Силабус освітнього компонента
Програма навчальної дисципліни

Mathematical Analysis

Шифр та назва спеціальності
122 – Applied Mathematics

Інститут
Institute of Computer Modeling, Applied Physics and Mathematics

Освітня програма
Computer and Mathematical Modeling

Кафедра
Applied Mathematics (170)

Рівень освіти
Bachelor

Тип дисципліни
General Education Course, mandatory

Семестр
1

Мова викладання
English

Викладачі, розробники

Vyacheslav N. Burlayenko

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Candidate of Sci. in Engineering, Associate Professor, Head of the Department of Applied Mathematics NTU "KhPI"

With 25 years of work experience, I have authored over 90 scientific and educational-methodological works, including contributions to high-rank international journals indexed in science metrics databases such as Scopus and Web of Science. I have presented reports at distinguished international conferences. My extensive teaching experience encompasses a diverse range of mathematics courses, involving linear algebra, analytic geometry, mathematical analysis, differential equations, series theory, and field theory.

More details on the web-page: https://web.kpi.kharkov.ua/apm/personal-ni-storinki/burlayenko-v-yacheslav-mikolajovich/

Larysa Dzyubak

Larysa.Dzyubak@khpi.edu.ua
Ph.D. in Physics and Mathematics,
Associate Professor of the Department of Applied Mathematics NTU “KhPI”

Work experience: over 25 years
Number of scientific and educational-methodological works: over 70
Number of papers indexed in Scopus and Web of Science: 19
Chapters in books: 3
Number of presentations at international scientific conferences: 30
Main courses: Higher Mathematics, Mathematical Analysis, Linear Algebra, Analytic Geometry

More details on the web-page https://web.kpi.kharkov.ua/apm/personal/larisa-p-dzyubak/

Загальна інформація

Анотація

The course in mathematical analysis provides a comprehensive foundation in both theoretical and applied aspects of mathematics, essential for the training of engineers in this field. It encompasses fundamental topics such as limit theory, differential and integral calculus of single-variable function.

Мета та цілі дисципліни

This course aims to build a solid understanding of mathematical theories and methods essential for solving problems in programming, algorithm design, computing, and data analysis, enabling students to analyze, model, and interpret complex processes and phenomena.

Формат занять

Lectures, practical classes, individual independent work, consultations. The final control is an exam.

Компетентності

GC01. Ability to abstract thinking, analysis and synthesis.
GC02. Ability to apply knowledge in practical situations.
GC05. Ability to search, process and analyze information from various sources.
GC06 Ability to learn and master modern knowledge.
GC12. The ability to solve practical problems involving the methods of mathematics, physics and engineering.

Результати навчання

LR01. Students are expected to gain proficiency in mathematical analysis, developing a solid understanding of key concepts such as functions, limits, continuity, derivatives, indefinite and definite integrals. They will also learn to apply differential and integral calculus to real-world problem-solving and gain experience with Taylor and Maclaurin approximations. This course provides a strong foundation for advanced studies in mathematics, computer science, machine learning, and engineering.

Обсяг дисципліни

150 hours (5 ECTS credits): lectures – 32 hours, practical classes – 48 hours, individual independent work – 70 hours

Передумови вивчення дисципліни (пререквізити)

A solid foundation in school-level mathematics, including algebra and trigonometry, along with a basic understanding of logic, abstract reasoning, and mathematical problem-solving skills.

Особливості дисципліни, методи та технології навчання

Lectures are delivered in an interactive format utilizing multimedia technologies and incorporate explanatory-illustrative, problem-based, and critical thinking approaches. Practical sessions employ exploratory and discussion-based methods, emphasizing the application of real-world problems within the domain of computer science. All educational materials are accessible to students via OneNote Class Notebook

Програма навчальної дисципліни

Теми лекційних занять

Topic 1 – Limit Theory

Logical symbols. Basic definitions of set theory. Operations on sets. Sets on the number line. Supremum and infimum of a numerical set. Bounded and unbounded sets. Accumulation points. Properties of elementary functions. Numerical sequences: basic definitions, the concept of the limit of a sequence, bounded, unbounded, infinitely large, and infinitesimal sequences. Properties of convergent sequences. Criteria for convergence of numerical sequences. Definition of the limit of a function according to Cauchy and Heine. Infinitely large and infinitesimal functions. Properties of functions that have a limit at a point. Criteria for the existence of a limit. Notable limits. Comparison of infinitely large and infinitesimal functions. Continuity of a function at a point and its various definitions. Properties of functions continuous at a point. Continuity of basic elementary functions. Classification of points of discontinuity. Properties of functions continuous on an interval. The concept of uniform continuity. Cantor's theorem.

Topic 2 – Differential Calculus of a Function of One Variable.

The concept of a derivative: geometric and physical interpretation. Differentiability. Rules for computing derivatives. Table of derivatives. First differential: definition, geometric meaning, invariance under form, and applications. Higher-order derivatives and differentials: rules for calculation, lack of invariance under form. Fundamental theorems of differential calculus. L'Hôpital's rule. Taylor's formula and various forms of the remainder term. Function increase and decrease on an interval. Extrema: necessary and sufficient conditions. Conditions for convexity and concavity. Inflection points: necessary and sufficient conditions. Asymptotes of function graphs. Procedure for a complete study of a function and construction of its graph.

Topic 3. – Integral Calculus of a Function of One Variable

Indefinite and initial integrals and their relationship. Properties of indefinite integrals. Table of indefinite integrals. Integration methods: substitution under the differential, variable substitution, and integration by parts. Trigonometric and hyperbolic substitutions. Rational functions and their properties. Decomposition of proper rational fractions into simplest terms. Integration of elementary rational functions. Integration of linear and simple irrationalities. Integration of functions rationally dependent on trigonometric functions.

