Federal State Autonomous Educational Institution
of Higher Education
"Peoples' Friendship University of Russia"

Engineering Academy

Recommended by the ISSC

WORKING PROGRAM OF THE DISCIPLINE

Name of the discipline: Dynamics, ballistics, motion control of aircraft

Direction of training: 01 .06.01 " Mathematics and Mechanics "

Directivity (profile): " Dynamics, ballistics, movement control of aircraft "

Moscow
2021

1. The purpose and objectives of the discipline

The purpose of mastering the discipline "Dynamics, ballistics, control of the movement of aircraft" is to form a system of scientific knowledge among graduate students about promising methods of research and solving professional problems, taking into account global trends in the development of aviation and rocket and space technology

The main **objectives** of the discipline are:

- –To know new methods of development and research of methods of analysis, synthesis, optimization and forecasting of the quality of the processes of functioning of aviation and rocket and space technology
- –To possess new methods of selection and transformation of mathematical models of phenomena, processes and systems in the field of rocket and space technology for the purpose of their research and implementation by means of computer technology
- –Be able to use new methods of developing mathematical models, methods, computer technologies and decision support systems in scientific research, design activities, management of technological, economic, social systems and in the humanitarian fields of human activity

2. The place of the discipline in the structure of the educational program

The discipline "Dynamics, ballistics, control of the movement of aircraft" belongs to the variable part of Block 1 of the curriculum. Table No. 1 shows the previous and disciplines aimed at the formation of the subsequent discipline's competencies in accordance with the competence matrix of the OP VO

Table 1-List of previous and subsequent disciplines

№ p/p	The cipher and the name of the competence	Previous disciplines	Subsequent disciplines (groups of disciplines)
Universal competencies			
	Ability to critically analyze and evaluate modern scientific achievements, generate new ideas when solving research and practical problems, including in interdisciplinary fields (UK-1)	History and philosophy of science Methodology of scientific research	
	The ability to plan and solve problems of their own professional and personal development (UK-5)	History and philosophy of science Priority areas of development of mathematics and mechanics Fundamentals of teaching methods for developing engineering applications	Scientific research (preparation of a scientific qualification work (dissertation) for the degree of Candidate of Sciences)

		based on mathematical modeling using computer science and computer technology in higher school	
General professional competencies			
	readiness to teach in the main educational programs of higher education (OPK-2)	Fundamentals of teaching methods for developing engineering applications based on mathematical modeling using computer science and computer technology in higher school	Teaching practice
Professional competencies (type of professional activity _____)			
	Willingness to apply promising methods of research and solving professional problems, taking into account global trends in the development of aviation and rocket and space technology (PK-1);	Methodology of scientific research Priority areas of development of mathematics and mechanics Practical training for obtaining professional skills and experience of professional activity (research)	
	Ability to create and research mathematical and software models of products and processes related to the functioning of aviation and rocket technology objects (PK-2);	Methodology of scientific research Practical training for obtaining professional skills and experience of professional activity (research)	
	Readiness to develop and research methods for analyzing, synthesizing, optimizing and predicting the quality of the processes of functioning of aviation and rocket technology (PK-3);	Methodology of scientific research Priority areas of development of mathematics and mechanics	
	Ability to select and transform mathematical models of phenomena, processes and systems in the field of rocket	Fundamentals of teaching methods for developing engineering applications based on mathematical modeling using computer science and computer technology in higher	

	and space technology for the purpose of their research (PK-4);	school Practical training for obtaining professional skills and experience of professional activity (research)	
	Ability to develop mathematical models, methods, computer technologies and decision support systems in scientific research, design and engineering activities (PK-5);	Fundamentals of teaching methods for developing engineering applications based on mathematical modeling using computer science and computer technology in higher school Practical training for obtaining professional skills and experience of professional activity (research)	
	The ability to develop new mathematical models of objects of aviation and rocket and space technology, to develop analytical and approximate research methods (PK-6).	Priority areas of development of mathematics and mechanics Fundamentals of teaching methods for developing engineering applications based on mathematical modeling using computer science and computer technology in higher school Practical training for obtaining professional skills and experience of professional activity (research)	
Professional and specialized competencies of specialization _____			

