Ministry of Science and Higher Education of the Russian Federation

Federal State Budgetary Educational Institution of Higher Education

Perm National Research Polytechnic University

APPROVED BY

Pro-rector for Academic Affairs

_____ N.V. Lobov

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ACADEMIC COURSE WORKING PROGRAM

Academic course: Mathematics, special chapters
(Name)

Form of education: Full-time
(Full-time /full-time – correspondence/correspondence)

Level of higher education: Bachelor's degree
(Bachelor's program/specialist program/
Master's program)

Workload in hours (in credits): 108 (3)
(Hours (CU))

Training program (degree): 21.03.01 Oil and Gas Engineering
(Code and denomination of degree)

Direction: Oil and Gas Engineering
(Title of curriculum)

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1. GENERAL PROVISIONS

1.1. GOALS AND OBJECTIVES OF THE COURSE

The goals of the discipline are mastering the basic methods of the mathematical apparatus necessary for the study of general theoretical and special disciplines; development of logical and algorithmic thinking; raising the general mathematical culture; developing skills in formalizing models of real processes; analysis of systems, processes and phenomena when searching for optimal solutions and choosing the best ways to implement these solutions; development of research skills and abilities of independent analysis of applied problems.

Objectives of the course are

– study of basic mathematical provisions, laws;

– study of basic concepts, methods and techniques of discrete mathematics;

– formation of the ability to use the basic laws of natural science disciplines in professional activities;

– formation of the ability to research and solve mathematically formalized problems;

– formation of the ability to use the methods of discrete analysis in solving professional problems;

– development of skills in solving typical problems in the main sections of the course, using the methods of discrete mathematics;

– development of skills in analyzing the results obtained.

In the process of studying this discipline, the student masters the parts of professional competencies:

Is able to solve problems concerning professional activity using methods of modelling, of mathematical analysis, natural-science and general engineering knowledge (GPC-1).

1.2. PRESCRIBED OBJECTS OF THE COURSE

Mathematical objects (sets, logical functions, combinatorial connections, graphs); Operations on objects and their properties; Analysis of the obtained results of solving mathematical problems.

1.3. STARTING CONDITIONS

Unstipulated

2. PLANNED RESULTS OF THE COURSE TRAINING

Compe-tence	Indicator's Index	Planned Results of the Course Training (to know, to be able, to master)	Indicator of Attaining Competence which the planned results of training are correlated with	Means of Assessment
GPC-1	IA-1_{gpc-1}	**To know** basic definitions of set theory; definition of a logical function; a method for checking the basicity of a system of logical functions; determination of the main combinatorial compounds; basic concepts of graph theory.	**Knows** basic definitions of set theory; definition of a logical function; a method for checking the basicity of a system of logical functions; definition of combinatorial compounds; basic concepts of graph theory	
GPC-1	IA-2_{gpc-1}	**To be able to** perform operations on sets; to prove the simplest identities of Boolean algebra; write down the perfect normal form of a logical function and minimize it; count the number of combinatorial compounds; build the adjacency and incidence matrices of the graph.	**Is able to** do operations on sets; prove the simplest identities of Boolean algebra; write the perfect normal form of a logical function and minimize it; count the number of combinatorial connections; build the adjacency and incidence matrices of the graph	
GPC-1	IA-3_{gpc-1}	**To master** basic methods of set theory; methods of constructing and minimizing normal forms; the main methods of combinatorics.	**Masters the skills** basic methods of set theory; methods of constructing and minimizing normal forms; the basic methods of combinatorics	

3. FULL TIME AND FORMS OF ACADEMIC WORK

Form of academic work	Hours in all	Distribution in hours according to semesters
		Number of semester
		7
1. Holding classes (including results monitoring) in the form: 1.1.Contact classwork, including:		
– lectures (L)	16	16
– laboratory work (LW)		
– practice, seminars and/or other seminar-type work (PW)	34	34
– control of self-work (CSW)	4	4
– test		
1.2. Students' self-work (SSW)	54	54
2. Interim/midterm assessment		
Exam		
Grading test		
Test (Credit)		
Course Project (CP)		
Course Work (CW)		
Workload in hours	**108**	**108**

