Federal State Autonomous Educational Institution
higher education
RUDN University

Academy of Engineering

THE WORKING PROGRAM OF THE DISCIPLINE

Discipline name: Additional sections of theoretical mechanics and mechanics of space flight

It is recommended for the direction of training/specialty
09.06.01 "Computer Science and Computer Engineering" (postgraduate course)

(the code and the name of the training direction/specialty are indicated)

Orientation of the program (profile)
Mathematical modeling, numerical methods and software packages

(name of the educational program in accordance with the orientation (profile)

1. The purpose and objectives of the discipline

The purpose of mastering the discipline "Additional sections of theoretical mechanics and mechanics of space flight" is to form a system of scientific knowledge among graduate students about promising research methods and solving professional problems, taking into account world trends in the development of aviation and rocket-space technology.

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

- 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
- Master new methods of selection and transformation of mathematical models of phenomena, processes and systems in the field of rocket and space technology in order to study and implement them 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 and development activities, management of technological, economic, social systems and in the humanitarian areas of human activity

2. Place of discipline in the structure of the educational program

The discipline "Additional sections of theoretical mechanics and mechanics of space flight" refers to the variable part of Block 1 of the curriculum. Its study is based on the material of previous disciplines, and it is also basic for the study of subsequent disciplines of the curriculum, the list of which is presented in table 1.

Table 1 - List of previous and subsequent disciplines

№ п/п	Preceding disciplines	Subsequent disciplines
1	Research methodology	Scientific research (preparation of scientific and qualifying work (dissertation) for the degree of candidate of sciences)
2	Priority areas of development of mathematics and mechanics	
3	Fundamentals of teaching methods for the development of engineering applications based on mathematical modeling using informatics and computer technology in higher education	
4	Practice for obtaining primary professional skills (research practice)	

3. The list of planned learning outcomes in the discipline, correlated with the planned results of mastering the educational program

The discipline "Additional sections of theoretical mechanics and mechanics of space flight " is aimed at developing the following competencies among students:

- Ability to critically analyze and evaluate modern scientific achievements, generate new ideas in solving research and practical problems, including in

interdisciplinary areas;

- Ability to independently carry out research activities in the relevant professional field using modern research methods and information and communication technologies
- Willingness to apply promising research methods and solve professional problems, taking into account world trends in the development of aviation and rocket and space technology;
- Ability to create and research mathematical and software models of products and processes associated with the operation of objects of aviation and rocket technology;
- Willingness to develop and research methods of analysis, synthesis, optimization and forecasting of the quality of the processes of functioning of aviation and rocket technology;
- Ability to select and transform mathematical models of phenomena, processes and systems in the field of rocket and space technology in order to study them;
- Ability to develop mathematical models, methods, computer technologies and decision support systems in scientific research, design and engineering activities;
- Ability to develop new mathematical models of objects of aviation and rocket-space technology, to develop analytical and approximate research methods.

The result of training in the discipline is knowledge, abilities, skills and (or) experience of activities that characterize the stages of the formation of competencies and ensure the achievement of the planned results of mastering the educational program, presented in Table 2.

Table 2 - Learning outcomes in the discipline correlated with the planned results of mastering

Competence	**Knowledge**	**Skills**	**Skills**
1	2	3	4
Ability to critically analyze and evaluate modern scientific achievements, generate new ideas when solving research and practical problems, including in interdisciplinary areas	Know the methods of critical analysis and assessment of modern scientific achievements, as well as methods of generating new ideas when solving research and practical problems, including in interdisciplinary fields	To be able, when solving research and practical problems, to generate new ideas that can be operationalized based on available resources and constraints	Possess the skills of analyzing methodological problems arising in the solution of research and practical problems, including in the interdisciplinary field
Ability to independently carry out research activities in the relevant professional field using modern research methods and information and communication technologies	Know the development plan of the scientific organization, the activity plan of the unit, data on competitions for the financing of scientific activities	Be able to select competitions for funding scientific activities	Own the directions and tasks of the unit for the implementation of the strategic development plan of the organization, the formation of proposals on research topics
Willingness to apply promising research methods and solving professional problems,	Know the methods of research and solving professional problems, taking into account the	To be able to apply research methods and solving professional	Possess promising methods of research and solving professional problems,