3. Requirements for the results of mastering the discipline:

The process of studying the discipline is aimed at the formation of the following competencies:

UK -1, UK -5, OPK -1, PK -1, PK -2, PK -3, PK -4, PK -5, PK -6

(are specified in accordance with the OS IN the RUDN)

As a result of studying the discipline, the student must:

To know:

Know specialized theoretical and practical knowledge that serves as the basis for the development of new ideas

Know the methods of research and solving professional problems, taking into account the global trends in the development of aviation and rocket and space technology.

To know new methods of creation and research of mathematical and software models of products and processes related to the functioning of objects of aviation and rocket technology

To know new methods of development and research of methods of analysis, synthesis, optimization and forecasting of the quality of the processes of functioning of aviation and rocket technology

To know new methods of selection and transformation of mathematical models of phenomena, processes and systems in the field of rocket and space technology for the purpose of their research

Know new methods of developing mathematical models, methods, computer technologies and decision support systems in scientific research

Know new methods of developing mathematical models of objects of aviation and rocket and space technology

Be able to:

Be able to analyze, prioritize, plan, monitor and provide feedback

Be able to apply research methods and solve professional problems taking into account global trends in the development of aviation and rocket and space technology.

Be able to use new methods of creating and researching mathematical and software models of products and processes related to the functioning of objects of aviation and rocket technology

Be able to use new methods of development and research of methods of analysis, synthesis, optimization and forecasting of the quality of the processes of functioning of aviation and rocket technology

Be able to use new methods of selection and transformation of mathematical models of phenomena, processes and systems in the field of rocket and space technology for the purpose of their research

Be able to use new methods of mathematical models, methods, computer technologies and decision support systems in scientific research

Be able to use new methods of developing mathematical models of objects of aviation and rocket and space technology

To master*:*

Master the technology of developing an action plan for conducting research, determine the necessary resources and coordinate them with colleagues and management

Possess promising methods of research and solving professional problems, taking into account global trends in the development of aviation and rocket and space technology.

Master new methods of creating and researching mathematical and software models of products and processes related to the functioning of objects of aviation and rocket technology

Master new methods of development and research of methods of analysis, synthesis, optimization and forecasting of the quality of the processes of functioning of aviation and rocket technology

Master new methods of selecting and transforming mathematical models of phenomena, processes and systems in the field of rocket and space technology for the purpose of their research

Master new methods of developing mathematical models, methods, computer technologies and decision support systems in scientific research

Master new methods of developing mathematical models of objects of aviation and rocket and space technology

4. The scope of the discipline and types of academic work

Table 3-The scope of the discipline and types of academic work
for full-time education

Type of educational work	Total ac. hours	Semester
		4
Classroom classes	58	58
including :	-	-
Lectures (L)	-	-

Practical / seminar classes (PC)		58	58
Laboratory work (LW)		-	-
Course project / course work		-	-
Independent work (SRS), including control		86	86
Type of certification test			Exam
Total labor intensity	academic hours	144	144
	credit units	4	4

5. Content of the discipline

5 . 1 . Contents of discipline sections

№ p/p	Name of the discipline section	Content of the section (topics)
1	1. Dynamic properties of the aircraft as a control object	1.1. Setting the tasks of ballistic and dynamic design 1.2. The principle of perturbed-undisturbed movements. The expediency of switching to the study of perturbed motion 1.3. Linearization as a method of converting equations to the form possible for obtaining a general solution 1.4. Separation of the disturbed motion of the aircraft into longitudinal and lateral 1.5. Compilation of linear equations of the perturbed motion of the aircraft. Dynamic coefficients 1.6. Free and forced disturbed movement 1.7. Longitudinal perturbed motion 1.8. The characteristic equation and its possible roots. Main conclusions on the stability and structure of perturbed motion 1.9. Two stages of the development of free longitudinal perturbed motion 1.10. The transfer function of the aircraft. The concept of the transmission coefficient of the aircraft 1.11. Frequency characteristics of the aircraft 1.12. Basic requirements for the dynamic properties of the aircraft. The role of the system approach
2.	2. Fundamentals of space flight mechanics. The two-body problem	2.1. The law of universal gravitation. Integrals of equations of motion. 2.2. The equation of the orbit. The speed of the satellite. The relationship of speed with the type of orbit. Characteristics of the orbits . The Kepler Equation .
3	3. The outraged movement of the CLA	3.1. General characteristics of the perturbed motion and the perturbations themselves. The general statement of the problem. 3.2. Scope of action, sphere of attraction, sphere of influence. 3.3. The method of osculating elements. 3.4. Disturbing effects that distort the Keplerian orbit.

