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

COMPLEX 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 "Complex Analysis" is part of the bachelor's program "Data Science and Space Systems" (27.03.04 "Control in Technical Systems") and is studied in the fourth semester of the second year. The course is offered by the Department of Mechanics and Control Processes. It consists of six sections and 17 topics and focuses on the methods and applications of complex function theory.

The purpose of mastering the discipline is to develop the student's mathematical culture and prepare him for mastering other basic mathematical courses

2. REQUIREMENTS FOR THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the discipline "Complex 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-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 "Complex 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 "Complex 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	Mathematical analysis; Space Flight Mechanics; Algebra and Geometry;	Research work / Scientific research work; Technological Training;

Cipher	Name of competence	Previous courses/modules, practical training*	Subsequent disciplines/modules, practices*
	methods in the field of natural sciences and mathematics	Physics;	Undergraduate Training; Research Work; Space Flight Mechanics;
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;	Research work / Scientific research work; Technological Training; Undergraduate Training; Space Flight Mechanics; Numerical Methods; Automatic Control Theory; 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 “Complex Analysis” is 3 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)**
			4
Contact work, academic hours	*51*		*51*
Lectures (LC)	17		17
Laboratory work (LW)	0		0
Practical/seminar classes (SC)	34		34
Independent work of students, academic hours	*57*		*57*
Control (exam/test with assessment), academic hours	*0*		*0*
Total complexity of the discipline	**academic hours**	***108***	*108*
	credit	***3***	*3*

5. CONTENT OF THE DISCIPLINE

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

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
Section 1	Introduction	1.1	Definition of a complex number. Algebraic form of a complex number. Operations on complex numbers. Properties of operations.	The concept of an imaginary unit. Algebraic form. Real and imaginary parts. Conjugate numbers. Arithmetic operations: addition, subtraction, multiplication, division. Commutativity, associativity, and distributivity. The modulus and argument of a complex number.	LC, SC
		1.2	Geometric interpretation of a complex number. Trigonometric and exponential forms of a complex number. Extracting the root of a complex number.	Representation of points on the complex plane. Vector interpretation. Trigonometric form. Euler's formula. Exponential form. De Moivre's formula. Extracting the nth root of a complex number. Multivalued roots, geometric meaning of the arrangement of roots on a circle.	LC, SC
Section 2	Functions of a complex variable	2.1	Sequences and series of complex numbers. Extended complex plane. Stereographic projection. Riemann sphere. Curves and regions on the complex plane.	The concepts of convergence of a sequence and the sum of a series of complex numbers. Introduction of the point at infinity and the extended complex plane. Stereographic projection as a method of mapping a plane onto a sphere. The Riemann sphere as a geometric model of the extended complex plane. Curves on the complex plane: smooth, piecewise smooth, and Jordan. Domains: simply connected and multiply connected.	LC, SC
		2.2	Continuous complex-valued functions of a real variable. Continuous functions of a complex variable. Exponential, trigonometric, and hyperbolic functions.	Complex-valued functions of a real argument and their parametric interpretation as curves. Concepts of limit and continuity of a function of a complex variable. Definition of the exponential function on the complex plane and its basic properties. Trigonometric and hyperbolic functions of a complex argument, their relationship to each other and to the exponential function.	LC, SC
Section 3	Differentiation and integration	3.1	Integration of functions of a complex variable. Definition of an integral. Properties of integrals. Estimates of integrals.	Definition of the integral of a function of a complex variable along a curve as the limit of integral sums. Key properties: linearity, additivity along the curve, dependence on the direction of the curve. Lemma on estimating the absolute value of an integral.	LC, SC
		3.2	Differentiation of functions of a complex variable. Definition of the derivative. Rules of differentiation.	Definition of the derivative of a function of a complex variable, its analytical and geometric meaning. Rules of differentiation: linearity, derivative of a product, quotient, and complex function. Derivatives of basic elementary functions.	LC, SC
		3.3	Cauchy-Riemann conditions. Differentiable functions at a point and in a domain. Nec-	Cauchy-Riemann conditions relating the partial derivatives of the real and imaginary parts of a function. Necessity and sufficiency of	LC, SC

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
			essary and sufficient conditions for differentiability of a function at a point.	these conditions for differentiability of a function at a point. The concept of a function that is analytic (regular) in a domain.	
		3.4	The geometric meaning of the derivative. The concept of conformality of a mapping. The inverse function theorem. Multivalued root and logarithm functions. Cauchy's integral theorem. The composite contour theorem.	Geometric interpretation of the derivative: the dilation factor and the rotation angle at a point. Conformal mappings as angle-preserving. The existence theorem of the inverse function. Multivalued functions of the root of a natural power and the logarithm: identifying single-valued branches. Cauchy's integral theorem for a simply connected domain and its generalization to multiply connected domains. The contour deformation theorem (composite contour).	LC, SC
		3.5	Antiderivative. Newton–Leibniz formula.	The concept of an antiderivative for a function of a complex variable. Conditions for the independence of an integral from the integration path in a domain. The Newton-Leibniz formula for calculating integrals of analytic functions.	LC, SC
Section 4	Regular functions	4.1	Regular functions. Power series. Absolute and uniform convergence of power series. Abel's theorem. Integration and differentiation of power series.	The concept of a regular (analytic) function. Power series in powers of the difference between the variable and the center. The circle and radius of convergence. Abel's theorem on the continuity of the sum of a series. The possibility of term-by-term integration and differentiation of a power series within the circle of convergence.	LC, SC
		4.2	Cauchy's integral formula. Properties of functions regular in a domain. Harmonic functions.	Cauchy's integral formula expressing the value of a regular function within a contour in terms of its values on the contour. Infinite differentiability of regular functions. Maximum modulus principle. Harmonic functions: definition and relationship to analytic functions (the real and imaginary parts of an analytic function are harmonic).	LC, SC
		4.3	Mean value theorems. Sufficient conditions for regularity of a function in a domain. Morera's theorem. Weierstrass's first and second theorems. Uniqueness theorem.	Mean value theorem for harmonic functions. Morera's theorem as a converse of Cauchy's integral theorem. Weierstrass's theorems on uniformly convergent sequences of regular functions. Uniqueness theorem for analytic functions.	LC, SC
		4.4	Analytic continuation of regular functions. Isolated singular points of single-valued nature.	The concept of analytic continuation of a function along a curve. The principle of continuity. Classification of isolated singular points of a single-valued nature: removable singular points, poles, and essential singular points. Their characteristics are determined by the behavior of the function in its neighborhood.	LC, SC
Section 5	Laurent series	5.1	Laurent series expansion of a regular function. Uniqueness of the expansion. Study of sin-	Expansion of a function analytic in a ring into a Laurent series containing both non-negative and negative powers. The regular and	LC, SC

