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

MATHEMATICAL ANALYSIS

(name of discipline/module)

Recommended for the field of study/specialty:

27.03.04 CONTROL IN TECHNICAL SYSTEMS

(code and name of the field of study/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)

2026

1. THE GOAL OF MASTERING THE DISCIPLINE

The course "Mathematical Analysis" is part of the "Data Science and Space Systems" bachelor's program, focusing on 27.03.04 "Control in Technical Systems," and is studied in semesters 1 and 2 of the first year. The course is offered by the Department of Mechanics and Control Processes. It consists of 7 sections and 42 topics and is aimed at developing fundamental knowledge of mathematical analysis, as well as general professional competencies necessary for solving scientific and industrial problems in the professional field.

The purpose of mastering the discipline is to develop skills in setting and practically solving problems of mathematical analysis, the formation of modern mathematical thinking, including the ability to describe various phenomena using mathematical apparatus.

2. REQUIREMENTS FOR THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the discipline "Mathematical Analysis" 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 Competency Achievement** (within this discipline)
GPC-1	Able to analyze the tasks of professional activity based on provisions, laws and methods in the field of natural sciences and mathematics	GPC-1.1 Possesses basic knowledge obtained in the field of mathematical and (or) natural sciences; GPC-1.2 Able to use them in professional activities; GPC-1.3 Has the skills to select methods for solving problems of professional activity based on theoretical knowledge;
GPC-2	Able to formulate objectives for professional activity based on knowledge of specialized sections of mathematical and natural science disciplines (modules)	GPC-2.1 Has a command of 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; 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;

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

Discipline "Mathematical Analysis" 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 "Mathematical Analysis".

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, practical training*	Subsequent disciplines/modules, practices*
GPC-1	Able to analyze the tasks of professional activity based on provisions, laws and methods in the field of natural sciences and mathematics		Research work / Scientific research work; Technological Training; Undergraduate Training; Research Work; Space Flight Mechanics; Complex analysis;
GPC-2	Able to formulate objectives for professional activity based on knowledge of specialized sections of mathematical and natural science disciplines (modules)		Space Flight Mechanics; Numerical Methods; Automatic Control Theory; Equations of mathematical physics; Analysis of Geoinformation Data; Research work / Scientific research work; Technological Training; Undergraduate Training; Research Work;
GPC-3	Able to use fundamental knowledge to solve basic control problems in technical systems in order to improve in professional activities		Research work / Scientific research work; Technological Training; Undergraduate Training; Space Flight Mechanics; Theoretical Mechanics; Numerical Methods; Automatic Control Theory; Theory of Probability and Mathematical Statistics; Differential equations; Complex analysis; Equations of mathematical physics; Optimal Control Methods; Analysis of Geoinformation Data;

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

** - elective courses/practices

4. SCOPE OF THE DISCIPLINE AND TYPES OF EDUCATIONAL WORK

The total workload of the discipline "Mathematical Analysis" is 15 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,**academic hours		**Semester(s)**	
			1	**2**
Contact work, academic hours	*157*		*72*	*85*
Lectures (LC)	70		36	34
Laboratory work (LW)	0		0	0
Practical/seminar classes (SC)	87		36	51
Independent work of students, academic hours	*320*		*117*	*203*
Control (exam/test with assessment), academic hours	*63*		*27*	*36*
Total complexity of the discipline	**academic hours**	***540***	*216*	*324*
	credit	***15***	*6*	*9*

