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Computer-based discrete mathematics

2024

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Discipline	
	Computer-based discrete mathematics

Lecturer (s)	
	Maryna Semeniuta, Associate Professor at the Department of Information Technology, PhD in Physics and Mathematics, Associate Professor

Discipline page	
	https://business.ieu.edu.ua/kafedry/kafedra-informatsiinykh-tekhnolohii#zzz-099

Consultations	
онлайн	-
оффлайн	Wednesday 4 p.m. – 5 p.m.

Contact number	

E-mail	
	marian_semenyuta@ieu.edu.ua

Discipline page	
	https://dist.ieu.edu.ua/course/view.php?id=571

Form of final control	Test	Fail test	Exam
	☒	☐	☒
	(I semester)		(II semester)

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1	Brief discipline annotation

The Computer-based discrete mathematics academic discipline is designed for Bachelors of the knowledge area: 12 Information Technology, specialty: 121 Software Engineering. It is one of the professional disciplines for future software developers.

2	Background for studying discipline

The discipline program is based on complete general secondary education or Junior specialist's degree.

3	Мета та цілі дисципліни

The **goal** of the Computer-based discrete mathematics discipline is to teach methods of discrete mathematics; to develop the students' ability to use them to analyze and model information processes, find the most appropriate solutions to practical problems; to develop abstract thinking, the ability to analyze, the ability to make reasonable decisions.

Key objectives of the discipline:
•   to provide students with the understanding of modern methods of set theory and binary relations, basics of Boolean algebra, algebraic structures, combinatorics, mathematical models of graph theory;
•   to master methods of solving problems with discrete data, develop skills in applying these methods to solve various theoretical and practical problems;
•   to create the necessary theoretical and practical foundations for further professional activities.

4	Learning outcomes

PLO 5. To know and apply appropriate mathematical concepts, methods of domain, system and object-oriented analysis and mathematical modeling for software development.

After learning the discipline, students should
know:
•   modern methods of set theory and binary relations, basics of Boolean algebra and Boolean transformations, basic concepts and algorithms of graph theory, basic concepts of algebraic structures, algebraic operations, basic concepts of combinatorics;
•   the role and place of mathematics in the modern information and communication space and in specialist's professional activities;
•   methods of mathematical research of applied problems.

be able to:
•   solve mathematical problems;
•   independently study and learn the mathematical apparatus found in the special literature required to master the profession;
•   study applied problems mathematically;
•   choose the most appropriate methods for solving problems, interpret and assess the results; choose and use the necessary computing tools.

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5	Credits

4 кредити ЄКТС / 120 академічних годин

6	Discipline structure

Topics	Type of classes/hours		
	Lectures	Laboratory work	Independent work
Topic 1. Sets and their operations	2	2	6
1.1. The concept of a set. Ways to specify sets			
1.2. Basic numerical sets, the method of mathematical induction			
1.3. Operations on sets. Algebra of sets			
1.4. Cartesian product of sets			
1.5. The power of a set. Computer representation of a set			
Topic 2. Binary relations.	2	2	6
2.1. Basic definitions and notation			
2.2. Operations on relations			
2.3. Properties of relations			
2.4. The main types of binary relations			
Topic 3. Boolean functions, basic concepts	2	4	7
3.1. Boolean variables and Boolean functions			
3.2. Ways to define Boolean functions			
3.3. Laws of algebra of Boolean functions			
3.4. Real and dummy variables			
3.5. Duality			
3.6. Special forms of representation of Boolean functions			
Topic 4. Completeness and closure of Boolean functions	2	2	6
4.1. Boolean algebra			
4.2. Zhegalkin algebra			
4.3. Functionally complete systems			
4.4. Closed classes of Boolean functions			
4.5. Criterion of functional completeness of a system of Boolean functions			
Topic 5. Minimization of Boolean functions. Implementation of Boolean functions by circuits of functional elements	2	4	7
5.1. Basic concepts.			
5.2. Quine's method for obtaining a reduced disjunctive normal form.			

