Syllabus
Course Program

Computer mathematics

Specialty
121 – Software Engineering

Institute
Institute of Computer Science and Information Technology

Educational program
Software Engineering

Department
Software Engineering and Management Intelligent Technologies (321)

Level of education
Bachelor's level

Course type
Special (professional), Mandatory

Semester
3-5

Language of instruction
English, Ukrainian

Lecturers and course developers

Nataliia Khatsko

nataliia.khatsko@khpi.edu.ua

Ph.D., associate professor at the Department of Software Engineering and Management Intelligent Technologies of NTU «KhPI», associate professor.

Prepared and published more than 40 research papers and textbooks
SCOPUS Author ID:
https://www.scopus.com/authid/detail.uri?authorId=57200820629;
Researcher ID https://app.webofknowledge.com/author/#/record/17252627;
Google Scholar:
https://scholar.google.com.ua/citations?user=US7Ovx4AAAAJ&hl=uk;
ORCID ID: https://orcid.org/0000-0002-2543-0280)
Basic courses: "Computer Mathematics (parts 1, 2, 3)", "Practical seminar on mathematical methods in software engineering", "Formal methods of software verification", "Formal methods of software systems research"
More about the lecturer on the department's website

Natalia Chernova

natalia.chernova@khpi.edu.ua

Ph.D., associate professor at the Department of Software Engineering and Management Intelligent Technologies of NTU «KhPI», associate professor

SCOPUS Author ID:
https://www.scopus.com/authid/detail.uri?authorId=57212460303
ORCID ID: https://orcid.org/0000-0002-0073-8457
Google Scholar:
https://scholar.google.com.ua/citations?user=wiZylc4AAAAJ&hl

More about the lecturer on the department's website

Rositsa Shvorak

rositsa.maneva@khpi.edu.ua

Ph.D., senior lecturer at the Department of Software Engineering and Management Intelligent Technologies of NTU «KhPI»

SCOPUS Author ID:
https://www.scopus.com/authid/detail.uri?authorId=57195737832

More about the lecturer on the department's website

Iryna Liutenko

iryna.liutenko@khpi.edu.ua
Candidate of Technical Sciences (PhD), Associate Professor, Associate Professor of the Department of Software Engineering and Management Intelligent Technologies of NTU "KhPI"

Prepared and published more than 60 publications, 1 collective monograph, 1 textbook with the university stamp, 3 articles in publications indexed in Scopus (Google Scholar: https://scholar.google.com/citations?user=9EhcsRcAAAAJ; ORCID: https://orcid.org/0000-0003-4357-1826).
More about the lecturer on the department's website

Kateryna Yahup

Kateryna.Yahup@khpi.edu.ua
Doctor of Technical Sciences, Professor, published more than 90 scientific papers, basic courses " Software Architecture Basics", "Discrete Mathematics".

More about the lecturer on the department's website

General information

Summary

Acquaintance of students with mathematical models and methodologies of operations research; study of general properties and solution of linear programming problems; study of nonlinear optimization methods, computer discrete mathematics.

Course objectives and goals

Formation of students' modern system of views in the field of computer mathematics, acquisition of practical skills in the use of formal methods and models of computer mathematics in information processing and description of processes related to software development; acquaintance of students with the basic concepts, models and methods of set theory, algebra of relations, mathematical logic, graph theory; formation of students' understanding of the basic models and methods of discrete mathematics, acquaintance with the possibilities of applying the studied modes Formation of students' theoretical and practical knowledge of the theory of finite automata and its accompanying concepts (grammar, language, regular expression). Formation of students' modern system of views in the field of computer discrete mathematics, acquisition of practical skills in the use of formal methods and models of discrete mathematics in the processing of discrete information and description of discrete processes related to software development.

Format of classes

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

Competencies

К01. Ability to think abstractly, analyze and synthesize.
К05. Ability to learn and master modern knowledge.
К06. Ability to search, process and analyze information from various sources.
К20. Ability to apply fundamental and interdisciplinary knowledge to successfully solve software engineering problems.
К26. Ability to think algorithmically and logically.

Learning outcomes

PLO01. Analyze, purposefully search and select information and reference resources and knowledge necessary for solving professional problems, taking into account modern achievements of science and technology.
PLO05. To know and apply relevant mathematical concepts, methods of domain, system and object-oriented analysis and mathematical modeling for software development.
PLO18. To know and be able to apply information technologies for data processing, storage and transmission.

Student workload

The total volume of the course is 390 hours (13 ECTS credits): lectures - 80 hours, workshops - 96 hours, self-study - 214 hours.

Course prerequisites

Higher mathematics.
Theory of algorithms.

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, in accordance with the schedule of the educational process (FAS).

Program of the course

Topics of the lectures

Topic 1: Introduction to operations research
Topic 2. Form of writing and geometric interpretation of LP problems
Topic 3. Linear programming problem reference plans and their properties Sub-topics / list of questions
Topic 4. Method of sequential improvement of the plan (first algorithm)
Topic 5: The method of successive improvement of the plan (second algorithm) or the inverse matrix method.
Topic 6. The method of artificial basis
Topic 7. M-method for solving linear programming problems
Topic 8: Post-optimization analysis in linear programming
Topic 9: General properties of integer programming problems
Topic 10. Methods for solving integer programming problems
Topic 11. Transport problems. Determination of the initial reference plan
Topic 12. Transport problems. Method of potentials
Topic 13. Dynamic programming
Topic 14. Markov chains
Topic 15. Game theory