taking into account world trends in the development of aviation and rocket and space technology	world trends in the development of aviation and rocket and space technology.	problems, taking into account the world trends in the development of aviation and rocket and space technology.	taking into account world trends in the development of aviation and rocket and space technology.
Ability to create and research mathematical and software models of products and processes associated with the functioning of objects of aviation and rocket technology	Know new methods of creating and researching mathematical and software models of products and processes associated with the functioning of objects of aviation rocket technology	To be able to use new methods of creating and researching mathematical and software models of products and processes associated with the functioning of objects of aviation missile technology	Possess new methods of creating and researching mathematical and software models of products and processes associated with the functioning of objects of aviation and missile technology
Willingness to develop and research methods of analysis, synthesis, optimization and forecasting of the quality of the processes of functioning of aviation and rocket technology	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 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	Possess 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
The ability to select and transform mathematical models of phenomena, processes and systems in the field of rocket and space technology in order to study them	Know new methods of selection and transformation of mathematical models of phenomena, processes and systems in the field of rocket and space technology in order to study them	To 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 in order to study them	Possess new methods of choosing and transforming mathematical models of phenomena, processes and systems in the field of rocket and space technology in order to study them
Ability to develop mathematical models, methods, computer technologies and decision support systems in scientific research, design and engineering activities	Know new methods of developing mathematical models, methods, computer technologies and decision support systems in scientific research	Be able to use new methods for the development of mathematical models, methods, computer technologies and decision support systems in scientific research	Possess new methods of developing mathematical models, methods, computer technologies and decision support systems in scientific research
Ability to develop new mathematical models of	Know new methods of developing	Be able to use new methods for the	Own new methods for the development of

objects of aviation and rocket and space technology, to develop analytical and approximate research methods	mathematical models of objects of aviation and rocket-space technology	development of mathematical models of objects of aviation and rocket and space technology	mathematical models of objects of aviation and rocket-space technology

4. Scope of discipline and types of educational work

Table 3 - Scope of discipline and types of educational work
for full-time education

Type of educational work		Total, ac. hours	Semester
			4
Auditory lessons		20	20
including:		-	-
Lectures (L)		-	-
Practical / Seminar Lessons (PZ)		20	20
Laboratory work (LR)		-	-
Course project / course work		-	-
Independent work, including control		88	88
Type of certification test			Exam
Total labor intensity	academic hours	108	108
	credit units	3	3

5. Content of the discipline

5.1. The content of the discipline sections

№ p/p	Name of the discipline section	Content of the section (topics)
	Section 1. Classification of tasks and methods of aircraft motion control	Topic 1.1. Classification of tasks and methods of aircraft motion control
	Section 2. Technical problem of aircraft entry into an orbital constellation and its mathematical formalization	Topic 2.1. Formulation of the technical problem of aircraft entry into the orbital constellation and its mathematical formalization
	Section 3. Mathematical models of controlled aircraft motion	Topic 3.1. Coordinate systems for calculating the aircraft motion Newton's equations. Equations in osculating elements Topic 3.2. Equations in Equinoxes. Equations in a spherical system Topic 3.3. Linearization of the equations of motion in various coordinate systems. Discrete motion model
	Section 4. Optimal control of the aircraft motion during additional placement into geostationary orbit	Topic 4 .1. Statement of the problem of launching an aircraft to the GSO using the upper stage. Reduction to a nonlinear programming problem Topic 4 .2. Launching the aircraft to the GSO with a low-thrust engine