5. CONTENT OF THE DISCIPLINE

*Table 5.1. Contents of the course*modules by type of academic work

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
Section 1	Introduction to the course	1.1	Elementary functions and their graphs	A review of the basic elementary functions: power, exponential, logarithmic, trigonometric, and inverse trigonometric. Properties and graphs. Graph transformations (shift, stretch, reflection).	LC, SC
		1.2	Elements of logic	Statements and predicates. Logical operations. Truth tables. Constructing the negation of a complex statement. Theorem as an implication. Direct, inverse, and opposite theorems, and the relationship between them.	LC, SC
		1.3	Method of mathematical induction	The principle of mathematical induction. Application examples. Bernoulli's inequality: formulation and proof.	LC, SC
		1.4	Binomial theorem	Newton's binomial theorem formula. Binomial coefficients and their properties. Special cases.	LC, SC
		1.5	Sets and operations on them	The concept of a set and methods of defining it. Operations: union, intersection, difference, complement, symmetric difference. Properties of operations.	LC, SC
		1.6	The set R of real numbers	Completeness of the set R. Neighborhoods of a finite point and infinity. Bounded and unbounded sets. Intervals. Supremum and infimum. The principle of nested segments. Archimedes' principle and its consequences.	LC, SC
		1.7	Display and function	The concept of a mapping (function). Domain, range. Graph of a function. Types of mappings: surjection, injection, bijection. Inverse mapping. Composition of mappings.	LC, SC
		1.8	Cardinality of a set	The concept of cardinality of a set. Countable sets. Uncountability of the set R.	LC, SC
Section 2	Limit of a numerical sequence	2.1	Numerical sequence	The concept of a numerical sequence. Methods of definition. Bounded and unbounded sequences. Monotone sequences	LC, SC
		2.2	Limit of a sequence	Definition of the limit of a sequence. Uniqueness of the limit. Infinitesimal and infinitely large sequences and the relationship between them. Properties of convergent sequences. Weierstrass's theorem. Theorem on arithmetic operations under the limit sign.	LC, SC
		2.3	Wonderful limits	The number e as the limit of a sequence. Hyperbolic functions. The first remarkable limit and its consequences. The second remarkable limit and its consequences.	LC, SC

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
		2.4	Limit points of a set. Convergence criterion.	Limit points of sets and sequences. The Bolzano–Weierstrass principle. Upper and lower limits. Fundamental sequences. The Cauchy criterion for convergence of a numerical sequence.	LC, SC
Section 3	Limit of a function	3.1	Definition of the limit of a function	Definition of the Cauchy limit of a function. Definition of the Heine limit of a function. Equivalence of the Heine and Cauchy definitions of the limit. One-sided limits. Theorem on the relationship between two-sided limits and one-sided limits. Theorem on the uniqueness of the limit of a function.	LC, SC
		3.2	Properties of a function that has a limit	A theorem on the local boundedness of a function with a finite limit. Infinitesimal functions. A theorem on the relationship between a function, its limit, and the infinitesimal. Properties of infinitesimal functions. A theorem on arithmetic operations on functions with a limit. A theorem on the limit of a composite function.	LC, SC
		3.3	Inequalities and overeating	A theorem on the constancy of sign of a function with a nonzero limit. Passage to the limit in an inequality. A theorem on the limit of an intermediate function.	LC, SC
		3.4	Infinitely large functions	Infinitely large functions. Theorem on the relationship between infinitely large and infinitely small functions. Weierstrass's theorem on the limit of a monotone and bounded function.	LC, SC
		3.5	Comparison of infinitely small and infinitely large functions	Comparison of infinitesimals. Order of smallness. Equivalent infinitesimals. Incomparable infinitesimals. Table of equivalent infinitesimals. Properties of equivalent infinitesimals. Rules for working with "small o". Comparison of infinitesimals. Theorems on equivalent infinitesimals.	LC, SC
Section 4	Continuity of function	4.1	Continuity of a function at a point and on a segment	Continuity of a function at a point. Various definitions of continuity and their equivalence. One-sided continuity at a point. The relationship between continuity and one-sided continuity. Continuity of a function on an interval. Continuity of a function on a segment.	LC, SC
		4.2	Properties of continuous functions	Local boundedness of a continuous function. Constancy of sign of a continuous function. Arithmetic operations with continuous functions. Passage to the limit under the sign of a continuous function. Continuity of a composite function.	LC, SC
		4.3	Breaking points	Points of discontinuity and their classification. Points of discontinuity of a monotone function. Criterion for the continuity of a	LC, SC