Topic 16. General properties of nonlinear programming problems
Topic 17. Numerical methods of one-dimensional unconditional optimization
Topic 18. Numerical methods of the 0th order
Topic 19. Numerical methods of the 1st order
Topic 20. Numerical methods of the 2nd order
Topic 21. Conditional optimization
Topic 22. Algebra of sets
Topic 23. Binary relations
Topic 24. Forms of representation and implementation of Boolean functions
Topic 25. The problem of minimizing Boolean functions
Topic 26. Graphs. Basic concepts and definitions.
Topic 27. Reachability and connectivity in graphs
Topic 28. Colouring graphs
Topic 29. The tree. The skeleton of a graph
Topic 30. Algorithms for finding the shortest paths in a graph
Topic 31. Cycles and the traveling salesman problem
Topic 32. Streaming algorithms
Topic 33. Introduction to the theory of formal proofs
Topic 34. Alphabets, grammars and languages
Topic 35. Regular expressions, languages.
Topic 36. Deterministic finite automata
Topic 37. Non-deterministic finite automata
Topic 38. Finite automata with epsilon transitions
Topic 39. Finite automata and regular expressions
Topic 40. Converting a regular expression to a finite state machine
Topic 41. Automata with store memory

Topics of the workshops

Topic 1: Mathematical models and methodology of operations research. Construction of mathematical models.
Topic 2. Reference plans of linear programming problems and their properties. Solving LP problems based on the theorem of the existence of a reference plan.
Topic 3. Finite methods for solving LP problems. The method of sequential plan improvement
Topic 4. Artificial basis method and M-method.
Topic 5. Elements of duality theory in linear programming.
Topic 6. Integer linear programming. Gomori method.
Topic 7. The method of branches and boundaries.
Topic 8. Transport problems. Northwest corner method. The method of potentials.
Topic 9. Dynamic programming
Topic 10. Markov chains
Topic 11. Game theory
Topic 12. Algebra of sets
Topic 13. Binary relations
Topic 14. Forms of representation and implementation of Boolean functions
Topic 15. Post classes
Topic 16. The problem of minimizing Boolean functions
Topic 17. Basic concepts of graph theory.
Topic 18. Matrix problem of a graph
Topic 19. Operations on graphs
Topic 20. Reachability and connectivity in graphs.
Topic 21. Tree. The skeleton of the graph.
Topic 22. Algorithms for finding the shortest paths in a graph
Topic 23. Hamiltonian paths, contours and the traveling salesman problem.
Topic 24. Streaming algorithms.

Topic 25. Solving problems of chain inference by inference rules, parsing chains
Topic 26. Solving problems. Description of deterministic finite automata.
Topic 27. Solving problems. Description of non-deterministic finite automata and their transformations.
Topic 28. Transformations of automata
Topic 29. Transforming a deterministic finite state machine into a regular expression.
Topic 30. Converting a regular expression to a finite state machine.

Topics of the laboratory classes

The course does not include laboratory classes.

Self-study

Information on self-study and individual assignments (reports, course projects, etc.), if it is necessary according to the plan. Also, methods of control and assessment of self-study. The curriculum includes the completion of coursework (CW). At the beginning of the semester, students choose the topics of the course work from the list or propose their own topics and agree them with the teacher. The CW is completed during the semester and is defended during the test week or examination session.
Students are recommended with additional materials (videos, articles) for self-study and processing.

Course materials and recommended reading

Compulsory materials

1.Hamdy A. Taha. (2017). Operations Research: An I Introduction (10th Global Edition). Pearson.
2. Godlevsky, M. D., Lisitsky, V. L., Stratienko, N. K. (2016). Operations Research: Problem Solving and Variants of Typical Calculations: Textbook for Students in Computer Science. Kharkiv : NTU KhPI.
3. Wayne L. Winston. (2021). Operations Research: Applications and Algorithms. (4th ed.). Cham: Springer Nature Switzerland AG.
4. Guzhva, V. O., Stratienko, N. K., Borodina, I. O. (2018). Methodical instructions for performing laboratory work in the course "Operations Research": [Electronic resource]: for students studying in speciality 121 "Software Engineering" and 122 "Computer Science". Kharkiv: NTU "KHPI".
5. John Vince. (2020). Foundation Mathematics for Computer Science: A Visual Approach. (2nd ed.). Springer.
6. Frederick S Hillier, Gerald J Lieberman. (2021). Introduction to operations research. (Eleventh ed.). New York, NY: McGraw-Hill EducG.
7. Ajit Singh (2019) Formal Language And Automata Theory.
8. Abejide Ade-Ibijola (2017) New Finite Automata Applications in Novice Program Comprehension. LAP LAMBERT Academic Publishing, 2017.
9. Neeru Gupta (2020) Beginner's Guide - Automata Theory.
10. Ezhilarasu Umadevi Palani (2019) Finite Automata Problems & Solutions. LAP Lambert Academic Publishing.
11. Stoyan Mihov, Klaus U. Schulz (2019) Finite-State Techniques: Automata, Transducers and Bimachines. - Cambridge University Press.

Additional materials

12. Jun Wu. (2018). The Beauty of Mathematics in Computer Science. Chapman & Hall.
13. Eric Lehman, F. Thomson Leighton, Albert R. Meyer. (2017). Mathematics for Computer Science. 12th Media Services.

Assessment and grading

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

100% final assessment in the form of a test (30%) and a current assessment (70%).
30% credit: semester credit, according to the schedule of the educational process
70% current assessment:
- 20% assessment of tasks in practical classes;
- 20% assessment of the calculation task;
- 30% intermediate control (2 module tests)

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	30.08.2023	Head of the department Ihor HAMAIUN
	30.08.2023	Guarantor of the educational program Uliya LITVINOVA