		Topic 4 .3. Launching the aircraft GSO using EPP, taking into account the shadow areas
	Section 5. Optimal control of the aircraft's motion when entering and holding an orbital position	Topic 5 .1. Mathematical model of motion when the aircraft is put into the orbital position in the GSO Topic 5 .2. Combined optimization method. Software and synthesized control components Topic 5 .3. Algorithm for searching for a synthesized component. The concept of suboptimal control. Algorithm for searching the software component Topic 5.4 . Software implementation of aircraft control algorithms

5.2. The content of the discipline sections

P / p No.	Name of the discipline section / topic of the lesson	Practice. / workshop.	IW	Total
hour.				
1	Section 1. Classification of tasks and methods of aircraft motion control	2	10	12
	Topic 1.1. Classification of tasks and methods of aircraft motion control	2	10	12
2.	Section 2. Technical problem of aircraft entry into an orbital constellation and its mathematical formalization	2	16	18
	Topic 2.1. Formulation of the technical problem of aircraft entry into the orbital constellation and its mathematical formalization	2	16	18
3.	Section 3. Mathematical models of controlled aircraft motion	4	18	22
	Topic 3.1. Coordinate systems for calculating the aircraft motion Newton's equations. Equations in osculating elements	1	6	7
	Topic 3.2. Equations in Equinoxes. Equations in a spherical system	1	6	7
	Topic 3.3. Linearization of the equations of motion in various coordinate systems. Discrete motion model	2	6	8
4 .	Section 4. Optimal control of the aircraft motion during additional placement into geostationary orbit	6	20	26
	Topic 4 .1. Statement of the problem of launching an aircraft to the GSO using the upper stage. Reduction to a nonlinear programming problem	2	6	8
	Topic 4 .2. Launching the aircraft to the GSO with a low-thrust engine	2	6	8
	Topic 4 .3. Launching the aircraft GSO using EPP, taking into account the shadow areas	2	8	10

P / p No.	Name of the discipline section / topic of the lesson	Practice. / workshop.	IW	Total
5 .	Section 5. Optimal control of the aircraft's motion when entering and holding an orbital position	6	20	26
	Topic 5 .1. Mathematical model of motion when the aircraft is put into the orbital position in the GSO	1	5	6
	Topic 5 .2. Combined optimization method. Software and synthesized control components	1	5	6
	Topic 5.3. Algorithm for searching for a synthesized component. The concept of suboptimal control. Algorithm for searching the software component	2	5	7
	Topic 5.4 . Software implementation of aircraft control algorithms	2	5	7

6. Laboratory practice-not provided

7. Practical classes (seminars) (if available)

№ p/p	№ of the discipline section	Topics of practical classes (seminars)	Labor intensity (hrs.)
1.	1.	Section 1. Classification of tasks and methods of aircraft motion control	2
2.	2	Section 2. Technical problem of aircraft entry into an orbital constellation and its mathematical formalization	2
3	3	Section 3. Mathematical models of controlled aircraft motion	4
4	4	Section 4. Optimal control of the aircraft motion during additional placement into geostationary orbit	6
5	5	Section 5. Optimal control of the aircraft's motion when entering and holding an orbital position	6

8. Educational-methodical and informational support of the discipline

Moscow, Ordzhonikidze str., 3, building 1, 5. Multimedia auditorium and equipment of the laboratory «Information Communication Management». The laboratory consists of three divisions - educational (room 110), educational and scientific (room 116) and scientific (room 123), and is equipped with modern network equipment and computer equipment (a set of Sharp PNL702B liquid crystal display, a 24" Acer V243HAOBD monitor, a system unit (Intel Core i7-2600 OEM processor <3.40 GHz, 8Mb, 95W, LGA1155(Sandy Bridge)>, 16GB OP, HDD 2 TB), a DMS800 projector with an interactive whiteboard Board 1077, HP XW7800, Intel Core2 2.4 GHz (8 pcs.)). The laboratory base allows you to carry out projects on the development of applied means of the infocommunication environment, conduct lectures and laboratory classes with multimedia teaching tools. Display classes DK3, DK4, DK6, DK7, Intel Core i3-550 3.2 GHz-60 pcs.