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
				monotone function.	
		4.4	Properties of functions continuous on an interval	Theorem on the zeros of a continuous function. Theorem on intermediate values. Theorem on the boundedness of a continuous function on an interval. Theorem on attaining the exact bounds of a continuous function on an interval.	LC, SC
		4.5	Continuity and monotonicity. Inverse function	Continuity on a segment of a monotone function. The relationship between continuity, injectivity, and strict monotonicity. The theorem on the existence of an inverse function. The theorem on the continuity of the inverse function. Continuity of basic elementary functions.	LC, SC
		4.6	Uniform continuity	Uniform continuity of a function. The relationship between uniform continuity on a set and continuity at a point of that set. Cantor's theorem on the uniform continuity of a function on an interval.	LC, SC
Section 5	Differential calculus of a function of one variable	5.1	Differential of a function	Differential of a function. Theorem on the relationship between derivative and differential. Geometric meaning of the differential. Rules for working with differentials: differential of a sum, difference, product, and quotient. Invariance of the notation of the first differential. Approximate calculations using differentials. Higher-order differentials, lack of invariance.	LC, SC
		5.2	Fundamental theorems of differential calculus	Fermat's theorem and its geometric meaning. Rolle's theorem and its geometric meaning. Cauchy's theorem and its geometric meaning. Lagrange's theorem and its geometric meaning.	LC, SC
		5.3	Bernoulli-L'Hôpital rule	Bernoulli-L'Hôpital theorem for the disclosure of 0/0 type uncertainty. Bernoulli-L'Hôpital theorem for the disclosure of ∞/∞ type uncertainty.	LC, SC
		5.4	Taylor's formula and Maclaurin's formula	Taylor's formula for polynomials. Taylor polynomial for arbitrary functions. Taylor's formula with remainder term in Peano form. Uniqueness theorem for expansion of a function by Taylor's formula with remainder term in Peano form. Taylor's formula with remainder term in general form. Remainder term in Cauchy form. Remainder term in Lagrange form. Maclaurin's formula. Expansion of basic elementary functions by Maclaurin's formula. Using expansions to resolve uncertainties. Approximate calculations using Taylor's formula.	LC, SC
		5.5	Monotonicity and extrema of a function	The relationship between derivative and monotonicity. Necessary and sufficient conditions for monotonicity. Local extremum of a	LC, SC

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
				function. A necessary condition for the existence of a local extremum of a differentiable function. Sufficient conditions for the existence of an extremum with respect to the first derivative. Sufficient conditions for the existence of an extremum with respect to the second derivative. Sufficient conditions for the existence of an extremum with respect to the nth derivative.	
		5.6	Convexity and inflection points	The concept of upward and downward convexity of a function. The geometric meaning of the definition of convexity of a function: the relative position of the graph of a function and a chord. The lemma on the convexity of a function and its geometric meaning. A necessary and sufficient condition for convexity with respect to the first derivative. A necessary and sufficient condition for the convexity of a twice-differentiable function.	LC, SC
		5.7	Asymptotes of the graph of a function	Asymptotes of the graph of a function: vertical asymptotes, horizontal asymptotes, oblique asymptotes. Oblique asymptote theorem.	LC, SC
		5.8	General scheme for studying functions and constructing graphs	A general framework for studying functions and constructing their graphs. Application of differential calculus to studying functions and constructing their graphs.	LC, SC
Section 6	Functions of several variables	6.1	Basic concepts	Functions of several variables. Domain, graph.	LC, SC
		6.2	Partial derivatives and differential	First-order partial derivatives. Total differential of a function of several variables. Higher-order partial derivatives.	LC, SC
		6.3	Directional derivative. Gradient	Directional derivative. Gradient of a function of several variables. Relationship between the gradient and the directional derivative. Properties of the gradient.	LC, SC
		6.4	Extrema of a function of several variables	Local extremum. Necessary condition for extremum. Sufficient conditions for extremum.	LC, SC
Section 7	Integral calculus	7.1	Indefinite integral	The concept of an antiderivative. The antiderivative theorem. The indefinite integral and its properties. Table of basic indefinite integrals.	LC, SC
		7.2	Integration methods	General integration methods: differential equations, variable substitution, substitution, integration by parts. Integration of rational functions by fractional expansion. Integration of expressions containing trigonometric functions. Integration of expressions containing irrational functions.	LC, SC
		7.3	Definite integral	Examples of problems leading to a definite integral. The definite	LC, SC

