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

Academy of Engineering
(name of the main educational unit (POU) - developer of the EP HE)

COURSE SYLLABUS

MATHEMATICAL ANALYSIS
(name of discipline/module)

Recommended by the Didactic Council for the Education Field of:

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

The course instruction is implemented within the professional education programme of higher education:

DATA ENGINEERING AND SPACE SYSTEMS CONTROL
(name (profile/specialization) EP HE)

2024

1. GOAL OF DISCIPLINE MASTERING

The discipline “Mathematical analysis” is included in the bachelor’s program “Data Engineering and Space Systems Control” in the direction of 27.03.04 “Control in Technical Systems” and is studied in the 1st and 2nd semesters of the 1st year. The discipline is implemented by the Department of Mechanics and Control Processes. The discipline consists of 8 sections and 151 topics and is aimed at studying basic knowledge of mathematical analysis, as well as the formation of general professional competencies necessary for solving scientific and production problems in the professional field.

The goal of mastering the discipline is to develop skills in posing and practical 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” is aimed at developing the following competencies (parts of competencies) in students:

Table 2.1. List of competencies formed in students when mastering the discipline (results of mastering the discipline)

Cipher	Competence	Indicators of Competency Achievement (within this discipline)
GPC -1	Able to analyze professional tasks based on regulations, laws and methods in the field of natural sciences and mathematics	GPC-1.1 Has basic knowledge acquired 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 tasks of professional activity based on knowledge, specialized sections of mathematical and natural science disciplines (modules)	GPC -2.1 Proficient in 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 the skills of 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, professional thinking skills 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 DISCIPLINE IN THE STRUCTURE OF HE EP

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

As part of the educational program of higher education, students also master other disciplines and/or practices that contribute to achieving the planned results of mastering the discipline “Mathematical Analysis”.

Table 3.1. List of components of EP HE that contribute to achieving the planned results of mastering the discipline

Cipher	Name of competency	Previous disciplines/modules, practices*	Subsequent disciplines/modules, practices*
GPC -1	Able to analyze professional tasks based on regulations, laws and methods in the field of natural sciences and mathematics		Research work / Scientific research work; Technological Training; Undergraduate practice / Pre-graduate practice; Space Flight Mechanics; complex analysis;
GPC -2	Able to formulate tasks of professional activity based on knowledge, 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 practice / Pre-graduate practice;
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 practice / Pre-graduate practice; 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;

* - to be filled out in accordance with the competency matrix and SUP EP VO
** - elective disciplines/practices

4. SCOPE OF DISCIPLINE AND TYPES OF STUDY WORK

The total labor intensity of the “Mathematical analysis” discipline is “15” credit units.

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

Type of educational work	**TOTAL,** ac.ch.		**Semester(s)**	
			1	**2**
Contact work, ac.ch.	*157*		*72*	*85*
Lectures (LC)	70		36	34
Laboratory work (LR)	0		0	0
Practical/seminar sessions (SZ)	87		36	51
Independent work of students, ac.ch.	*329*		*153*	*176*
Control (exam/test with assessment), academic degree.	*54*		*27*	*27*
Total labor intensity of the discipline	**ac.ch.**	***540***	*252*	*288*
	credit units	***15***	*7*	*8*

5. CONTENT OF DISCIPLINE

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

Section number	Name of the discipline section	Contents of the section (topic)		Type of educational work*
Section 1	Elementary functions and their graphs	1.1	Introduction to the course	LC, LR, SZ
		1.2	Elements of logic	LC, LR, SZ
		1.3	Statements and predicates, operations on them	LC, LR, SZ
		1.4	Constructing the negation of a complex statement	LC, LR, SZ
		1.5	Theorem as implication	LC, LR, SZ
		1.6	Necessity and sufficiency	LC, LR, SZ
		1.7	Direct, inverse and opposite theorems, connection between them	LC, LR, SZ
		1.8	Proof by contradiction	LC, LR, SZ
		1.9	Method of mathematical induction	LC, LR, SZ
		1.10	Bernoulli's inequality	LC, LR, SZ
		1.11	Binomial theorem	LC, LR, SZ
		1.12	Sets, operations on them, their properties	LC, LR, SZ
		1.13	The set R of real numbers and its axiomatics	LC, LR, SZ
		1.14	Completeness of the set R	LC, LR, SZ
		1.15	Gaps	LC, LR, SZ
		1.16	Neighborhoods of endpoint and infinity	LC, LR, SZ
		1.17	Nested segment principle (Cauchy-Cantor)	LC, LR, SZ
		1.18	Bounded and Unbounded Sets in R	LC, LR, SZ
		1.19	Exact upper and lower bounds of a set	LC, LR, SZ
		1.20	Archimedes' principle and consequences from it	LC, LR, SZ
		1.21	Display and function	LC, LR, SZ
		1.22	Graph of a function	LC, LR, SZ
		1.23	Types of mappings: surjective, injective, bijective	LC, LR, SZ
		1.24	Reverse mapping	LC, LR, SZ
		1.25	The concept of power of a set	LC, LR, SZ
		1.26	Countable sets	LC, LR, SZ
		1.27	Uncountability of the set R	LC, LR, SZ