9. Information support of the discipline

(the list of information technologies used in the implementation of the educational process in the discipline (module) is indicated, including a list of software and information reference systems (if necessary))

a) software Standard personal computer software

b) ProjectLibre software

c) database, directory and search engine Yandex, Google

10. Educational and methodological support of the discipline:

Main literature:

1. Ed. Byushgens G.S. Flight dynamics. M .: Mashinostroenie, 2011 .-- 776 p.
2. Statistical dynamics and optimization of aircraft control Textbook for universities / Under the general editorship of M. N. Krasil'shchikov, V. V. Malysheva / 2nd ed. revised and add. - M .: Alliance, 2013 .- 468 p., Illustrated.
3. Fedorov A.V. Collection of assignments for term paper in the discipline "Optimal aircraft control", MAI, department. 604, 2012
4. Malyshev V.V. Optimization methods in problems of system analysis and management textbook. manual for universities of the Russian Federation on specials. 160703 "Flight dynamics and aircraft motion control" direction. 160700 "Hydroaerodynamics and flight dynamics" and special. 23031 "Modeling and research of operations in organizational and technical systems" direction. 230300 "Organizational and technical systems". MAI-PRINT, 2010 .- 440 p.

Additional literature:

1. Alekseev K.B., Bybenin G.G., Yaroshevsky V.A. Spacecraft maneuvering. - Moscow: Mechanical Engineering, 1970 .-- 232 p.
2. Fedorov A.V. Solving mathematical programming problems in the Delphi environment. Problems of unconstrained minimization of functions. MAI department 606, 2014
3. Fedorov A.V. Programming tasks for modeling complex systems in the Delphi environment. Simulate + class library. MAI, dept. 604, 2012.
4. Fedorov A.V. Simulate + / Space class library. Simulation of spacecraft motion. MAI department 606, 2014.
5. Malyshev V.V. Optimization methods in problems of system analysis and control: Textbook. — M .: Publishing house MAI-PRINT, 2010. - 440p.: illustrated.

Resources of the information and telecommunications network "Internet":

1. Electronic library system (ELS) of RUDN University and third-party ELS to which university students have access on the basis of concluded agreements:

- RUDN University Electronic Library System - RUDN University Library System http://lib.rudn.ru/MegaPro/Web
- ELS "University Library Online" http://www.biblioclub.ru
- ELS Yurayt http://www.biblio-online.ru
- ELS "Student Consultant" www.studentlibrary.ru
- ELS "Lan" 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/

11. Methodological guidelines for students on the development of the discipline (module)

During practical classes in the discipline, control measures are carried out in order to identify the acquired knowledge, skills, skills and competencies. As part of their independent work, graduate students study the educational and methodological support of the discipline, prepare homework, work on questions and tasks for self-preparation, search and review scientific publications and electronic sources of information. Independent work should be systematic and controlled by the teacher, taken into account by the teacher for issuing certification.

To improve the quality level of mastering the discipline, a graduate student should prepare for a lecture, since it is the leading form of organizing student learning and implements functions that contribute to:

- formation of the basic concepts of the discipline,
- stimulating interest in the discipline, the topics of its study,
- systematization and structuring of the entire body of knowledge in the discipline,
- orientations in the scientific literature that reveals the problems of the discipline.

Preparation for the lecture is as follows:

- study of the material of the previous lecture,
- анализ analysis of the topic of the upcoming lecture (according to the thematic plan, according to the information of the lecturer),
- familiarization with the educational material on the textbook and teaching aids,
- analysis of the place of the studied topic in your professional training,
- preparation of questions that can be asked to the lecturer at the lecture.

