Syllabus
Course Program

Mathematical Analysis Part 1

Specialty
113 Applied mathematics

Institute
Educational and Scientific Institute of Computer Science and Information Technology

Educational program
Intelligent Data Analysis

Department
Computer Mathematics and Data Analysis

Level of education
Bachelor's level

Course type
General, Mandatory

Semester
1

Language of instruction
Ukrainian

Lecturers and course developers

Olena Akhiiezer

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Candidate of Technical Sciences, Associate Professor of the Department of Computer Mathematics and Mathematical Modeling, Head of Computer Mathematics and Data Analysis Department.

Work experience – more than 30 years. The author of many scientific, educational, and methodological works. Leading lecturer in the courses: “Mathematical Analysis”, ”Differential Equations and Complex Analysis”, ‘Functional Analysis’, ”Higher Mathematics”, etc.

More about the lecturer on the department's website

General information

Summary

The course is aimed at mastering the theoretical foundations of mathematical analysis. The course covers the basic concepts of set theory, numerical sequences, limit theory functions of one variable, continuous functions of one variable, differential calculus of a function of one variable.

Course objectives and goals

Development of abilities to logical thinking, research and solution of mathematically formalized tasks. Teaching the basic mathematical methods necessary for the analysis and modeling of processes, phenomena, devices. Developing the ability to analyze the results obtained, skills of independent study of literature on mathematics and its applications.

Format of classes

Lectures, laboratory classes, consultations, self-study. Final control in the form of an exam.

Competencies

GC 1. Ability to learn and master modern knowledge.
GC 2. Ability to apply knowledge in practical situations.
GC 5. Ability to conduct research at the appropriate level. GC 6. Ability to abstract thinking, analysis and synthesis.
GC 7. Ability to search, process and analyze information from various sources.
GC 8. Knowledge and understanding of the subject area and understanding of professional activities.
SC 1. Ability to use and adapt mathematical theories, methods and techniques to prove mathematical statements and theorems.
SC 2. Ability to perform tasks formulated in mathematical form.
SC 3. Ability to select and apply mathematical methods for solving applied problems, modeling, analysis, design, management, forecasting, decision-making.
GC 15. Ability to formulate a mathematical statement of the problem, based on the statement in the language of the subject area, and choose a method of solving it that provides the required accuracy and reliability of the result.

Learning outcomes

ELO 1. Demonstrate knowledge and understanding of the basic concepts, principles, theories of applied mathematics and apply them in practice.
PLO 2. To master the basic principles and methods of mathematical, complex and functional analysis, linear algebra and number theory, analytical geometry, theory of differential equations, including partial differential equations, probability theory, mathematical statistics and random processes, numerical methods.
ELO 3. Formalize problems formulated in the language of a particular subject area; formulate their mathematical formulation and choose a rational method of solution; solve the obtained problems by analytical and numerical methods, evaluate the accuracy and reliability of the results.
ELO 12. Solve individual engineering problems and/or problems arising in at least one subject area: sociology, economics, ecology and medicine.
ELO 14. Show the ability to self-learn and continue professional development.

Student workload

The total volume of the course is 180 hours (6 ECTS credits): lectures – 42 hours, practical classes – 48 hours, self-study – 90 hours.

Course prerequisites

Students must have the basics of mathematical knowledge gained earlier in school or other educational institutions

Features of the course, teaching and learning methods, and technologies

Lectures are conducted interactively with the use of multimedia technologies. Practical classes use a project-based learning approach. Teaching materials are available to students through OneNote Class Notebook.

Program of the course

Topics of the lectures

Topic 1: Logical signs. Basic definitions of set theory. Actions on sets. Sets on the number axis.
Topic 2. Supremum and infimum of a numerical set. The existence theorem.
Topic 3: Numerical sequences. Basic definitions. The concept of the limit of a sequence. Unbounded and infinitely large sequences.
Topic 4. Infinitesimal sequences and their properties.
Topic 5. Properties of convergent sequences.
Topic 6: Signs of convergence of numerical sequences. Fundamental sequences.
Topic 7. Determination of the Cauchy and Heine limits. Infinitely large functions.
Topic 8. Signs of the existence of a limit. Distinctive limits.