4. COURSE CONTENTS

Course sections with brief contents	Full time of classroom activity in hours according to the forms			Full time of extracurricular work in hours according to the forms
	L	LW	PW	SSW
Semester 7				
Sets, relations and mathematical logic	8		16	30
Sets and relations: Sets and operations on them. Basic Identities of Set Theory. Relations on sets, their properties and types. Equivalence relations, order relations. *Algebra of propositions*: Propositions. Basic operations on propositions. Equivalence of propositional algebra formulas. Inference rules. Normal forms. Zhegalkin's algebra. *Predicates and quantifiers*: Definition of a predicate. Quantifiers of generality and existence, their properties.				
Combinatorial analysis	4		8	8
Combinatorial compounds: Combinatorial compounds, their properties. Binomial Newton, binomial formula.				
Graph theory	4		10	16
Types of graphs: Definition of a graph, types of graphs. Digraphs, tree graphs. *Graph properties*: Connectivity, planarity. Euler and Hamiltonian graphs. Coloring of graphs. Graphs and codes.				
Total with regard to semester	**16**		**34**	**54**
Total with regard to the course	**16**		**34**	**54**

Topics of exemplary practical work

Sl.№	Topic of practical work (seminars)
1	Sets. Operations on sets.
2	Relations and their properties. Equivalence and order relations.
3	Algebra of propositions. Operations on statements.
4	Proof of the identities of the propositional algebra. Application of inference rules.
5	Construction of normal forms and perfect normal forms.
6	Zhegalkin's algebra. Checking the completeness of the system of logical functions.
7	Predicates and quantifiers.
8	Control work on mathematical logic.
9	Combinatorial compounds and their properties.
10	Counting the number of combinatorial connections.
11	Binomial theorem. Polynomial formula.
12	Control work on combinatorics.
13	Graphs. Graph operations. Addition. Isomorphic graphs.
14	Building an adjacency matrix and an incidence matrix. Control work.
15	A tree graph and its basic properties.
16	Determination of graph connectivity. Finding connectivity components. Planar graphs.
17	Graphs and codes.

Topics of exemplary laboratory practice

Sl. №	Topic of laboratory work

5. ORGANIZATIONAL AND PEDAGOGICAL CONDITIONS

5.1. EDUCATIONAL TECHNOLOGIES USED FOR COMPETENCES FORMATION

Holding lectures in the discipline is based on the active method of training in the process of which students are not passive but active participants of the lesson answering questions of the teacher. Teacher's questions are aimed at activating the process of learning material as well as at the development of logical thinking. The questions stimulating associative thinking and connecting new material with the previous one are identified by the teacher in advance.

Practical lessons are hold by realization of the method based on active training: problem areas are determined, groups are formed. The following aims are pursued in the process of practical education: use of definite disciplines knowledge and creative methods in solving problems and decision-making; students' skill-building of teamwork, interpersonal communication and development of leadership skills; consolidation of the basic theoretical knowledge.

Interactive lectures, group discussions, role-playing games, training sessions, and analysis of situations and simulation models are used in academic studies.

5.2. STUDENTS' MANUAL FOR THE COURSE STUDY

Learning the course students are recommended to fulfill the following positions:

1. Learning of the discipline should be done systematically.

2. After learning one of the course unit with the help of the text-book or lecture notes it is recommended to reproduce the basic terms, definitions, notions of the unit from memory.

3. Special attention should be paid to the reports on practical studies, laboratory works and individual complex tasks for self-work.

4. The topics list for individual study is given by the teacher at the lectures. The teacher also provides students with literary sources (first of all, new ones in the periodical scientific literature) for a more detailed understanding of the issues presented at the lectures.