Section number	Name of the discipline section	Contents of the section (topic)		Type of educational work*
		1.28	Composition of functions	LC, LR, SZ
Section 2	Number sequence limit	2.1	Numerical sequence, its limitations and monotony	
		2.2	Sequence limit	
		2.3	Infinitesimal and infinitely large sequences	
		2.4	Properties of convergent sequences	
		2.5	Weierstrass's theorem	
		2.6	Theorem on arithmetic operations under the limit sign	
		2.7	The number e as the limit of a number sequence	
		2.8	Hyperbolic functions	
		2.9	Set limit points	
		2.10	Bolzano-Weierstrass principle	
		2.11	Sequence limit points	
		2.12	Fundamental number sequence	
		2.13	Cauchy criterion for the convergence of a number sequence	
Section 3	Function limit	3.1	Determination of the limit of a function according to Cauchy	
		3.2	Theorem on the connection between the two-sided limit and the one-sided limit	
		3.3	Determination of the limit of a function according to Heine	
		3.4	Equivalence of the definitions of the limit according to Heine and Cauchy	
		3.5	Theorem on the uniqueness of the limit of a function	
		3.6	Theorem on the local boundedness of a function having a finite limit	
		3.7	Infinitesimal functions	
		3.8	Theorem on the connection between a function, its limit and an infinitesimal	
		3.9	Properties of infinitesimal functions	
		3.10	Theorem on arithmetic operations on functions having a limit	
		3.11	Theorem on the limit of a complex function (change of variable in the limit)	
		3.12	Theorem on the constancy of sign of a function having a nonzero limit	
		3.13	Limit passage in inequality	
		3.14	Theorem on the limit of an intermediate function	
		3.15	Infinitely large functions	
		3.16	Theorem on the connection between infinitely large and infinitesimal functions	
		3.17	The first and second remarkable limits and consequences from them	
		3.18	Weierstrass's theorem on the limit of a monotone and bounded function	
		3.19	Comparison of infinitesimals	
		3.20	Order of smallness, equivalent infinitesimals, incomparable infinitesimals	
		3.21	Table of equivalent infinitesimals	
		3.22	Properties of equivalent infinitesimals	
		3.23	Rules for working with “small things”	
		3.24	Comparison of infinitely large	
		3.25	Theorems on equivalent infinitesimals	
Section 4	Continuity of function	4.1	Continuity of a function at a point	

