MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL TECHNICAL UNIVERSITY "DNIPRO POLYTECHNIC"
Department of Applied Mathematics

APPROVED
Head of the Department

O.O. Sdvizhkova

"28" August 2025

WORK PROGRAMME OF THE ACADEMIC DISCIPLINE
"DISCRETE MATHEMATICS"

Field of Knowledge	11 Mathematics and Statistics
Specialty	113 Applied Mathematics
Educational Level	First (Bachelor's)
Status	Mandatory
Total Volume	5 ECTS credits (150 hours)
Form of Final Assessment	Differentiated Pass/Fail
Teaching Term	5th, 6th quarters
Language of Instruction	English

Instructor: T.S. Kagadiy

Dnipro
NTU "DP"
2025

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Work programme of the academic discipline "Discrete Mathematics" for students pursuing the first (Bachelor's) level in specialty 113 Applied Mathematics, Educational and professional program "Mathematical modeling of systems and processes"/ National Technical University "Dnipro Polytechnic," Department of Applied Mathematics. – Dnipro: NTU "DP," 2025. – 12 pages.

Developer(s):
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The Work Programme regulates:
— the purpose of the discipline;
— the learning outcomes of the discipline, formed on the basis of the transformation of the expected learning outcomes of the educational program;
— prerequisite disciplines;
— the volume and distribution by forms of the educational process and types of classes;
— the discipline's syllabus (thematic plan by types of classes);
— the algorithm for assessing the level of achievement of the discipline's learning outcomes (scales, tools, procedures, and assessment criteria);
— tools, equipment, and software;
— recommended information sources.

The Work Programme is intended to implement a competency-based approach in planning the educational process, teaching the discipline, preparing students for assessment activities, monitoring the delivery of educational services, internal and external quality assurance in higher education, and accreditation of educational programs within the specialty. Additionally, it will be useful for designing the content of advanced training for academic staff in the University's departments.

Approved by the decision of the methodological committee for the specialty F1 Applied Mathematics (113 Applied Mathematics) (minutes No. 8 dated 08/29/2025).

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INTRODUCTION

In the educational and professional program of NTU "Dnipro Polytechnic" for specialty 113 Applied Mathematics, the program learning outcomes are allocated according to the organizational forms of the educational process. In particular, the following learning outcomes are attributed to discipline F5 "Discrete Mathematics":

LO04	Perform mathematical description, analysis, and synthesis of discrete objects and systems using concepts and methods of discrete mathematics and the theory of algorithms.
LO06	Master the main methods of developing discrete and continuous mathematical models of objects and processes, and conduct analytical research on these models regarding the existence and uniqueness of their solutions.

The purpose of the "Discrete Mathematics" discipline is to develop competencies related to the capacity for abstract thinking, analysis, and synthesis, as well as the ability to use and adapt mathematical theories, methods, and techniques to prove mathematical statements in information security and theorems in the professional training of bachelor's students majoring in 113 Applied Mathematics.

Achieving this purpose requires transforming the program learning outcomes into discipline-specific ones and selecting the content of the academic discipline based on this criterion.

1. EXPECTED DISCIPLINARY LEARNING OUTCOMES

The expected disciplinary learning outcomes are presented in Table 1.1.

Table 1.1 – Expected disciplinary learning outcomes for the discipline "Higher Mathematics"

Code	Content of the Learning Outcome (by the Educational Program)	Code (DLO)	Content of the Disciplinary Learning Outcome (DLO)
LO04	Perform mathematical description, analysis, and synthesis of discrete objects and systems using concepts and methods of discrete mathematics and the theory of algorithms.	LO04	Apply concepts of discrete mathematics in modeling systems and processes across various fields.

LO06	Master the main methods for developing discrete and continuous mathematical models of objects and processes, and conduct analytical research on these models regarding the existence and uniqueness of their solutions.	LO06	Be able to apply discrete mathematics to problems related to information security, mathematical modeling, and programming.

2. PREREQUISITE DISCIPLINES

Title of the Discipline	Acquired Disciplinary Learning Outcomes
B2 Algebra and Geometry	Understand the basics and principles of applying linear and vector algebra, as well as analytical geometry.
B1 Mathematical Analysis	Understand the basics and principles of limit theory, apply differential and integral calculus, and employ mathematical analysis methods to solve technical tasks.
B3 Probability Theory	Know the fundamentals and principles of applying the basic concepts of probability theory and certain methods of probability estimation.
B5 Mathematical Statistics	Know the fundamentals and principles of applying the basic concepts of mathematical statistics, including selecting and applying certain criteria for evaluating experimental results.

