Syllabus
Course Program

Differential Equations and Complex Analysis

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
Special (professional), Mandatory

Semester
4

Language of instruction
Ukrainian

Lecturers and course developers

Yuriy Reshetnyak
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Candidate of physical-mathematical sciences, associate professor, associate professor of Computer mathematics and data analysis Department (NTU “KhPI”). 40 years of work experience.
Authored and co-authored over 70 scientific publications.
Leading lecturer of the courses: "Higher Mathematics", "Computer's discrete mathematics".
More about the lecturer on the department's website

General information

Summary

The discipline "Differential equations and complex analysis" is a basic educational discipline, which is studied in the 4th semester according to the educational program for bachelors in specialty 113 "Applied mathematics" of full-time education. The discipline is aimed at students mastering new theoretical knowledge and practical skills, mastering the basic methods and tools of differential equations and complex analysis. The course examines the basic concepts of the theory of differential equations and complex analysis.

Course objectives and goals

Acquisition of the necessary competencies in the field of differential equations and complex analysis. Formation of students' basic theoretical knowledge and practical skills in solving problems of differential equations and complex analysis. Education of students in the skills of mathematical research of applied issues and the ability to reduce the problem to mathematical models.

Format of classes

Lectures, workshops, consultations. Final control – exam.

Competencies

GC 1. Ability to learn and master modern knowledge.

GC 2. Ability to apply knowledge in practical situations.
GC 6. Ability to abstract thinking, analysis and synthesis.
GC 7. Ability to search, process and analyse information from various sources.
GC 1. Ability to learn and master modern knowledge.
GC 2. Ability to apply knowledge in practical situations.
GC 3. Ability to generate new ideas (creativity).

Learning outcomes

LO 1. Demonstrate knowledge and understanding of basic concepts, principles, theories of applied mathematics and use them on practice.
LO 2. To know the basic principles and methods of mathematical, complex and functional analysis, linear algebra and theory numbers, analytic geometry, theory of differential equations, in particular partial differential equations, probability theory, mathematical statistics and random processes, and numerical methods.
LO 14. Demonstrate the ability to self-learn and continue professional development.
LO 15. Be able to organize your own activities and get results within a limited time frame.

Student workload

The total volume of the course is 120 hours (4 ECTS credits): lectures - 28 hours, practical classes - 32 hours, self-study - 60 hours.

Course prerequisites

"Mathematical Analysis", "Linear Algebra", "Analytic Geometry"

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

Lectures are held in an interactive mode using multimedia technologies. Practical classes focus on the practical application of differential equations and complex analysis. Completion of individual tasks (motivational method of learning).

Program of the course

Topics of the lectures

Topic 1. Field of complex numbers. Sets on the complex plane. The concept of a function of a complex variable. Basic elementary functions.

Topic 2. Differentiation of a function of a complex variable. Cauchy-Riemann conditions. Analyticality.

Topic 3. Integration of the function of a complex variable. Series of analytical functions.

Topic 4. Special points. Classification of isolated special points.

Topic 5. Residues. Use of residues.

Topic 6. Differential equations and mathematical models. Integrals as general and partial solutions. Differential equations of the first order. Fields of directions and integral curves.

Topic 7. Differential equations of the 1st order with separable variables. Homogeneous differential equations of the 1st order. Linear differential equations of the 1st order. Bernoulli's differential equation.

Topic 8. Wrapping of a family of curves. Special solutions of differential equations of the first order. Clairo's differential equations. Differential equations of Lagrange.

Topic 9. Equations in complete differentials. Integrating multiplier.

Topic 10. Differential equations of higher orders. Differential equations of the second order, allowing a reduction of the order.

Topic 11. Linear differential equations of the nth order. Homogeneous linear differential equations of the nth order. Liouville-Ostrogradsky formula. Homogeneous linear differential equations with constant coefficients. Linear inhomogeneous differential equations. Method of variation of constants.

Topic 12. Nonhomogeneous linear differential equations with a special right-hand side.

Topic 13. Formulation of the boundary value problem. A rotating string.

Topic 14. Systems of differential equations. Integration of normal systems of differential equations by the method of exclusion of variables.

Topic 15. Normal homogeneous linear system of differential equations. Heterogeneous system of linear differential equations. Normal homogeneous linear systems of differential equations with constant coefficients.

Topic 16. Stability of solutions of differential equations

Topics of the workshops

Topic 1. Field of complex numbers. Geometric representation of complex numbers. Trigonometric form of a complex number. Functions of a complex variable. Basic elementary functions.

Topic 2. Differentiation of a function of a complex variable. Analytical functions. Harmonic functions. Solving problems.

Topic 3. Integral along a curve and its calculation. Cauchy's integral formula. Taylor series. Laurent series.

Topic 4. Finding isolated singular points. Types of isolated special points. Classification of singular points using the expansion of a function in a Laurent series.

Topic 5. Finding residues of a function. Application of remainders to the calculation of definite and improper integrals. Control work #1.

Topic 6. Examples of different types of problems that lead to differential equations. Checking solutions of differential equations. Determination of the field of directions and integral curves of various differential equations.

Topic 7. Differential equations of the 1st order with separable variables. Examples of homogeneous, linear differential equations of the 1st order. Bernoulli's differential equation.

Topic 8. Parameter input method. Finding singular solutions of differential equations of the 1st order. Examples of Clerot and Lagrange differential equations.

Topic 9. Equations in complete differentials. Finding the integrating factor.
Control work #2.

Topic 10. Samples of differential equations of the second order, which allow a decrease in order.

Topic 11. The fundamental system of solutions of higher-order linear differential equations. Solution of homogeneous linear differential equations with constant coefficients and different types of roots of the characteristic equation. Solution of a nonhomogeneous linear differential equation.

Topic 12. Solutions of inhomogeneous linear differential equations with constant coefficients and a right-hand special part.

Topic 13. Finding solutions to boundary value problems.

Topic 14. Integration of systems of differential equations by the method of exclusion of variables.

Topic 15. Solving linear systems of differential equations with constant coefficients by the matrix method.

Topic 16. Verification of solutions of systems of differential equations for stability. Control work #4.

Topics of the laboratory classes

Not provided for in the curriculum.

Self-study

During independent work, students study lecture material, do individual homework, prepare for tests, tests and exams. The result of calculations and modeling is drawn up in a written report. Correctly executed IHW are counted, incorrectly - returned for revision. IHWs are evaluated as completed after errors are corrected. Students are also recommended additional materials (videos, articles) for self-study and analysis.

Non-formal education Within the framework of non-formal education, according to the relevant Regulation (http://surl.li/pxssv), the educational component or its individual topics may be taken into account in the case of independent completion of professional courses/trainings, civic education, online education, vocational training, etc. In particular, certain topics of this component can be taken into account in case of successful completion of the following courses:
- Topic 1. "The field of complex numbers. Sets on the complex plane. The concept of a function of a complex variable. Basic elementary functions."
https://coursera.org/learn/complex-analysis
- Topic 6. "Examples of various types of problems that lead to differential equations. Verification of solutions of differential equations. Determination of the field of directions and integral curves of various differential equations."
https://coursera.org/specializations/differential-calculus-data-modeling

Course materials and recommended reading

References

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Assessment and grading

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

The student is recommended to attend both lectures and practical classes. Performing calculation work is a prerequisite for obtaining an assessment. Tests are mandatory. The student's points in the discipline are awarded according to the following ratio:
- tests: 40% of the semester grade;
- independent work: 20% of the semester grade;
- Exam: 40% of the semester grade.

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 29.08.2024		Guarantor of the educational program Olena AKHIIEZER