Federal State Autonomous Educational Institution of Higher Education
«RUDN University»

Engineering Academy

WORKING PROGRAM OF THE DISCIPLINE

Name of the discipline

System analysis, management and information processing

Recommended for the educational program

01.06.01 Mathematics and Mechanics

Focus of the program (profile)
Dynamics and strength of machines, devices and equipment» (technical sciences)

1. Aims and objectives of the discipline:

The aim of the course is to equip postgraduate students of the profile " Dynamics and strength of machines, devices and equipment " with professional competences in scientific research on modern methods of system analysis, control and information processing.
The objectives of the course are to teach the skills of finding and understanding new, as well as rethinking current methods of systems analysis, management and information processing.

2. The place of the discipline in the structure

The discipline " System analysis, management and information processing " 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 № 1

Prior and subsequent disciplines aimed at the formation of competencies

№	Code and name of competence	Preceding disciplines	Subsequent disciplines (groups of disciplines)
Universal competences			
1	ability to critically analyze and evaluate modern scientific achievements, generate new ideas when solving research and practical problems, including interdisciplinary areas (UC-1)	History and philosophy of science Dynamics and strength of machines, devices and equipment	
General professional competencies			
2	ability to independently carry out research activities in the relevant professional field using modern research methods and information and communication technologies (GPC-1)	Research methodology Priority areas for the development of mathematics and mechanics Dynamics and strength of machines, devices and equipment	
Professional competence			
3	willingness to apply promising research methods and solve professional problems, taking into account global trends in the development of technical objects for various purposes (PC-1)	Research methodology Priority areas for the development of mathematics and mechanics Dynamics and strength of machines, devices and equipment	
4	ability to identify the essence of scientific and technical problems arising in the course of professional activity, and to apply the physical and mathematical apparatus, theoretical,	Research methodology Dynamics and strength of machines, devices and equipment	

	computational and experimental research methods, methods of mathematical and computer modeling, for solving the previously mentioned problems (PC-2)		
5	willingness to carry out research work and solve scientific and technical problems in the field of applied mechanics based on the achievements of engineering and technology, classical and technical theories and methods, physical-mechanical, mathematical and computational models that have a high degree of adequacy to real processes, machines and structures (PC-3)	Research methodology Priority areas for the development of mathematics and mechanics Dynamics and strength of machines, devices and equipment	
6	ability to create new generations of machines, devices, equipment, technologies and materials with qualitatively new functional properties, as well as to improve existing machines, devices, equipment and technologies with improved performance characteristics, less material and energy consumption (PC-4)	Fundamentals of teaching methods for the development of engineering applications based on mathematical modeling using informatics and computer technology in higher education Dynamics and strength of machines, devices and equipment	
7	ability to develop methods of mechanics and computational mathematics, computer technology 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 Dynamics and strength of machines, devices and equipment	
8	ability to study patterns and relationships, dynamic processes, stress states and strength of machines,	Priority areas for the development of mathematics and mechanics Fundamentals of teaching methods for the	

	devices and equipment (PC-6).	development of engineering applications based on mathematical modeling using informatics and computer technology in higher education Dynamics and strength of machines, devices and equipment	

3. requirements for the results of the discipline:

As a result of the discipline, the postgraduate student should:

Knowledge of the main modern methods of implementing software packages, current scientific literature and journal articles in the periodical press dealing with such problems.

To **be able** to identify relevant contemporary theoretical problems in systems analysis, control and information processing and to explain on this basis the existing facts and processes of development of approximate methods in modern mathematics.

To be able to find and comprehend new as well as rethink previously known facts, processes and trends that characterise the formation, evolution and transformation of systems analysis, management and information processing in a historical retrospective.

