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

ЗАТВЕРДЖЕНО
на засіданні кафедри
вищої математики та економіко-математичних методів
Протокол № 1 від 21.08.2023 р.

ПОГОДЖЕНО
Проректор з навчально-методичної роботи
_____ Каріна НЕМАШКАЛО

ДИСКРЕТНА МАТЕМАТИКА

робоча програма навчальної дисципліни (РПНД)

Галузь знань	**12 "Інформаційні технології"**
Спеціальність	**121 "Інженерія програмного забезпечення"**
Освітній рівень	**перший (бакалаврський)**
Освітня програма	**"Інженерія програмного забезпечення"**

Статус дисципліни	**обов'язкова**
Мова викладання, навчання та оцінювання	**англійська**

Розробники:

к.т.н., доцент _____ Євгенія МІСЮРА

к.т.н., доцент _____ Тетяна ДЕНИСОВА

Завідувач кафедри
економіко-математичних
методів _____ Людмила МАЛЯРЕЦЬ

Гарант програми _____ Олег ФРОЛОВ

Харків
2024

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

APPROVED
at the meeting of the department
of higher mathematics, economics and
mathematical method
Protocol № 1 of 21.08.2023

AGREED
Vice-rector for educational and methodical work
_____ Karina NEMASHKALO

DISCRETE MATHEMATICS

Program of the course

Field of knowledge	**12 "Information Technologies"**
Specialty	**121 "Software Engineering"**
Study cycle	**first (bachelor)**
Study programme	**"Software Engineering"**
Course status	**mandatory**
Language	**English**

Developers:

PhD (Technics),
Associate Professor _____ Ievgeniia MISIURA

PhD (Technics),
Associate Professor _____ Tetiana DENYSOVA

Head of Higher Mathematics
and Economic Mathematical
Methods Department _____ Lyudmyla MALYRETS

Head of Study Programme _____ Oleg FROLOV

Kharkiv
2024

INTRODUCTION

The program of studying the course “Discrete Mathematics” is compiled according to the study programme in the specialty 121 "Software Engineering" of preparation of bachelors "Software Engineering" in the field of knowledge 12 "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 successfully applying mathematics in solving specific problems. 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 course: to acquaint students with the basic concepts, ideas and methods of logical analysis, to teach them to use them when solving specific practical problems, to prepare students for the study of special courses and self-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 students of 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
LO05	GC01, GC02, SC02, SC03, SC08, SC14

where, LO05. Know and apply relevant mathematical concepts, methods of domain, system and object-oriented analysis and mathematical modeling for software development;

GC01. Ability to abstract thinking, analysis and synthesis;

GC02. Ability to apply knowledge in practical situations;

SC02. Ability to participate in software design, including modeling (formal description) of its structure, behavior and functioning processes;

SC03. Ability to develop architectures, modules and components of software systems;

SC08. Ability to apply fundamental and interdisciplinary knowledge to successfully solve software engineering tasks;

SC14. Ability to algorithmic and logical thinking.

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 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: 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).

TM: 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

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 3.

Table 3

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 individual creative task
Topic 1-7	Preparation for laboratory studies
Topic 1-7	Performing individual 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 (Topic 1–7)).

Practical (practical studies (Topic 1–7), laboratory studies (Topic 1–7), presentations (Topic 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 students.

Current control is carried out during lectures, practical, laboratory and

seminar classes and is aimed at checking the level of readiness of the student 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 student.

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 10 points (two colloquiums during the semester – the total maximum number of points – 20)); written tests (maximum score – 10 points (three written tests during the semester, total maximum number of points – 30)); homework (maximum score – 3 points (eight homework during the semester, total maximum number of points – 24 points)); laboratory work (maximum score – 2 points (nine laboratory work during the semester, total maximum number of points – 18 points)); an individual creative task (maximum score – 8 points).

Semester control: Grading.

More detailed information on the assessment system is provided in 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. 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 .

3. 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

4. Дискретна математика. Методичні рекомендації до самостійної роботи з теми «Теорія множин і відношень» для студентів галузі знань 12 «Інформаційні технології» першого (бакалаврського) рівня / уклад. Т. В. Денисова. – Харків : ХНЕУ ім. С. Кузнеця, 2021. – 79 с. – Режим доступу : http://www.repository.hneu.edu.ua/handle/123456789/26063 .