6. LIST OF TEACHING MATERIALS AND INFORMATION SUPPLY FOR STUDENTS' SELF WORK IN THE DISCIPLINE

6.1. PAPER-BASED COURSEWARE

Sl.№	Bibliographic entry (author, title, mode of publication, place, publishing house, year of publication, number of pages)	Number of copies in the library
	1. Basic literature	
1	Balakrishnan V. K. Introductory Discrete Mathematics. – New York: Dover, 1997.	1
2	Bobrow L. S. and Arbib M. A. Discrete Mathematics: Applied Algebra for Computer and Information Science. – Philadelphia, PA: Saunders, 1974.	1
3	Dossey J. A., Otto A. D., Spence L. and Eynden C. V. Discrete Mathematics, 3rd ed. – MA: Addison-Wesley, 1997.	1
4	Hall C. and O'Donnell J. Discrete Mathematics Using a Computer. – London: Springer-Verlag, 2000.	1
5	Azbelev N.V., Maksimov V.P., Rakhmatullina L.F. Introduction to the Theory of Functional Differential Equations : Methods and Applications. New York : Hindawi Publ. Corr., 2007. 314 p.	1
	2. Additional literature	
	2.1. Educational and scientific literature	
1	Lipschutz S. and Lipson M. L. 2000 Solved Problems in Discrete Mathematics. – New York: McGraw-Hill, 1991.	1
2	Rosen K. Applications of Discrete Mathematics, 4th ed. – New York: McGraw-Hill, p. 1998.	1
3	Rosenstein J. G., Franzblau D. S. and Roberts F. S. Discrete Mathematics in the Schools. – Providence, RI: Amer. Math. Soc., 1997.	1
	2.2. Standardized and Technical literature	
	No provision	
	3. Students' manual in mastering discipline	
	No provision	
	4. Teaching and learning materials for students' self work	
	No provision	

6.2. ELECTRONIC COURSEWARE

Kind of literature	Name of training tool	Reference to information resource	Accessibility of EBN (Internet/local net; authorized free assess)
Book	Azbelev N.V., Maksimov V.P., Rakhmatullina L.F. Introduction to the Theory of Functional Differential Equations : Methods and Applications. New York : Hindawi Publ. Corr., 2007. 314 p.	https://elib.pstu.ru/vufind/Record/RUPSTUbooks126449	authorized free access

6.3. LICENSE AND FREE DISTRIBUTED SOFTWARE USED IN THE COURSE EDUCATIONAL PROCESS

Type of Software	Software branding
Operating system	Windows 10 (Azure Dev Tools for Teaching)
Office application	Adobe Acrobat Reader DC
Image processing software	Corel CorelDRAW Suite X4
General purpose application software	Mathematica Professional Version (license L3263-7820*)
General purpose application software	Microsoft Office Visio Professional 2016 (Azure Dev Tools for Teaching)
General purpose application software	WinRAR (license №879261.1493674)
Management systems for projects, research, development, design, modeling and implementation	Autodesk AutoCAD 2019 Education Multi-seat Stand-alone

6.4. MODERN PROFESSIONAL DATA BASES AND INQUIRY SYSTEMS USED IN THE COURSE EDUCATIONAL PROCESS

Branding	Reference to information resource
Scopus database	*https://www.scopus.com/*
Web of Science Database	*https://www.webofscience.com/*
Scientific electronic library database (eLIBRARY.RU)	*https://elibrary.ru/*
Scientific Library of the Perm National Research Polytechnic University	*https://lib.pstu/*
Lan Electronic Library System	*https://e.lanbook.com/*
Electronic library system IPRbooks	*https://www.iprbookshop.ru/*
Information resources of the Network ConsultantPlus	*https://www.consultant.ru/*
Company database EBSCO	*https://www.ebsco.com/*

7. LOGISTICS OF THE COURSE EDUCATIONAL PROCESS

Type of classes	Name of the necessary basic equipment	Number of units
Lecture	Projector	1

8. FUND OF THE COURSE EVALUATING TOOLS

Ministry of Science and Higher Education of the Russian Federation

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FUND OF ESTIMATING TOOLS

For students' midterm assessment in the discipline
"Mathematics, special chapters"
Supplement to the Academic Course Working Program

Training program	21.03.01 Oil and Gas Engineering
Direction (specialization) of educational program	Oil and Gas Engineering
Graduate qualification	Bachelor's degree
Graduate academic chair	Oil and Gas Technology
Form of study	Full-time studies

Year (-s): 4 **Semester (-s)**: 7

Workload:
in credits: 3 CU
in hours: 108 h

The form of midterm assessment:
Test 7 semester

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Fund of estimating tools for midterm assessment of students' learning the subject **"Mathematics, special chapters"** is the part (supplement) to the academic course working program. Fund of estimating tools for midterm assessment of students' learning the discipline has been developed in accordance with the general part of the fund of estimating tools for midterm assessment of the basic educational program which determines the system of the midterm assessment results and criteria of putting marks. Fund of estimating tools for midterm assessment of students' learning the subject determines the forms and procedures of monitoring results and midterm assessment of the subject learning by the students.

