

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
SIMON KUZNETS KHARKIV NATIONAL UNIVERSITY OF ECONOMICS

APPROVED

at the meeting of Economic and
Mathematical Modeling Department
Protocol № 8 of 08.01.2026

AGREED

Vice-rector for educational and methodical
work

_____ Karina NEMASHKALO



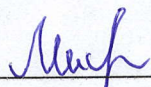
DISCRETE MATHEMATICS
Program of the course

Field of knowledge	F Information Technologies
Specialty	F3 Computer Sciences
Study cycle	first (bachelor)
Study programme	Computer Sciences


Course status
Language

mandatory
English

Developers:
PhD (Technics),
Associate Professor
PhD (Technics),
Associate Professor

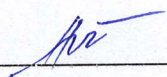
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Ievgeniia MISIURA

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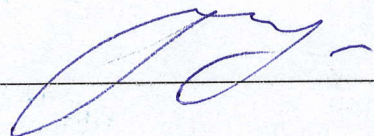
Tetiana DENYSOVA

Head of Economic and
Mathematical Modeling
Department

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Lyudmyla MALYRETS

Head of Study Programme

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Dmytro GOLUBNYCHIY

Kharkiv
2026

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
ХАРКІВСЬКИЙ НАЦІОНАЛЬНИЙ ЕКОНОМІЧНИЙ УНІВЕРСИТЕТ
ІМЕНІ СЕМЕНА КУЗНЕЦЯ

ЗАТВЕРДЖЕНО

на засіданні кафедри
економіко-математичного моделювання
Протокол № 8 від 08.01.2026 р.

ПОГОДЖЕНО

Проректор з навчально-методичної роботи


Каріна НЕМАШКАЛО

ДИСКРЕТНА МАТЕМАТИКА

робоча програма навчальної дисципліни (РПНД)

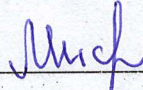
Галузь знань
Спеціальність
Освітній рівень
Освітня програма

F Інформаційні технології
F3 Комп'ютерні науки
перший (бакалаврський)
Комп'ютерні науки

Статус дисципліни
Мова викладання, навчання та оцінювання


обов'язкова
англійська

Розробники:
к.т.н., доцент



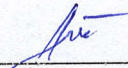
Євгенія МІСЮРА

к.т.н., доцент



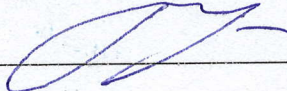
Тетяна ДЕНИСОВА

Завідувач кафедри
економіко-математичного
моделювання



Людмила МАЛІЯРЕЦЬ

Гарант програми



Дмитро ГОЛУБНИЧИЙ

Харків
2026

INTRODUCTION

The program of studying the course "Discrete Mathematics" is compiled according to the study programme in the specialty F3 "Computer Sciences" of preparation of bachelors "Computer Sciences" in the field of knowledge F "Information Technologies". The course "Discrete Mathematics" belongs to the cycle of mandatory educational units of bachelor's training.

Mathematical methods of research, modeling and design play an increasingly important role in modern science and technology. This is due to the improvement of computer technology, thanks to which the possibility of successfully applying mathematics in solving specific problems has significantly increased. Mathematical sciences are closely related to the development of information computer technologies, which have penetrated into almost all spheres of human activity and play a decisive role in the education of a modern competitive specialist, providing him with the apparatus for researching complex systems of any nature and the logic of building project activities. On the other hand, high-performance information technologies have turned into the most important segment of knowledge-intensive high-tech production, which can be implemented only by specialists with in-depth training in the field of mathematics and information technologies.

Discrete mathematics is a branch of mathematics, **the object** of study of which is discrete sets and discrete variables, and **the subject** is the properties of these objects, the establishment and study of various correspondences between them, their application to the construction of mathematical problems of a professional orientation.

The purpose of the educational course: to acquaint applicants for higher education with the basic concepts, ideas and methods of logical analysis, to teach them to use them when solving specific practical problems, to prepare applicants for the study of special courses and independent study of mathematical and scientific and technical literature, to form an integrated system of theoretical knowledge, necessary for the professional activity of a competent specialist in the field of information technologies, to develop the skills of analytical thinking and the skills of applying mathematical apparatus to the formalization of real processes and phenomena.