4. The process of studying the discipline aims to form the following competences:

Universal competences	
UC-1	ability to critically analyze and evaluate modern scientific achievements, generate new ideas when solving research and practical problems, including in interdisciplinary fields
General professional competencies	
GPC-1	the ability to independently carry out research activities in the relevant professional field using modern research methods and information and communication technologies
Professional competences	
PC-1	willingness to apply promising research methods and solve professional problems, taking into account global trends in the development of technical objects for various purposes
PC-2	the ability to identify the essence of scientific and technical problems arising in the course of professional activity, and to apply for their solution the physical and mathematical apparatus, theoretical, computational and experimental research methods, methods of mathematical and computer modeling
PC-3	readiness to carry out research work and solve scientific and technical problems in the field of applied mechanics based on the achievements of engineering and technology, classical and technical theories and methods, physical and mechanical, mathematical and computer models that have a high degree of adequacy to real processes, machines and structures

PC-4	the ability to create new generations of machines, devices, equipment, technologies and materials with qualitatively new functional properties, as well as to improve existing machines, devices, equipment and technologies with increased operational characteristics, less material and energy consumption
PC-5	ability to develop methods of mechanics and computational mathematics, computer technology and decision support systems in scientific research, design and engineering activities
PC-6	the ability to study patterns and relationships, dynamic processes, stress states and strength of machines, devices and equipment

5. Scope of the discipline and types of study

Scope of the discipline	3 ZU 108 hours
The volume of training sessions	40 hours
Lectures	20 hours
Practitioners	20 hours
Seminars	-
Laboratory work	-
Independent work	68 hours

6. Content of the discipline

6.1 Content of the sections of the discipline

Main sections of the discipline: Topical issues of systems analysis. Topical issues of management. Current issues of information processing

No. n/a	**Name section disciplines**	**Contents of the section**
1	Current issues of systems analysis.	Mathematical models of mechanical systems, multi-link robots. The laws of mechanics for constructing mathematical models. Lagrange method. Dalamber's principle. Examples of constructing mathematical models of mechanical objects. Uncertainties in mathematical models. Probabilistic methods of uncertainty description. Fuzzy forms of uncertainty description. Methods for solving parametric identification problems. Structural uncertainty. Problems of solving structural identification problem and structural-parametric identification problem. Mathematical models of flying vehicles, flying robots. Non-parametric identification of nonlinear systems. Pontryagin's maximum principle. Problems of solving optimal control task. Computing methods for solving optimal control tasks. Bellman's equation. Analytical design of optimum controllers. Lyapunov Functions Method for Synthesis of Stabilizing Systems. The method of analytical design of aggregated regulators. The problem of uncertainty in the problem of control synthesis.
2	Topical issues of	Numerical synthesis problem formulation for control systems. Optimal robust control. H2 and H∞ optimal control theory.

	governance.	Representation of a random process by methods of polynomial chaos theory. Probabilistic uncertainty in stochastic dynamic control systems. Artificial Neural Networks. The Widrow-Hoff Delta Rule and the Error Backpropagation Algorithm. Adaptive control systems based on neural networks. Neural networks for identification tasks. Neural network method for solving the tasks of control synthesis. Genetic algorithm. Algorithm of differential evolution. Ant colony algorithm. Bee swarm algorithm. Particle swarm algorithm. The principle of small variations of a basis solution for solving numerical and nonnumerical optimization problems.
3	Current issues in information processing	A variational genetic algorithm for training a neural network. A variational genetic algorithm for solving an optimal control problem. Genetic programming method. A method for variational genetic programming. Grammar evolution method. Method for variational grammatical evolution. Analytical programming method. The method of variational analytical programming. Network operator method. Multilayer network operator method. Solving identification and control synthesis problems by symbolic regression methods. The solution of the task of optimum control by the method of symbolic regression. Systems with shared memory. Systems with distributed memory. Graphical accelerators Parallel technology software. OpenMP, MPI, OpenCL, CUDA libraries. Parallelization efficiency evaluation.