1. LIST OF CONTROLLED RESULTS OF STUDYING DISCIPLINE, OBJECTS OF ASSESSMENT AND FORMS OF CONTROL

According to the Academic Course Working Program mastering course content is planned during one semester (the seventh semester of curriculum) and is divided into two educational modules. Classroom activities, lectures as well as students' self-work are provided for every module. In the frames of mastering course content such competences as *to know, to be able, to master* pointed out in the ACWP are formed. These competences act as the controlled results of learning the discipline "Mathematics, special chapters" (Table 1.1).

Monitoring of the acquired knowledge, abilities and skills is made in the frames of continuous assessment, progress check and formative assessment in the process of studying theoretical material, control works, case-tasks and during the test. Types of control is given in Table 1.1

Table 1.1 – List of controlled results of learning the discipline

Controlled results of learning the discipline (KAS)	**Type of control**					
	Continuous assessment		**Progress check**		**Formative assessment**	
	D	**AC**	**LWR/ PWR**	**T/CW**		**Test**
1	**2**	**3**	**4**	**5**	**6**	**7**
Acquired knowledge						
K.1 basic definitions of set theory;	D					TQ
K.2 definition of a logical function; a method for checking the basicity of a system of logical functions;	D					TQ
K.3. definition of combinatorial compounds;	D					TQ
K.4. basic concepts of graph theory;	D					TQ
Acquired abilities						
A.1 do operations on sets;			PWR1	CW1		PT
A.2 prove the simplest identities of Boolean algebra;			PWR2	CW2		PT
A.3. write the perfect normal form of a logical function and minimize it;			PWR2	CW2		PT
A.4 count the number of combinatorial connections;			PWR3	CW3		PT

1	2	3	4	5	6	7
A.5 build the adjacency and incidence matrices of the graph;				CW4		PT
Mastered skills						
S.1 basic methods of set theory;			PWR1	CW1		
S.2 methods of constructing and minimizing normal forms;			PWR2	CW2		
S.3 the basic methods of combinatorics;			PWR3	CW3		

D – topic discussion; AC – colloquium (discussion of theoretical material, academic conference); CT – case-task (individual task); LWR – report on laboratory work; PWR – report on practical work; T/CW – progress check (control work); TQ – theoretical question; PT – practical task; CT – complex task of grading test.

Final assessment of the learned discipline results is the midterm assessment which is made in the form of test taking into consideration the results of the running and progress check.

2. TYPES OF CONTROL, STANDARD CONTROL TASKS AND SCALES OF LEARNING RESULTS ASSESSMENT

Continuous assessment of the academic performance is aimed at maximum effectiveness of the educational process, at monitoring students' specified competencies formation process, at increase of learning motivation and provides the assessment of mastering the discipline. In accordance with the regulations concerning the continuous assessment of the academic performance and midterm assessment of students taught by the educational programs of Higher education – programs of the Bachelor's Course, Specialists' and Master's Course the next types of students' academic performance continuous assessment and its periodicity is stipulated in PNRPU:

– acceptance test, check of the student's original preparedness and his correspondence with the demands for the given discipline learning;

– continuous assessment of mastering the material (the level of mastering the component "to know" defined by the competence) at every group studies and monitoring of lectures attendance;

– interim and progress check of students' mastering the components "to know" and "to be able" of the defined competences by computer-based or written testing, control discussions, control works (individual home tasks), reports on laboratory works, reviews, essays, etc.

Discipline progress check is conducted on the next week after learning the discipline module, while the interim control is made at every monitoring during the discipline module study;

– interim assessment, summarizing of the current students' performance at least once a semester in all disciplines for every training program (specialty), course, group;

– retained knowledge control.

