Federal State Autonomous Educational Institution
higher education
RUDN University

Academy of Engineering

Recommended by the ISSC

THE WORKING PROGRAM OF THE DISCIPLINE

Discipline Name: Mathematical modeling and control of the movement 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 goal of mastering the discipline "Mathematical modeling and 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 world trends in the development of aviation and rocket and space technology.

The main objectives of the discipline are:

 Know new methods of mathematical modeling and aircraft motion control

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

 Knowledge of the methodology of theoretical and experimental research in the field and on the problems of ensuring environmental and industrial safety, monitoring and control of the human environment

 Knowledge of the culture of scientific research of human-sized systems based on the use of the principles of synergetics and transdisciplinary technologies, including the use of the latest information and communication technologies and geoinformation systems

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

The discipline "Mathematical modeling and control of the movement of aircraft" refers to the variable part of Block 1 of the curriculum. Table 1 shows the previous and subsequent disciplines aimed at the formation of discipline competencies in accordance with the competence matrix of EP HE.

Table No. 1

№ п/п	Code and name of competence	Previous disciplines	Subsequent disciplines (groups of disciplines)
Universal competences			
	Ability to critically analyze and evaluate modern scientific achievements, generate new ideas in solving research and practical problems, including in interdisciplinary fields (UC-1)	History and philosophy of science Research methodology	
General professional competencies			
Professional competencies (type of professional activity _____)			
	Willingness to apply promising research methods and solve professional problems, taking into account the world trends in the development of aviation and rocket and space technology (PC-1);	Research methodology	
	Ability to create and	Research methodology	

	research mathematical and software models of products and processes associated with the functioning of objects of aviation and rocket technology (PC-2);		
	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 (PC-3);	Research methodology Priority areas for the development of mathematics and mechanics	
	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 (PC-4);	Fundamentals of teaching methods for the development of engineering applications based on mathematical modeling using informatics and computer technology in higher education	
	Ability to develop mathematical models, methods, computer technologies and decision support systems in scientific research, design and engineering activities (PC-5);	Fundamentals of teaching methods for the development of engineering applications based on mathematical modeling using informatics and computer technology in higher education	
	Ability to develop new mathematical models of objects of aviation and rocket and space technology, to develop analytical and approximate research methods (PC-6).	Priority areas for the development of mathematics and mechanics Fundamentals of teaching methods for the development of engineering applications based on mathematical modeling using informatics and computer technology in higher education	
Vocational and specialized competencies of specialization			

3. Требования к результатам освоения дисциплины:

Процесс изучения дисциплины направлен на формирование следующих компетенций:

УК-1, ПК-1, ПК-2, ПК-3, ПК-4, ПК-5, ПК-6

(указываются в соответствии с ОС ВО РУДН)

3. Requirements for the results of mastering the discipline:

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

UC-1, PC-1, PC-2, PC-3, PC-4, PC-5, PC-6

(indicated in accordance with the OS VO RUDN University)

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

Know:

- 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
- Know the development plan of the scientific organization, the activity plan of the unit, data on competitions for financing scientific activities
- Know the methods of research and solving professional problems, taking into account the world trends in the development of aviation and rocket and space technology.
- Know new methods of creating and researching mathematical and software models of products and processes associated with the functioning of objects of aviation missile 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
- 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
- Know new methods of developing mathematical models, methods, computer technologies and decision support systems in scientific research
- Know new methods for the development of mathematical models of objects of aviation and rocket-space technology

Be able to:

- - To be able, while solving research and practical problems, to generate new ideas that can be operationalized based on available resources and constraints
- - Be able to select competitions for funding scientific activities
- - To be able to apply research methods and solving professional problems, taking into account the world 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 associated with the functioning of objects of aviation and missile 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

- - 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
- - Be able to use 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 of objects of aviation and rocket-space technology

Possess:

- Possess the skills of analyzing methodological problems arising in the solution of research and practical problems, including in the interdisciplinary field

- Possess 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

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

- Possess new methods of creating and researching mathematical and software models of products and processes associated with the operation of objects of aviation and missile 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

- Possess 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 developing mathematical models, methods, computer technologies and decision support systems in scientific research

- Possess new methods for the development of mathematical models of objects of aviation and rocket-space technology

4. Scope of discipline and types of educational work

The total workload of the discipline is 3 credit points.

