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

Academy of Engineering
(name of the main educational unit (MEU) that developed the educational program of higher education)

WORKING PROGRAM OF THE DISCIPLINE

AUTOMATIC CONTROL THEORY
(name of discipline/module)

Recommended for the field of study/specialty:

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

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

DATA SCIENCE AND SPACE SYSTEMS
(name (profile/specialization) of the educational institution of higher education)

2025

1. THE GOAL OF MASTERING THE DISCIPLINE

The course "Automatic Control Theory" is part of the bachelor's program "Data Science and Space Systems" in the direction 27.03.04 "Control in Technical Systems" and is studied in semesters 5 and 6 of the 3rd year. The course is implemented by the Department of Mechanics and Control Processes. The course consists of 10 sections and 76 topics and is aimed at studying the fundamental principles of mathematical models and dynamic characteristics of linear stationary automatic control systems, stability of linear systems, quality of automatic control systems, correction of automatic control systems, mathematical models of nonlinear deterministic systems, stability of nonlinear systems, research of random processes in automatic control systems, synthesis of automatic control systems and optimization, research of discrete automatic control systems, non-stationary systems, general information, analysis of the main methods for solving typical problems and acquaintance with the area of their application in professional activities.

The purpose of mastering the discipline is to develop fundamental knowledge and skills in applying methods for solving problems necessary for professional activity, and to increase the general level of literacy of students in this discipline.

2. REQUIREMENTS TO THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the discipline " Automatic Control Theory " is aimed at developing the following competencies (parts of competencies) in students:

Table 2.1. List of competencies developed in students while mastering the discipline (results of mastering the discipline)

Cipher	**Competence**	**Indicators of Competence Achievement** (within the framework of this discipline)
UC-12	Able to search for the necessary sources of information and data, perceive, analyze, remember and transmit information using digital means, as well as using algorithms when working with data obtained from various sources in order to effectively use the information received to solve problems; evaluate information, its reliability, build logical conclusions based on incoming information and data	UC-12.1 Searches for the necessary sources of information and data, perceives, analyzes, remembers and transmits information using digital means, as well as using algorithms when working with data obtained from various sources in order to effectively use the information obtained to solve problems; UC-12.2 Conducts an assessment of information, its reliability, builds logical conclusions based on incoming information and data;
GPC-10	Capable of developing (based on current standards) technical documentation (including in electronic form) for routine maintenance of control, automation and control systems and equipment	GPC-10.1 Knows the current standards for the development of technical documentation for routine maintenance of control, automation and control systems and equipment; GPC-10.2 Knows the basic approaches to the development of technical documentation (including in electronic form) for routine maintenance of control, automation and control systems and equipment; GPC-10.3 Possesses the skills to develop (based on current standards) technical documentation (including in electronic form) for routine maintenance of control, automation and control systems and equipment;
GPC-2	Able to formulate tasks of professional activity based on knowledge, specialized sections of mathematical and natural science disciplines (modules)	GPC-2.1 Has mastered mathematical methods, programming fundamentals and specialized programming systems for implementing algorithms for solving applied problems; GPC-2.2 Able to select and adapt mathematical methods and software to solve practical problems;

