Syllabus
Course Program

PARTIAL DIFFERENTIAL EQUATIONS

Specialty
113 Applied mathematics

Institute
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
5

Language of instruction
Ukrainian

Lecturers and course developers

Oleh Konovalov

o.y.konovalov@gmail.com
Candidate of Science (Technical), Engeneer of Computer Mathematics and Data Analysis Department.

Author and co-author of over 50 scientific publications, manuals, and patents.
Lead lecturer for the disciplines: "Partial Differential Equations" and "Cross-Platform Mobile Application Development."

More about the lecturer on the department's website

General information

Summary

The course is aimed at mastering the theoretical foundations and methods of partial differential equations theory. The course covers the formulation of mathematical models and analytical and numerical methods for solving them, as well as the application of these approaches to practical problems. Solution analysis and error estimation are also considered

Course objectives and goals

To train specialists capable of formulating, solving, and generalizing practical problems in their professional activities using fundamental and specialized applied methods of mathematical and computer sciences, to develop mathematical models and algorithms, and to create and maintain corresponding software. Students will learn the basics of the theory of partial differential equations and their applications, forming general functional and subject-specific knowledge of the course.

Format of classes

Lectures, laboratory work, independent study, consultations. Final control - credit.

Competencies

General Competencies (GC):
GC 1: Ability to learn and acquire modern knowledge.
GC 2: Ability to apply knowledge in practical situations.
GC 5: Ability to conduct research at an appropriate level.
GC 6: Ability to think abstractly, analyze, and synthesize.
GC 8: Knowledge and understanding of the subject area and understanding of professional activities.
GC 9: Ability to learn and acquire modern knowledge

Special (Professional) Competencies (SC):
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 choose and apply mathematical methods for solving applied problems in modeling, analysis, design, control, forecasting, and decision-making.
SC 7: Ability to solve professional tasks using computer technology, computer networks, and the internet within modern operating systems using standard office applications.
SC 14: Ability to understand the formulation of a problem in the language of a specific subject area and search for and collect the necessary input data

Learning outcomes

LO 3: Formalize problems formulated in the language of a specific subject area, formulate their mathematical statement, and choose a rational method for solving; solve the problems analytically and numerically, assess the accuracy and reliability of the obtained results.

Student workload

Total course load: 90 hours (3 ECTS credits): lectures – 16 hours, practical classes – 16 hours, independent study – 58 hour.

Course prerequisites

To successfully complete the course, students should have previously completed courses in: "Mathematical Analysis," "Linear Algebra," "Ordinary Differential Equations," "Numerical Methods."…….

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

Lectures are conducted interactively. A project-based approach is emphasized in practical assignments, focusing on the application of information technologies in mathematical modeling of applied problems; independent study of software products for solving problems with partial differential equations using numerical methods and electronic resources. Educational materials are available to students via Office 365

Program of the course

Topics of the lectures

- **Topic 1**: Introduction. Classification of partial differential equations.
- **Topic 2**: Canonical form of second-order partial differential equations.
- **Topic 3**: Parabolic equations.

  - Subtopic 1: Electromagnetic field penetration into a metal plate. Mathematical formulation of the problem.
  - Subtopic 2: Fourier method for solving problems without initial conditions.
  - Subtopic 3: Solution of the first boundary value problem for the heat equation.
  - Subtopic 4: Mathematical formulation and solution of the problem of alternating current flow through a cylindrical conductor.
  - Subtopic 5: Method of separation of variables.

- **Topic 4**: Hyperbolic equations.

    - Subtopic 1: Wave equation on a line. D'Alembert's formula.
    - Subtopic 2: Wave equation on a half-line. D'Alembert's formula.
    - Subtopic 3: Wave equation and boundary conditions. Standing waves.
    - Subtopic 4: Transition to dimensionless variables.
    - Subtopic 5: Canonical form of the hyperbolic equation.
    - Subtopic 6: First-order nonlinear equations and conservation laws.
- **Topic 5**: Elliptic equations.

    - Subtopic 1: The Laplacian and its significance in various fields.
    - Subtopic 2: Inverse problems in electrical engineering.

Topics of the workshops

- **Topic 1**: Gradient, divergence, and curl operators in various coordinate systems.

    - Subtopic 1: Gradient, divergence, and curl operators in Cartesian and cylindrical coordinate systems.
    - Subtopic 2: Gradient, divergence, and curl operators in spherical coordinate systems.
- **Topic 2**: Parabolic equations.

    - Subtopic 1: Essence of the finite difference method.
    - Subtopic 2: Explicit and implicit four-point stencils.
    - Subtopic 3: The sweep method.
    - Subtopic 4: Analysis of the numerical solution.
- **Topic 3**: Elliptic equations.

    - Subtopic 1: Formulation of the Cauchy problem for the Laplace equation.
    - Subtopic 2: Analytical solution of the Cauchy problem for the Laplace equation.
    - Subtopic 3: Finite difference solution of the Cauchy problem for the Laplace equation.
    - Subtopic 4: A model problem for numerical solution analysis.
    - Subtopic 5: Stability analysis of numerical methods for the Cauchy problem of elliptic equations.
- **Topic 4**: Hyperbolic equations.

    - Subtopic 1: Analytical solution of the wave equation on a line.
    - Subtopic 2: Analytical solution of the wave equation on a half-line.

Topics of the laboratory classes

Not included in the program

Self-study

...The course includes an individual project assignment involving modeling and calculation of the planned parameters for specific examples. The results of the calculations and modeling are documented in a written report. Students are also recommended additional materials for independent study and analysis.....

Non-formal education

... Not included in the program.....

Course materials and recommended reading

Basic literature

1. Stanley J. Farlow, *Partial Differential Equations for Scientists and Engineers*. Online Resource
2 M.A. Ruvinsky, *Methods of Mathematical Physics*. Online Resource
3 V.V. Marinetz, M.M. Paprya, V.L. Rego, *Mathematical Physics Equations*. Uzhhorod, 2001. [Online Resources](https://www.uzhnu.edu.ua/uk/infocentre/get/30402; https://www.uzhnu.edu.ua/en/infocentre/get/3900)

Additional literature

4. Peter J. Olver, *Introduction to Partial Differential Equations*. DOI: 10.1007/978-3-319-02099-0.

Assessment and grading

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

100% of the final grade consists of the results of the assessment in the form of a test (30%), a pass/fail exam (30%), and ongoing assessment (40%). The test and pass/fail exam consist of two parts: a written assignment (1 theory question + solving a problem) and an oral report. Ongoing assessment: 2 extended written reports based on modeling results (20% each)..

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