The mathematical apparatus of "Discrete Mathematics" is necessary in the process of studying educational courses related to the theories of information, algorithms and programs, management processes, mass service, etc., and can also be directly applied to solving many applied problems of a professional orientation.

The objectives of the course are:

- development of skills in mathematical research of applied problems related to professional activity;
- formation of analytical and research competences in applicants for higher education regarding the use of tools of the theory of sets and relations, combinatorial analysis, graph theory, mathematical logic and automata theory in professional activities, namely: analysis, composition and decomposition of information complexes and processes; mastering the basic principles of creating and operating automated control and design systems, integrated information processing systems and their

components (application program packages, distributed data banks, data transmission networks);

– gaining experience in solving problems of economic dynamics, theories of information, algorithms of mass service, optimization problems of the economy.

The learning outcomes and competencies formed by the course are defined in table 1.

Table 1

Learning outcomes and competencies formed by the course

Learning outcomes	Competencies
LO1	GC1, GC4, SC2, SC4, SC5, SC6, SC8, SC11
LO2	GC1, GC2, GC3, GC4, GC5, GC6, GC10, GC12, GC13, SC3
LO3	GC1, GC2, GC10, GC12, GC13, SC1, SC2

where, LO1. Apply knowledge of the fundamental forms and laws of abstract and logical thinking, the basics of scientific methodology, and the forms and methods of extracting, analyzing, processing, and synthesizing information in the field of computer science;

LO2. Use modern mathematical tools of continuous and discrete analysis, linear algebra, and analytical geometry in professional activities to solve theoretical and applied problems in the process of designing and implementing informatization objects;

LO3. Use knowledge of the laws of random phenomena, their properties and operations, models of random processes, and modern software environments to solve problems of statistical data processing and to build predictive models;

GC1. Ability to think abstractly, to analyze and to synthesize;

GC2. Ability to apply knowledge in practical situations;

GC3. Knowledge and understanding of the subject area and of professional activity;

GC4. Ability to communicate in the official (state) language, both orally and in writing;

GC5. Ability to communicate in a foreign language;

GC6. Ability to learn and to master modern knowledge;

GC10. Ability to be critical and self-critical;

GC12. Ability to evaluate and ensure the quality of the work performed;

GC13. Ability to act on the basis of ethical considerations;

SC1. Ability to formulate and investigate continuous and discrete mathematical models, justify the choice of methods and approaches for solving theoretical and applied problems in the field of computer science, and analyze and interpret the results;

SC2. Ability to identify statistical patterns in non-deterministic phenomena and to apply methods of computational intelligence, in particular statistical, neural network, and fuzzy data processing, as well as machine learning and genetic programming methods;

SC3. Ability to think logically, draw logical conclusions, use formal languages and models of algorithmic computation, design, develop, and analyze algorithms, and evaluate their efficiency, complexity, and the solvability or insolvability of algorithmic problems for adequate modelling of subject areas and the development of software and information systems;

SC4. Ability to use modern methods of mathematical modelling of objects, processes, and phenomena; to develop models and algorithms for the numerical solution of mathematical modelling problems; and to take into account the errors of approximate numerical solutions when solving professional problems;

SC5. Ability to formally describe operations research problems in organizational, technical, and socio-economic systems of various purposes, determine their optimal solutions, develop optimal management models taking into account changes in the economic environment, and optimize management processes in systems of different purposes and hierarchy levels;

SC6. Ability to think systematically and to apply systems analysis methodology to the study of complex problems of various nature, as well as methods of formalization and solving systemic problems with conflicting goals, uncertainties, and risks;

SC8. Ability to design and develop software using various programming paradigms, including generalized, object-oriented, functional, and logical paradigms, with appropriate computational models, methods, and algorithms, data structures, and control mechanisms;

SC11. Ability to perform intelligent data analysis using computational intelligence methods, including large and poorly structured datasets, as well as to conduct their operational processing and visualization of analysis results in the process of solving applied problems.

COURSE CONTENT

Content module 1: Set theory and combinatorial analysis. Graph theory.