3. BASIC DISCIPLINES

Name of discipline	Disciplinary learning outcomes achieved
B2 Algebra and Geometry	To master the basic principles and methods of mathematical, complex and functional analysis, linear algebra and number theory, analytic geometry, the theory of differential equations, in particular partial differential equations, probability theory, mathematical statistics and random processes, and numerical methods.

4. SCOPE AND DISTRIBUTION BY FORMS OF THE EDUCATIONAL PROCESS AND TYPES OF ACADEMIC ACTIVITIES

Type of Academic Activity	Hours	Type of academic activities, *hours*					
		full-time		evening		part-time	
		in-class	independent work	in-class	independent work	in-class	independent work
Lectures	75	26	49	-	-	-	-
Practical Sessions	75	26	49	-	-	-	-

	TOTAL	**150**	52	98	-	-	-	-

5. PROGRAM OF THE DISCIPLINE BY TYPES OF ACADEMIC ACTIVITIES

LO Code	Types and Topics of Academic Activities	Hours
	LECTURES	**75**
LO04, LO06	Fundamental laws of set theory. Set partitions.	10
LO04, LO06	Relations.	**6**
LO04, LO06	Algebraic structures.	**6**
LO04, LO06	Boolean functions. Theorems of Boolean algebra.	**12**
LO04, LO06	Decomposition of Boolean functions. Zhegalkin algebra.	**10**
LO04, LO06	Minimization of Boolean functions. Logical circuits.	**6**
LO04, LO06	Elements of graph theory.	**6**
LO04, LO06	Finding the shortest path in a graph.	**6**
LO04, LO06	Trees	**6**
LO04, LO06	The traveling salesman problem.	**4**
LO04, LO06	Transportation networks.	**3**
LO04, LO06	**PRACTICAL SESSIONS**	**75**
LO04, LO06	Sets, relations, algebraic structures.	15
LO04, LO06	Boolean functions, decomposition.	15
LO04, LO06	Zhegalkin algebra, minimization.	15
LO04, LO06	Graph theory, Dijkstra's algorithm.	15
LO04, LO06	Trees, transportation networks.	15
	TOTAL	**150**

6 ASSESSMENT OF LEARNING OUTCOMES

The certification of student achievements is carried out through transparent procedures based on objective criteria, in accordance with the University Regulation "On the Assessment of Learning Outcomes of Higher Education Students."

The level of competencies achieved, as measured against the expected ones during assessment activities, reflects the student's actual learning outcome in the discipline.

6.1 Scales

Academic achievements of NTU "DP" students are evaluated using both a rating (100-point) scale and an institutional scale. The latter is needed (because there is no officially adopted national scale) to convert the grades of higher education applicants from different institutions

Rating Scale (points)	Institutional Scale
90…100	Excellent
74…89	Good
60…73	Satisfactory
0…59	Fail

Credits for the academic discipline are awarded if the student's final grade is at least 60 points. A lower grade is considered an academic deficiency, which must be resolved according to the Regulations on the Organization of the Educational Process at NTU "DP."

6.2 Tools and procedures

The diagnostic tools are designed to monitor students' level of knowledge, skills, communication, autonomy, and responsibility in accordance with the requirements of the 6th qualification level of the National Qualifications Framework, as they demonstrate the learning outcomes specified by the working program.

Students, during assessment activities, must complete tasks aimed exclusively at demonstrating the disciplinary learning outcomes (Section 3). The diagnostic tools presented to students at assessment activities, in the form of tasks for ongoing and final assessments, are created by specifying the initial data and the method of demonstrating the disciplinary learning outcomes. These diagnostic tools (assessment tasks) for both ongoing and final control of the discipline are approved by the Department.

The types of diagnostic tools and assessment procedures for ongoing and final control of the discipline are provided

CURRENT CONTROL			FINAL CONTROL	
Type of Class	Diagnostic Tools	Procedures	Diagnostic Tools	Procedures
Lectures	Control tasks for each topic	Performing tasks during lectures	Comprehensive Control Test (CCT)	The final grade is determined by the weighted average result of ongoing assessments; performing the CCT during the pass/fail exam at the student's request.
Practical	Control tasks for each topic	Performing tasks during practical sessions		
	or individual assignment	or during independent work		

During the current assessment, lecture classes are graded based on the quality of completed, specific control tasks. Practical classes are graded on the quality of completed control or individual assignments.