6.2 Sections of the discipline and interdisciplinary links with the (further) disciplines provided.

No. n/a	Name of disciplines to be provided (follow-up)	No. of sections of the discipline which are necessary for the study of the (further) disciplines to be covered		
		1	2	3
1.	Research practice	1		3
2.	Pedagogical practice	1	2	3
3.	Scientific research	1	2	3

6.3 Sections of the disciplines and types of classes

No. n/a	Name of discipline section	Lect.	Practice	Lab.	Semin	SRS	All-hour.
1.	Current issues of systems analysis.	6	6			24	36
2.	Topical issues of governance.	6	6			24	36
3.	Current issues in information processing	8	8			20	36
	TOTAL	20	20			68	108

7. Laboratory and practical exercises

7.1 Practical exercises

No. n/a	Discipline section no.	Topics of practical exercises	Labour input (hours)
1.	1	Computational methods for solving optimal control problems. The Bellman equation.	2
2	1	Analytical design of optimum controllers (ACCOR). Lyapunov function method for the synthesis of stabilisation systems.	2
3	1	A method for the analytical design of aggregated controllers. The uncertainty problem in the control synthesis problem.	2
4	2	The algorithm for differential evolution. The ant colony algorithm.	2
5	2	The algorithm for a swarm of bees. The particle swarming algorithm.	2
6	2	The principle of small variations of a basis solution for numerical and non-numerical optimisation problems.	2
7	3	Solving the optimum control problem by symbolic regression.	2
8	3	Software tools for parallel technology.	2
9	3	OpenMP, MPI, OpenCL, CUDA libraries.	2
10	3	Evaluations of paralleling efficiency.	2

7.2 Laboratory workshop

Not provided.

8. Types of independent work

No. n/a	Discipline section no.	Topics for independent work	Labour input (hours)
1.	1	Reviewing scientific conference proceedings in Russian and English to identify the most topical research issues in the physical and mathematical sciences	12
2	1	Preparation of articles on the subject of the thesis research	12
3	2	Preparing scientific papers at regional, national and international conferences	12
4	2	Development of research projects and participation in regional, national and international competitions in the technical sciences	12
5	3	Preparation of materials for participation in grants awarded to postgraduate students and young scientists in Russia and abroad in the technical sciences	10
6	3	Preparing and running a research seminar, a methodological seminar or a master class.	10

9. Educational and methodological and informational support of the discipline:

(a) Basic literature

1. Diveyev A. I., Cofronova Ye. A. Metod setevogo operatora i yego primeneniye v zadachakh upravleniya. M.: Izd-vo RUDN, 2012. – 182 s.

b) further literature

1. Bobenko A. I., Suris YU. B. Diskretnaya differentsial'naya geometriya. Integriruyemaya struktura - M.; Izhevsk: NITS "Regulyarnaya i khaoticheskaya dinamika»: Izhevskiy institut komp'yuternykh issledovaniy, 2010. - 448 s.
2. Samarskiy A. A., Vabishchevich P. N. Chislennyye metody resheniya obratnykh zadach matematicheskoy fiziki: Uchebnoye posobiye. - M.: Izd-vo LKI, 2014. - 480 s.
3. Naats V. I., Naats I. E. Matematicheskiye modeli i chislennyye metody v zadachakh ekologicheskogo monitoringa atmosfery: Monografiya - M.: FIZMATLIT, 2010. - 328 s.
4. Rumyantsev A. V. Metod konechnykh elementov v zadachakh teploprovodnosti: Uchebnoye posobiye - Kaliningrad: Izd-vo KGU, 1995. - 170 s.:
5. Sveshnikov A. G. i dr. Lineynyye i nelineynyye uravneniya sobolevskogo tipa - M.: Fizmatlit, 2007. - 736 s.

c) Software: only licensed software installed at PFUR is used. Microsoft Office software package and specialised software Dev-C++, Scilab.

d) databases, reference and retrieval systems

Russian State Library Digital Library http://www.rsl.ru/

PFUR Library website http://lib.rudn.ru/

Science Direct http://www.sciencedirect. Description: This resource contains a collection of scientific, technical full-text and bibliographic information. A multidisciplinary database of scientific journals in the exact and technical sciences.

EBSCO http://search.ebscohost.com, Academic Search Premier (a comprehensive database containing information on the humanities and the natural sciences).

Oxford University Press http://www3.oup.co.uk/jnls. Oxford University Press Science and Engineering journals in the HSS collection

Sage Publications http://online.sagepub.com . The Sage Publications database includes journals from a variety of disciplines: Sage_STM - over 100 journals in science, engineering and technology.

Springer/Kluwer http://www.springerlink.com. The journals and books from Springer/Kluwer cover different fields of knowledge and are divided into subject categories.