Cipher	Competence	Indicators of Competence Achievement (within the framework of this discipline)
		GPC-2.3 Possesses skills in developing and implementing algorithms for solving applied problems in the field of professional activity;
GPC-3	Able to use fundamental knowledge to solve basic control problems in technical systems in order to improve in professional activities	GPC-3.1 Knows the theoretical foundations and principles of mathematical modeling; GPC-3.2 Able to develop and use methods of mathematical modeling, information technologies to solve problems of applied mathematics; GPC-3.3 Possesses practical skills in solving problems of applied mathematics, methods of mathematical modeling, information technologies and the basics of their use in professional activities, skills of professional thinking and an arsenal of methods and approaches necessary for the adequate use of methods of modern mathematics in theoretical and applied problems;
GPC-5	Capable of solving problems of development of science, engineering and technology in the field of control in technical systems, taking into account legal regulation in the field of intellectual property	GPC-5.1 Knows the theoretical foundations of digital technologies, the basics of modeling objects of professional activity, the basics of data analysis and presentation of information; GPC-5.2 Able to solve problems of professional activity using existing methods of modeling, data analysis, and information presentation; GPC-5.3 Possesses skills in developing algorithms and computer programs suitable for practical application;
GPC-6	Capable of developing and using algorithms and programs, modern information technologies, methods and means of control, diagnostics and control, suitable for practical application in the field of his professional activity	GPC-6.1 Knows the basic algorithms and programs, modern information technologies, methods and means of control, diagnostics and control, suitable for practical application in the field of his professional activity; GPC-6.2 Able to apply algorithms and programs, modern information technologies, methods and means of control, diagnostics and control, suitable for practical application in the field of his professional activity; GPC-6.3 Confidently uses algorithms and programs, modern information technologies, methods and means of control, diagnostics and control, suitable for practical application in the field of his/her professional activity;
GPC-7	Capable of making the necessary calculations of individual units and devices of control, automation and control systems, selecting standard automation, measuring and computing equipment when designing automation and control systems	GPC-7.1 Knows the procedure for performing the necessary calculations of individual blocks and devices of control, automation and control systems, select standard automation, measuring and computing equipment when designing automation and control systems; GPC-7.2 Can perform the necessary calculations of individual blocks and devices of control, automation and control systems, select standard automation, measuring and computing equipment when designing automation and control systems; GPC-7.3 Proficient in technologies for performing calculations of individual units and devices of control, automation and control systems, selecting standard automation, measuring and computing equipment when designing automation and control systems;
PC-1	Capable of collecting, processing and interpreting modern scientific research data necessary to draw conclusions on relevant scientific research, including Earth remote sensing data	PC-1.1 Knows modern methods of collecting, processing and interpreting data from modern scientific research necessary for drawing conclusions on relevant scientific research; PC-1.2 Able to apply modern methods and tools for processing and interpreting scientific research data; PC-1.3 Possesses the basic skills of collecting, processing and interpreting data from modern scientific research necessary for drawing conclusions on relevant scientific research;

3. PLACE OF THE DISCIPLINE IN THE STRUCTURE OF THE EDUCATIONAL EDUCATIONAL EDUCATION

Discipline " Automatic Control Theory " refers to the mandatory part of block 1 “Disciplines (modules)” of the educational program of higher education.

As part of the higher education program, students also master other disciplines and/or practices that contribute to the achievement of the planned results of mastering the discipline "Automatic Control Theory ".

Table 3.1. List of components of the educational program of higher education that contribute to the achievement of the planned results of mastering the discipline

Cipher	**Name of competence**	**Previous courses/modules, practices***	**Subsequent disciplines/modules, practices***
UC-12	Able to search for the necessary sources of information and data, perceive, analyze, remember and transmit information using digital means, as well as using algorithms when working with data obtained from various sources in order to effectively use the information received to solve problems; evaluate information, its reliability, build logical conclusions based on incoming information and data	Analysis of Geoinformation Data; *Fundamentals of Information Security and Cyber Resilience***; *Fundamentals of Information Security and Cyber Resilience***;	Optimal Control Methods; Technological Training; Undergraduate Training; Research Work;
GPC-6	Capable of developing and using algorithms and programs, modern information technologies, methods and means of control, diagnostics and control, suitable for practical application in the field of his professional activity	Computer Science and Programming; Space Flight Mechanics;	Undergraduate Training; Space Flight Mechanics;
GPC-2	Able to formulate tasks of professional activity based on knowledge, specialized sections of mathematical and natural science disciplines (modules)	Mathematical analysis; Space Flight Mechanics; Algebra and Geometry; Analysis of Geoinformation Data;	Technological Training; Undergraduate Training; Research Work; Space Flight Mechanics; Equations of mathematical physics;
GPC-3	Able to use fundamental knowledge to solve basic control problems in technical systems in order to improve in professional activities	Mathematical analysis; Space Flight Mechanics; Theoretical Mechanics; Algebra and Geometry; Theory of Probability and Mathematical Statistics; Differential equations; Complex analysis; Analysis of Geoinformation Data;	Space Flight Mechanics; Equations of mathematical physics; Optimal Control Methods; Technological Training; Undergraduate Training;
GPC-5	Capable of solving problems of development of science, engineering and technology in the field of control in technical systems, taking into account legal regulation	Theoretical Mechanics; Analysis of Geoinformation Data; Fundamentals of Artificial Intelligence;	Technological Training; Undergraduate Training;