Preparation for practical classes:

- introduction to the practical lesson plan: first with the main questions, then with questions for discussion, assessment of the scope of the task;
- study of the lecture summary on the topic of the practical lesson, selection of the material necessary for studying the questions posed;
- familiarization with the recommended main and additional literature on the topic, new publications in periodicals;
- identification of the main concepts of the topic under study, the possession of which contributes to the effective development of the discipline;
- preparation of abstracts or mini-notes that can be used for public speaking in the classroom.

The working program of the discipline in terms of goals, a list of knowledge, skills, terms and educational questions can be used by you as a guide in the organization of training.

Preparation for the test. It is necessary to prepare for the test purposefully, regularly, systematically and from the first days of training in this discipline. At the very beginning of studying the discipline, the graduate student gets acquainted with the program for the discipline, the list of knowledge and skills that the graduate student should possess, control measures, a textbook, textbooks on the discipline being studied, electronic resources, a list of questions for the test.

Systematic performance of educational work at lectures, practical classes and classes will allow you to successfully master the discipline and create a good basis for passing the test.

Graduate students are required to attend classes, perform tasks of the head of the discipline, get acquainted with the recommended literature and prepare an essay for a round table (the choice of the topic of the essay is carried out in agreement with the head of the discipline and the scientific supervisor). Graduate students carry out projects, creative tasks for independent work, taking into account the profile of the disciplines that they will implement in the course of industrial practice. The results of completing tasks for independent work are evaluated on the basis of a point-rating assessment and are reflected in the educational route of the graduate student. When certifying a graduate student, the quality of work in the classroom is evaluated (the ability to conduct a scientific discussion, the ability to clearly and succinctly formulate their thoughts), the level of preparation for independent research activities of a specialist in the field of higher school pedagogy, the history of pedagogy and education, the quality of tasks (presentations, reports, analytical notes, etc.).

The organization of classes in the discipline "Additional Topics of Theoretical Mechanics and Mechanics of Space Flight" is carried out in the following types of educational work: interactive practical classes (seminars), preparation of independent work and subsequent defense.

The implementation of the competence-based approach in the framework of the training area 09.06.01 "Computer Science and Computer Engineering " 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 during control measures.

The graduate student is obliged to master all the topics provided for by the curriculum of the discipline. Certain topics and issues of training are designed for independent study. The postgraduate student covers the recommended literature and briefly notes the material and clarifies the most difficult issues requiring clarification during tutorials. The same should be done with sections of the course that were skipped due to various circumstances.

The purpose of practical classes and seminars is to obtain knowledge and practical skills for graduate students in the field of ballistics and navigation of launch vehicles. To achieve these goals, both traditional forms of work are used - solving problems, working with technological equipment / specialized software when performing laboratory work, etc., as well as interactive methods - group work, analysis of specific situations, etc.

Using the method of analyzing a specific situation, students develop such skills 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 carried out in an individual format based on the teaching materials of the discipline (*Appendices 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.

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

1. A course of lectures on the discipline "Additional sections of theoretical mechanics and mechanics of space flight" (*Appendix 2*).
2. Methodical instructions for independent work of students in the discipline "Additional sections of theoretical mechanics and mechanics of space flight" (*Appendix 3*).

12. Performance assessment documentation package for the intermediate certification of students in the discipline (module)

Materials for assessing the level of mastering the educational material of the discipline "Additional sections of theoretical mechanics and mechanics of space flight" (evaluation materials), which include a list of competencies indicating the stages of their formation, a description of indicators and criteria for evaluating competencies at various stages of their formation, a description of assessment scales, standard control tasks or other materials necessary for evaluating knowledge, skills, skills and (or) experience of activity that characterize the stages of competence formation in the process of mastering an educational program, methodological materials that determine the procedures for evaluating knowledge, skills, skills and (or) experience of activity that characterize the stages of competence formation are fully developed and are available to students on the discipline page in the TUIS RUDN.

The program is compiled in accordance with the requirements of OS VO RUDN

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