2.1. CONTINUOUS ASSESSMENT OF EDUCATION

Continuous assessment of learning is made in the form of discussion or selective recitation on every topic. According to the four-point system the results of assessment are put into the teachers' note-book and are considered in the form of integral marks in the process of the midterm assessment.

2.1.1. Topic discussion

Standard questions of topic discussion:

1. Basic identities of set theory.
2. Equivalence relations.
3. Relations of order.
4. Equivalence of propositional algebra formulas.
5. Normal forms.
6. Combinatorial compounds, their properties.
7. Binomial of Newton.
8. Types of graphs.
9. Euler graphs.
10. Hamiltonian graphs.

2.2. PROGRESS CHECK

For the complex assessment of the acquired knowledge, abilities and skills (Table 1.1) it is made the progress check in the form of reports on practical work and midterm control works (after learning a certain section of the discipline).

2.2.1. Reports on practical work

It is planned 3 practicals all in all. Standard topics of practical work are: "Sets and relations", "Boolean algebra" and "Combinatorics".

Presentation of practical work is made by the student individually. Standard scale and criteria of assessment are given in the general part of FET of the educational program.

Standard tasks of the first PWR:

Task 1. Instead of a sign "?" put a symbol suitable for the meaning, for example $\in, \notin, \subset, \supset, =$ etc.

a) $1 \,?\, (-2;3)$;

b) $3 \,?\, \{1;3\}$;

c) $4 \,?\, \{1;3\}$;

d) $[2;3] \,?\, (2;3)$;

e) $(-2;0] \,?\, [-5;5)$.

Task 2. Let the universal set $U=\{-5;-4;-3;-2;-1;1;2;3;4;5\}$ is given and the set A is given by a list. The set B is the set of roots of the following equation $(x^2+3x-4)(x^2-4)(x^2+x-2)=0$.

1) Find the sets $A\cup B$, $A\cap B$, $A\setminus B$, $B\setminus A$, $A\Delta B$, $\bar{B}$, $C=(A\Delta B)\Delta A$.

2) Find out which of the five possibilities is fulfilled for the sets A and C: $A\subset C$, or $C\subset A$, or $A=C$, or $A\cap C=\varnothing$, or A is incomparable with C.

3) Find the set $P(B)$ of all subsets of the set B and its potency $|P(B)|$.

Task 3. Let the compliance $\Gamma=(X;Y;G)$ is given. Draw the correspondence as a graph. Find out whether the given correspondence possesses the properties of definition, subjectivity, functionality, injectivity everywhere. Find the image of the set A and the preimage of the set B for the given correspondence.

X	Y	G	A	B
a,b,c,d	1,2,3,4,5	$(a,2),(b,1),(b,5),(d,4)$	a,b	3,4

Task 4. The relation $\Phi_1=\{(x,y)|2x\le y\}$ is given on a finite set $A=\{1;2;3;4\}$. Build a graph of the relation Φ_1. Write the ratio Φ_1 as a set. Build the matrix of the ratio Φ_1. Find out if the relation Φ_1 has the properties of reflexivity, anti-reflexivity, symmetry, antisymmetry, and transitivity. Determine if Φ_1 an order or equivalence relation is.

The ratio $\Phi_2=\{(x,y)|x-y\,devided\,by\,2\}$ is given on the infinite set $\Phi_2\subseteq Z^2$. Find out whether the relation Φ_2 has the properties of reflexivity, anti-reflexivity, symmetry, antisymmetry, transitivity. Establish whether the relation Φ_2 is an ordering or equivalence relation.

Standard tasks of the second PWR:

Task 1. Using equivalent transformations reduce the following formula $(x_2\vee x_1)\left|\left(\overline{(x_3\approx x_1)}\right)\right.$ to disjunctive normal form.

Task 2. Using equivalent transformations reduce the following formula $\overline{x_2}((x_3\to x_1)\oplus x_2)$ to conjunctive normal form.

Task 3. Check the equivalence of the following formulas Φ and Ψ: $\Phi=(x_3\approx(x_2x_3))\oplus((x_2\vee x_1)x_1)$, $\Psi=\overline{x_1}\oplus(x_3\to x_2)$.

