Syllabus
Course Program

Mathematical modeling and systems analysis

Specialty
122 – Computer Science

Institute
Institute of Computer Science and Information Technology

Educational program
Computer Science and Intelligent Systems

Department
Software Engineering and Management Intelligent Technologies (321)

Level of education
Bachelor's level

Course type
Special (professional), Mandatory

Semester
3

Language of instruction
English, Ukrainian

Lecturers and course developers

Ihor Hamaiun

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Doctor of Technical Sciences (05.13.06 - automated management systems and advanced information technologies), Professor of the Department of Software Engineering and Management Intelligent Technologies.

Work experience - since 1975. Author (co-author) of more than 120 scientific and educational publications (https://www.scopus.com/authid/detail.uri?authorid=6506853631; https://orcid.org/0000-0003-2099-4658). Main courses: "Fundamentals of Scientific Research" (lectures), "Mathematical Modelling and System Analysis" (lectures, workshops), "Experiment Planning" (lectures, workshops).
More about the lecturer on the department's website

Oleksandr Shmatko

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PhD., Senior Lecturer, Ass. Professor of the Department of Software Engineering and Intelligence Technologies of NTU "KhPI"

Prepared and published more than 90 scientific and educational works Google Scholar: https://scholar.google.com/citations?user=Wyv6ESUAAAAJ
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Scopus: https://www2.scopus.com/authid/detail.uri?authorId= 6602623478
More about the lecturer on the department's website

General information

Summary

The course "Mathematical Modelling and System Analysis" is a discipline in the cycle of special mandatory training in the specialty 122 "Computer Sciences". It is taught in the seventh semester in the amount of 150 hours (5 ECTS credits), in particular: lectures - 32 hours, workshops - 32 hours, independent work - 86 hours. There are no individual tasks. The study of the discipline ends with a test.

Course objectives and goals

Formation of students' necessary theoretical knowledge and practical skills of building mathematical models of complex systems, which are necessary to determine the properties of systems, the dynamics of their functioning and forecast their development.

Format of classes

Lectures, laboratory classes. Continuous assessment - workshops, intermediary modular assessment. Final assessment - credit.

Competencies

GC1. Ability to think abstractly, analyze and synthesize.
GC2. Ability to apply knowledge in practical situations.
GC3. Knowledge and understanding of the subject area and understanding of professional activities.
GC6. Ability to learn and master modern knowledge.
GC7. Ability to search, process and analyze information from various sources.
PC1. Ability to mathematically formulate and study continuous and discrete mathematical models, justify the choice of methods and approaches for solving theoretical and applied problems in the field of computer science, analysis and interpretation.
PC3. Ability to think logically, build logical conclusions, use formal languages and models of algorithmic computing, design, develop and analyze algorithms, evaluate their effectiveness and complexity, solvability and intractability of algorithmic problems for adequate modeling of subject areas and creation of software and information systems.
PC4. Ability to use modern methods of mathematical modeling of objects, processes and phenomena, to develop models and algorithms for numerical solution of mathematical modeling problems, to take into account the errors of approximate numerical solution of professional problems.
PC5. Ability to carry out a formalized description of the tasks of researching operations in organizational, technical and socio-economic systems for various purposes, to determine their optimal solutions, to build models of optimal management taking into account changes in the economic situation, to optimize management processes in systems of various purposes and hierarchy levels.
PC6. Ability to think systematically, apply the methodology of system analysis to study complex problems of different nature, methods of formalizing and solving systemic problems with conflicting goals, uncertainties and risks.
PC18. Ability to apply modern methods of decision-making theory, including: methods of ranking, formation and coordination of collective expert opinions, multi-criteria optimization and others, to build intelligent control systems.
PC19. Ability to comprehensively use methods of mathematical modeling and analysis of complex systems, methods of modeling and analysis of business processes, information technology for managing business systems to create intelligent control systems.

Learning outcomes

PLO1. To apply knowledge of the basic forms and laws of abstract and logical thinking, the basics of the methodology of scientific knowledge, forms and methods of extracting, analyzing, processing and synthesizing information in the subject area of computer science.
PLO2. To use the modern mathematical apparatus of continuous and discrete analysis, linear algebra, analytical geometry in professional activities to solve theoretical and applied problems in the design and implementation of information objects.
PLO6. To use methods of numerical differentiation and integration of functions, solution of ordinary differential and integral equations, features of numerical methods and possibilities of their adaptation to engineering problems, to have skills in software implementation of numerical methods.
PLO7. Understand the principles of modeling organizational and technical systems and operations; use methods of researching operations, solving single and multi-criteria optimization problems of linear, integer, nonlinear, stochastic programming.
PLO8. To use the methodology of system analysis of objects, processes and systems for the tasks of analysis, forecasting, management and design of dynamic processes in macroeconomic, technical, technological and financial objects.