5. Дискретна математика: методичні рекомендації до самостійної роботи за темою «Комбінаторний аналіз» для студентів галузі знань 12 «Інформаційні

технології» першого (бакалаврського) рівня / уклад. Т. В. Денисова. – Харків : ХНЕУ ім. С. Кузнеця. – 2022. – 48 с. – Режим доступу : http://www.repository.hneu.edu.ua/handle/123456789/28196 .

Additional

6. Борисенко О. А. Дискретна математика : підручник для студентів вищих навчальних закладів / О. А. Борисенко. – Суми : Університетська книга, 2019. – 255 с.

7. Дискретна математика для інформатиків : навч. посіб. / С. В. Бразинська, Т. М. Дубовик ; за ред. д-ра фіз.-мат. наук, проф. А. І. Косолапа ; ДВНЗ «Укр. держ. хім.-технол. ун-т». – Дніпро : ДВНЗ УДХТУ, 2018. – 150 с.

8. Журавчак Л. М. Дискретна математика для програмістів : навч. посіб. / Л. М. Журавчак. – Львів : Видавництво Львівської політехніки, 2019. – 420 с.

9. Журавчак Л. М. Практикум з комп'ютерної дискретної математики : навч. посіб. / Л. М. Журавчак, Н. І. Мельникова, П. В. Сердюк ; Нац. ун-т «Львів. Політехніка». – Львів : Вид-во Львів. політехніки, 2020. – 313 с.

10. Наконечна Т. В. Дискретна математика. Практикум : навч. посіб. для студентів спец. 124 − «Системний аналіз» / Наконечна Т. В. – Дніпро : Біла К. О. [вид.], 2019. – 88 с.

11. Нікольський Ю. В. Дискретна математика : підручник / Ю. В. Нікольський, В. В. Пасічник, Ю. М. Щербина ; за ред. В. В. Пасічника. – 5-те вид., випр. та допов. – Львів : Магнолія-2006, 2019. – 432 с.

12. Сенчуков В. Ф. Мінімізація булевих функцій за номерами наборів значень аргументів / В. Ф. Сенчуков, Т. В. Денисова // Відкриті інформаційні та комп'ютерні інтегровані технології: зб. наук. пр. – Харків : Нац. аерокосм. ун-т «ХАІ», 2019. – Вип. 83. – С. 156-167. – Режим доступу : http://nti.khai.edu/ojs/index.php/oikit/article/view/696/751 .

13. Сенчуков В. Ф. ν-мінімізація булевих функцій за матрицею відстаней та зведенням до задачі математичного програмування / В. Ф. Сенчуков, Т. В. Денисова // Відкриті інформаційні та комп'ютерні інтегровані технології: зб. наук. пр. – Харків : Нац. аерокосм. ун-т «ХАІ», 2020. – Вип. 88. – С. 123-133. doi: 10.32620/oikit.2020.88.10 – Режим доступу : http://nti.khai.edu/ojs/index.php/oikit/article/view/1254/1330 .

Information resources

14. Дискретна математика : теорія множин і відношень, комбінаторика, числення висловлювань : навч. посіб. / Н. П. Тмєнова. – Київ : ВПЦ «Київський університет», 2018. – 103 с. – Режим доступу : http://pdf.lib.vntu.edu.ua/books/2020/Tmenova_2018_103.pdf .

15. Дискретна математика : навчальний посібник для студентів спеціальності 123 «Комп'ютерна інженерія», спеціалізації «Комп'ютерні системи та мережі» [Електронний ресурс] / М. А. Новотарський ; КПІ ім. Ігоря Сікорського. – Електронні текстові дані (1 файл: 10,66 Мбайт). – Київ : КПІ ім.

Ігоря Сікорського, 2020. – 278 с. – Режим доступу : https://ela.kpi.ua/handle/123456789/37806 .

16. 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 .

17. Методичні вказівки до практичних занять та самостійної роботи студентів з дисципліни «Дискретна математика» галузь знань 12 «Інформаційні технології» / уклад: О.П. Ясній, П.Б. Гащин, Н.Р. Крива – Тернопіль : Тернопільський національний технічний університет імені Івана Пулюя, 2019. – 40 с. – Режим доступу : http://elartu.tntu.edu.ua/handle/lib/29428 .

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

19. Lecture Notes on Discrete Mathematics [Web document] (2019) // https://home.iitk.ac.in/~arlal/book/mth202.pdf

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