MATHEMATICAL ANALYSIS. Part 1.

Differential and integral calculus of functions of one variable

Working program of the academic discipline (Syllabus)

Details of the academic discipline

Level of higher education	*First (undergraduate)*
Branch of knowledge	*12 Information technologies*
Specialty	*121 Software engineering*
Educational program	*Software Engineering of Multimedia and Information Retrieval Systems*
Discipline status	*Normative*
Form of education	*Daytime*
Year of training, semester	*First year of training, first semester*
Scope of the discipline	*Lectures: 36 hours, practical classes: 36 hours, independent work: 78 hours.*
Semester control	*Exam, modular control work, calculation and graphic work, calendar control*
Timetable	*According to the schedule for the autumn semester of the current academic year (rozklad.kpi.ua)*
Language of teaching	*English*
Information about the course leader / teachers	*Lecturer: doctor of science, professor, Legeza Viktor Petrovych legeza@pzks.fpm.kpi.ua Practical training: Ph.D., associate professor, Oleksandr Mykhailovych Neshchadym, om.neshchadym@gmail.com*
Placement of the course	*first semester: https://classroom.google.com/w/MTYzMDc4MjAyMjc5/t/all*

1. Description of the educational discipline, its purpose, subject of study and learning outcomes

Study of the discipline “Mathematical analysis. Part 1. Differential and integral calculus of functions of one variable” allows students to develop the competencies necessary for building mathematical models and algorithms in the process of research and solving practical problems of natural science and information technologies.

The purpose of studying the discipline “Mathematical analysis. Part 1. Differential and integral calculus of functions of one variable” is the formation of a higher education student's abilities for abstract thinking, independent analysis and synthesis of complex multidimensional systems, as well as the ability to use the acquired fundamental knowledge at the stages of posing a problem in mathematical and symbolic form, followed by its algorithmization and development of modern software.

The subject of the discipline is “Mathematical analysis. Part 1. Differential and integral calculus of functions of one variable” are methods, techniques and technologies of mathematical analysis and its additional sections, which make up the theoretical justification and mathematical support of the process of solving a wide range of problems belonging to the field of knowledge 12 "Information technologies".

Study of the discipline “Mathematical analysis. Part 1. Differential and integral calculus of functions of one variable” will contribute to the formation of the following **general (GC)** and **professional competences** (PC):

GC01 Ability to abstract thinking, analysis and synthesis.

GC02 Ability to apply knowledge in practical situations.

GC06 Ability to search, process and analyze information from various sources.

PC15 Ability to apply fundamental and interdisciplinary knowledge to build advanced retrieval algorithms.

PC16 Ability to develop algorithms for implementing statistical data analysis methods.

PC18 Ability to develop methods for mathematical problems numerical solutions using software.

PC20 Ability to apply the acquired fundamental mathematical knowledge to develop calculation methods in the multimedia and information retrieval systems creation.

Study of the discipline “Mathematical analysis. Part 1. Differential and integral calculus of functions of one variable” will contribute to the formation of the following **program learning outcomes** (PLO) for students under the EP:

PLO05 To know and apply relevant mathematical concepts, domain methods, system and object-oriented analysis and mathematical modeling for software development.

PLO11 To select initial data for design, guided by formal methods of describing requirements and modeling.

PLO25 To know and to be able to use fundamental mathematical tools in the algorithms construction and modern software development.

PLO26 To be able to develop and use methods and algorithms for the mathematical problems approximate solution during the multimedia and information retrieval systems design.

PLO27 To be able to use statistical data analysis methods.

PLO28 To know the mathematical and algorithmic basics of computer graphics and to be able to apply them to develop multimedia software.

2. Pre-requisites and post-requisites of the discipline (place in the structural and logical scheme of training according to the relevant educational program)

Successful study of the discipline "Mathematical analysis. Part 1. Differential and integral calculus of functions of one variable" should be provided as part of the thoroughly learned educational material of the school course in mathematics (geometry, algebra and the beginnings of analysis) and physics. In addition, mastering "Mathematical analysis. Part 1. Differential and integral calculus of functions of one variable" should take place during the parallel study of the disciplines "Linear algebra and analytical geometry".

Received during mastering the discipline "Mathematical analysis. Part 1. Differential and integral calculus of functions of one variable" theoretical knowledge and practical skills are necessary for studying the disciplines "Mathematical analysis. Part 2. Functions of many variables, ordinary differential equations and series", "Probability theory", "Mathematical support of multimedia and information retrival systems", "Physical foundations of multimedia systems", "Algorithmic support of multimedia and information retrival systems" of the training plan bachelors in the specialty 121 Software Engineering, as well as the disciplines "Operations Research and Mathematical Programming" and "Information Retrival Systems and Services" of the master's training curriculum under EP "Software Engineering of Multimedia and Information and Retrival Systems".

3. Content of the academic discipline.

Discipline "Mathematical analysis. Part 1. Differential and integral calculus of functions of one variable " involves the study of the following topics:

Topic 1. Introduction to mathematical analysis.

Topic 2. Numerical sequence and its limit.

Topic 3. A function of one variable and its limit. The technique of revealing the main uncertainties.

Topic 4. Continuity of FOV. Classification of breakpoints. Properties of functions continuous on an interval.

Topic 5. Differential calculus of FOV. Practical application of the derivative for the study of FOV.

Topic 6. Indefinite integrals. The technique of integrating indefinite integrals.

Topic 7. Definite integrals and their practical application in problems of geometry and physics.

Topic 8. Improper integrals of the first and second kind. Signs of convergence.

Modular control work (MCW).