If the content of a particular type of activity corresponds to multiple components from the description of the qualification levels, an integrated score may be determined using weighting coefficients set by the instructor.

If a student's performance in all types of academic activities under the current assessment is at least 60 points, the final assessment is carried out without the student's direct participation by calculating the weighted average of the current grades.

Regardless of the current assessment results, each student is entitled to take a Comprehensive Control Test (CCT) during the final pass/fail exam, which includes tasks covering the key disciplinary learning outcomes.

The number of specified tasks within the CCT should be consistent with the allocated time for completion. The number of CCT versions must ensure the individualization of the task.

The score for completing the CCT is determined by the average score of its components (the specified tasks) and is final. An integrated score for the CCT can be determined using weighting coefficients set by the department for each component of the National Qualifications Framework (NQF) qualification level description.

6.3 CRITERIA

The student's actual learning outcomes are identified and measured against the expected outcomes during assessment activities using criteria that describe the student's actions in demonstrating the achievement of these learning outcomes.

To evaluate the completion of control tasks during the current assessment of lectures and practical sessions, a **learning coefficient** is used as the criterion, which automatically adapts the score to the rating (100-point) scale:

$$O_i = 100 \, a/m,$$

where a is the number of correct answers or correctly performed essential steps according to the solution standard; m is the total number of questions or essential steps in the standard.

Individual assignments and comprehensive control tests are graded through expert evaluation using criteria that reflect the relationship between the required level of competencies and the rating scale indicators.

The content of these criteria is based on the competency characteristics defined by the National Qualifications Framework (NQF) for the Bachelor's level of higher education (presented in Table 5.3).

Description of the Qualification Level	Requirements	Score Range
Knowledge		
♦ Conceptual scientific and practical knowledge, critical reflection of theories, principles, methods, and concepts in the field of professional activity and/or study.	- **Excellent Answer** – correct, well-reasoned, and clearly understood. Demonstrates: • conceptual knowledge; • a high degree of familiarity with the topic; • critical reflection on the main theories, principles, methods, and concepts in study and professional activity.	95-100
	The answer contains no major errors but may have minor slips or typos.	90-94
	The answer is correct but has some inaccuracies.	85-89
	The answer is correct but has some inaccuracies and is insufficiently reasoned.	80-84
	The answer is correct but contains certain inaccuracies, is not well-reasoned, and shows limited depth of understanding.	74-79
	The answer is fragmentary.	70-73
	The answer demonstrates that the student's understanding of the subject is unclear.	65-69
	The level of knowledge is minimally satisfactory.	60-64
	The level of knowledge is unsatisfactory.	<60
Skills		
♦ Advanced cognitive and practical skills, proficiency, and innovation at a level required to solve complex specialized tasks and practical problems in professional activity or study.	- The answer demonstrates the ability to: • identify problems; • formulate hypotheses; • solve problems; • choose appropriate methods and tools; • gather and logically interpret information; • use innovative approaches to solve the problem.	95-100
	The answer shows the ability/skills to apply knowledge in practice with no major errors.	90-94
	The answer shows the ability/skills to apply knowledge in practice, but with some inaccuracies in fulfilling **one** requirement.	85-89
	The answer shows the ability/skills to apply knowledge in practice, but with some inaccuracies in fulfilling **two** requirements.	80-84
	The answer shows the ability/skills to apply knowledge in practice, but with some inaccuracies in fulfilling **three** requirements.	74-79
	The answer shows the ability/skills to apply knowledge in practice, but with some inaccuracies in fulfilling **four** requirements.	70-73
	The answer shows the ability/skills to apply knowledge in practice only following a given model.	65-69