Tailor & Francis http://www.informaworld.com . The magazine collection has over 1,000 titles in all fields of knowledge.

American Mathematical Society http://www.ams.org/ Resource of the American Mathematical Society.

European Mathematical Society http://www.euro-math-soc.eu/ European Mathematical Society Resource.

Portal to Mathematics Publications http://www.emis.de/projects/EULER/

Catalogue of mathematical Internet resources http://www.mathtree.ru/.

Zentralblatt MATH (zbMATH) https://zbmath.org

All-Russian mathematics portal mathnet.

Web of Science http://www.isiknowledge.com

Resources of the Institute of Scientific Information on Social Sciences of the Russian Academy of Sciences (ISIS RAS) http://elibrary.ru.

University Information System RUSSIA. http://www.cir.ru/index.jsp.

Gosts system of standards for information, librarianship and publishing http://www.ifap.ru/library/gost/sibid.htm

PFUR Digital Library http://www.rsl.ru/

e) periodicals

- Algebra and analysis
- Discrete mathematics
- Journal of Computational Mathematics and Mathematical Physics
- Proceedings of the Russian Academy of Sciences. Mathematical Series
- Mathematical notes
- A mathematical compendium
- Mathematical modelling
- Theoretical and mathematical physics
- Probability theory and its applications
- Advances in mathematical sciences
- Functional analysis and its applications
- Computer science and its applications
- Problems of information transfer
- Informatics systems and tools
- Proceedings of the V.A. Steklov Mathematical Institute
- Mathematical issues in cryptography
- Current problems in mathematics
- Computational methods and programming
- Proceedings of the I. G. Petrovsky Seminar
- Scientific Notes of Moscow State University
- Fundamental and applied mathematics

10. Material and technical support of the discipline:

Moscow, 3 Ordzhonikidze St., Bld. 1, 5. Training and Research Laboratory of Integrated Management Systems, room 350.

Basic equipment: software and hardware complex "Kontar" - 12 pcs; computers (workstation) - 13 pcs; printer Xerox Phaser 3125 - 1 pc; scanner EPSON PERFECTION V10 - 1 pc; projector Toshiba TLP-XC3000 - 1 pc; interactive board Polyvision TSL 610 - 1 pc; floor cabinet DG-Rack 26U 600 x 800 x 1390 - 1 pc.Fan module for DG-Rack floor standing enclosures - 1 pc; Cisco Catalyst 2960 Switchboard 24 10/100 + 2T/SFP LAN Base Image + CWDM 1590 NM SFP Gigabit Ethernet and 1G/2G FC - 2 pcs.; HP DL380G5 server - 2XeonE5410- 2 pcs; APC Smart-UPS RT 5000VA RM 230V - 2 pcs; HP Proliant DL785G5 8356 server - 1 pc; Software:

ABBYY Finereader 9 Corporate Edition;

ABBYY Lingvo 12 European version; Adobe Acrobat 8 Professional;

Matlab 2008a;Mathcad 14.

11. methodological guidelines for organising the study of the discipline:

11.1 Guidelines for postgraduate students.

In practical classes of the discipline there are control activities to identify the obtained knowledge, skills and competences. In the framework of independent work postgraduate students study educational-methodical support of the discipline, prepare homework, work on questions and assignments for self-study, search and review scientific publications and electronic sources of information. Independent work must be systematic and controlled by the teacher, taken into account by the teacher for grading.

In order to improve the quality of the discipline, the postgraduate student should prepare for a lecture, as it is the leading form of organisation of student learning and realises the functions that contribute to it:

- to form the basic concepts of the discipline,

- stimulate interest in the discipline and its topics of study,
- The main objective is to systematise and structure the whole body of knowledge in the discipline,
- orientation in the scientific literature revealing the problems of the discipline.

The preparation for the lecture is as follows:

- study of the material from the previous lecture,
- Analysis of the topic of the forthcoming lecture (from the thematic plan, from the lecturer's information),
- familiarise yourself with the teaching material in the textbook and teaching aids,
- analyse the place of the topic under study in their professional training,
- prepare questions to ask the lecturer during the lecture.