Topic 4. Definite Integrals

Definition of definite integrals. Classes of integrable functions. Properties of the definite integral and its geometric interpretation. The Newton–Leibniz formula. Techniques of integration: integration by parts and substitution of variables in definite integrals. Integration of even and odd functions over symmetric intervals. Applications: calculation of areas of plane figures, arc lengths, and volumes of solids of revolution. Definition and properties of improper integrals of the first and second kind.

Теми практичних занять

According with lectures:

Topic 1 – Limit Theory

Numerical sets and operations on them. Calculation of limits of functions. The first remarkable limit. Comparison of infinitely small and infinitely large functions. The second remarkable limit. Analysis of functions for continuity.

Topic 2 – Differential Calculus of a Function of One Variable.

The concept of a derivative: geometric and physical interpretation. Differentiability. Rules for computing derivatives. Table of derivatives. First differential: definition, geometric meaning, invariance under form, and applications. Higher-order derivatives and differentials: rules for computation and lack of invariance under form. Application of L'Hôpital's rule. Analysis of function growth and decrease over an interval. Determination of extrema using necessary and sufficient conditions. Investigation of convexity and concavity. Identification of inflection points. Asymptotes of function graphs. Procedure for a complete study of a function and construction of its graph.

Topic 3. Integral Calculus of a Function of One Variable

Indefinite integrals and antiderivatives and their relationship. Properties of indefinite integrals. Integration methods: substitution under the differential, variable substitution, and integration by parts. Trigonometric and hyperbolic substitutions. Rational functions and their properties. Decomposition of proper rational fractions into simplest terms. Integration of elementary rational functions. Integration of linear and simple irrationalities. Integration of functions rationally dependent on trigonometric functions..

Topic 4. Definite Integrals.

Calculation of definite integrals using the Newton-Leibniz formula. Calculation by variable substitution and integration by parts. Determination of the area of a plane figure in Cartesian coordinates and given by parametric equations. Determination of the area in polar coordinates. Calculation of arc lengths. Determination of surface areas and volumes of bodies of revolution, as well as volumes of bodies with a given law of cross-sectional change. Application of definite integrals to problems in physics and mechanics. Calculation of improper integrals of the first kind and analysis of convergence of improper integrals of the first and second kinds.

Теми лабораторних робіт

Not provided

Самостійна робота

The course involves students' engagement with lecture materials, preparation for practical classes, completion of individual tasks, and readiness for tests. Supplementary materials for individual independent study on course topics are also provided to students. Throughout the semester, students are evaluated on their performance in individual home tasks, which are composed of assignments aligned with the semester's themes, namely:
1. Limits and continuity of functions.
2. Derivatives and their application to function analysis and ploting graphs.
3. Evaluation of indefinite integrals.
4. Evaluation of definite integrals and their application to fsolving physical and geometrical tasks.

Література та навчальні матеріали

Basic references

1. Higher Mathematics. Problem-solving and variants of typical calculations. Vol. 1. Edited by Prof. Kurpa L.V. – Kharkiv: NTU KhPI, 2006. – 236 p.
2. Kurpa L.V., Shmatko T.V. Differential calculus for one variable functions : The textbook for the students of technical universities. – Kharkiv: NTU KhPI, 2008. – 160 p.
3. L.V. Kurpa, T.V.Shmatko. Differential and integral calculus for one variable functions: The textbook. – Kharkiv: NTU KhPI: 2017. – 324 pages.

Additional references

3. Robert Wrede, Murray R. Spiegel, Theory and Problems of Advanced Calculus 2nd Ed. Mcgraw-Hill Companies, Inc. 2002. – 442 p.
4. B. Lafferriere, G. Lafferriere, M. N. Nguyen. Introduction to Mathematical Analysis I. 3rd Ed. Portland State University, Portland. 2022. – 176 p.
5. David S.G. Stirling. Mathematical Analysis and Proof. 2nd. Ed. WP, Cambridge, 2009. - 253 p.
6. L. V. Kurpa, A.B. Linnik, T. V. Shmatko. Mathematical analysis in examples and problems. Part 1. – Kharkiv: NTU «KhPI», 2024. – 209 p.

Система оцінювання

Критерії оцінювання успішності студента та розподіл балів

The final grade for the semester is determined by combining the points earned during the semester (80 points) and those obtained in the exam (20 points). The exam comprises a written assignment, which includes one theoretical question and two practical problem-solving questions, followed by an oral presentation.
The current evaluation, accounting for 80%, comprises three control works, three individual obligatory tasks, and two tests. During the intervals between modular knowledge assessments, students are engaged in independent work, as outlined in the educational program.

Шкала оцінювання

Сума балів	Національна оцінка	ECTS
90–100	Відмінно	A
82–89	Добре	B
75–81	Добре	C
64–74	Задовільно	D
60–63	Задовільно	E
35–59	Незадовільно (потрібне додаткове вивчення)	FX
1–34	Незадовільно (потрібне повторне вивчення)	F

Норми академічної етики і політика курсу

The student is required to adhere to the Code of Ethics for Academic Relations and Integrity of NTU 'KhPI,' demonstrating discipline, education, benevolence, honesty, and responsibility. Any conflict situations should be openly discussed within study groups with the teacher. If it proves impossible to resolve the conflict at this level, it should be brought to the attention of the institute's directorate employees.
The regulatory and legal support for implementing the principles of academic integrity at NTU 'KhPI' is available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Погодження

Syllabus approved by	Date of approval, signature	Head of the AM Department Vyacheslav BURLAYENKO
	Date of approval, signature	Garantee of EP Oksana TATARINOVA