Section number	Name of the discipline section	Contents of the section (topic)		Type of educational work*
		4.2	Various definitions of continuity and their equivalence	
		4.3	Continuity of a function over an interval	
		4.4	One-sided continuity at a point	
		4.5	Continuity of a function on a segment	
		4.6	Properties of functions continuous at a point (relationship of continuity with one-sided continuity, local boundedness, constancy of sign, arithmetic operations with continuous functions, passage to the limit, continuity of a complex function)	
		4.7	Breakpoints and their classification	
		4.8	Properties of functions continuous on an interval (theorems on zeros, on intermediate values, on boundedness, on reaching the exact edges of a function continuous on an interval)	
		4.9	Continuity on a segment of a monotonic function, connection between continuity, injectivity and strict monotonicity	
		4.10	Theorem on the existence of an inverse function	
		4.11	Breakpoints of a monotonic function	
		4.12	Continuity criterion for a monotonic function	
		4.13	Continuity theorem for the inverse function	
		4.14	Continuity of basic elementary functions	
		4.15	Uniform continuity of functions	
		4.16	The connection between uniform continuity on a set and continuity at a point on this set	
		4.17	Cantor's theorem on the uniform continuity of a function on an interval	
Section 5	Differential calculus of a function of one variable	5.1	Function differential	
		5.2	Theorem on the connection between derivative and differential	
		5.3	Geometric meaning of differential	
		5.4	Rules for working with differentials (differential of sum, difference, product, quotient)	
		5.5	Invariance of the form of writing the first differential	
		5.6	Approximate calculations using differentials	
		5.7	Higher order differentials, lack of invariance	
		5.8	Basic theorems of differential calculus (Fermat, Rolle, Cauchy, Lagrange) and their geometric meaning	
		5.9	The Bernoulli-L'Hopital theorem and the disclosure of uncertainty of type [0/0]	
		5.10	The Bernoulli-L'Hopital theorem and the disclosure of uncertainty of the type [infinite. / infinite] (no proof)	
		5.11	Comparison of the orders of growth of logarithmic, power and exponential functions at infinity	
		5.12	Disclosure of uncertainties like [0, infinite], [infinite, -infinite], [0 to degree. 0], [1 to degree infinite], [infinite in the steppe 0]	
		5.13	Taylor's formula for polynomials	
		5.14	Taylor polynomial for arbitrary functions	
		5.15	Taylor formula with remainder term in Peano form	

Section number	Name of the discipline section	Contents of the section (topic)		Type of educational work*
		5.16	Theorem on the uniqueness of the expansion of a function according to the Taylor formula with a remainder term in Peano form	
		5.17	Taylor's formula with a remainder term in general form	
		5.18	Corollaries: remainder term in Cauchy form and in Lagrange form	
		5.19	Maclaurin formula	
		5.20	Expansion of basic elementary functions using the Maclaurin formula	
		5.21	Using Decompositions to Unravel Uncertainties	
		5.22	Approximate calculations using Taylor's formula	
		5.23	Application of differential calculus to study functions and construct their graphs	
		5.24	Relationship between derivative and monotonicity	
		5.25	Necessary and sufficient conditions for monotonicity. Local extremum of a function	
		5.26	A necessary condition for the existence of a local extremum of a differentiable function	
		5.27	Sufficient conditions for the existence of an extremum in the first derivative, in the second derivative, in the nth derivative	
		5.28	Concept of upward (downward) convexity of a function	
		5.29	The geometric meaning of determining the convexity of a function is the relative position of the graph of the function and the chord	
		5.30	Lemma on the convexity of a function and its geometric meaning	
		5.31	Necessary and sufficient condition for convexity with respect to the first derivative	
		5.32	Corollaries: necessary and sufficient condition for the convexity of a twice differentiable function, sufficient condition for the strict convexity of a twice differentiable function	
		5.33	Relationship between the direction of convexity of the graph of a function and the position of the tangent	
		5.34	Inflection points of a function graph	
		5.35	Necessary and sufficient conditions for the existence of an inflection point of a twice differentiable function	
		5.36	Asymptotes of the graph of a function: vertical, horizontal, oblique	
		5.37	Oblique asymptote theorem	
		5.38	General scheme for studying functions and constructing their graphs	
Section 6	Indefinite integral	6.1	The concept of an antiderivative	
		6.2	Antiderivative theorem	
		6.3	Indefinite integral and its properties	
		6.4	Table of basic indefinite integrals	
		6.5	General methods of integration: substitution under the differential sign (replacement of a variable), substitution, integration by parts	
		6.6	Integration of rational functions by decomposition into simple fractions	

