Syllabus
Course Program

Mathematical logic

Specialty
113 Applied mathematics

Institute
Educational and Scientific Institute of Computer Science and Information Technology

Educational program
Intelligent Data Analysis

Department
Computer Mathematics and Data Analysis.

Level of education
Bachelor's level

Course type
Special (professional), Mandatory.

Semester
1

Language of instruction
Ukrainian

Lecturers and course developers

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Doctor of Science (Technical), Full Professor, Professor of Computer Mathematics and Data Analysis Department.

Work experience – more than 20 years. Author and co-author of more than 170 scientific and educational and methodological works. Leading lecturer in the disciplines: "Mathematical logic", "Fundamentals of scientific research", "Metaheuristic methods of optimization".
and http://sira.pro/
More about the lecturer on the department's website and http://sira.pro/

General information

Summary

The discipline is aimed at students acquiring the necessary competencies regarding the specifics of logical research, which will allow students to improve the logical culture of thinking, to realize the importance of logical concepts and methods for setting and solving modern research and practical tasks. formation of students' conscious attitude to: the process of reasoning and decision-making, substantiation of their ideas, correct formulation and justification of their opinion; understanding the basic logical patterns of the thinking process, avoiding logical errors in one's own reasoning and identifying them in the opinion of others.

Course objectives and goals

Acquisition of the necessary competences in the field of set theory, mathematical logic and theory of algorithms, to form in them generally functional, subject-specific knowledge on this course, to instill skills in solving problems related to the algebra of logic and the theory of algorithms.

Format of classes

Lectures, practical classes, independent work, consultations. Final control - credit.

Competencies

GC 1. Ability to learn and master modern knowledge.
GC 2. Ability to apply knowledge in practical situations.
GC 3. Ability to generate new ideas (creativity).
GC 4. Ability to be critical and self-critical.
GC 6. Capability of abstract thinking, analysis and synthesis.
GC 7. Ability to search, process and analyse information from various sources.
GC 8. Knowledge and understanding of the subject area and understanding of professional activities.
GC 10. Skills in the use of information and communication technologies.

SC 1. Ability to use and adapt mathematical theories, methods and techniques to prove mathematical statements and theorems.
SC 2. Ability to perform tasks formulated in mathematical form.
SC 3. Ability to choose and apply mathematical methods for solving applied problems, modelling, analysis, design, management, forecasting, decision-making.
SC 5. Ability to develop algorithms and data structures, software tools and program documentation.
SC 7. Ability to solve professional problems with the help of computer equipment, computer networks and the Internet, in the environment of modern operating systems, using standard office applications.
SC 14. Ability to understand the task statement formulated in the language of a particular subject area, to search and collect the necessary initial data.
SC 15. Ability to formulate a mathematical statement of a problem, based on the statement in the language of the subject area, and choose a method of solving it that ensures the required accuracy and reliability of the result.

Learning outcomes

LO 1. Demonstrate knowledge and understanding of the fundamental and applied mathematics concepts, principles, and theories and apply them in practice.
LO 3. Formalize tasks formulated in the language of a particular subject fields; formulate their mathematical formulation and choose rational method of solution; solve the resulting problemswith analytical and numerical methods, evaluate the accuracy and reliability of the results obtained.
LO 12. Solve individual engineering problems and/or tasks thatarise in at least one subject area: sociology, economy, ecology, and medicine.
LO 14. Demonstrate the ability to self-learn and continueprofessional development.
LO 15. Be able to organize your own activities and get resultswithin a limited time frame.
LO 19. Gather and interpret relevant data and analyse complexities within their area of specialization to make judgments that reflect relevant social and ethical issues.

Student workload

The total volume of the discipline is 90 hours. (3 ECTS credits): lectures – 16 hours, practical work – 16 hours, independent work – 58 hours.

Course prerequisites

School courses in mathematics and computer science.

Features of the course, teaching and learning methods, and technologies

When teaching this discipline, such teaching and learning methods as gamification and peer-to-peer are used. LMS (learning management systems) systems are used in the learning process.

Program of the course

Topics of the lectures

Topic 1. Basic concepts of set theory.
Methods of solving sets. Attribution and inclusion. Paradoxes of Euler diagram set theory.
Topic 2. Power of sets.
The concept of power. Piano axiomatics. Power comparison. Power of the set of real numbers. Cantor's theorem. Arithmetic of the infinite. Contrasting systemic and theoretical-multiple approaches. Finite sets and combinatorics
Topic 3. Combinatorial equations
Pascal's triangle. Solving combinatorial equations
Topic 4. Algebraic structures.
Concept of algebra. Concept of model. Concept of algebraic structure. Algebraic operations. Properties of operations. Grids. Terms. Hasse diagram. Algebraic representation of a lattice.
Topic 5. Logical functions.
Distribution of logical functions by variables. Theorem on the decomposition of logical functions by variables. Completeness of the system of Boolean functions.
Topic 6. Zhekalkin's algebra. Post's theorem.
Zhekalkin algebra and linear functions. Closed classes of Boolean functions. Post's theorem.
Topic 7. Logic of statements.
General concepts. Formulas of the logic of statements. Rules for converting formulas. Basic schemes of logical correct reasoning. Laws of the logic of statements. Tautologies. Minimization of complex expressions by Quine's method. Minimization using Veitch maps.
Topic 8. Elements of proof theory.
Axiomatic (formal) theory. Counting predicates. The method of resolutions. Horniv disjuncts. Unification.