Preparing for the practical exercises:

- The training session plan: first the main questions, then the discussion questions, assessing the scope of the assignment;
- Study the lecture notes on the topic of the practical session, selecting the material necessary for the study of the questions posed;
- Familiarisation with the recommended basic and additional literature on the topic, and new publications in periodicals;
- To highlight the main concepts of the topic, which will contribute to an effective mastery of the discipline;
- Prepare an abstract or mini-abstract that can be used for public speaking in class.

You can use the syllabus in terms of objectives, list of knowledge, skills, terms and training issues as a guide for the organisation of your studies.

Preparing for a test. It is necessary to prepare for the test in a purposeful, regular, systematic manner and from the first days of study in the discipline. At the very beginning of the discipline the postgraduate student gets acquainted with the discipline programme, the list of knowledge and skills that the postgraduate student should possess, control activities, textbook, textbooks on the discipline studied, electronic resources, the list of questions for the test.

Systematically completing the coursework in lectures, practical classes and tutorials will enable you to successfully master the discipline and create a good basis for passing the examination.

Postgraduate students are required to attend classes, complete the assignments of the Head of Discipline, get acquainted with the recommended literature and prepare an essay for the round table (the choice of essay topic is made in consultation with the Head of Discipline and academic supervisor). Postgraduate students carry out projects, creative tasks for independent work, taking into account the profile of the disciplines that will be implemented by them during the industrial practice. The results of independent work assignments are evaluated on the basis of the grade-rating and are reflected in the educational route of the postgraduate student. During the attestation of postgraduate student the quality of work in the classroom (ability to conduct a scientific discussion, the ability to clearly and concisely formulate his thoughts), the level of preparation for independent research activities of a specialist in the field of pedagogy of higher education, history of pedagogy and education, the quality of assignments (presentations, reports, analytical papers, etc.) are evaluated.

11.2 Guidelines for teachers.

During the study of the discipline "System analysis, management and information processing" the teacher should pay special attention to the organisation of practical classes and monitor the independent work of postgraduate students. In the process of mastering the discipline postgraduate students should be focused not only on active mastering of the set of pedagogical knowledge, but also on the ability to creatively apply them in practice, extrapolating to the modern educational process in higher education.

During the study of section 1 "Topical issues of system analysis" the teacher should draw postgraduate students' attention to the content of the categorical apparatus of the discipline, its relationship with other concepts. It is important to consider in practical classes the applied possibilities of applying various methods of scientific research.

Lectures should involve postgraduate students in discussions that address current scientific issues in the field of computer science and computing.

The content of the section 2 "Topical issues of management" is mastered in lectures and practical classes. Work in practical classes should be aimed at active acquisition of a set of theoretical knowledge, emphasising the peculiarities of the content of the stages of scientific research. The teacher should guide postgraduate students to the ability to organise and conduct various types of scientific research on computer science and computer engineering.

Mastering the content of Unit 3 "Current Issues of Information Processing" the teacher uses a variety of technologies and forms of classes and creates conditions for postgraduate students to demonstrate communication skills, readiness to lead a discussion on scientific problems.

The interim assessment evaluates the quality of postgraduate students' mastery of basic research categories, their ability to use knowledge to solve scientific problems and their readiness to actualise scientific competence in the actual research process of the university, scientific organisation, etc.

11.3 Assessment tools for assessing the mastery of the competence.

Compliance of grading systems (previously used grades of final academic achievement, ECTS grades and grading-rating system (GRS) of assessments of current progress) (In accordance with the Rector's Order No. 996 of 27.12.2006)

BRS scores	Traditional assessments in the RF	Scores for transferring grades	Assessments	ECTS grades
86 - 100	5	95 - 100	5+	A
		86 - 94	5	B
69 - 85	4	69 - 85	4	C
51 - 68	3	61 - 68	3+	D
		51 - 60	3	E
0 - 50	2	31 - 50	2+	FX
		0 - 30	2	F

A	***"Excellent"*** - the theoretical content of the course has been fully mastered without any gaps, the necessary practical skills to work with the mastered material have been formed, all the learning tasks in the study programme have been completed, the quality of their performance is assessed with a number of points close to the maximum**.**
B	***"Very good"*** - the theoretical content of the course has been fully mastered without any gaps, the necessary practical skills to work with the mastered material have been mostly formed, all the learning tasks in the curriculum have been completed, the quality of most of them has been assessed as close to the maximum number of points.