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
				integral as a limit of integral sums. Darboux sums and integrals. A criterion for the existence of a definite integral. Basic properties of the definite integral. Theorems on estimating a definite integral. A theorem on the mean value of the integrand.	
		7.4	Newton-Leibniz formula	The derivative of an integral with respect to its upper limit. The Newton-Leibniz formula. Calculating a definite integral by integration by parts. Calculating a definite integral by a change of variable. Integration of even and odd functions on a segment symmetric about the origin.	LC, SC
		7.5	Improper integrals	Improper integrals of continuous functions over an infinite interval. Improper integrals of unbounded functions on an interval. Tests for convergence and divergence of an improper integral. Absolute and conditional convergence of improper integrals.	LC, SC
		7.6	Geometric applications of the definite integral	Area of a plane figure. Calculating the area of a plane figure in rectangular coordinates. Calculating the area of a plane figure in polar coordinates.	LC, SC
		7.7	Practical component	Solving problems involving calculating indefinite and definite integrals using various methods. Investigating the convergence of improper integrals. Calculating the areas of plane figures. Individual assignments.	SC

* - to be completed 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 for the discipline

Audience type	Equipment of the auditorium	Specialized educational/laboratory equipment, software and materials for mastering the discipline (if necessary)
Lecture	A lecture hall equipped with specialized furniture, a whiteboard (screen), and multimedia presentation equipment.	Projector
Seminar	An auditorium for conducting seminar-type classes, group and individual consultations, ongoing monitoring and midterm assessment, equipped with a set of specialized furniture and technical means for multimedia presentations.	No
For independent work	A classroom for independent student work (can be used for seminars and consultations), equipped with a set of specialized furniture and computers with access to the Electronic Information System.	No

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

7. EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT OF THE DISCIPLINE

Main literature:

1. Kudryavtsev L.D. Course of mathematical analysis. V.1, 2 -M., 2006

2. Demidovich B.P. Collection of problems and exercises in mathematical analysis. - M., 2002

3. Kudryavtsev L.D. et al. Collection of problems in mathematical analysis: Textbook: In 2 parts. Moscow, 2010

4. Ilyin V.A., Poznyak E.G. Fundamentals of Mathematical Analysis: Textbook: In 2 parts: M., Nauka, 2002

5. Zorich V. M. Mathematical Analysis: Textbook for Universities: In 2 Parts. 2002. 787 p. Irodov Igor Evgenievich. Problems in General Physics: Textbook for Universities. - 8th ed.; Electronic text data. - Moscow: BINOM. Knowledge Laboratory, 2010.

Further reading:

1. Fichtenholz G.M. Course of differential and integral calculus: Textbook. In 3 volumes. 2003, 2006

2. Kolmogorov Andrey Nikolaevich. Elements of the theory of functions and functional analysis [Text]. - 7th ed. - M.: Fizmatlit, 2004, 2006. - 572 p.

3. Ilyin V.A., Sadovnichy V.A., Sendov B.Kh. Mathematical analysis: Textbook: M., Nauka, 1979. 719 p.

Resources of the information and telecommunications network "Internet":

1. RUDN University Electronic Library System and third-party electronic library systems to which university students have access based on concluded agreements

- Electronic library system of RUDN - ELS RUDN http://lib.rudn.ru/MegaPro/Web

- Electronic Library System "University Library Online" http://www.biblioclub.ru
- EBS Yurayt http://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 regulatory 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/

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

1. Lecture course on the subject "Mathematical Analysis".

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

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