Exam

4. Educational materials and resources

Basic literature

1. G. M. Fikhtengol'ts, The Fundamentals of Mathematical Analysis. (International Series of Monographs in Pure and Applied Mathematics, Vol. 72/73) Vol. 1: 491 p. Oxford/London/Edinburg/New York/Paris/Frankfurt 1965.
2. G. M. Fikhtengol'ts, The Fundamentals of Mathematical Analysis. (International Series of Monographs in Pure and Applied Mathematics, Vol. 72/73) Vol. 2: 518 p. Oxford/London/Edinburg/New York/Paris/Frankfurt 1965.
3. S. M. Nikolsky. Course in Mathematical Analysis. Vol. 1: Mir Publishers, 1977. 460 p. https://archive.org/details/nikolsky-a-course-of-mathematical-analysis-vol-1-mir/page/29/mode/2up
4. V.A.Ilyin and E.G.Pozyak. Fundamentals of mathematical analysis. Part 1. Mir Publishers, 1982, 637 p. https://www.biblio.com/book/fundamentals-mathematical-analysis-ilyin-v-e/d/734370748.
5. V.A. Ilyin and E.G. Pozyak. Fundamentals of mathematical analysis. Part 2 Mir Publishers, 1982, (438 p.). https://www.biblio.com/book/fundamentals-mathematical-analysis-ilyin-v-e/d/734370748.
6. B.P. Demidovich. Problems in Mathematical Analysis. Gordon & B., 1969, 496 p. https://ia902803.us.archive.org/9/items/problemsinmathem031405mbp/problemsinmathem031405mbp.pdf
7. V.P. Legeza. Mathematical analysis: a collection of problems. - Kyiv, KPI, Polytechnic Publishing House, 2018. - 240 p.

Additional literature.

8. S.V.Budak, B.M.Fomin. Multiple Integrals, Field Theory and Series**.** An Advanced Course in Higher Mathematics. Mir Publishers; First printing edition, 1973. – 608 p. https://books.google.com.ua/books/about/Multiple_Integrals_Field_Theory_and_Seri.html?id=XKQNAQAAIAAJ&redir_esc=y

9. Y.B.Zel`dovich, A.D.Myshkis. Elements of Applied Mathematics. Mir Publishers, 1976, 656 p.
10. R.Courant. Differential and Integral Calculus. Vol. 1. Ishi press international, 2010, 668 p. https://www.amazon.com/Differential-Integral-Calculus-Vol-One/dp/4871878384
11. G.N.Berman. A problem book in mathematical analysis. MTG Learning Media (P) Ltd., New Delhi/Gurgaon, 2017, 490 p.
12. N.Piskunov. Differential and Integral calculus. Vol. 1,2, Mir Publishers, 1969. 895 p. https://mmsallaboutmetallurgy.com/wp-content/uploads/2019/01/differential-and-integral-calculus-by-piskunov.pdf.

5. Methods of mastering an educational discipline (educational component)

№	Educational type occupation	Description of the training session
	Topic 1. Introduction to mathematical analysis.	
1	**Lecture №1**. Definition of set, algebra of sets. Actions on sets. Natural series. Mathematical induction. Newton's binomial.	The concept of a function as a mapping of sets. Image and prototype. Surjection, injection, bijection. Equivalence of sets. Finite and countable sets. Actions on sets. Euler-Venn diagrams. Theorem on the uncountability of the set of infinite decimal fractions. Power of sets. Natural series. Mathematical induction. Newton's binomial. **Tasks for IWS**: [1,3,4,6.10,12], [71,p.p.5-34
2	**Practical lesson №1.** Mathematical induction. Newton's binomial. Countable sets and uncountable sets. Actions on sets. Euler-Venn diagrams.	Mathematical induction. Newton's binomial. Proving identities and inequalities by the method of mathematical induction. Countable sets and uncountable sets. Actions on sets. Euler-Venn diagrams. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.5-34
3	**Lecture №2**. Concept of real numbers and their comparison. Topology of the number line. Exact upper and lower edges of the set. The completeness of the set of real numbers.	Comparison of real numbers through rational numbers. Topology of the number line. A sequence of nested segments. The concept of continuity of the set of real numbers. A mutually unique correspondence between the set of real numbers and the set of points on the number line. Ordered and bounded sets. Concept of exact upper and lower faces of a set, their properties. Theorem on the existence of exact faces of a bounded set. Completeness property of the set of real numbers. Dedekind's theorem. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.5-34
4	**Practical lesson №2.** Limit points. Exact upper and lower bounds of a set and their calculation. The technique of calculating the limits of a recurrently given numerical sequence.	Limit points. Exact upper and lower bounds of a set and their calculation. Mutually unambiguous correspondence between sets, its geometric interpretation. The technique of calculating the limits of a recurrently given numerical sequence. An example of Fibonacci numbers. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.5-34
	Topic 2. Numerical sequence and its limit.	
5	**Lecture №3.** Introduction to the theory of numerical sequences. Infinitely small and infinitely large sequences. The simplest properties of convergent sequences.	Definition of numerical sequence. Common term of the sequence. Different ways of specifying numerical sequences. The concept and two definitions of the limit of a numerical sequence. Bounded and unbounded sequences. Infinitely small and infinitely large sequences. Theorem on the unity of the limit. Theorem on the necessary condition for sequence convergence. The simplest properties of convergent sequences. Theorem on the limit of the sum, difference, product, and quotient. Theorem about "two policemen". **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.5-34
6	**Practical lesson №3.** Study of monotonic sequences for convergence. Calculation of limits using Stoltz's Theorem.	Study of monotonic sequences for convergence. An example of recurrent sequences. Number e. Transition to the limit in inequalities. Calculation of limits using Stoltz's Theorem. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.5-34.
7	**Lecture №4**. Monotonic sequences: definition, properties, convergence conditions. Theorem on the	Sufficient conditions for the convergence of a monotonic sequence. The main theorem on the existence of a limit in a monotone bounded sequence. Lemma about nested segments.