Topic 9: Infinitesimal functions. Comparison of infinitesimal functions. The ratio “O”, “o”, “ ≈ ”.
Topic 10. Continuity of a function at a point. Different definitions. Properties of a continuous function at a point.
Topic 11. Continuity of basic elementary functions. Classification of breakpoints.
Topic 12: Properties of functions that are continuous on a segment
Topic 13. The concept of uniform continuity. The finite coverage lemma. Cantor's theorem.
Topic 14: The concept of derivative. Geometric and physical meaning. Differentiability.
Topic 15: Rules for calculating the derivative. Table of derivatives.
Topic 16. First differential. Definition, geometric meaning, form invariance. Application.
Topic 17. Derivatives and differentials of higher orders. Rules of calculation. Lack of form invariance.
Topic 18: Basic theorems of differential calculus.
Topic 19. First and second Lopital's rule. Taylor's formula. Different forms of surplus.
Topic 20. Increasing and decreasing functions in the interval. Extremum. Necessary and sufficient conditions for an extremum.
Topic 21. Conditions of convexity. Inflection points. Necessary and sufficient conditions of inflection points. Asymptotes of the graph of a function.

Topics of the workshops

Topic 1: Logical signs. The method of mathematical induction. Some inequalities.
Topic 2. Elements of set theory. Actions on sets. Bounded and unbounded sets.
Topic 3: Supremum and infimum of a numerical set. The point of condensation of a numerical set.
Topic 4. Basic definitions of a numerical sequence. Properties of a numerical sequence.
Topic 5. Determining the limit of a sequence. Infinitely large and unbounded sequences. Properties of convergent sequences.
Topic 6: Signs of the existence of a sequence limit. Topic 7. Calculating the limits of sequences.
Topic 8 Thematic control “Elements of set theory. The limit of a sequence” Topic 9. Determination of the limit of a function by Cauchy and Heine.
Topic 10. Calculating simpler limits. Topic 11. The first and second outstanding limits.
Topic 12: Calculating limits using the table of equivalent infinitesimals.
Topic 13. Comparison of infinitesimal and infinitely large functions. Calculating limits using the relations “O”, “o”,.
Topic 14: Continuous functions. Investigation of breakpoints of functions.
Topic 15 Thematic control “Limit of a function of one variable. Continuity of the function”
Topic 16. Definition of a derivative. Geometric and physical meaning.
Topic 17. Technique of differentiation.
Topic 18. Derivative of functions that are defined parametrically and implicitly. Logarithmic derivative of a function.
Topic 19. First differential. Application of differentiation for approximate calculations
Topic 20: Calculating derivatives and differentials of higher orders.
Topic 21: Taylor's formula. Application of Taylor's formula
Topic 22. Calculating bounds using Lopital's rule and Taylor's formula.
Topic 23. Elements of the behavior of a function graph. Construction of graphs.
Topic 24 Thematic control “Differential calculus of a function of one variable”.

Topics of the laboratory classes

Laboratory work is not included in the course

Self-study

The course involves completing an individual calculation task. It is formalized in
in written form. Independent work involves studying lecture material, solving problems, preparing for module tests, performing calculations, and preparing for the exam. Independent work with the possibility of consultations with the teacher.
Students are also recommended additional materials (videos, articles, books) for self-study.

Non-formal education

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Course materials and recommended reading