Section number	Name of the discipline section	Contents of the section (topic)		Type of educational work*
		6.7	Integrating expressions containing trigonometric functions and irrational functions	
		6.8	Examples of integrals that cannot be expressed through elementary functions	
Section 7	Definite integral	7.1	Examples of problems leading to a definite integral	
		7.2	Definite integral as a limit of integral sums	
		7.3	Darboux sums and integrals	
		7.4	Criterion for the existence of a definite integral	
		7.5	Basic properties of the definite integral	
		7.6	Theorems on the evaluation of the definite integral and on the mean value of the integrand	
		7.7	Derivative of the integral with respect to the upper limit	
		7.8	Newton-Leibniz formula	
		7.9	Calculation of a definite integral by integration by parts and by replacing a variable (substitution)	
		7.10	Integration of even and odd functions on a segment symmetrical about the origin	
		7.11	Improper integrals of continuous functions over an infinite interval	
		7.12	Improper integrals of unbounded functions on an interval	
		7.13	Signs of convergence and divergence of an improper integral	
		7.14	Absolute and conditional convergence of improper integrals	
		7.15	Area of a flat figure	
		7.16	Calculating the area of a flat figure in rectangular and polar coordinates	
		7.17		
		7.18		
		7.19		
		7.20		
		7.21		
		7.22		
Section 8	Functions of several variables			

* - to be filled out only for full-time education: LC – lectures; LR – laboratory work; SZ – practical/seminar classes.

6. MATERIAL AND TECHNICAL SUPPORT OF DISCIPLINE

Table 6.1. Material and technical support of the discipline

Audience type	Auditorium equipment	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; board (screen) and technical means of multimedia presentations.	

Audience type	Auditorium equipment	Specialized educational/laboratory equipment, software and materials for mastering the discipline (if necessary)
Seminar	An auditorium for conducting seminar-type classes, group and individual consultations, ongoing monitoring and intermediate certification, equipped with a set of specialized furniture and technical means for multimedia presentations.	
For independent work	An auditorium for independent work by students (can be used for seminars and consultations), equipped with a set of specialized furniture and computers with access to EIOS.	

* - the audience for independent work of students is MANDATORY!

7. EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT OF DISCIPLINE

Main literature:

1. Kudryavtsev L.D. Course of mathematical analysis.T.1, 2 -M., 2006
2. Demidovich B.P. Collection of problems and exercises in mathematical analysis.-M., 2002
3. Kudryavtsev L.D. and others. Collection of problems in mathematical analysis: Textbook. manual: At 2 o'clock. M., 2010
4. Ilyin V.A., Poznyak E.G. Fundamentals of mathematical analysis: Textbook: In 2 hours: 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. - M.: BINOM.Knowledge Laboratory, 2010.

Additional literature:

1. Fikhtengolts G.M. Course of differential and integral calculus: Proc. allowance.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 Bl.Kh. Mathematical analysis: Textbook: M., Nauka, 1979.719 p.

Resources of the information and telecommunications network “Internet”:

1. EBS of RUDN University and third-party EBS, to which university students have access based on concluded agreements
   - Electronic library system of RUDN University - EBS RUDN Universityhttp://lib.rudn.ru/MegaPro/Web
   - EBS “University Library Online”http://www.biblioclub.ru
   - EBS Lawhttp://www.biblio-online.ru
   - EBS “Student Consultant”www.studentlibrary.ru
   - EBS “Trinity Bridge”
2. Databases and search engines
   - electronic fund of legal and regulatory technical documentationhttp://docs.cntd.ru/
   - Yandex search enginehttps://www.yandex.ru/
   - search systemGoogle https://www.google.ru/

- abstract databaseSCOPUS http://www.elsevierscience.ru/products/scopus/

Educational and methodological materials for students' independent work when mastering a discipline/module:*

1. A course of lectures on the discipline "Mathematical Analysis".

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

8. ASSESSMENT MATERIALS AND POINT-RATING SYSTEM FOR ASSESSING THE LEVEL OF COMPETENCIES FOR A DISCIPLINE

Evaluation materials and point-rating system* for assessing the level of development of competencies (parts of competencies) based on the results of mastering the discipline"Mathematical analysis" is presented in the Appendix to this Work Program of the discipline.

* - OM and BRS are formed on the basis of the requirements of the relevant local regulatory act of RUDN University.

DEVELOPERS:

Assistant professor		Saltykova Olga Alexandrovna
Position	*Signature*	*Last name I.O.*
Assistant professor		Samokhin Alexander Sergeevich
Position	*Signature*	*Last name I.O*

HEAD OF DEPARTMENT:

Head of the department		Razumny Yuri Nikolaevich
Position	*Signature*	*Last name I.O.*

HEAD OF EP HE:

Professor		Razumny Yuri Nikolaevich
Position	*Signature*	*Last name I.O.*