	convergence of a monotone bounded sequence.	Definition of a "chargeable" segment system. Number e. Application of the Basic Theorem to proving the existence of limits of monotone sequences. Stoltz's theorem and Remarks on it. Examples of application of the results of Stoltz's Theorem **For IWS**: apply the Fundamental Theorem of this lecture to prove the existence of a limit associated with the number e. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.5-34
8	**Practical lesson №4.** Subsequences. The concept of partial boundaries. Practical use of the results of the partial limit theorem. Calculation of the upper and lower limits of the sequence.	Subsequences. Calculation of partial limits. Practical use of the results of the partial limit theorem. Calculation of the upper and lower limits of the sequence. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.5-34
9	**Lecture №5**. Subsequences. Partial borders. Bolzano-Weierstrass theorem. Theorem about partial limits. The upper and lower limits of the sequence.	Concept and definition of subsequence. Partial borders. The Bolzano-Weierstrass theorem on the existence of a convergent subsequence in a bounded sequence. Proof in the editorship of B. Bolzano. Theorem on partial limits $\overline{x} = \sup A$ and $\underline{x} = \inf A$. Determination of the upper and lower limits of the sequence. Bolzano-Weierstrass principle. The statement about the existence of an arbitrary bounded sequence $\{x_n\}$ of its upper and lower limits. Necessary and sufficient conditions for sequence convergence. Remarks on the number of partial limits in a bounded sequence $\{x_n\}$. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.5-34
10	**Practical lesson №5.** Fundamental sequences. Cauchy criterion. Elements of complex numbers. Operations on complex numbers. Sequences with complex terms and calculation of their limits.	Fundamental sequences. Cauchy criterion. Proving the convergence of a sequence using the Cauchy criterion. Elements of complex numbers. Operations on complex numbers. Moivre's and Euler's formulas. Sequences with complex members. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.5-34
11	**Lecture №6**. Fundamental sequences. Cauchy criterion. Elements of complex numbers. Operations on complex numbers. Moivre's formula. Euler's formula.	Definition and properties of the fundamental sequence. The theorem on the boundedness of the fundamental sequence. Theorem (Cauchy Criterion). Necessary and sufficient conditions for the convergence of an arbitrary sequence. Complex numbers: general concepts and definitions. Different forms of representation of complex numbers and operations on them. Geometric representation of complex numbers. Operations on complex numbers given in algebraic form. Peculiarities of extracting roots from complex numbers. Moivre's formula. Euler's formula. Sequences with complex members. The Cauchy criterion and Theorem on the limit of the sum (difference), product, and quotient of two sequences with complex terms. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.5-34
12	**Practical lesson №6.** Infinitely large and infinitely small functions. Comparison of infinitesimal functions. The first and second important limits, their practical value.	Infinitely large and infinitely small functions. The connection between them. Comparison of infinitesimal functions. The first and second important limits, their practical value. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.5-34
Topic 3. The function of one real variable and its limit. The technique of revealing the main uncertainties.		
13	**Lecture №7.** A function of one real variable and its limit. An infinitely large function. Infinitesimal functions and their properties.	Function: basic concepts and definitions. Classification and graphs of elementary functions. Basic properties of functions. Three definitions of the limit of the FOV. The Cauchy criterion for the existence of a limit of a function. The concept of unilateral limits. Theorem on the necessary and sufficient conditions for the existence of the limit of a function using its one-sided limits. The limit of the function along x→∞. An infinitely large function. Infinitesimal functions and their properties.

		Tasks for IWS: [1,3,4,6.10,12], [71, p.p.35-64
14	**Practical lesson №7.** Application of the first and second important limits for the disclosure of uncertainties. Comparison of infinitesimal functions. Table of equivalences.	Application of the first and second important limits for the disclosure of uncertainties. Comparison of infinitesimal functions**.** Table of equivalences. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.35-64
15	**Lecture №8.** Basic theorems about limits. The first and second important boundaries. Comparison of infinitesimal functions.	Basic theorems about limits. Theorem on the limit of an intermediate function. The first important border. Application of the first important limit in the disclosure of uncertainties. The second important limit. The technique of using the second important boundary to reveal uncertainties. Comparison of infinitesimals. Equivalent infinitesimal functions, their properties. Theorems about equivalent infinitesimals. Table of equivalences. The technique of revealing some uncertainties. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.35-64
16	**Practical lesson №8.** The technique of calculating the limits of functions. Disclosure of uncertainties of various types.	Mastering the technique of calculating limits of functions. Disclosure of uncertainties of various types. Transition to two classical types of uncertainties. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.35-64
	Topic 4. Continuity of FOV. Classification of breakpoints. Properties of functions continuous on an interval.	
17	**Lecture №9.** Continuity of functions of one real variable. Operations on continuous functions. Properties of functions continuous on an interval. Two Theorems of Weierstrass. Uniform continuity. Cantor's theorem.	The concept of continuity of a function. Three definitions of continuity of a function at a point. The concept of one-sided continuity. Disruptive functions. Classification of breakpoints. Definition of functions continuous on an interval and on a segment. Operations on continuous functions. Continuity of elementary functions. Theorem on the continuity of composite functions. Properties of functions continuous on an interval. Two Bolzano-Cauchy theorems. The geometric meaning of these Theorems. Two Theorems of Weierstrass. Uniform continuity. Cantor's theorem**.** **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.35-64
18	**Practical lesson №9. On the first half-pair:** The concept of continuous functions. Classification of breakpoints. The technique of researching functions for continuity. Research on uniform continuity by definition. **In the second half: the first part of MCW on topics No. 1-4.**	Continuous functions. The main types of breaks. The technique of researching functions for continuity. Uniform continuity**.** **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.35-64
	Topic 5. Differential calculus of FOV. Practical application of the derivative for the study of FOV.	
19	**Lecture №10.** Derivative: definition, mechanical and geometric content. Theorem on the connection between continuity and differentiability of a function. Rules of differentiation of the FOV.	Definition of derivative function. Practical problems leading to the concept of the derivative: the problem of the speed of a material point in the process of rectilinear movement; the problem about the tangent to the curve. Mechanical, physical and geometric content of the derivative. The concept of tangent and subtangent, normal and subnormal to a curve. The angle between the curves. One-sided derivatives. Theorem on the connection between continuity and differentiability of a function. Basic rules of differentiation of functions. Theorem on derivatives of sums, differences, products and quotients. The technique of differentiation of elementary functions by definition. Derivatives of composite and inverse functions. The geometric content of the