Basic literature

1. Ляшко І. І. Математичний аналіз : підручник : у 2 ч. / І. І. Ляшко, В. Ф. Ємельянов, О. К. Боярчук. – Київ : Вища школа, 1992. – Ч. 1. – 495 с.
https://chtyvo.org.ua/authors/Yemelianov_Vladyslav/Matematychnyi_analiz_Chastyna_1/
2. Дороговцев А. Я. Математичний аналіз : підручник у двох частинах. —Київ : Либідь, 1993. – 320 с.
ISBN 5-325-00380-1
https://pdf.lib.vntu.edu.ua/books/2015/Dorogovtsev_P1_1993_320.pdf
3. Курченко О. О. Диференціальне числення функції однієї змінної: підручник. – Київ, 2014.– 238 с
https://mechmat.knu.ua/wp-content/uploads/2018/03/merged.pdf
4. Збірник задач з математичного аналізу. Функції однієї змінної / Денисьєвський М. О., Курченко О. О., Нагорний В. Н., Нестеренко О. Н., Петрова Т. О., Чайковський А. В. – Київ : ВПЦ «Київський університет», 2005. — 257 с.
https://www.mechmat.univ.kiev.ua/wp-content/uploads/2018/03/all.pdf
5. Математичний аналіз: навчальні завдання до практичних занять для студентів освітньої програми "комп'ютерна механіка" механікоматематичного факультету (1 семестр першого курсу) / Упорядн. М. О. Назаренко, О. Н. Нестеренко, Т. О. Петрова, А. В. Чайковський. – Електронне видання. – 2020. – 90 с
https://www.mechmat.univ.kiev.ua/wp-content/uploads/2020/04/mathankomp-1sem.pdf
6. Практикум з курсу "Математичний аналіз". Теорія границь : навч.-метод. посібник / О. В. Костюк [та ін.] ; Нац. техн. ун-т "Харків. політехн. ін-т". – Харків : Друкарня Мадрид, 2022. – 195 с.
https://repository.kpi.kharkov.ua/handle/KhPI-Press/62942
7. Практикум з курсу "Математичний аналіз". Диференціальне числення : навч.-метод. посібник / О. В. Костюк [та ін.] ; Нац. техн. ун-т "Харків. політехн. ін-т". – Харків : Друкарня Мадрид, 2022. – 291 с.
https://repository.kpi.kharkov.ua/handle/KhPI-Press/62939
8. Нестандартні та олімпіадні задачі з алгебри та аналізу: практикум для підготовки студентів 1-го курсу [Електронний ресурс] : навчальний посібник для студентів ступеня бакалавра / КПІ ім. Ігоря Сікорського ; уклад.: С. В. Боднарчук, М. К. Ільєнко, Т. В. Маловічко, В. В. Павленков, А. В.Сиротенко – Електронні текстові дані (1 файл: 1,33 Мбайт). – Київ: КПІ ім. Ігоря Сікорського, 2020.– 183 с.
https://ela.kpi.ua/bitstream/123456789/39002/1/Olimp_metodychka_for_students.pdf
9. Математика в технічному університеті : Підручник / І. В. Алєксєєва, В. О. Гайдей, О. О. Диховичний, Л. Б. Федорова ; за ред. О. І. Клесова ; КПІ ім. Ігоря Сікорського. — Київ : Видавничий дім «Кондор», 2019. — Т. 2. — 504 с.ISBN 978-617-7841-40-0
https://core.ac.uk/download/pdf/323525525.pdf
10. Вища математика у прикладах і задачах : навч.-метод. посібник : у 2-х ч. Ч. 2. Теорія границь. Диференціальне та інтегральне числення / Т. Л. Корніль [та ін.] ; Нац. техн. ун-т "Харків. політехн. ін-т". – Харків : Друкарня Мадрид, 2022. – 188 с.
https://repository.kpi.kharkov.ua/handle/KhPI-Press/62938
11. Вища математика : навч. посібник : у 2 ч. / О. П. Олійник, Н. П. Тупко, О. М. Гришко, В. О. Варивода. – Ч. 1. – К. : НАУ, 2021. – 217 с.
https://er.nau.edu.ua/handle/NAU/58038

12. Дудкін М. Є. Вища математика [Електронний ресурс] : підручник для здобувачів ступеня бакалавра за інженерними спеціальностями / М. Є. Дудкін, О. Ю. Дюженкова, І. В. Степахно ; КПІ ім. Ігоря Сікорського. – Електронні текстові дані (1 файл: 10,96 Мбайт). – Київ : КПІ ім. Ігоря Сікорського, 2022. – 449 с. – Назва з екрана.
https://ela.kpi.ua/handle/123456789/51064

Assessment and grading

Criteria for assessment of student performance, and the final score structure

Description of the final score structure, course requirements, and necessary steps to earn points, especially paying attention to self-study and individual assignments.

Grading scale

Total points	National	ECTS
90–100	Excellent	A
82–89	Good	B
75–81	Good	C
64–74	Satisfactory	D
60–63	Satisfactory	E
35–59	Unsatisfactory (requires additional learning)	FX
1–34	Unsatisfactory (requires repetition of the course)	F

Norms of academic integrity and course policy

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU «KhPI»: to demonstrate discipline, good manners, kindness, honesty, and responsibility. Conflict situations should be openly discussed in academic groups with a lecturer, and if it is impossible to resolve the conflict, they should be brought to the attention of the Institute's management.
Regulatory and legal documents related to the implementation of the principles of academic integrity at NTU «KhPI» are available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Approval

Approved by

Date, signature
29.08.2024

Head of the Department
Olena AKHIIEZER

Date, signature
24.08.2024

Guarantor of the Educational Program
Olena AKHIIEZER