Syllabus
Course Program

Discrete Mathematics

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
4

Language of instruction
English, Ukrainian

Lecturers and course developers

Nataliia Khatsko

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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; GoogleScholar https://scholar.google.com.ua/citations?user=US7Ovx4AAAAJ&hl=uk; ORCID 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

Vasyl Lysytskyi

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Candidate of Technical Sciences (PhD), Associate Professor, Associate Professor of the Department of Software Engineering and Information Technologies of NTU "KhPI"

Prepared and published more than 223 scientific and educational works (Google Scholar: https://scholar.google.com/citations?user=FxRkzQoAAAAJ).
More about the lecturer on the department's website

General information

Summary

The course "Discrete Mathematics" is an academic discipline from the cycle of special compulsory training in the specialty 122 - "Computer Science". It is taught in the third semester in the amount of 120

hours (4 ECTS credits), in particular: lectures - 32 hours, laboratory classes - 32 hours, independent work - 56 hours. There are no individual assignments. The discipline ends with a test.

Course objectives and goals

The aim of the discipline is to form students' modern system of views in the field of computer discrete mathematics, to acquire 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. Continuous assessment - laboratory work, intermediate module assessment. The final control is a test.

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.

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.
PLO5. Design, develop and analyze algorithms for solving computational and logical problems, evaluate the effectiveness and complexity of algorithms based on the use of formal models of algorithms and computable functions.

Student workload

The total volume of the course is 120 hours (4 ECTS credits): lectures - 32 hours, laboratory classes - 32 hours, self-study - 56 hours.

Course prerequisites

Higher mathematics
Algorithms and data structures
Probability theory and mathematical statistics
Mathematical modeling and systems analysis

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 1-2. Algebra of sets
The concept of sets. Specification of sets. Venn diagrams. Basic operations on sets. Tautologies. Basic laws of set algebra. Algebraic expressions and their transformations.
Topic 3. Binary relations
Cartesian product of sets, its properties. The concept of a relation. Binary relations, ways to set them. Types of binary relations. Functions and mappings. Equivalence relations and their properties. Quasi-, partial, linear order relations. Ordered sets and their properties.
Topic 4. Forms of representation and implementation of Boolean functions
The concept of a Boolean function (BF), its properties. Elementary BF, the relationship between them. Carrier of BF and its properties. Superposition of BF. Special types of BF.
Topic 5-6. The problem of minimizing Boolean functions.
The concept of complexity of a Boolean function. Formulation of the problem of minimizing BF in the class of disjunctive normal forms (DNF). The implicant of a BF and its properties. Reduced DNF, minimal DNF. General scheme of construction of minimal DNF. The general scheme of constructing a reduced DNF. The second stage of minimizing the BF in the class of DNFs. Zhuravlev's criterion.
Topic 7. Logic of statements
Statements and logical connections. Conditional statements. Equivalent statements.
Topic 8. The logic of predicates
The concept of a predicate. Logical operations on predicates. Quantifiers. The concept of multi-place predicates
Topics 9-10. Fundamentals of combinatorics
Basic concepts of combinatorics. The rule of sums and products. Permutations, placements and combinations without repetitions. Permutations, placements and combinations with repetitions. Examples of combinatorial problems from various fields of knowledge.
Topics 11-12. Recurrence relations
Basic concepts. Linear homogeneous recurrence relations with constant coefficients. Linear recurrence relations with constant coefficients.
Topic 13. Graphs
Basic concepts and definitions. Types of graphs. Strongly connected graphs and graph components. Matrix image. Operations on graphs.
Topic 14: Achievability and connectivity
Matrixes of reachability and counter-reachability. Finding strong components. Application to the study of the structure of organizations.
Topic 15-16. Trees. Properties of trees.
The process of building a tree set and restoring a tree from a set. Counting the number of trees in a graph. The shortest spanning tree of a graph. Algorithm for constructing the skeleton.

Topics of the workshops

Workshops are not provided within the discipline.