PLO18. To apply modern methods of decision-making theory to build intelligent control systems, including methods of ranking, formation and coordination of collective expert opinions, multi-criteria optimization, and others.
PLO19. To create intelligent management systems using methods of mathematical modeling and analysis of complex systems, methods of modeling and analysis of business processes, information technology management of business systems.

Student workload

The total volume of the course is 150 hours (5 ECTS credits): lectures - 32 hours, laboratory classes - 32 hours, self-study - 86 hours.

Course prerequisites

Higher mathematics
Fundamentals of computer science and artificial intelligence methods
Algorithmization and programming
Algorithms and data structures

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

Teaching and learning methods:
interactive lectures with presentations, discussions, laboratory classes, teamwork, case method, student feedback, problem-based learning.
Forms of assessment:
written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), express surveys (CAS), online tests (CAS), final/semester control in the form of a semester exam, according to the schedule of the educational process (FAS).

Program of the course

Topics of the lectures

Topic 1. The concept of a mathematical model of a complex system and methods of implementing the process of its construction.
Construction of models of complex systems taking into account the hierarchy of their structure. Problems of building aggregate models.
Topic 2. Analytical modelling of the main types of processes in complex systems
Models of combination of elements of a complex system.
Topic 3. The essence of simulation and features of its use
The choice of simulation language at the stage of software implementation of the simulation model.
Topic 4. Statistical modelling in analytical and simulation models
Methods of processing and analysis of results of experiments with models of systems.

Topics of the workshops

Workshops are not provided within the discipline.

Topics of the laboratory classes

Topic 1. Familiarization with the AnyLogic simulation environment
Topic 2. Building models of system dynamics in the AnyLogic environment
Topic 3. Construction of discrete-event models in the AnyLogic environment
Topic 4. Building agent models in the AnyLogic environment

Self-study

Individual assignments are not provided in the curriculum.
Students are recommended with additional materials (videos, articles) for self-study and processing.

Course materials and recommended reading

Key literature

1. Zelenskyi K.H., Keith G.V., Chumachenko O.I. Computer modeling of systems. University "Ukraine", 2014. - 314 p.
2. Dubovoi V.M., Kvetny R.N., Mykhalyov O.I., Usov A.V. Modeling and optimization of systems. - Vinnytsia: PE TD "Edelweiss". 2017. - 804 p.
3. Pavlenko P.M., Filonenko S.F., Cherednikov O.M., Treytyak V.V. Mathematical modeling of systems and processes: teaching. guide/P.M. Pavlenko, S.F. Filonenko - K.: NAU. 2017. - 392 p.
4. Easter S.S. Modeling of systems. - K.: KPI. 2018. - 186 p.
5. Savchuk O.V. Modeling processes and systems. - K.: KPI.2021. - 220s.
6. Complex D.M. Modeling and optimization of objects and management systems. - K.: KPI. 2021. - 199 p.
7. Pasichnyk V.V., Vyklyuk Y.I., Kaminsky R.M. Modeling of complex systems. University "Ukraine". 2021. - 404 p.

Additional literature

1. Tabunshchik, G. V., Kaplienko, T. I., Petrova, O. A. (2016). Design and modeling of software of modern information systems: Education. manual Zaporizhzhia.
2. Petryk, M.R., Petryk O.Yu. (2015). Software modeling: Scientific method. manual Ternopil: Publishing House of TNTU.
3. Banerjee S. (2021). Mathematical Modeling: Models, Analysis and Applications. CRC Press.
4. Borshchev A. (2013). The Big Book of Simulation Modeling: Multimethod Modeling with AnyLogic. AnyLogic North America.
5. Educational information for Ukrainian students. [Electronic resource] - Access mode: http://ni.biz.ua/3/3_20/3_20563_analiz-trebovaniy-k-avtomatizirovannim-informatsionnim-sistemam.html
6. Lyushenko, L. A. Development and analysis of software requirements: Education. manual [Electronic resource] - Access mode: https://ela.kpi.ua/handle/123456789/38101
7. Business Process Model and Notation (BPMN), Version 2.0. Retrieved from. https://www.omg.org/spec/BPMN/2.0/PDF
8. How to learn AnyLogic. Retrieved from. https://www.anylogic.com/getting-started/

Assessment and grading

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

100% Final assessment as a result of Final credit (30%) and Continuous assessment (70%).
30% Final credit
70% Continuous assessment:
Module №1 (10%)
Module №2 (20%)
Workshop (40%)
Workshop №1 (10%)
Workshop №2 (10%)
Workshop №3 (10%)
Workshop №4 (10%)

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	08.06.2023	Head of the department Ihor HAMAIUN
	08.06.2023	Guarantor of the educational program Andrii KOPP