Description of the Qualification Level	Requirements	Score Range
	The answer shows the ability/skills to apply knowledge in a modeled situation, but with inaccuracies.	60-64
	The level of skills is unsatisfactory.	<60
Communication		
♦ • Conveying information, ideas, problems, solutions, personal experience, and arguments to both specialists and non-specialists; • Collecting, interpreting, and applying data; • Communicating on professional issues, including in a foreign language, both orally and in writing.	- Displays full command of the field. The answer (or presentation) is: • comprehensible; • linguistically correct, clear, precise, logical, expressive, concise; Communication strategy: • consistent and coherent flow of ideas; • logical personal judgments; • relevant argumentation aligned with defended statements; • well-structured answer (or presentation); • correct answers to questions; • appropriate technique for responding to questions; • ability to draw conclusions and make proposals.	95-100
	Displays sufficient command of the field with minor flaws. The answer/presentation is sufficiently clear with minor flaws. The communication strategy is appropriate with minor flaws.	90-94
	Displays good command of the field, clarity of the answer/presentation, and an appropriate communication strategy (in total, three requirements are not fully met).	85-89
	Displays good command of the field, clarity of the answer/presentation, and an appropriate communication strategy (in total, four requirements are not fully met).	80-84
	Displays good command of the field, clarity of the answer/presentation, and an appropriate communication strategy (in total, five requirements are not fully met).	74-79
	Displays satisfactory command of the field, clarity of the answer/presentation, and appropriate communication strategy (in total, seven requirements are not fulfilled).	70-73
	Partial command of the field. The answer/presentation is satisfactory but contains errors in communication strategy (in total, nine requirements are not fulfilled).	65-69
	Fragmented command of the field. The answer/presentation is satisfactory but with flaws in the communication strategy (in total, ten requirements are not fulfilled).	60-64
	The communication level is unsatisfactory.	<60
Responsibility and Autonomy		
♦ • Managing complex technical or professional activities	- **Excellent** mastery of personal management competencies focused on: **(1) Managing complex projects**, including:	95-100

Description of the Qualification Level	Requirements	Score Range
or projects; • Ability to assume responsibility for making decisions in unpredictable work and/or learning contexts; • Formulating judgments that take social, scientific, and ethical aspects into account; • Organizing and guiding the professional development of individuals and groups; • Ability to continue learning with a significant degree of autonomy.	• a research-based approach to learning, characterized by the ability to independently assess various real-life situations, phenomena, facts, and to identify and defend one's own position; • teamwork capability; • self-control; **(2) Responsibility for making decisions in unpredictable conditions**, including: • justifying decisions based on regulatory frameworks at the sectorial and national levels; • independence in completing assigned tasks; • initiative in discussing problems; • accountability for interpersonal relations; **(3) Responsibility for the professional development** of individuals and/or groups, including: • using professionally oriented skills; • presenting evidence with independent and correct arguments; • mastering all types of learning activities; **(4) Ability to continue learning** with a high degree of autonomy, implying: • mastery of fundamental knowledge; • independent evaluative judgments; • a high level of general academic skills; • independent search for and analysis of information sources.	
	Confident mastery of personal management competencies (two requirements are not fulfilled).	90-94
	Good mastery of personal management competencies (three requirements are not fulfilled).	85-89
	Good mastery of personal management competencies (four requirements are not fulfilled).	80-84
	Good mastery of personal management competencies (four requirements are not fulfilled).	74-79
	Satisfactory mastery of personal management competencies (seven requirements are not fulfilled).	70-73
	Satisfactory mastery of personal management competencies (eight requirements are not fulfilled).	65-69
	Fragmentary level of responsibility and autonomy.	60-64
	The level of responsibility and autonomy is unsatisfactory.	<60

7. TOOLS, EQUIPMENT, AND SOFTWARE

Multimedia projector
Moodle distance learning platform, MS Teams.

8. RECOMMENDED SOURCES OF INFORMATION

1. Бондаренко М.Ф., Білоус Н.В., Руткас А.Г. Комп'ютерна дискретна математика, 2004
2. The fundamentals of discrete mathematics = Основи дискретної математики: textbook / T. Kagadiy, A. Shporta; The Ministry of Education and Science of Ukraine, Dnipro University of Technology //Dnipro: Dniprotech, 2022. - 77 p.

3. Кагадій Т.С., Шпорта А.Г., Онопрієнко О.Д. Основи дискретної математики (частина 1). Методичні рекомендації до опанування лекційних занять з дисципліни «Дискретна математика» здобувачами ступеня бакалавра спеціальності 113 Прикладна математика / м-во освіти і науки, молоді та спорту України, НТУ «Дніпровська политехника» – Д. : НТУ «ДП», 2023, 48 с.

4. Кагадій Т.С., Шпорта А.Г., Онопрієнко О.Д. Основи дискретної математики (частина 2). Методичні рекомендації до опанування лекційних занять з дисципліни «Дискретна математика» здобувачами ступеня бакалавра спеціальності 113 Прикладна математика / м-во освіти і науки, молоді та спорту України, НТУ «Дніпровська политехника» – Д. : НТУ «ДП», 2024, 44 с.

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113 Applied Mathematics

Developer:

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In the author's edition