Cipher	Name of competence	Previous courses/modules, practices*	Subsequent disciplines/modules, practices*
	in the field of intellectual property		
GPC-7	Capable of making the necessary calculations of individual units and devices of control, automation and control systems, selecting standard automation, measuring and computing equipment when designing automation and control systems		Undergraduate Training;
GPC-10	Capable of developing (based on current standards) technical documentation (including in electronic form) for routine maintenance of control, automation and control systems and equipment		Technological Training; Undergraduate Training;
PC-1	Capable of collecting, processing and interpreting modern scientific research data necessary to draw conclusions on relevant scientific research, including Earth remote sensing data	Space Flight Mechanics; Computer Science and Programming; *Discrete Mathematics***; *Discrete Mathematics***; Analysis of Geoinformation Data;	Technological Training; Undergraduate Training; Space Flight Mechanics; *Virtual and Augmented Reality Technology***; *Virtual and augmented reality technologies***; Optimal Control Methods;

* - filled in in accordance with the competency matrix and the SUP EP HE

** - elective disciplines/practices

4. SCOPE OF THE DISCIPLINE AND TYPES OF STUDY WORK

The total workload of the discipline "Automatic Control Theory" is 10 credit units.

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

Type of academic work	**TOTAL,**ac.h.		**Semester(s)**	
			5	**6**
Contact work, academic hours	*144*		*72*	*72*
Lectures (LC)	72		36	36
Laboratory work (LW)	72		36	36
Practical/seminar classes (SC)	0		0	0
Independent work of students, academic hours	*171*		*54*	*117*
Control (exam/test with assessment), academic hours	*45*		*18*	*27*
General complexity of the discipline	**ac.h.**	***360***	*144*	*216*
	credit.ed.	***10***	*4*	*6*

5. CONTENT OF THE DISCIPLINE

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

Section number	Name of the discipline section	Section Contents (Topics)		Type of academic work*
Section 1	Mathematical models and dynamic characteristics of linear stationary automatic control systems	1.1	Introduction. The apparatus of the theory of automatic control. Concepts: optimization, regulation, correction.	LC, LW
		1.2	General structural diagram of the ACS.	LC, LW
		1.3	Classification of SAR, including static and astatic.	LC, LW
		1.4	Obtaining mathematical models. Methodology for compiling input-output equations. Input signals.	LC, LW
		1.5	Linearization of the SAR equations. The superposition principle.	LC, LW
		1.6	Fourier transform. Concept of frequency response. Using frequency responses to determine the response of the ACS. Experimental determination.	LC, LW
		1.7	Laplace transform. Properties of the Laplace transform.	LC, LW
		1.8	The concept of transfer function. The concept of LAH. The relationship between frequency response and PF ("s", "jw", "p").	LC, LW
		1.9	Typical structural links of the ACS. Example of the output of the PF of an aperiodic link	LC, LW
		1.10	Structural transformations of LSS circuits. Examples. Types of PF (closed, by error).	LC, LW
		1.11	Oscillatory link - properties. General table of properties of typical PF.	LC, LW
		1.12	Construction of frequency characteristics, linear characteristics of connections of typical structural links.	LC, LW
		1.13	Duhamel integral. Connection of IPF with frequency response and PF.	LC, LW
		1.14	Description of the ACS in state space. Transition matrix, properties. Canonical forms,	LC, LW
Section 2	Stability of linear systems	2.1	The concept of stability of the SAR. Necessary and sufficient condition of stability. Properties. The principle of argument.	LC, LW
		2.2	Frequency criteria of stability. Mikhailov criterion. Nyquist-Mikhailov criterion.	LC, LW
		2.3	Modification of the Nyquist-Mikhailov criterion for astatic systems.	LC, LW
		2.4	Limits of applicability of assessment methods using frequency criteria.	LC, LW
		2.5	Margin of stability.	LC, LW
		2.6	Analytical criteria of stability: Hurwitz, Routh, Zubov criteria	LC, LW
		2.7	Limits of applicability of assessment methods using analytical criteria.	LC, LW
		2.8	The influence of the SAR parameters on stability: D-partition, root hodograph.	LC, LW
Section 3	Quality of automatic control systems	3.1	The concept of quality of SAR. Primary quality indicators.	LC, LW
		3.2	Frequency and integral methods of quality assessment.	LC, LW
		3.3	Relationship of frequency characteristics with the transition function.	LC, LW
		3.4	Signal processing capability as an assessment of the quality of the ACS. Error rates. Methods for	LC, LW