5.3. McCluskey modification of the 1st stage of the Quine method for obtaining a reduced disjunctive normal form			
5.4. Minimization of Boolean functions using Weich diagrams			
5.5. Karnaugh maps			
Topic 6. Basic concepts of graph theory	2	2	8
6.1. Basic definitions and properties			
6.2. Some special classes of graphs			
6.3. Ways to represent graphs			
6.4. Eulerian and Hamiltonian graphs			
6.5. Planar graphs			
6.6. Coloring graphs			
Topic 7. Trees	2	2	6
7.1. Definition and properties of a tree.			
7.2. Kelly's theorem. The spanning tree. Binary trees			
7.3. Algorithm for building a spanning tree (search algorithm in depth and width)			
7.4. Prim's and Kruskal's algorithms			
Topic 8. Algorithms for finding shortest paths in graphs	2	4	6
8.1. Searching for minimum paths in a weighted graph			
8.2. Dijkstra's algorithms			
8.3. Floyd's algorithms			
Topic 9. Basic concepts of the theory of algebraic systems. Algebra with one binary operation	1	2	6
9.1. The concept of operation, algebra, subalgebra			
9.2. Groupoids. Semigroups. Monoids. Groups			
9.3. The group of permutations			
9.4. Subgroups			
Topic 10. Algebra with two binary operations	1	2	6
10.1. Rings			
10.2. Euclidean rings			
10.3. The field			
Topic 11. Basic rules and formulas of combinatorics. Basic combinatorial algorithms	2	2	8
11.1. Rules of combinatorics.			
11.2. Ordered and unordered sets. Formulas of combinatorics.			
11.3. Partitioning a set into subsets			
11.4. Algorithms for generating subsets. Generating all subsets.			
11.5. Algorithm for generating all binary vectors of length n in lexicographic order. Generating subsets with a condition. Generating k-element subsets.			
11.6. Permutation algorithms. Selection by sorting.			

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7	List of obligatory tasks

1. Representation of sets in different ways. Performing operations on sets. Simplification of expressions of set algebra. Application of the mathematical induction method. Construction of a mathematical model of the problem based on knowledge of set theory.
2. Representation of binary relations in different ways. Study of the properties of binary relations. Determining the type of binary relation. Solving practical problems.
3. Representation of Boolean functions in different ways.
3. Simplifying Boolean functions using the laws of Boolean algebra.
4. Identification of real and dummy variables.
5. Ways to construct the Perfect Disjunctive Normal Form and the Perfect Conjunctive Normal Form.
6. Research on the completeness of Boolean functions, selection of the basis.
7. Minimization of Boolean functions.
8. Construction and simplification of functional diagrams.
9. Problems of financial mathematics.
10. Determining the type of graph. Ways to specify graphs.
11. Find the Eulerian and Hamiltonian cycle of a graph.
12. Application of the criteria of graph planarity.
13. Problems of constructing the correct coloring of the graph.
14. Problems of constructing spanning trees of a graph.
15. Problems of finding minimal routes in graphs.
16. Problems on algebraic structures.
17. Problems of combinatorics.

8	List of selective tasks

1. Proof of identities with sets. The principle of duality.
2. Problems with countable and uncountable sets.
3. Problems with functional relations.
4. Functions and features of the use of basic logic elements. Switches. Multiplexers. Shift devices. Selector multiplexers. Encoding and decoding devices. Encoders. Decoders.
5. Optimization problems on graphs.
6. Problems on algebraic structures.
7. Formula of inclusions and exclusions. Recurrence relations.

9	Discipline features

Period of teaching	Semester	International discipline integration	Year of study	Courses: general training/professional training/elective
1 semester	2	Available	1	professional training

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10	Hardware and software

11	Assessment system and requirements

As part of discipline teaching, one carries out the current and final control of students' knowledge. The final grade is given according to the total rating of students.

The results of the current control of students' knowledge is assessed in general between 0 and 100 points.

Students are admitted to the final control if they fulfil the requirements of the training program and obtain at least 36 points for the current learning activity.

Final assessment of students' knowledge is conducted in the form of exam.