C	***"Good"*** - the theoretical content of the course has been fully mastered without any gaps, some practical skills in working with the mastered material have been insufficiently formed, all the learning tasks in the curriculum have been completed, none of them has been assessed with a minimum score, some types of tasks have been completed with mistakes**.**
D	***"Satisfactory"*** - the theoretical content of the course has been partly mastered, but the gaps are not significant, the necessary practical skills to work with the mastered material have been mostly formed, most of the curriculum tasks have been completed, some of the completed tasks may contain mistakes.
E	***"Intermediate"*** - the theoretical content of the course has been partly mastered, some practical work skills have not been developed, many of the curricular tasks have not been completed, or the quality of some of them has been assessed as close to the minimum number of points.
FX	***"Conditionally unsatisfactory"*** - the theoretical content of the course has been partially mastered, the necessary practical work skills have not been formed, most of the learning tasks in the curriculum have not been completed or the quality of their completion is assessed as close to the minimum; with additional independent work on the course material, the quality of completion of the learning tasks can be improved.
F	***"Absolutely unsatisfactory"*** - the theoretical content of the course has not been mastered, the necessary practical work skills have not been formed, all completed assignments contain gross errors, additional independent work on the course material will not lead to any meaningful improvement in the quality of the course assignments.

12. Assessment toolkit.

12.1 Issues to be examined at the mid-term evaluation (topic 1).

1. Mathematical models of mechanical systems, multi-link robots.
2. The laws of mechanics for constructing mathematical models.
3. Lagrange method.
4. Dalembert's principle.
5. Examples of constructing mathematical models of mechanical objects. Uncertainties in mathematical models.
6. Probabilistic methods for describing uncertainties.
7. Fuzzy forms of uncertainty description.
8. Methods for solving parametric identification problems.
9. Structural uncertainty.
10. Problems in solving the structural identification problem and structural-parametric identification.
11. Mathematical models of aircraft, flying robots. Non-parametric identification of non-linear systems.
12. Pontryagin's principle of maximum.
13. Problems in solving the optimal control problem.
14. Computational methods for solving optimal control problems.
15. The Bellman equation.
16. Analytical design of optimum controllers (ACCOR).
17. Lyapunov function method for the synthesis of stabilisation systems.
18. A method for the analytical design of aggregated regulators.
19. The uncertainty problem in the control synthesis problem.

12.2 Questions to be taken for credit (topics 2 and 3).

20. Formulation of the numerical synthesis problem for control systems.
21. Optimal robust control. H2 and H∞ optimal control theory.
22. Representation of a random process by methods of polynomial chaos theory. Probabilistic uncertainty in stochastic dynamic control systems. Artificial neural networks.
23. Widrow-Hoff's delta rule and error back propagation algorithm.
24. Adaptive control systems based on neural networks.
25. Neural networks for solving identification problems. A neural network method for solving control synthesis problems. A genetic algorithm.
26. The algorithm for differential evolution. The ant colony algorithm.
27. The algorithm for a swarm of bees. The particle swarming algorithm.
28. The principle of small variations of a basis solution for numerical and non-numerical optimisation problems.
29. A variational genetic algorithm for training a neural network. A variational genetic algorithm for solving an optimal control problem. A method for genetic programming.
30. The method of variational genetic programming.
31. The method of grammatical evolution. The method of variational grammatical evolution. Analytical programming method.
32. The method of variational analytical programming. The network operator method. The multilayer network operator method.
33. Solving identification and control synthesis problems using symbolic regression methods.
34. Solving the optimal control problem by symbolic regression. Systems with shared memory.
35. Distributed memory systems. Graphic accelerators
36. Software tools for parallel technology.
37. OpenMP, MPI, OpenCL, CUDA libraries.
38. Evaluations of paralleling efficiency.

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