		derivative of the inverse function. The technique of differentiation of inverse trigonometric functions. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.35-64
20	**Practical lesson №10.** The concept of derivative, its mechanical and geometric content. The technique of differentiation of elementary functions by definition. Derivatives of composite and inverse functions	The concept of derivative. The technique of differentiation of elementary functions by definition. The concept of tangent and subtangent, normal and subnormal to a curve. The speed of rectilinear movement of a material point. Derivatives of composite and inverse functions**.** **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.35-64
21	**Lecture №11.** Differentiation of parametrically and implicitly given functions. The first differential: concepts, properties and applications for approximate calculations.	Peculiarities of differentiation of parametrically defined and implicitly defined functions. Logarithmic differentiation and the derivative of an exponential-power function. Table of derivatives. The concept of the first differential: definition, properties. geometric and mechanical content. Invariance of the form of the first differential. Application of the first differential in approximate calculations**.** **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.35-64
22	**Practical lesson №11.** The technique of differentiation of parametrically and implicitly given functions. Logarithmic differentiation and exponential-power derivative Application of the first differential for approximate calculations.	The technique of differentiation of parametrically and implicitly given functions. Logarithmic differentiation and the derivative of an exponential-power function. Application of the first differential for approximate calculations. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.35-64
23	**Lecture №12.** Basic "French theorems" of differential calculus. Derivatives of higher orders. Leibniz formula. Differentials of higher orders.	Fermat's, Darboux's and Rolle's theorems, their geometric meaning. Theorems of Lagrange and Cauchy. The geometric content of Lagrange's Theorem. Lagrange's formula, or the formula of finite increments. Mechanical interpretation of Lagrange's Theorem. Derivatives of higher orders. Leibniz's formula. Derivatives of higher orders of an implicitly given function. Derivatives of higher orders of a parametrically specified function. Differentials of higher orders. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.35-64
24	**Practical lesson №12.** Calculation of derivatives of higher orders. Their geometric and physical meaning. The technique of using the Leibniz formula. Differentials of higher orders.	Calculation of derivatives of higher orders. Their geometric and physical meaning. The technique of using the Leibniz formula. Differentials of higher orders (IWS). **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.35-64
25	**Lecture №13.** The Lopital-Bernoulli rule. Formulas of Taylor and McLaren.	Calculation of limits using the Lopital-Bernoulli rule. The technique of revealing uncertainties of various types. Taylor's formula and residual terms in various forms. McLaren formula. Taylor's formulas, written: a) through differentials of higher orders; b) for a polynomial. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.35-64
26	**Practical lesson** №13. Calculation of derivatives of higher orders. Their geometric and physical meaning. The technique of using the Leibniz formula. Differentials of higher orders (IWS). Calculation of derivatives of higher orders. Their geometric and physical meaning. The technique of using the Leibniz formula. Differentials of higher orders (IWS). Taylor and McLaren formulas for elementary functions and their practical value.	The technique of applying the Lopital-Bernoulli rule to finding boundaries of various types. Representation of elementary functions by Taylor and McLaren formulas. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.35-64
27	**Lecture №14.** Monotonicity of the function. Local extremum. The	The concept of monotonicity of a function. Definition of decreasing and increasing functions. Necessary and sufficient