Topic 1: Set theory and relations.

1.1. Sets: definition of basic concepts, operations on sets.

The purpose, object, subject and main tasks of the educational course, its role in the development of the fundamentals of systems theory. Initial information related to the concept of "set": element, empty set, equal sets, subset, universe. Methods of specifying sets. Operations on sets: union, intersection, difference, addition. Euler - Venn diagrams. Splitting sets.

1.2. Types of sets. Algebra of sets.

Bijection Equivalent sets. Power of sets. Finite and infinite, countable and uncountable sets. Continuous and discrete numerical sets. Closed set. Algebra of sets: definition, basic laws, principle of duality. Tuples Direct (Cartesian) product of sets.

1.3. Binary relations (BR).

BR: basic definitions, operations on BR. Geometric and matrix representations of BR. The main characteristics (properties) of BR: reflexivity, antireflexivity, symmetry, antisymmetry, asymmetry, transitivity. The main types of BR: equivalence,

relation of order, dominance, tolerance. Use of BR in information systems. Functional BR: definition, varieties depending on the area of an existence and the area of values. functions, functionals, operators. Composition of functions, injective, bijective, inverse functions, bounded functions, their properties.

Topic 2. Combinatorial analysis (CA)

CA: subject, main tasks, basic rules (product, amounts, inclusion and exclusion (screening method)). Basic combinatorial configurations (rearrangement, placement, combinations) without repetitions and with repetitions: definitions, formulas for calculating their number. Scheme of "urns and balls" for interpretation (modeling) of combinatorial configurations. General recommendations for solving problems on finding the number of basic combinatorial configurations. Combinatorial problems of enumeration and list. Recurrent relations. Enumerators (creative functions) and denumerators. The problem of splitting natural numbers.

Topic 3. Graph Theory

3.1. Undirected graphs.

Types of graphs. Undirected graphs: definition of basic concepts, methods of assignment. Subgraph, route, chain, cycle. Finding the chains of the smallest length. Connectivity of graphs, trees and forest on graphs. Construction of an economic tree. Analysis of features of tree graphs.

3.2. Oriented graphs.

Oriented graphs: definition of basic concepts, methods of assignment. Path, outline. Grid charts (GC): basic definitions, construction rules. Solving optimization problems on GC: the problem of finding the critical time and the critical path.

3.3. Transport networks (TN).

TN: basic definitions, finding the full flow. Cuts on TN.

Theorem about minimum cuts and maximum flows. The problem of finding the maximum flow on TN (Ford-Fulkerson algorithm).

Content module 2: Mathematical logic. Elements of the theory of finite automata

Topic 4. Algebra of statements. Logical formulas

4.1. Algebra of statements.

Expressions: basic definitions, logical operations. Algebra of statements, laws of algebra of logic. Isomorphic algebras, Boolean algebras. Areas of practical application of mathematical logic.

4.2. Logical formulas.

Logical formulas: definition, classification, principle of duality. Solvability problem: statement and methods of solution. Disjunctive and conjunctive normal forms (DNF, CNF): definition, construction. Perfect DNF, CNF: definition, construction according to known DNF, CNF. Formulas for the decomposition of logical formulas and their application to the construction of normal forms.

Topic 5. Boolean functions (BF)

5.1. BF: basic concepts, area of an existence, assignment methods, normal forms. Canonical minimization of BF: formulation of the problem, methods of minimization (analytical, tabular, graphical).

5.2. Application of BF to the analysis and synthesis of contact circuits.

Contacts: definition, varieties, operations on contacts. Algebra of contact circuits. Problems of analysis and synthesis of contact circuits: formulation, solution algorithms.

5.3. The application of BF to the analysis and synthesis of logic circuits.

Logical elements: varieties, schematic representation. Input, output, internal variables. Logic schemes. Problems of analysis and synthesis of logical schemes: formulation, solution algorithms.

Topic 6. Predicates and quantifiers

Free variables. Predicates: examples, basic definitions, methods of assignment. Operations on predicates. Identically true and equivalent predicates. Quantifiers of generality and existence: definition, properties. Writing statements in the language of predicate logic. Predicate formulas.