5 . 2 . Sections of disciplines and types of classes

№ p/p	The name of the discipline section / topic of the lesson	Practice/ seminars	SRS	Total hour.
1	**Section # 1. Dynamic properties of the aircraft as a control object**	**22**	**36**	**58**
	Topic 1.1. Statement of ballistic and dynamic design problems	1	3	4
	Topic 1.2. The principle of indignant-unperturbed movements. Feasibility of transition to the study of disturbed motion	1	3	4
	Topic 1.3. Linearization as a way of transforming equations to a form that is possible to obtain a general solution	2	3	5
	Topic 1.4. Separation of the disturbed aircraft movement into longitudinal and lateral	2	3	5
	Topic 1.5. Compilation of linear equations of the perturbed aircraft motion. Dynamic coefficients	2	3	5
	Topic 1.6. Free and forced indignant movement	2	3	5
	Topic 1.7. Longitudinal disturbed motion	2	3	5
	Topic 1.8. Characteristic equation and its possible roots. About the main conclusions on the stability and structure of the disturbed motion	2	3	5
	Topic 1.9. Two stages of development of free longitudinal disturbed motion	2	3	5
	Topic 1.10. Aircraft transfer function. The concept of the aircraft gear ratio	2	3	5
	Topic 1.11. Aircraft frequency characteristics	2	3	5
	Topic 1.12. Basic requirements for the dynamic properties of aircraft. The role of the systems approach	2	3	5
2.	**Section # 2. Fundamentals of space flight mechanics. Two-body problem**	**18**	**25**	**43**
	Topic 2.1. The law of universal gravitation. Integrals of the equations of motion.	6	8	1 4
	Topic 2.2. Orbit equation. Satellite speed. Relationship between speed and type of orbit.	6	8	1 4
	Topic 2.3. Orbit characteristics. Kepler's equation	6	9	15
3.	**Section # 3. Outraged by the movement of the spacecraft**	**18**	**25**	**43**
	Topic 3.1. General characteristics of the disturbed movement and the disturbances themselves. General problem statement.	4	6	10
	Topic 3.2. Sphere of action, sphere of attraction, sphere of influence.	4	6	10
	Topic 3.3. Osculating element method	5	6	11
	Topic 3.4. Disturbances that distort Kepler's orbit	5	7	12
	Exam	**58**	**86**	**144**

6 . Laboratory workshop *(if available) - not provided*

7. Practical lessons (seminars) *(if any)*

№ p/p	Discipline section	Practical lessons (seminars)	Labor intensity (hour.)

