documentationhttp://docs.cntd.ru/
- Yandex search enginehttps://www.yandex.ru/
- search systemGoogle https://www.google.ru/
- abstract databaseSCOPUS http://www.elsevierscience.ru/products/scopus/

Educational and methodological materials for students' independent work when mastering a discipline/module:*

1. A course of lectures on the discipline "Modern methods of space flight mechanics."

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

8. ASSESSMENT MATERIALS AND POINT-RATING SYSTEM FOR ASSESSING THE LEVEL OF COMPETENCIES FOR A DISCIPLINE

Evaluation materials and point-rating system* for assessing the level of development of competencies (parts of competencies) based on the results of mastering the discipline"Modern

methods of space flight mechanics" are presented in the Appendix to this Work Program of the discipline.

* - OM and BRS are formed on the basis of the requirements of the relevant local regulatory act of RUDN University.

DEVELOPER:

Professor		Baranov Andrey Anatolevich
Position	*Signature*	*Last name I.O.*

HEAD OF DEPARTMENT:

Head of the department		Razumny Yuri Nikolaevich
Position	*Signature*	*Last name I.O.*

HEAD OF EP HE:

Professor		Razumny Yuri Nikolaevich
Position	*Signature*	*Last name I.O.*