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
			gular points using Laurent series. Criteria for the existence of a removable singular point, pole, and essential singular point. Behavior of a function in the neighborhood of an essential singular point. Theorems of Sokhotski and Picard.	principal parts of the series. Uniqueness of the expansion. Criteria for the type of isolated singular point based on the type of Laurent series: absence of the principal part (removable point), finite number of terms of the principal part (pole), infinite number of terms of the principal part (essential singular point). The behavior of the function near each type of singular point.	
		5.2	Entire functions. Liouville's theorem. Fundamental theorem of algebra.	Definition of entire functions as functions analytic on the entire complex plane. Liouville's theorem: every bounded entire function is constant. Proof of the fundamental theorem of algebra: the existence of a root for every polynomial of nonzero degree, using Liouville's theorem.	LC, SC
Section 6	Theory of Deductions and its Application	6.1	Residue theory and its applications. The fundamental theorem of residue theory. Calculating integrals using residues.	The concept of a function residue at an isolated singular point. Formulas for calculating residues at poles of different orders. The fundamental theorem on residues: the integral of a function over a closed contour is expressed in terms of the sum of the residues inside the contour.	LC, SC
		6.2	Closed-loop integrals. Calculating improper integrals of a real variable. Jordan's lemma.	Application of the residue theorem to the calculation of integrals over closed contours. Methods for calculating improper integrals of rational functions of a real variable. Calculation of integrals of trigonometric functions over a full period. Jordan's lemma and its application to special integrals.	LC, 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.	
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.	

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

7. EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT OF THE DISCIPLINE

Main literature:

1. Sveshnikov, A.G. Theory of functions of a complex variable: textbook / A.G. Sveshnikov, A.N. Tikhonov. - 6th ed., stereotype. - Moscow: Fizmatlit, 2010. - 334 p. http://biblioclub.ru/index.php?page=book&id=75710

2. Malysheva, N.B. Functions of a complex variable: textbook / N.B. Malysheva, E.R. Rozendorn. - Moscow: Fizmatlit, 2010. - 168 p. - ISBN 978-5-9221-0977-2; Ditto [Electronic resource]. - URL: http://biblioclub.ru/index.php?page=book&id=68367

3. Popov, V.N. Applied Issues of the Theory of Functions of a Complex Variable: a tutorial / V.N. Popov; Ministry of Education and Science of the Russian Federation, Federal State Autonomous Educational Institution of Higher Professional Education Northern (Arctic) Federal University named after M.V. Lomonosov. - Arkhangelsk: IPC NArFU, 2013. - 164 p.: ill. - Bibliography in the book. - ISBN 978-5-261-00850-7; Ditto [Electronic resource]. - URL: http://biblioclub.ru/index.php?page=book&id=436400.

4. Khatskevich V.P. Theory of functions of a complex variable. http://web-local.rudn/ru/web-local/prep/prep_2071

5. Khatskevich V.P. Examples and exercises in the theory of functions of a complex variable. http://web-local.rudn/ru/web-local/prep/prep_2071

Further reading:

1. Tuganbaev, A.A. Functions of a complex variable: textbook / A.A. Tuganbaev. - 2nd ed., erased. - Moscow: Flinta Publishing House, 2017. - 48 p. - ISBN 978-5-9765-1406-5; The same [Electronic resource]. - URL: http://biblioclub.ru/index.php?page=book&id=115140

2. Minkova, R.M. Functions of a complex variable in examples and problems: a teaching aid / R.M. Minkova; Ministry of Education and Science of the Russian Federation, Ural Federal

University named after the first President of Russia B.N. Yeltsin. - Ekaterinburg: Ural University Publishing House, 2014. - 57 p.: ill., table, diagram. - ISBN 978-5-7996-1216-0; Ditto [Electronic resource]. - URL: http://biblioclub.ru/index.php?page=book&id=275814

3. Aramanovich I.G., Lunts G.L., Elsgolts L.E. Functions of a complex variable. Operational calculus. Stability theory. Moscow: Nauka, 2010.

4. Leontiev T.A., Panferov V.S., Serov V.S. Problems in the theory of functions of a complex variable. - M.: Mir, 2015.

5. Shabunin M., Polovinkin E., Karpov M. Collection of problems in the theory of functions of a complex variable. - M.: UNIMEDIASTYLE, 2016.

6. Shabunin M.I., Sidorov Yu.V. Theory of functions of a complex variable.-M.: UNIMEDIASTYLE, 2014.

7. Collection of problems in the theory of analytic functions edited by Evgrafov M.A. - M.: Nauka, 2012.

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 "Complex 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!

DEVELOPERS:

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