	largest and smallest value of the function on the segment.	conditions for non-strict monotonicity of the function. A sufficient condition for strict monotonicity of the function. Scheme for finding intervals of monotonicity of a function. Local extremum of the function. Necessary and sufficient conditions for the existence of a local extremum. The largest and smallest value of the function on the segment. The technique of solving practical problems to the extreme. Examples. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.35-64
28	**Practical lesson №14.** Study of functions for monotonicity and local extremum. The largest and smallest value of the function on the segment. Setting the convexity-concavity intervals of the curve. Finding inflection points and asymptotes of a curve.	Study of functions for monotonicity and local extremum. The largest and smallest value of the function on the segment. Setting the convexity-concavity intervals of the curve. Finding inflection points and asymptotes of a curve. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.35-64
29	**Lecture №15.** Convexity-concavity of the curve. Inflection points. Asymptotes of the curve. A complete study of functions by the methods of differential calculus.	Three definitions of convexity-concavity of a curve. Intervals of convexity and concavity of the curve. Determination of the inflection point. Sufficient conditions for the existence of an inflection point. The scheme for finding the inflection points of the curve. Asymptotes of the curve, their classification and method of finding. A complete scheme of the study of functions by the methods of differential calculus. Examples with construction of graphs. **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.35-64
30	**Practical lesson №15. On the first half-pair**: The complete scheme of the study of functions by the methods of differential calculus. Examples with construction of graphs. **In the second half: the second part of the MCW on topic No. 5**.	A complete scheme of the study of functions by the methods of differential calculus. Examples with construction of graphs**.** **Tasks for IWS**: [1,3,4,6.10,12], [71, p.p.35-64
Topic 6. Indefinite integrals. The technique of integrating indefinite integrals.		
31	**Lecture №16.** Primitive and indefinite integral: definition, properties, basic methods of integration.	Concept of primitive and indefinite integral. Basic properties of the indefinite integral. Table of integrals. Table of differentials. Tabular integration. Method of direct integration. Substitution of a variable: method of entering a function under the sign of the differential. Substitution of a variable: the method of transferring a function from the sign of the differential. Method of integration by parts. **Tasks for IWS**: [2, 4, 6. 8, 11, 12], [71, p.p.65-79
32	**Practical lesson №16.** Integration of the indefinite integral: directly by the table, by the method of substitution of the variable and by parts.	The concept of an indefinite integral. Integration of the indefinite integral: directly by the table, by the method of substitution of the variable and by parts**.** **Tasks for IWS**: [2, 4, 6. 8, 11, 12], [71, p.p.65-79
33	**Lecture №17.** Correct and incorrect rational fractions. The technique of integrating correct rational fractions. Integration of some irrational and trigonometric functions. Trigonometric substitutions. Euler substitutions	Definition of a rational function. Definition of a correct and incorrect rational fraction. The main theorem on the decomposition of a proper rational fraction into elementary fractions. Basic methods of decomposition of a proper rational fraction into elementary fractions. Technique of integration of a proper rational fraction. Technique of integration of some irrational functions. Change of variable as a powerful method of rationalization of integrable irrational functions. Definition and integration of differential binomials. Chebyshev's theorem. Integration of trigonometric functions. Universal trigonometric substitution. Trigonometric substitutions. The technique of using trigonometric substitutions (three types). Euler substitutions. **Tasks for IWS**: [2, 4, 6. 8, 11, 12], [71, p.p.65-79
34	**Practical lesson №17.** The technique of integration of rational and	Integration of rational and irrational and trigonometric functions. The technique of using trigonometric substitutions (three types). Euler substitutions.

	irrational and trigonometric functions.	**Tasks for IWS**: [2, 4, 6. 8, 11, 12], [71, p.p.65-79
Topic 7. Definite integrals and their practical application in problems of geometry and physics.		
35	**Lecture №18.** Definite integral: definition, basic properties, classes of integral functions. The definite integral as a function of the variable upper bound. The Newton-Leibnitz formula and other methods of calculating the definite integral.	Formal definition of the definite integral. The concept and technique of constructing an integral sum. Definition of function integrability. Geometric and physical meaning of the definite integral. Classes of integrable functions. The necessary and sufficient conditions for the integrability of the function. The connection between the continuity of the integrand function and its integrability. Properties of the definite integral. The definite integral as a function of its variable upper limit. Newton-Leibnitz formula. Double substitution. Connection between definite and indefinite integrals. Substituting a variable in the definite integral and its differences from substituting a variable in the indefinite integral. Integration by parts in a definite integral**.** **Tasks for IWS**: [2, 4, 6. 8, 11, 12], [71, p.p.65-79
36	**Practical lesson №18. On the first half pair:** Technique of integration of the definite integral. Features of its integration by the variable replacement method**.** **and the second half: the third part of the MKR on topics №6-8**	The technique of integrating the definite integral. Newton-Leibnitz formula. Features of its integration by the variable replacement method. Method of integration by parts in a definite integral. **Tasks for IWS**: [2, 4, 6. 8, 11, 12], [71, p.p.65-79

6. Independent work of the student (IWS)

Mastering the educational material from the discipline "Mathematical analysis. Part 1. Differential and integral calculus of functions of one variable" is based on self-preparation for classroom classes on theoretical and practical topics.

№	*The name of the topic submitted for independent processing*	*Number of hours*	*Literature*
1	*Preparation for the lecture 1.*	*1*	[1,3,4,6.10,12], [71, p.p.5-34
2	*Preparation for practical lesson 1*	*0.5*	[1,3,4,6.10,12], [71, p.p.5-34
3	*Preparation for the lecture 2.*	*1*	[1,3,4,6.10,12], [71, p.p.5-34
4	*Preparation for practical lesson 2*	*0.5*	[1,3,4,6.10,12], [71, p.p.5-34
5	*Preparation for the lecture 3*	*1*	[1,3,4,6.10,12], [71, p.p.5-34
6	*Preparation for practical lesson 3*	*0.5*	[1,3,4,6.10,12], [71, p.p.5-34
7	*Preparation for the lecture 4*	*1*	[1,3,4,6.10,12], [71, p.p.5-34
8	*Preparation for practical lesson 4*	*0.5*	[1,3,4,6.10,12], [71, p.p.5-34
9	*Preparation for the lecture 5*	*1*	[1,3,4,6.10,12], [71, p.p.5-34
10	*Preparation for practical lesson 5*	*0.5*	[1,3,4,6.10,12], [71, p.p.5-34