Topic 7. Elements of the theory of finite automata

7.1. Finite automata: basic definitions, classification.

Cybernetic systems: definition of basic concepts. Finite automata as control systems: basic definitions, assignment methods, properties, classification.

7.2. Analysis, synthesis and minimization of finite automata.

Problems of analysis, synthesis and minimization of finite automata: formulation of problems and their solution.

The list of practical (seminar) studies in the course is given in table 2.

Table 2

The list of practical (seminar) studies

Name of the topic and/or task	Content
Topic 1	Practice 1. Theory of sets. Analysis of binary relations
Topic 2	Practice 2. Combinatorial analysis
Topic 3	Practice 3. Undirected graphs Practice 4. Oriented graphs
Topic 4	Practice 5. Algebra of expressions. Logical formulas
Topic 5	Practice 6. Boolean functions Practice 7. Application of Boolean functions
Topic 6	Practice 8. Predicates and quantifiers
Topic 7	Practice 9. Analysis and synthesis of finite automata

The list of laboratory studies in the course is given in table 3.

Table 3

The list of laboratory studies

Name of the topic and/or task	Content
Topic 1	Laboratory study 1. Theory of sets. Analysis of binary relations
Topic 2	Laboratory study 2. Combinatorial analysis
Topic 3	Laboratory study 3. Undirected graphs Laboratory study 4. Oriented graphs
Topic 4	Laboratory study 5. Algebra of statements. Logical formulas
Topic 5	Laboratory study 6. Boolean functions Laboratory study 7. Application of Boolean functions
Topic 6	Laboratory study 8. Predicates and quantifiers
Topic 7	Laboratory study 9. Analysis and synthesis of finite automata

The list of self-studies in the course is given in table 4.

Table 4

List of self-studies

Name of the topic and/or task	Content
Topic 1-7	Search, selection and review of literature on a given topic
Topic 1-7	Preparation for practical studies
Topic 1-7	Performing homework
Topic 1-7	Performing an independent creative task
Topic 1-7	Preparation for laboratory studies
Topic 1-7	Performing individual educational and research tasks

The number of hours of lectures, practical (seminar) and laboratory studies and hours of self-study is given in the technological card of the course.

TEACHING METHODS

In the process of teaching the course, in order to acquire certain learning outcomes, to activate the educational process, it is envisaged to use such teaching methods as:

Verbal (problem lectures (Topic 1, Topic 2, Topic 4, Topic 5, Topic 7), lecture-discussion (Topic 3, Topic 6), brainstorming (Topic 3, Topic 6).

Visual (demonstration (Topics 1–7)).

Practical (practical studies (Topics 1–7), laboratory studies (Topics 1–7), presentations (Topics 1, Topic 3, Topic 5, Topic 7), brainstorming (Topic 2, Topic 6).

FORMS AND METHODS OF ASSESSMENT

The University uses a 100-point cumulative system for assessing the learning outcomes of applicants for higher education.

Current control is carried out during lectures, practical, laboratory and seminar classes and is aimed at checking the level of readiness of the applicant to perform a

specific job and is evaluated by the amount of points scored:

– for courses with a form of semester control as grading: maximum amount is 100 points; minimum amount required is 60 points.

The final control includes current control and assessment of the applicant.

Semester control is carried out in the form of a semester exam or grading.

The final grade in the course is determined:

– for courses with a form of grading, the final grade is the amount of all points received during the current control.

During the teaching of the course, the following control measures are used:

Current control: colloquiums (estimated at 8 points (two colloquiums during the semester – the total maximum number of points – 16)); written tests (maximum score – 7 points (two written tests during the semester, total maximum number of points – 14)); homework (maximum score – 3 points (twelve homework during the semester, total maximum number of points – 36 points)); laboratory work (maximum score – 2 or 3 points (nine laboratory work during the semester, total maximum number of points – 26 points)); an independent creative task (maximum score – 8 points).

Semester control: Grading.

More detailed information on the assessment system is provided in the technological card of the course.