	number		
1	1	Topic 1.1. Statement of ballistic and dynamic design problems	1
2	1	Topic 1.2. The principle of indignant-unperturbed movements. Feasibility of transition to the study of disturbed motion	1
3	1	Topic 1.3. Linearization as a way of transforming equations to a form that is possible to obtain a general solution	2
4	1	Topic 1.4. Separation of the disturbed aircraft movement into longitudinal and lateral	2
5	1	Topic 1.5. Compilation of linear equations of the perturbed aircraft motion. Dynamic coefficients	2
6	**1**	Topic 1.6. Free and forced indignant movement	2
7	**1**	Topic 1.7. Longitudinal disturbed motion	2
8	**1**	Topic 1.8. Characteristic equation and its possible roots. About the main conclusions on the stability and structure of the disturbed motion	2
9	**1**	Topic 1.9. Two stages of development of free longitudinal disturbed motion	2
10	**1**	Topic 1.10. Aircraft transfer function. The concept of the aircraft gear ratio	2
11	**1**	Topic 1.11. Aircraft frequency characteristics	2
12	**1**	Topic 1.12. Basic requirements for the dynamic properties of aircraft. The role of the systems approach	2
13	**2**	Topic 2.1. The law of universal gravitation. Integrals of the equations of motion.	6
14	**2**	Topic 2.2. Orbit equation. Satellite speed. Relationship between speed and type of orbit.	6
15	**2**	Topic 2.3. Orbit characteristics. Kepler's equation	6
16	**3**	Topic 3.1. General characteristics of the disturbed movement and the disturbances themselves. General problem statement.	4
17	**3**	Topic 3.2. Sphere of action, sphere of attraction, sphere of influence.	4
18	**3**	Topic 3.3. Osculating element method	5
19	**3**	Topic 3.4. Disturbances that distort Kepler's orbit	5

8. Logistics of the discipline

Table 5 - Material and technical support of the discipline

Auditorium with a list of logistics	**Location**
Educational laboratory "Laboratory of computing systems and methods of processing big data": № 409 Equipment and furniture: - Personal graphic workstations based on the AVK -1 system unit + monitor (13 pcs.); –Interactive whiteboard Polyvision TSL 610; –Projector Epson EB - X 02; –Switch Cisco Catalyst 2960 24; –Line filter. There is Internet access. –List of licensed software. Details of the supporting document: 1. Windows 7 (Microsoft Subscription) Enrollment for Education Solutions № 86626883 from 01.04.2018 g .); 2. Microsoft Office 2007 (Microsoft	Moscow, st. Ordzhonikidze, 3

	Subscription) Enrollment for Education Solutions № 86626883 from 01.04.2018 g .); 3. Borland Developer Studio 2006 (License Certificate Number: 33080, 33081, 33082); 4. MATLAB R 2008 b (361405 2008); **5. Notepad ++ (free application).** **6. Acrobat Reader DC (free application)**	

9. Information support of the discipline

Resources of the information and telecommunications network "Internet":

1. EBS of RUDN University and third-party EBS to which university students have access on the basis of concluded agreements:

- Electronic library system RUDN - EBS RUDN http://lib.rudn.ru/MegaPro/Web
- EBS "University Library Online" http://www.biblioclub.ru
- EBS Yurayt http://www.biblio-online.ru
- EBS "Student Consultant" www.studentlibrary.ru
- EBS "Doe" http://e.lanbook.com/

2. Websites of ministries, departments, services, manufacturing enterprises and companies whose activities are core to this discipline:

3. Databases and search engines:

- electronic fund of legal and normative-technical documentation http://docs.cntd.ru/
- Yandex search engine https: // www .yandex.ru /
- Google search engine https://www.google.ru/
- SCOPUS abstract database http: // www .elsevierscience.ru / products / scopus /

Methodological materials for independent work of students and studying the discipline (also posted in the TUIS RUDN University in the corresponding section of the discipline):

1. A course of lectures on the discipline "Dynamics, ballistics, traffic control of aircraft" (*Appendix 2*).
2. Methodical instructions for independent work of students in the discipline "Dynamics, ballistics, control of the movement of aircraft" (*Appendix 3*).

10 . Educational and methodological support of the discipline

Main literature:

1. Ed. Byushgens G.S. Flight dynamics. M .: Mashinostroenie, 2011 .-- 776 p.
2. Space flight mechanics. Ed. acad. Mishina V.P. - M.: Mechanical Engineering , 1989.
3. Lysenko L.N. Ballistic missile guidance and navigation. - M: Publishing house of MSTU im. N.E Bauman, 2007, 670s.
4. Dmirievsky A.A., Lysenko L.N. External ballistics. 4th edition. - M: Mechanical Engineering , 2005.
5. Ivanov N.M. , Lysenko L.N. Ballistics and spacecraft navigation. 2nd edition. - M: Bustard, 2004.