11	*Preparation for the lecture 6*	*1*	[1,3,4,6.10,12], [71, p.p.5-34
12	*Preparation for practical lesson 6*	*0.5*	[1,3,4,6.10,12], [71, p.p.5-34
13	*Preparation for the lecture 7*	*1*	[1,3,4,6.10,12], [71, p.p.5-34
14	*Preparation for practical lesson 7*	*0.5*	[1,3,4,6.10,12], [71, p.p.5-34
15	*Preparation for the lecture 8*	*1*	[1,3,4,6.10,12], [71, p.p.5-34
16	*Preparation for practical lesson 8*	*0.5*	[1,3,4,6.10,12], [71, p.p.5-34
17	*Preparation for the lecture 9*	*1*	[1,3,4,6.10,12], [71, p.p.5-34
18	*Preparation for practical lesson 9*	*0.5*	[1,3,4,6.10,12], [71, p.p.5-34
19	*Preparation for the lecture 10*	*1*	[1,3,4,6.10,12], [71, p.p.35-64
20	*Preparation for practical lesson 10*	*0.5*	[1,3,4,6.10,12], [71, p.p.35-64
21	*Preparation for the lecture 11*	*1*	[1,3,4,6.10,12], [71, p.p.35-64
22	*Preparation for practical lesson 11*	*0.5*	[1,3,4,6.10,12], [71, p.p.35-64
23	*Preparation for the lecture12*	*1*	[1,3,4,6.10,12], [71, p.p.35-64
24	*Preparation for practical lesson 12*	*0.5*	[1,3,4,6.10,12], [71, p.p.35-64
25	*Preparation for the lecture 13*	*1*	[1,3,4,6.10,12], [71, p.p.35-64
26	*Preparation for practical lesson 13*	*0.5*	[1,3,4,6.10,12], [71, p.p.35-64
27	*Preparation for the lecture 14*	*1*	[1,3,4,6.10,12], [71, p.p.35-64
28	*Preparation for practical lesson 14*	*0.5*	[1,3,4,6.10,12], [71, p.p.35-64
29	*Preparation for the lecture 15*	*1*	[1,3,4,6.10,12], [71, p.p.35-64
30	*Preparation for practical lesson 15*	*0.5*	[1,3,4,6.10,12], [71, p.p.35-64
31	*Preparation for the lecture 16*	*1*	[2, 4, 6. 8, 11, 12], [71, p.p.65-79
32	*Preparation for practical lesson 16*	*0.5*	[2, 4, 6. 8, 11, 12], [71, p.p.65-79
33	*Preparation for the lecture 17*	*1*	[2, 4, 6. 8, 11, 12], [71, p.p.65-79
34	*Preparation for practical lesson 17*	*0.5*	[2, 4, 6. 8, 11, 12], [71, p.p.65-79

35	*Preparation for the lecture 18*	*1*	[2, 4, 6. 8, 11, 12], [71, p.p.65-79
36	*Preparation for practical lesson 18*	*0.5*	[2, 4, 6. 8, 11, 12], [71, p.p.65-79
37	**Application of the definite integral in geometric and physical problems.** Calculation of areas of flat figures in rectangular Cartesian coordinates. Calculation of the areas of flat figures bounded by curves, which are specified in the polar coordinate system. Calculation of arc lengths of plane curves. Calculation of volumes of bodies. Calculation of the areas of the surfaces of rotation. Calculation of the work performed by a variable force when moving a material point. Calculation of the force of liquid pressure on a vertical wall (plate) immersed in it. Calculation of the center of mass of an inhomogeneous rod.	*4*	[2, 4, 6. 8, 11, 12], [71, p.p.65-79
38	**Improper integrals of the first and second kind, calculation technique and research on convergence**. Concept of improper integrals of the first and second kind. Geometric meaning of improper integrals. Convergence is the divergence of improper integrals. Cauchy criterion. Connection between improper integrals of the first and second kind. The simplest signs of convergence: the sign of comparison by inequality and the limit comparison sign. Test integrals. The concept of absolute and conditional convergence of improper integrals. Theorem on necessary and sufficient conditions for the convergence of improper integrals. Dirichlet sign. The concept of the main value of improper integrals of the first kind.	*4*	[2, 4, 6. 8, 11, 12], [71, p.p.65-79
39	*Preparation for MCW*	*5*	[1-6], [8-12], [71, p.p. 5-79
40	*Preparation for IWS*	*8*	[1-6], [8-12], [71, p.p. 5-79
41	*Preparation for the exam*	*30*	[1-6], [8-12], [71, p.p. 5-79

Policy and control

7. Policy of academic discipline (educational component)

1. **General policy of teaching** the discipline *"Mathematical analysis. Part 1. Differential and integral calculus of functions of one variable"* is aimed at independent performance of educational tasks, tasks of current and final control of learning results (for persons with special educational needs, this requirement is applied taking into account their individual needs and capabilities); mandatory correct reference to sources of information in the case of using other people's ideas, developments, statements, technologies; providing reliable information about the results of one's own educational (scientific, creative) activities, used research methods, technologies and sources of information,
2. **Visitation Policy**. In the normal course of study, attendance at both lectures and practical classes is a mandatory component of assessment. In long-term force majeure circumstances (military actions, pandemics, international internships), training can be conducted remotely. In this case, the absence of a classroom lesson does not involve the calculation of penalty points, since the student's final rating score is formed exclusively during the final examination. At the same time, independent performance of modular control tasks and

defense of individual thematic tasks, as well as speeches (reports) at colloquiums and active work in practical classes will be evaluated during classroom classes.