RECOMMENDED LITERATURE

Main

1. Дискретна математика : навчальний посібник / Т. В. Денисова, В. Ф. Сенчуков. – Харків : ХНЕУ ім. С. Кузнеця, 2019. – 288 с. – Режим доступу : <http://www.repository.hneu.edu.ua/handle/123456789/22003> .

2. Epp S. S. Discrete Mathematics with Applications (5th Edition). – Boston: DePaul University, Cengage, 2020. – 1057 p.

3. Erciyes K. Discrete Mathematics and Graph Theory: A Concise Study Companion and Guide. – Cham: Springer, 2021. – 336 p.

4. Gavdzinski V.N. Discrete mathematics: Textbook // V.N. Gavdzinski, L.N. Korobova. – Odessa: ONAZ named after A.S.Popov, 2011. – 60 p.

5. Kagadiy T. The fundamentals of discrete mathematics: Textbook / T. Kagadiy, A. Shporta. – Dnipro : Dniprotech (Dnipro University of Technology), 2022. – 76 p.

6. Levin O. Discrete Mathematics: An Open Introduction (4th Edition). – Northern: Science University of Northern Colorado, Greeley, 2025. – 527 p. – Link: <https://discrete.openmathbooks.org/pdfs/dmoi4.pdf>

7. O'Regan G. Guide to Discrete Mathematics: Textbook. – Cham: Springer. – 2021. – 452 p.

8. Rosen K. H. Discrete mathematics and its applications (8th Edition). – New York : McGraw-Hill, 2019. – 1118 p.

9. Turlakis G. Discrete Mathematics: A Concise Introduction. – Cham: Springer, 2024. – 253 p.

10. Yadav S. K. Discrete Mathematics with Graph Theory. – Simi Valley, CA, U.S.A.: Springer. – 2023. – 648 p.

Additional

11. Дискретна математика. Методичні рекомендації до лабораторних робіт для студентів галузі знань 12 «Інформаційні технології» першого (бакалаврського) рівня / уклад. Т. В. Денисова, В. Ф. Сенчуков. – Харків : ХНЕУ ім. С. Кузнеця, 2018. – 113 с. Режим доступу : <http://www.repository.hneu.edu.ua/handle/123456789/27993>.

12. Дискретна математика. Методичні рекомендації до самостійної роботи з теми «Теорія графів» для студентів галузі знань 12 «Інформаційні технології» першого (бакалаврського) рівня / уклад. Т. В. Денисова, В. Ф. Сенчуков. – Харків : ХНЕУ ім. С. Кузнеця, 2020. – 99 с. – Режим доступу : <http://www.repository.hneu.edu.ua/handle/123456789/23848>

13. Balakrishnan V. K. Introductory Discrete Mathematics. – Mineola, NY: Dover Publications. – 2012. – 256 p.

14. Grami A. Discrete Mathematics: Essentials and Applications. – London: Academic Press. – 2022. – 464 p.

15. Johnsonbaugh R. Discrete Mathematics (8th Edition) – New York: Pearson Education. – 2018. – 912 p.

16. Kolman B. Discrete Mathematical Structures (6th Edition) // B. Kolman, R. Busby, S. Ross. – Boston: Pearson. – 2018. – 672 p.

17. Rosenberg A. L. Understand Mathematics, Understand Computing: Discrete Mathematics That All Computing Students Should Know // A.L. Rosenberg, D. Trystram. – Cham: Springer, 2020. – 550 p.

Information resources

18. Основи дискретної математики : навч. посіб. / В. М. Коцовський. – Ужгород : ПП «АУТДОР-ШАРК», 2020. – 128 с. – Режим доступу : <https://dspace.uzhnu.edu.ua/jspui/handle/lib/31664>.

19. Aspnes J. Notes on Discrete Mathematics [Web document] (2022) // <https://www.cs.yale.edu/homes/aspnes/classes/202/notes.pdf>

20. Bangert P. Lecture Notes on Discrete Mathematics [Web document] (2019) // https://www.academia.edu/74798360/Lecture_Notes_on_Discrete_Mathematics

21. Misiura Ie. Iu. Discrete Mathematics // S. Kuznets KhNUE PTS website [Electronic resource]. – Access mode: <https://pns.hneu.edu.ua/course/view.php?id=10852>.