Topics of the laboratory classes

Topic 1-2. Sets, ways of setting and operations on them. Correspondences between sets.
Topic 3-4. Binary relations, ways to set them. Equivalence relations and their properties.
Topics 5-6. Boolean functions. Realization of functions by formulas. Equivalence of formulas. The principle of duality.
Topic 7. Minimization of Boolean functions. Methods for obtaining reduced and minimal Boolean functions.
Topic 8. Logical statements and predicates

Topics 9-10. Permutations, placements and combinations without repetitions. Permutations, placements and combinations with repetitions. Examples of combinatorial problems from various fields of knowledge.
Topic 11. Linear recurrence relations with constant coefficients
Topics 12-13. Complete and bipartite graphs. Operations on graphs. Strongly connected graphs and graph components.
Topic 14. Matrixes of achievement and counter-achievement.
Topics 15-16. The process of building a tree set and restoring a tree from a set. Counting the number of trees in a graph. The shortest spanning tree of a graph. Algorithm for constructing the skeleton.

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. Kwong H. A Spiral Work book for Discrete Mathematics - New York: Open SUNY Textbooks, 2015.
2. R. Pass and Wei-Lung D. Tseng A Course in Discrete Structures
3. Stein C., Drysdale R.L., Bogart K. Discrete Mathematics for Computer Scientists - Boston: Pearson Education, Inc. 2011.
4. Computer discrete mathematics: Textbook / M.F. Bondarenko, N.V. Bilous, A.G. Rutkas - Kharkiv: SMIT Company, 2004. 480 p.

Additional literature

1. Oscar Levin. Discrete Mathematics. University of Northern Colorado, -2019. 412p.
2. Clifford Stein, Robert L. Drysdale, Kenneth Bogart. DISCRETE MATHEMATICS FOR COMPUTER SCIENTISTS. Pearson Education: Boston. -2011. 526 p.
3. Eric Lehman, F Thomson Leighton, Albert R Meyer. Mathematics for Computer Science. - Massachusetts, 2017. 1006p.
4. Douglas B. (2020). West. Combinatorial Mathematics. Cambridge University Press.
5. Jon Pierre Fortney (2021). Discrete Mathematics for Computer Science An Example-Based Introduction. Chapman and Hall/CRC.
6. Sriraman Sridharan, R. Balakrishnan. (2019). Discrete Mathematics, Graph Algorithms, Algebraic Structures, Coding Theory, and Cryptography. Chapman and Hall/CRC.
7. Ryan T. White, Archana Tikayat Ray (2021). Practical Discrete Mathematics. Packt.
8. James A. Anderson, Jerome Lewis, O. Dale Saylor (2003). Discrete Mathematics With Combinatorics. Prentice Hall. Subsequent edition.
9. David Guichard (2021). An Introduction to Combinatorics and Graph Theory.
10. Susanna Epp. (2019). Discrete Mathematics with Applications. Cengage Learning. Inc.
11. Novotarsky, M. A. (2020). Discrete mathematics. Kyiv: Igor Sikorsky Kyiv Polytechnic Institute.
12. Kotsovskyi, V. M. (2020). Fundamentals of discrete mathematics. Uzhhorod.
13. Konovalenko, O. E., Tkachuk, M. A., Grabovsky, A. V. (2016). Discrete mathematics: a study guide. Kharkiv: NTU "KHPI".
14. Kubliy LI (2020). Computer discrete mathematics. Kyiv: Igor Sikorsky Kyiv Polytechnic Institute.
15. Nikolsky, Y. V., Pasichnyk, V. V., Shcherbyna, Y. M. (2016). Discrete mathematics: Textbook (4th ed.). Lviv: Magnolia.
16. D. Goswami and K. V. Krishna. Formal Languages and Automata Theory: http://www.iitg.ernet.in/dgoswami/Flat-Notes.pdf.
17. Introduction to Automata and Complexity Theory: http://infolab.stanford.edu/~ullman/ialc/spr10/spr10.html
18. Formal Languages and Automata Theory: http://cs.fit.edu/~dmitra/FormaLang

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, respectively to the schedule of the educational process
70% current assessment:
- 18% assessment of tasks in laboratory work;
- 22% assessment of the calculation task;
- 30% intermediate assessment (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 08.06.2023 Head of the department
Ihor HAMAIUN

08.06.2023 Guarantor of the educational program
Andrii KOPP