3. **Policy on working out and redoing assessment control measures**. According to the regulation "Regulations on current, calendar and semester control of study results at Igor Sikorsky Kyiv Polytechnic Institute" (https://kpi.ua/files/n3277.pdf) every student has the right to make up for classes missed for a good reason and assessment control measures (hospital, mobility, etc.) at the expense of independent work.
4. **The procedure for contesting the results of assessment control measures**. According to the "Regulations on the resolution of conflict situations in the Igor Sikorsky Kyiv Polytechnic Institute" (https://osvita.kpi.ua/node/169) students have the right to challenge the results of the control measures with arguments, explaining which criterion they disagree with according to the assessment. A student may raise any issue relating to the assessment procedure and expect it to be dealt with in accordance with pre-defined procedures.
5. **Academic integrity**. The policy and principles of academic integrity are governed by the norms set forth in Chapter 3 of the Code of Honor of the Igor Sikorsky Kyiv Polytechnic Institute (https://kpi.ua/code).
6. **Norms of ethical behavior**. The norms of ethical behavior of students and scientific and pedagogical workers are regulated by the provisions set forth in Chapter 2 of the Code of Honor of the Igor Sikorsky Kyiv Polytechnic Institute (https://kpi.ua/code).
7. **Inclusive education**. Acquisition of knowledge and skills in the course of studying the discipline *"Mathematical analysis. Part 1. Differential and integral calculus of functions of one variable"* is accessible to most people with special educational needs, except for those with severe visual impairments who cannot complete tasks using personal computers, laptops and/or other technical aids.
8. **Calendar control** is carried out in order to improve the quality of students' education and monitor the student's fulfillment of the syllabus requirements. Read more: Chapter 3 "Regulations on current, calendar and semester control of study results at the Igor Sikorsky Kyiv Polytechnic Institute" (https://kpi.ua/files/n3277.pdf).
9. **Studying in a foreign language**. In the process of mastering the lecture material and performing practical tasks in the discipline *"Mathematical analysis. Part 1. Differential and integral calculus of functions of one variable"* students are recommended to refer to the English-language sources listed in the lists of basic and additional literature.
10. **Assignment of incentive and penalty points**. In accordance with the "Regulations on the system of evaluation of learning results at the Igor Sikorsky Kyiv Polytechnic Institute" the sum of all incentive points cannot exceed 10% of the rating scale (https://osvita.kpi.ua/node/37). The rules for assigning incentive and penalty points are as follows.

    Incentive points are awarded for: a) writing theses, articles, design of a new mathematical problem/technology as a scientific work for participation in a competition of student scientific works (on the subject of the academic discipline *"Mathematical analysis. Part 1. Differential and integral calculus of functions of one variable")*– up to 2 points; b) participation in international or all-Ukrainian events and competitions (on the subject of the academic discipline *"Mathematical analysis. Part 1. Differential and integral calculus of functions of one variable"*) - up to 3 points.

    Penalty points are awarded for violations of the principles of academic integrity (non-independent performance of MCW and IWS, writing off during the exam): - 5 points for each violation (attempted plagiarism).

    Self-examination, preparation for practical classes, performance of individual tasks and control measures are carried out during independent work of students with the possibility of consulting with the teacher at the specified consultation time or by means of electronic correspondence (e-mail, messengers).

8. Types of control and rating system for evaluating learning outcomes (ELO)

Rating of the discipline *"Mathematical analysis. Part 1. Differential and integral calculus of functions of one variable" "* consists of:
1) points for individual calculation and graphic work (IWS),
2) points for the integrated modular control work (MCW),
3) points for answering the exam,
4) incentive points,
5) penalty points.

RATING SYSTEM OF EVALUATION (ELO)

8.1 Points for the implementation and protection of an individual IWS.

During each semester, students perform one individual IWS, which is divided into all thematic sections.

The maximum number of points for a semester individual IWS: 20 points (total).

Points are awarded for:
- quality of execution (for individual IWS): 0-8 points;
- answer during the defense (for individual IWS): 0-8 points;
- timely submission of work for defense: 0-4 points.

Performance evaluation criteria:
8 points – the work is done qualitatively, in full;
6 points - the work is done qualitatively, in full, but has shortcomings;
3 points - the work is completed in full, but contains minor errors;
0 points – the work is incomplete or contains significant errors.
Criteria for evaluating the quality of the answer:
8 points – the answer is complete, well-argued;
6 points – the answer is generally correct, but has flaws or minor errors;
3 points – there are significant errors in the answer;
0 points - there is no answer or the answer is incorrect.
Criteria for evaluating the timeliness of work submission for defense:
4 points – the work is presented for defense no later than the specified deadline;
2 points – the work is submitted for defense 1 week later than the specified deadline;
0 points – the work is submitted for defense more than 1 week later than the specified deadline.
The maximum number of points for the implementation and defense of the semester individual IWS: 8+8+4=20 points (in total for three thematic sections).

8.2 Points for the completion of the semester integrated modular control work (MCW).

During the semester, students complete one semester-long integrated modular test, divided by thematic sections into four equal parts in terms of points and time; all tasks are written, including one theoretical and three practical.

The maximum total number of points for the integrated semester MCW is 30 points.

Criteria for evaluating written tasks of the integrated MCW:
30 points - the solution of the MCW tasks is absolutely (100%) correct;
27 points - the solution of the vast majority of tasks is correct, but in 10% of the tasks there are insignificant errors;
24 points – most tasks are solved correctly, but 20% of the tasks contain errors;
10-15 points - half of the tasks are solved correctly, but 50% of the tasks have significant errors;
5-6 points - the solution of 20% of the tasks is correct, but there are significant errors in 80% of the tasks;
1-3 points – the solution of 10% of tasks is correct, but 90% of tasks have significant errors;

0 points - there is no answer or the answer is 100% incorrect.

The semester component of the rating scale: $\mathbf{R_S = R_{IWS} + R_{MCW}}$ **= 20+30 points = 50 points**.

8.3. Penalty points.

Penalty points are calculated for:
- academic dishonesty (plagiarism, non-independent performance of MCW, IWS, etc.) - 5 points for one attempt.