Auditory lessons
Lectures (L)
Practical / Seminar Lessons (PZ)
Laboratory work (LR)
Course project / course work
Independent work (IWS), including control
Type of certification test
Total workload of academic hours
credit units

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

5. Content of the discipline

5.1. Contents of discipline sections

№ п/п	The name of the discipline section	The content of the section (topic)
1.	1. Basic concepts of modeling theory	1.1. The role and place of mathematical modeling in solving problems of analysis, synthesis and management of the functioning of organizational and technical systems
2	2. Analytical models of systems	2.1. The concept of analytical models of systems as models that are built using physical laws or theories 2.2. Analytical models of static and dynamic systems 2.3. Lumped and Distributed Dynamical Systems 2.4. Types of mathematical models of dynamic systems 2.5. Analytical models of continuous dynamic systems 2.6. Analytical models of discrete dynamical systems
3	3. Simulation models of systems	3.1. The concept of simulation of systems 3.2. Necessary information from the theory of probability, mathematical statistics and stochastic processes 3.3. Main components of the simulation model 3.4. Simulation of dynamic systems with continuous time. 3.5. Features of simulation of dynamic systems with discrete states and continuous time. Event approach
4	4. Using optimization methods in problems of mathematical modeling	4.1. Using mathematical programming methods to optimize a system using its mathematical model 4.2. Review of mathematical programming methods 4.3. The problem of optimizing the structure and parameters of the system and the problem of optimal control of a dynamic system 4.4. Problems of Programming and Synthesis of Controlling the Functioning of a Dynamic System 4.5. System optimization by vector criterion. Optimization problem according to the criterion "costs - effectiveness" 4.6. Stages of solving the problem by the vector criterion: search for a dominant alternative, formation of a set of Pareto optimal alternatives
5	5. Applied research software	5.1. The main functions performed by applied software (PPP) scientific research. Requirements for RFP 5.2. RFP architecture and the process of processing the input task. Forms of presentation of complexes of applied programs 5.3. Technology for the development of complexes of applied programs. Application of tools for the development of PPP and dialogue systems
6	6. Simulation automation tools	6.1. Information Systems 6.2. Automation tools for modeling: basic definitions, life cycle models, object-oriented models, using CASE tools

5.2. Sections of disciplines and types of classes

№ п/п	The name of the section of the discipline / topic of the lesson.	Pract. / workshop	CPC	Total hour.
1.	**Section # 1. Basic concepts of modeling theory**	**1**	**8**	**9**
	Topic 1.1. The role and place of mathematical modeling in solving problems of analysis, synthesis and management of the functioning of organizational and technical systems	1	8	9
2.	**Section # 2. Analytical systems models**	**3**	**16**	**19**
	Topic 2.1. The concept of analytical models of systems as models that are built using physical laws or theories	0,5	2	2,5
	Topic 2.2. Analytical models of static and dynamic systems	0,5	2	2,5
	Topic 2.3. Lumped and Distributed Dynamical Systems	0,5	3	3,5
	Topic 2.4. Types of mathematical models of dynamic systems	0,5	3	3,5
	Topic 2.5. Analytical models of continuous dynamic systems	0,5	3	3,5
	Topic 2.6. Analytical models of discrete dynamical systems	0,5	3	3,5
3.	**Section # 3. System simulation models**	**2**	**16**	**18**
	Topic 3.1. The concept of simulation of systems	0,5	4	4,5
	Topic 3.2. Necessary information from the theory of probability, mathematical statistics and stochastic processes	0,5	4	4,5
	Topic 3.3. Main components of the simulation model	0,5	4	4,5
	Topic 3.4. Simulation of dynamic systems with continuous time	0,5	4	4,5
4	**Section No. 4. The use of optimization methods in problems of mathematical modeling**	**6**	**16**	**22**
	Topic 4.1. Using mathematical programming methods to optimize a system using its mathematical model	1	2	3
	Topic 4.2. Review of mathematical programming methods	1	2	3
	Topic 4.3. The problem of optimizing the structure and parameters of the system and the problem of optimal control of a dynamic system	1	3	4
	Topic 4.4. Problems of Programming and Synthesis of Controlling the Functioning of a Dynamic System	1	3	4
	Topic 4.5. System optimization by vector criterion. Optimization problem according to the criterion "costs - effectiveness"	1	3	4
	Topic 4.6. Stages of solving the problem by the vector criterion: search for a dominant alternative, formation of a set of Pareto	1	3	4