The maximum amount of scores that can be obtained during the exam is 40 points.

The overall points of the discipline are 100. The total grade for the discipline is given according to the national and European scale.

12	Absence policy

Teaching of the discipline is based on cutting-edge educational technologies aimed at increasing the level of students' interest in the course, providing theoretical and practical knowledge of the discipline.

To activate the learning and cognitive activity of students, the discipline includes the consolidation of knowledge obtained at the lecture and acquisition of practical skills in lecture topics during laboratory classes.

13	Absence policy

Points are not given for missed lectures. If students miss a laboratory work, they should perform the homework before the next laboratory work and present the results to the lecturer.

Students who have missed classes without valid reasons and have not participated in current control activities are not admitted to the final semester control. In this case, a mark 'non-admission' is put in the exam record on the day of the exam. Repeated taking of the exam of the discipline is appointed in case of accomplishing all types of educational, independent (individual) work stipulated by the working program of the academic discipline and is carried out according to the approved schedule of academic failure liquidation.

14	Policy of late task performance

Tasks submitted later are assessed with a lower grade.

15	Academic integrity policy

Participants in the educational process rely on the academic integrity principles. One should provide references to sources of information when using someone else's ideas, statements, data, as well as verified information.

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16	Recommended sources of information

Primary:

1. Bardachov Y.M. et al. Discrete mathematics: textbook. – K.: Higher School, 2002. – 287 p.

2. Bondarenko M.F., Bilous N.V., Ratkas A.H. Computer-based discrete mathematics: Textbook. – Kharkiv: SMIT Company, 2004. – 480 p.

3. Zhuravchak L.M. Workshop on computer-based discrete mathematics: Study guide / L.M. Zhuravchak, N.I. Melnykova, P.V. Serdiuk. – Lviv: Lviv Polytechnic Publishing House, 2019. – 279 p.

4. Zhuravchak L.M. Discrete mathematics for programmers. Study guide. Lviv: Lviv Polytechnic Publishing House, 2019. – 420 p.

5. Nikolskyi Y.V. Discrete mathematics. Y.V. Nikolskyi, V.V. Pasichnyk, Y. Shcherbyna. Lviv, Magnolia Plus, 2005, 2006 (1st edition), 2007 (2nd edition, revised and supplemented), 2008 (3rd edition, revised and supplemented).

6. Novotarskyi M.A. Discrete mathematics: textbook for students in the 123 Computer engineering specialty, specializing in Computer Systems and Networks / M.A. Novotarskyi; Igor Sikorsky Kyiv Polytechnic Institute, 2020. – 278 p., https://ela.kpi.ua/handle/123456789/37806.

7. Rosen, Kenneth H. Discrete mathematics and its applications / Kenneth H. Rosen. — 7th ed. p. cm. Includes index. ISBN 0–07–338309–0 1. Mathematics. 2. Computer science—Mathematics.

Additional:

8. Bordachov Y.M., Sokolova N.A., Khodakov V.Y. Discrete mathematics: Textbook. – K.: Higher School, 2002. – 287 p.

9. Kapitonov Y.V. et al. Fundamentals of discrete mathematics: Textbook. – K.: Scientific thought, 2002. – 579 p.

10. Kovalenko L.B. Discrete mathematics: Study guide for students of economic, managerial and electrical engineering specialties of higher education institutions / L.B. Kovalenko, S.O. Stanishevskyi. Kharkiv: O.M. Beketov National University of Urban Economy in Kharkiv, 2006. – 192 p.

11. Discrete mathematics / Kryvyi S.L. Chernivtsi-Kyiv: Bukrek. – 2014. – 567 p.

12. Spektorskyi I.Y. Study guide for the Discrete mathematics discipline. Algebra of expressions, set theory, theory of relations, elements of combinatorics, graph theory, elements of the theory of groups and rings. – K.: NTUU KPI, IASA, 2002. – 120 p.

17	Tips on successful study during the course

Note: examine lecture materials and perform laboratory tasks synchronously with the curriculum. Thus, your abilities and insistence will be the key to success!