8.4. Points for answers on the exam.

The examination ticket consists of 6 questions - 1 theoretical and 5 practical. The answer to a theoretical question is worth 10 points, and the answer to each practical question is worth 8 points.
Evaluation criteria for the theoretical question of the examination paper:
10 points – the answer is correct, complete, well-argued;
8-9 points – the answer is correct, detailed, but not very well argued;
6-7 points - in general, the answer is correct, but has flaws;
4-5 points – there are minor errors in the answer;
1-3 points – there are significant errors in the answer;
0 points - there is no answer or the answer is incorrect.
Evaluation criteria for the practical question of the examination work:
8 points – the answer is correct, the calculations are completed in full;
6-7 points - the answer is correct, but not very well supported by calculations;
5 points - in general, the answer is correct, but has flaws;
3-4 points – there are minor errors in the answer;
1-2 points – there are significant errors in the answer;
0 points - there is no answer or the answer is incorrect.

The maximum number of points for an answer on the exam:
$\mathbf{R_E}$ **= 10 points × 1 theoretical question + 8 points × 5 practical tasks = 50 points.**

8.5. Calculation of the rating scale (R).

The semester component of the rating scale R_S= 50 points, it is defined as the sum of positive points received for the completion of the integral modular control work, for the completion and defense of the individual IWS and negative penalty points.
The examination component of the rating scale is equal to: R_E = 50 points.
The rating scale for the discipline is equal to: $\mathbf{R = R_S + R_E}$ **= 100 points**.

8.6. Calendar control: is carried out twice a semester as a monitoring of the current state of fulfillment of the syllabus requirements:

At the first certification (8th week), the student receives "credited" if his current rating is at least 10 points (50% of the maximum number of points a student can receive before the first certification).
At the second certification (14th week), the student receives "passed" if his current rating is at least 20 points (50% of the maximum number of points a student can receive before the second certification).

8.7. Conditions for admission to the exam and determining the grade.

A necessary condition for a student's admission to the exam is the completion and defense of all individual works and the student's semester rating of at least 60% of the R_S, i.e. at least 30 points. Otherwise, the student must do additional work and improve his rating.
The total rating of the R student is defined as the sum of the semester rating of the student R_S and the R_E points received on the exam. The grade is assigned according to the value of R according to the table. 1.

Table 1

Total rating R_D	**Grade**
95-100	excellent
85-94	very good
75-84	good
65-74	satisfactory
60-64	enough
$\mathbf{R_D} \leq 59$	unsatisfactory
$\mathbf{r_C} < 30$ or not performed (not protected) all types of work.	not allowed

8.8 Additional information on the discipline (educational component)

A copy of the typical exam tickets issued for each semester control is given in Appendix 1.

Working program of the academic discipline (syllabus):

Compiled by DcS., prof. Legeza V.P.

Adopted by Computer Systems Software Department (protocol № 12 from 26.04.23)

Approved by the Faculty Board of Methodology (protocol № 10 from 26.05.23)

Appendix 1

TYPICAL EXAMINATION TICKET

FROM THE DISCIPLINE "MATHEMATICAL ANALYSIS-1"

FOR SEMESTER CONTROL (FIRST SEMESTER)

<table>
<tr><td colspan="4" align="center">Igor Sikorsky Kyiv Polytechnic Institute</td></tr>
<tr>
<td>Educational and qualification level Bachelor Specialty 121 "Software Engineering"</td>
<td>Department of software of computer systems

2022 – 2023 education year</td>
<td>EXAMINATION TICKET No. 1 from the academic discipline

MATHEMATICAL ANALYSIS-1
First semester</td>
<td>I approve Chief Department of software of computer systems

____
(signature)
DcS., Assoc.prof.
E.S. Sulema

Prot. No. 13 dated 06/22/2022</td>
</tr>
<tr><td colspan="4" align="center">Examination theoretical questions</td></tr>
<tr><td colspan="4">1. Stoltz's Th (Main Th with proof, Remarks - without proof). An example of the use of Th Stoltz.</td></tr>
<tr><td colspan="4" align="center">Practical tasks of various types</td></tr>
<tr><td colspan="4">2. Find the limit of the sequence: $f(x)=\lim\limits_{n\to\infty}\frac{1}{n}\left[\left(x+\frac{1\cdot 5}{n}\right)^3+\left(x+\frac{2\cdot 5}{n}\right)^3+\ldots+\left(x+\frac{5(n-1)}{n}\right)^3\right]$.</td></tr>
<tr><td colspan="4">3. The vertex of an isosceles triangle lies in the left focus of the ellipse $x^2/6+y^2/5=1$. At what point on the axis OX should the base of this triangle be drawn parallel to the axis OY so that its area is the largest? Make a picture.</td></tr>
<tr><td colspan="4">4. Find the limit of the function: $\lim\limits_{x\to 0}\dfrac{\int_x^{x^2} e^{-x^2}dx}{\int_{2x}^{x^2} e^{-x}\cos(x^2)dx}$.</td></tr>
<tr><td colspan="4">5. Find the volume of a body bounded by a single-cavity hyperboloid $z^2/9+y^2/16-x^2=1$, an elliptic cone $z^2/9+y^2/16-x^2=1$ and a plane $x=0$ (the body inside the hyperboloid). Make a picture.</td></tr>
<tr><td colspan="4">6. What work must be done when building a regular quadrangular pyramid, if the height of the pyramid H, the side of the base a, the density of the building material γ? Яку роботу треба виконати при побудові правильної чотирикутної піраміди, якщо висота піраміди H, сторона основи a, густина будівельного матеріалу γ?</td></tr>
</table>

Lecturer of the academic discipline, prof. ____________ V.P. Legeza