№ п/п	The name of the section of the discipline / topic of the lesson.	Pract. / workshop	CPC	Total hour.
	optimal alternatives			
5	**Section # 5. Scientific research application software**	**4**	**16**	**20**
	Topic 5.1. The main functions performed by applied software (PPP) scientific research. Requirements for RFP	1	5	6
	Topic 5.2. RFP architecture and the process of processing the input task. Forms of presentation of complexes of applied programs	1	5	6
	Topic 5.3. Technology for the development of complexes of applied programs. Application of tools for the development of PPP and dialogue systems	2	6	8
6	**Section # 6. Simulation automation tools**	**4**	**16**	**20**
	Topic 6.1. Information Systems	2	8	10
	Topic 6.2. Automation tools for modeling: basic definitions, life cycle models, object-oriented models, using CASE tools	2	8	10
	Exam	**20**	**88**	**108**

6. Laboratory workshop (if any) - not provided

7. Practical lessons (seminars) (if any)

№ п/п	No. of discipline section	Topic of practical classes (seminars)	Labor capacity
1.	**1**	Topic 1.1. The role and place of mathematical modeling in solving problems of analysis, synthesis and management of the functioning of organizational and technical systems	2
2	**2**	Topic 2.1. The concept of analytical models of systems as models that are built using physical laws or theories	2
3	**2**	Topic 2.2. Analytical models of static and dynamic systems	0,5
4	**2**	Topic 2.3. Lumped and Distributed Dynamical Systems	0,5
5	**2**	Topic 2.4. Types of mathematical models of dynamic systems	0,5
6	**2**	Topic 2.5. Analytical models of continuous dynamical systems	0,5
7	**2**	Topic 2.6. Analytical models of discrete dynamical systems	0,5
8	**3**	Topic 3.1. The concept of simulation of systems	0,5
9	**3**	Topic 3.2. Necessary information from the theory of probability, mathematical statistics and stochastic processes	0,5
10	**3**	Topic 3.3. Main components of the simulation model	0,5
11	**3**	Topic 3.4. Simulation of dynamic systems with continuous time	0,5
12	**4**	Topic 4.1. Using mathematical programming methods to optimize a system using its mathematical model	1
13	**4**	Topic 4.2. Review of mathematical programming methods	1
14	**4**	Topic 4.3. The problem of optimizing the structure and parameters of the system and the problem of optimal control of a dynamic system	1
15	**4**	Topic 4.4. Problems of Programming and Synthesis of Controlling the Functioning of a Dynamic System	1
16	**4**	Topic 4.5. System optimization by vector criterion.	1

		Optimization problem according to the criterion "costs - effectiveness"	
17	**4**	Topic 4.6. Stages of solving the problem by the vector criterion: search for a dominant alternative, formation of a set of Pareto optimal alternatives	1
18	**5**	Topic 5.1. The main functions performed by applied software (PPP) scientific research. Requirements for RFP	1
19	**5**	Topic 5.2. RFP architecture and the process of processing the input task. Forms of presentation of complexes of applied programs	1
20	**5**	Topic 5.3. Technology for the development of complexes of applied programs. Application of tools for the development of PPP and dialogue systems	2
21	**6**	Topic 6.1. Information Systems	2
22	**6**	Topic 6.2. Automation tools for modeling: basic definitions, life cycle models, object-oriented models, using CASE tools	2