Topics of the workshops

Topic 1. Graphs. Correspondence.
Concept of schedule. Graph properties. Correspondence. The concept of compliance. Matching properties. Inverse relation and composition of relations. Features and display. Inverse functions and composition of functions. Operations. Homomorphisms and isomorphisms.
Topic 2. Combinatorics.
Ordered subsets. Placing. Placement with repetitions. Compounds Compounds with repetitions. Properties of compounds. Sum of power series. By Newton. The set of injections. and bijective reflections. Number of surjects. reflections
Topic 3. Combinatorial problems.
Combinatorial problems with constraints. Problems with order constraints. Restrictions on the order of selection.
Topic 4. Algebras.
Algebras with three algebraic operations. Boolean algebras. Boolean functions. Tabular presentation of Boolean functions.
Topic 5. Algebra of logic.
Functions of the algebra of logic. Superpositions and formulas. Tabular presentation of functions of logic algebra. Algorithms for calculating Boolean functions. Solution tree.
Topic 6. DDNF and DCNF.
Perfect disjunctive normal form (DDNF). Perfect conjunctive normal form (DCNF). (table and formula transformations).
Topic 7. Boolean algebra and set theory.
Minimization of partially given functions. Quine's algorithm. The Quine-McCluskey method. Boolean algebra and set theory.
Topic 8. Switching functions.

Switching functions and methods of their assignment. Elementary binary logical switching functions and functional completeness of the system of switching functions.

Topics of the laboratory classes

Laboratory classes within the discipline are not provided.

Self-study

The course involves the completion of individual tasks, the results of which are monitored and evaluated by teachers. Students are also recommended additional materials (videos, articles) for independent study.

Non-formal education

Within the framework of non-formal education according to the relevant Regulation (http://surl.li/pxssv), the educational component or its separate topics can be taken into account in case of independent completion of professional courses/trainings, obtaining civic education, online education, professional internship, etc.
In particular, individual topics of this component may be taken into account upon successful completion of the following courses:
- Topic 1 – Topic 4 https://www.classcentral.com/course/swayam-logic-and-sets-203328
- Topic 5 – Topic 8 https://itvdn.com/ua/video/math-logic

Course materials and recommended reading

Basic literature

1. Математична логіка, теорія алгоритмів та структури даних [Електронний ресурс] : методичні вказівки для для студентів спеціальності 122 "Комп'ютерні науки" / уклад.: А. О. Татарінова, Ю. М. Андрєєв ; Нац. техн. ун-т "Харків. політехн. ін-т". – Електрон. текст. дані. – Харків, 2023. – 104 с. https://repository.kpi.kharkov.ua/items/70ec7a14-a186-41dd-945b-1155d8ff1ffc
2. Капітонова Ю.В. Основи дискретної математики. Підручник / Ю. В. Капітонова, С. Л. Кривий, О. А. Летичевський, Г. М. Луцький, М. К. Печорін – К.: Наукова думка, 2002. 579 с. https://pdf.lib.vntu.edu.ua/books/2015/Kapitanova_2002_580.pdf
3. Нікольський Ю.В., Пасічник В.В., Щербина Ю.М. Дискретна математика. – К.: Видавнича група BHV, 2007. 368 с. https://library.kre.dp.ua/Books/2-4%20kurs/Дискретна%20математика/nikolskii_iuv_pasichnik_vv_shcherbina_ium_diskretna_matemati.pdf

Additional literature

4. Математична логіка. Практикум. [Електронний ресурс]: навч. посіб. для студ. спеціальності 113 «Прикладна математика», освітньої програми «Наука про дані та математичне моделювання» / О.Л.Темнікова ; КПІ ім. Ігоря Сікорського.– Київ : КПІ ім. Ігоря Сікорського, 2020. – 76 с. https://ela.kpi.ua/bitstream/123456789/42844/1/WorkshopLogicTemnikova.pdf
5. Зубенко В. В., Шкільняк С. С. Основи математичної логіка: навчальний посібник. К.: НУБіП України, 2020. 102 с. http://csc.knu.ua/media/filer_public/3b/80/3b805f5a-fb43-4249-b587-f13852e8ba37/osnovy_mat_logyky_posibn_020620.pdf

Internet resources

6. https://logic.ly/ - онлайн моделювання логічних вентилів та цифрових схем.

Assessment and grading

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

Description of the final score structure, course requirements, and necessary steps to earn points, especially paying attention to self-study and individual assignments.

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

Date, signature 29.08.2024  Head of the Department

Date, signature 29.08.2024  Guarantor of the Educational Program