Section number	Name of the discipline section	Section Contents (Topics)		Type of academic work*
			calculating error rates. The effect of astatism on error rates and steady-state error.	
Section 4	Correction of automatic control systems	4.1	Synthesis of SAR. Basics of synthesis.	LC, LW
		4.2	Types of SAR synthesis (structural, parametric).	LC, LW
		4.3	Approaches to correcting SAD.	LC, LW
		4.4	Solodovnikov's method of desired LAH. Synthesis algorithm, connection of frequency response and primary quality indicators for minimum-phase links.	LC, LW
		4.5	PID controller. Typical correction links.	LC, LW
		4.6	Sensitivity theory. The concept of invariance.	LC, LW
Section 5	Mathematical models of nonlinear deterministic systems	5.1	The concept of nonlinear systems. Typical structural diagram of a nonlinear system. Types of nonlinear elements.	LC, LW
		5.2	The concept of a phase plane. Construction of phase diagrams, the fitting method.	LC, LW
		5.3	Construction of switching lines. Sliding mode. Isocline method. Effect of feedback on switching lines in a relay system.	LC, LW
		5.4	Imaginary switching lines, construction rule. Accounting for pure delay.	LC, LW
		5.5	The concept of self-oscillations, evaluation of self-oscillation parameters.	LC, LW
		5.6	Harmonic linearization. Fourier series. Example of signal passage through a nonlinear element. Filter hypothesis.	LC, LW
		5.7	Derivation of the linearization equation. Calculation of the linearization coefficients using an example.	LC, LW
Section 6	Stability of nonlinear systems	6.1	The concept of stability of nonlinear systems. Special modes of motion of nonlinear systems.	LC, LW
		6.2	Methods for assessing the stability of a self-oscillation cycle: algebraic, graphical.	LC, LW
		6.3	Lamerey diagrams. Testing the self-oscillation cycle for stability.	LC, LW
		6.4	Methods for assessing the stability of self-oscillations: using the Mikhailov, Nyquist-Mikhailov frequency criteria. Analogies with the stability of linear systems.	LC, LW
		6.5	Phase boundary of stability. Construction algorithm.	LC, LW
		6.6	Forced motion of nonlinear systems under harmonic influence. Displacement function. Extension of the method to search for forced motion of an arbitrary deterministic signal.	LC, LW
		6.7	General approaches to assessing the stability of systems. Stability according to Lyapunov. The first Lyapunov method. The concept of stability in the large, in the small, asymptotic stability.	LC, LW
		6.8	Lyapunov equation. Stability theorem and instability theorem.	LC, LW
		6.9	Criteria of hyperstability (absolute stability). Frequency criterion of V.M. Popov.	LC, LW
Section 7	Study of random processes in automatic control systems	7.1	The concept of random variables. Application of the main characteristics in the problems of the SAR study: mathematical expectation, dispersion, spectral density, correlation.	LC, LW
		7.2	Properties of characteristics of random variables, the concept of a "white noise" signal.	LC, LW

Section number	Name of the discipline section	Section Contents (Topics)		Type of academic work*
		7.3	Passage of a random signal through a linear stationary automatic control system. Derivation of the equation for the connection of spectral densities.	LC, LW
		7.4	Mathematical models of stochastic automatic control systems in state space. Dispersion equations.	LC, LW
		7.5	Shaping filter. Application examples.	LC, LW
		7.6	Methods of studying nonlinear ACS under random influences. Approaches to statistical linearization.	LC, LW
		7.7	Comparison of statistical linearization methods. Exelby, Bouton (Kazakov), Pupkov.	LC, LW
Section 8	Synthesis of automatic control systems. Optimization.	8.1	Modal control. Methods of assigning roots.	LC, LW
		8.2	Observation devices.	LC, LW
		8.3	Methods of optimization of automatic control systems. Concept of quality functionality.	LC, LW
		8.4	Classical calculus of variations. Application of Lagrange equations to optimization.	LC, LW
		8.5	Pontryagin's maximum principle.	LC, LW
		8.6	Application of approaches with fixed and non-fixed control time. Transversality equation.	LC, LW
		8.7	Example of control optimization (Brachistochrone).	LC, LW
		8.8	Dynamic programming method. Hamilton-Jacobi-Bellman equation.	LC, LW
		8.9	Stochastic optimization methods. Wiener problem. Kalman filter. Separability principle.	LC, LW
		8.10	The task of AKOR (analytical design of optimal regulators).	LC, LW
Section 9	Research of discrete automatic control systems	9.1	Discrete ACS. Types of quantization: quantization by level, by value	LC, LW
		9.2	State space and models of continuous-discrete systems.	LC, LW
		9.3	Typical links of discrete ACS. Effect of extrapolator. Comparison of reaction to typical impacts of continuous and discrete systems.	LC, LW
		9.4	Features of mathematical modeling of discrete systems. Difference between pulse and discrete systems.	LC, LW
		9.5	Kotelnikov's theorem. Frequency transposition effect.	LC, LW
		9.6	Transfer function of discrete systems.	LC, LW
		9.7	Direct and inverse Z-transform.	LC, LW
		9.8	Direct and inverse w-transform.	LC, LW
		9.9	Application of methods for studying linear stationary continuous systems for the case of discrete ACS: stability assessment, correction, optimization.	LC, LW
Section 10	Non-stationary systems, general information.	10.1	Non-stationary automatic control systems. Description methods, research approaches.	OK
		10.2	Construction of dynamic characteristics of non-stationary systems	OK