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": No. 345 Equipment and furniture: - Personal graphic workstations based on the AVK-1 system unit + monitor (13 pcs.); Interactive whiteboard Polyvision TSL 610; Epson EB-X02 projector; 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 No. 86626883 dated 01.04.2018); 2. Microsoft Office 2007 (Microsoft Subscription) Enrollment for Education Solutions No. 86626883 dated 04/01/2018); 3. Borland Developer Studio 2006 (License Certificate Number: 33080, 33081, 33082); 4. MATLAB R2008b (361405 2008); 5. Notepad ++ (free application). **1.** 6. Acrobat Reader DC (free application)	Moscow, Ordzhonikidze st, 3

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 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 "Mathematical modeling and control of the movement of aircraft" (Appendix 2).
2. Methodical instructions for independent work of students in the discipline "Mathematical modeling and control of the movement of aircraft" (Appendix 3).

10. Educational and methodological support of the discipline

Main literature:

1. Malyshev V.V. Optimization methods in problems of system analysis and control: Textbook. - M .: Publishing house MAI-PRINT, 2010.

2. Modern problems of computational mathematics and mathematical modeling: in 2 volumes / [otv. ed. NS Bakhvalov, VV Voevodin] Inst. Vychisl. mathematics. - M .: Nauka, 2005.

3. Wentzel E.S. Operations research. Tasks, principles, methodology - M.: Higher School, 2007.

4. Samarskiy A.A., Mikhailov A.P. Mathematical modeling: Ideas, methods, examples. - M .: Fizmatlit, 2008.

5. Councils B. Ya., Yakovlev SA Modeling of systems: Textbook. for universities - 3rd ed., rev. and add. - M .: Higher. shk., 2001.

6. Averchenkov V.I., Fedorov V.P., Kheifets M.L. Fundamentals of mathematical modeling of technical systems / Tutorial. Bryansk: BSTU Publishing House, 2004 .-- 271 p.

7. Tikhonov N.A., Tokmachev M.G. Fundamentals of Mathematical Modeling / Tutorial. Moscow: Faculty of Physics, Moscow State University, 2013

Additional literature:

1. Gill F, Murray W., Wright M. Practical optimization. - M.: Mir, 1985 -512 p.
2. Lebedev A.A., Bobronnikov V.T., Krasilshchikov M.N., Malyshev V.V. Statistical dynamics and optimization of aircraft control. - M .: Mechanical engineering, 1985. - 280 p.
3. Malyshev V.V. Optimization methods for complex systems. Tutorial. - M .: MAI, 1981.- 76 p.
4. Malyshev V.V. Programming optimal control of aircraft. - M .: MAI, 1982.
5. Polak E. Numerical optimization methods. One approach. - M .: Mir, 1974- 376 p.
6. Samarskiy A.A., Mikhailov A.P. Math modeling. Moscow: Nauka, 1997.320 p.
7. Bakhvalov NS Numerical methods / NS Bakhvalov, NP Zhidkov, GM Kobelkov. - M .: Laboratory of basic knowledge, 2001 .-- 632 p.
8. Gultyaev A.K. MatLaЬ 5.2 Simulation modeling in the Windows environment. SP .: Crown-print, 1999.
9. Computer networks. Comprehensive manual for construction, operation and planning. User encyclopedia. Per. from English Kiev: Diasoft, 1998.

10. Samarskiy A.A., Mikhailov A.P. Math modeling. Moscow: Nauka, 1997.320c.
11. Korobeynikov V.P. Principles of mathematical modeling. Vladivostok: Dalnauka, 1997, 240 p.
12. Samarsky A.A., Vablitsevich P.N., Samarskaya E.A. Problems and exercises on numerical methods. Moscow: Editorial URSS, 2000.208 p.

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

The organization of classes in the discipline "Mathematical modeling and 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 01.06.01 "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 during control measures.
The postgraduate 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. The postgraduate student studies the recommended literature and briefly notes 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 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 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 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.

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 "Mathematical modeling and control of the movement 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 ES of HE of RUDN University

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
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signature — initials, surname