Syllabus
Course Program

Mathematical and Computer Modeling

Specialty
113 Applied mathematics

Institute
Educational and Scientific Institute of Computer Sciencse and Information Technology.

Educational program
Intelligent Data Analysis

Department
Computer Mathematics and Data Analysis.

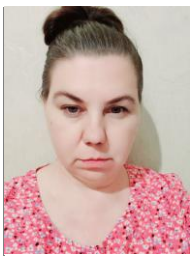
Level of education
Bachelor's level

Course type
Special (professional), Mandatory.

Semester
6

Language of instruction
Ukrainian

Lecturers and course developers



Svitlan Reshetnikova

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Candidate of Technical Sciences, Associate Professor of the Department of Computer Mathematics and Data Analysis of KhPI National Technical University

Over 20 years of work experience. Author and co-author of more than 10 scientific and educational publications. Lecturer in the disciplines: "Higher Mathematics," "Mathematical and Computer Modeling," "Mathematical Modeling of Complex Systems", etc.

More about the lecturer on the department's website

General information

Summary

The discipline is aimed at mastering the theoretical and practical foundations of mathematical modeling. It covers methods for constructing mathematical models based on knowledge and data, methods for analyzing dynamic mathematical models, and methods for identifying mathematical models.

Course objectives and goals

Acquisition of the necessary competencies in the course of mathematical and computer modeling, namely the ability to develop mathematical models and algorithms for solving scientific and practical problems, managing systems, processes, and projects, and making optimal decisions.

Format of classes

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

Competencies

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, modelling, analysis, design, management, forecasting, decision-making.
SC 13. Ability to search, systematically study and analyse scientific and technical information, domestic and foreign experience related to the use of mathematical methods to study various processes, phenomena and systems.
SC 14. Ability to understand the task statement formulated in the language of a particular subject area, to search and collect the necessary initial data.

Learning outcomes

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 3. Formalize tasks formulated in the language of a particular subject fields; formulate their mathematical formulation and choose rational method of solution; solve the resulting problems with analytical and numerical methods, evaluate the accuracy and reliability of the results obtained.
LO 4. Perform mathematical description, analysis and synthesis of discrete objects and systems, using the concepts and methods of discrete mathematics and algorithm theory.
LO 5. Be able to develop and use algorithms in practice, associated with the approximation of functional dependencies, numerical differentiation and integration, solution of algebraic, differential and integral systems of equations, solving of boundary value problems, searching for optimal solutions.
LO 6. To know the basic methods of developing discrete and continuous mathematical models of objects and processes, analytical studying these models for their existence and unity the solution.
LO 7. Be able to conduct practical research and find a solution of incorrect tasks.
LO 9. Build algorithms that are effective in terms of calculation accuracy, stability, speed, and system resource consumption for numerical research of mathematical models and solving practical problems

Отформатировано: Шрифт: 11 пт, Цвет шрифта: Текст 1

Student workload

The total volume of the course is 90 hours (3 ECTS credits): lectures – 16 hours, laboratory classes – 28 hours, self-study – 46 hours.

Course prerequisites

Mathematical Analysis (Parts 1, 2, 3), Linear Algebra, Analytical Geometry, Differential Equations and Complex Analysis, Algorithmization and Programming.

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

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Program of the course

Topics of the lectures

Topic 1. Introduction. Subject and objectives of mathematical modeling. Definition of a model, types of models. The role of mathematical modeling in engineering. The concept of model adequacy.
Topic 2. Main definitions and structural classification of mathematical models. Static and dynamic, linear and nonlinear models. Continuous and discrete-time models. Deterministic and stochastic models. Model quality criteria and methods for determining the best model.
Topic 3. Mathematical models and the main principles of mathematical modeling. Using the laws of nature. Applying analogies in model construction. Using a hierarchical approach to model creation.
Topic 4. Methods for analyzing mathematical models of dynamic systems. Stability analysis of equilibrium states and processes. Process analysis in dynamic systems.
Topic 5. Consideration of examples of modeling certain physical processes and phenomena (problems related to the movement of a body from one position to another).

Topic 6. Methods for simplifying mathematical models of complex systems. Decomposition and aggregation methods. Methods of bifurcation and catastrophe theory.
Topic 7. Numerical analysis methods for models. Simulation and computer modeling methods.
Topic 8. Modern software systems for computer mathematics and their applications for system modeling.

Topics of the workshops

Practical classes are not included in the scope of the discipline.

Topics of the laboratory classes

Topic 1. Mathematical models described by first-order differential equations. The Malthusian model.
Topic 2. Mathematical models described by first-order differential equations. The Ferhulst model.
Topic 3. Mathematical models described by first-order differential equations.
Topic 4. Mathematical models described by second-order differential equations.
Topic 5. Mathematical models described by second-order differential equations.
Topic 6. Mathematical models described by second-order differential equations.
Topic 7. Mathematical models described by systems of differential equations.
Topic 8. Mathematical models described by systems of differential equations.
Topic 9. Mathematical models described by systems of differential equations.
Topic 10. Construction of mathematical models based on dynamic and kinematic analogies.
Topic 11. Investigation of processes in conservative and dissipative dynamic systems, stability analysis.
Topic 12. Investigation of processes in conservative and dissipative dynamic systems, stability analysis.
Topic 13. Modeling in MATLAB & SIMULINK.
Topic 14. Modeling in MATLAB & SIMULINK.

Self-study

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Non-formal education

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Course materials and recommended reading

Basic literature

1. І.І. Обод, Г.Е. Заволодько, І.В. Свид. Математичне моделювання систем: навчальний посібник. / За редакцією І.І. Обода – Харків : НТУ «ХПІ», Друкарня МАДРИД, 2019. – 268 с. https://core.ac.uk/download/pdf/249365409.pdf
2. Математичне моделювання: комп'ютерний практикум з дисципліни «Математичне моделювання» [Електронний ресурс]: навч. посіб. для студ. спеціальності 113 «Прикладна математика», спеціалізації «Наука про дані та математичне моделювання» / Т. С. Ладогубець, О. Д. Фіногенов; КПІ ім. Ігоря Сікорського. – Київ: КПІ ім. Ігоря Сікорського, 2018. – 58 с. https://ela.kpi.ua/bitstream/123456789/43388/1/KompPrakt_MM.pdf
3. Sheldon Lee, Megan Buzby. Mathematical Modeling and Simulation with MATLAB. 2021. http://mitran-lab.amath.unc.edu/courses/MATH768/biblio/introduction-to-prob-models-11th-edition.PDF
4. Савченко В. М. Системний аналіз та математичне моделювання у GNU Octave: навчальний посібник / В. М. Савченко, О. Б. Маций, О. В. Мнушка. - Харків: ХНАДУ, 2020. –128 с. https://dspace.khadi.kharkov.ua/dspace/handle/123456789/2912
Бахрушин В.Є. Математичне моделювання. – Запоріжжя: ГУ «ЗІДМУ», 2004.
5. Комп'ютерне моделювання процесів та систем. Чисельні методи: підручник / С. П. Вислоух, О. В. Волошко, Г. С. Тимчик, М. В. Філіппова. – Київ: КПІ ім. Ігоря Сікорського, Вид-во «Політехніка», 2021. – 228 с.
https://ela.kpi.ua/handle/123456789/42195

Assessment and grading

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

The final grade consists of exam results (30%) and continuous assessment (laboratory work 50% + independent work 20%).
Exam: written assignment (theory questions + problem-solving) and oral presentation.
Continuous assessment: online tests, laboratory work, and a computational assignment.

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