* - filled in only for FULL-TIME education: LC – lectures; LW – laboratory work; SC – practical/seminar classes.

6. LOGISTIC AND TECHNICAL SUPPORT OF DISCIPLINE

Table 6.1. Material and technical support of the discipline

Audience type	Equipping the auditorium	Specialized educational/laboratory equipment, software and materials for mastering the discipline (if necessary)
Lecture	An auditorium for conducting lecture-type classes, equipped with a set of specialized furniture; a board (screen) and technical means for multimedia presentations.	
Computer class	A computer room for conducting classes, group and individual consultations, ongoing monitoring and midterm assessment, equipped with personal computers (15 units), a board (screen) and technical means for multimedia presentations.	
For independent work	A classroom for independent work of students (can be used for conducting seminars and consultations), equipped with a set of specialized furniture and computers with access to the Electronic Information System.	

* - the audience for independent work of students MUST be indicated!

7. EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT OF THE DISCIPLINE

Main literature:

1. Methods of classical and modern theory of automatic control: Textbook in 5 volumes / Under the general editorship of K.A.Pupkov. - 2nd ed., revised and enlarged. - Moscow: Publishing house of Moscow State Technical University, 2004. - 656 p.

2. Pupkov Konstantin Aleksandrovich. Theory of nonlinear automatic control systems: Textbook for universities. - Anniversary edition. - M.: RUDN University Press, 2009. - 258 p.

3. Andrievsky B.R., Fradkov A.L. Selected chapters of the theory of automatic control with examples in the languageMATLAB. - SPb.: NaUCa, 1999. - 475 p.

4. Solodovnikov Vladimir Viktorovich. Theory of automatic control of technical systems: Textbook / V.V.Solodovnikov, V.N.Plotnikov, A.V.Yakovlev. - M.: Publishing house of Bauman Moscow State Technical University.N.E.Bauman, 1993. - 492 p.

Further reading:

1. Pupkov Konstantin Aleksandrovich. Modern methods, models and algorithms of intelligent systems: Study guide. - M.: IPK RUDN, 2008. - 154 p.

2. Pupkov Konstantin Aleksandrovich. Statistical methods of analysis, synthesis and identification of nonlinear automatic control systems: Textbook for universities / K. A. Pupkov, N. D. Egupov, A. I. Trofimov; Ed. N. D. Egupov. - M.: Publishing house of Bauman Moscow State Technical University, 1998. - 562 p.

3. Nikulchev E.V. Workshop on the theory of control in the environmentMATLAB: Tutorial. - M.: MGAPI, 2002. - 88 p.

4. Besekersky Viktor Antonovich. Theory of automatic control systems. - M.: NaUCa, 1966. - 992 p.

Resources of the information and telecommunications network "Internet":

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

- Electronic library system of RUDN - ELS RUDNhttp://lib.rudn.ru/MegaPro/Web
- Electronic library system "University library online"http://www.biblioclub.ru
- EBS Yuraithttp://www.biblio-online.ru
- Electronic Library System "Student Consultant" www.studentlibrary.ru
- Electronic library system "Troitsky Bridge"

2. Databases and search engines

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

Educational and methodological materials for independent work of students in mastering a discipline/module:*

1. Lecture course on the subject "Theory of automatic control".

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

DEVELOPER:

Associate Professor		Saltykova Olga Alexandrovna
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