Additional literature:

1. *Alekseev K.B. , Bybenin G.G. , Yaroshevsky V.A.* Spacecraft maneuvering. - Moscow: Mechanical Engineering, 1970 .-- 232 p.
2. *Elyasberg P.E.* Introduction to the theory of flight of artificial earth satellites. - Moscow: Nauka, 1965 .-- 540 p.
3. *Himmelblau D.* Applied nonlinear programming. - Moscow: Mir, 1975 .-- 534 p.
4. *Herrick C* . Astrodynamics . - Moscow: Mir, 1978 .-- 359p.
5. *Sikharulidze Yu.G.* Aircraft ballistics. - Moscow: Nauka, Main edition of physical and mathematical literature, 1982 .-- 352 p.
6. *Reshetnev M.F. , Lebedev A.A. , Bartenev V.A. , Krasil'shchikov M.N. , Malyshev V.A. , Malyshev V.A.* , Control and navigation of artificial earth satellites in near - circular orbits. - Moscow: Mechanical Engineering, 1988.336s.
7. *Soloviev Ts.V. , Tarasov E.V.* Prediction of interplanetary flights. - Moscow: Mechanical Engineering, 1973 .-- 400 p.

11. Methodical instructions for students on mastering the discipline (module)

The organization of classes in the discipline "Dynamics, ballistics, control of the movement of aircraft" is carried out in the following types of educational work: interactive practical classes (seminars), preparation of independent work and their subsequent defense.

The implementation of the competence-based approach in the framework of the training area 0 1 .06.01 " Mathematics and Mechanics " provides for a combination in the educational process of contact work with a teacher and extracurricular independent work of students for a more complete formation and development of his professional skills, independent study of some topics of the course and confirmation of their knowledge in the course of control activities.

Graduate student is obliged to master all the topics provided for by the curriculum of the discipline. Certain topics and issues of training are submitted for independent study. Graduate students studies the recommended literature and briefly outlines the material, and clarifies the most difficult issues requiring clarification during consultations. The same should be done with sections of the course that were skipped due to various circumstances.

The aim of practical training and seminars is to provide graduate students knowledge and develop practical skills in the field of ballistics and navigation rockets. To achieve this purpose both traditional forms of work - the tasks, work with the process equipment / specialized software under execution and laboratory work and the like and interactive methods - group work, analysis of specific situations, etc.

Using the method of analyzing a specific situation, students develop such qualifications as the ability to clearly formulate and express their position, the ability to communicate, discuss, perceive and evaluate information received in verbal form. Practical classes and seminars are held in special classrooms equipped with the necessary visual aids.

Independent work covers the study of individual questions of the theoretical course by students.

Independent work is performed individually on the basis of the format of teaching materials discipline (*application 2 -4*). The level of mastering the material

on independently studied issues of the course is checked during current control and certification tests (exam and / or test) in the discipline.

12. Fund of assessment tools for intermediate certification of students in the discipline (module)

The fund of assessment tools, formed for the current monitoring of progress and intermediate certification of students in the discipline "Dynamics, ballistics, traffic control of aircraft" is presented in *Appendix 1* to the work program of the discipline and includes:

- a list of competencies with an indication of the stages of their formation in the process of mastering the educational program;
- description of indicators and criteria for assessing competencies at various stages of their formation, description of assessment scales;
- typical control tasks or other materials necessary to assess knowledge, skills, skills and (or) experience of activity, characterizing the stages of the formation of competencies in the process of mastering the educational program;
- methodological materials that determine the procedures for assessing knowledge, skills, skills and (or) experience of activities, characterizing the stages of the formation of competencies.

The program has been drawn up in accordance with the requirements of the OS of VO RUDN

Developers:

Associate Professor of the Department of Mechanics and Mechatronics		O. E. Samusenko
position		initials, surname
Senior Lecturer of the Department of Mechanics and Mechatronics		T. A. Morozova
position		initials, surname

Supervisor of the Master Program
Professor of the Department of Mechanics and Mechatronics — Yu.N. Razumny

Director of the Department of Mechanics and Mechatronics — Yu. N. Razumny

signature — initials, surname