Task 4. Transform the function $f=(11001001)$ into PDNF. Construct the DNF. Transform the function $g=(0011000001110011)$ into PDNF. Minimize the resulting PDNF. For minimization, you can use the Karnot method, Quine method,

combinations of indices or the analytical method. Transform the function $h=(01110110)$ into PKNF.

Standard tasks of the third PWR:

Task 1. How many even positive five-digit numbers can be formed from the digits of 13754, if each digit can be used no more than once?

Task 2. In how many ways can a tricolor flag be made if there are five different colors of material?

Task 3. It is necessary to deliver advertising brochures to 6 different companies. How many ways can three couriers do this?

2.2.2. Midterm control work

According to ACWP 4 midterm control works (CW) are planned to be realized after learning the educational modules of the discipline by the students.

The first and second CW is realized with respect to the module 1: "Sets and relations" and "Algebra of statements", the third and fourth CW – with respect to the module 2: "Combinatorics" and "Graphs".

Standard tasks of the first CW:

Task 1. Let $U=\{1,2,3,4\}$, $A=\{1,2,3\}$, $B=\{1,2\}$, $C=\{3,4\}$ be given sets. Find $A\cup(B\cup C)$ and $\overline{A\setminus B}$.

Task 2. In May there were 12 rainy, 8 windy, 4 cold, 5 rainy and windy, 3 rainy and cold, 2 windy and cold days, and one day was rainy, windy and cold. How many warm days without wind and rain there were in May?

Task 3. The relation $\Phi=\{(x,y)|2x\le y\}$ is given on the set $A=\{1,2,3,4\}$. Construct the graph of the relation Φ. Write the relation Φ in the form of a set. Build the matrix of the relation Φ. Find out whether the relation Φ has the properties of reflexivity, anti-reflexivity, symmetry, antisymmetry, transitivity. Establish whether the relation Φ is an order or equivalence relation.

Standard tasks of the second CW:

Task 1. Write the DNF of the following function $f=(x\to y)\downarrow\overline{(y\to z)}$.

Task 2. Simplify the expression:

$$\left((c\vee\bar{a})\wedge(\bar{a}\vee\bar{b})\wedge(a\vee c)\wedge(\bar{b}\vee a)\right)\vee(b\wedge\bar{d})\vee(b\wedge d).$$

Task 3. Construct the PDNF and DNF of the function given by the vector of values $f=(11010101)$. Build an SFE and a combinational scheme.

Standard tasks of the third CW:

Task 1. How many ways can be selected four persons out of 15 candidates for four different positions?

Task 2. There are 10 letters on the disc, and the code word consists of 5 letters. How many unsuccessful attempts can be made by a person who does not know the code word?

Task 3. Count how many different words (including meaningless ones) can be obtained by rearranging the letters of the word "logarithm" in which the second, fourth and sixth places are occupied by the consonants?

4. Solve the inequality $P_n > C_{10}^2$.

5. Find the numerical coefficient of x^2 in the following expansion $(2+3x)^6$.

Standard tasks of the fourth CW:

Task 1. For a given vertex adjacency matrix construct a graph and an incidence matrix. Give answers to the questions.

$$\begin{pmatrix} 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \end{pmatrix}$$

a) Specify vertex degrees 2 and 4.

b) Specify the vertices with a degree equal to 3.

c) How many even vertices are there in the graph? Indicate their numbers.

d) Indicate dangling vertices.

e) How many edges does the complement of the graph contain?

f) The vertex 2 was removed from the given graph. How many edges are there in the resulting subgraph?

Task 2. Build a graph for a given incidence matrix and answer the questions.

$$\begin{pmatrix} 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \end{pmatrix}$$

a) How many edges in the graph are incident to vertex 3?

b) Pick the vertices with degree 4.

c) Indicate the numbers of the dangling vertices.

d) Indicate the numbers of the even vertices and their degrees.

e) How many edges are in the complement of the graph?

Task 3. For a given weight matrix:

$$\begin{pmatrix} - & 5 & 4 & \infty & 10 & \infty \\ \infty & - & \infty & 8 & \infty & 13 \\ \infty & 6 & - & 5 & 8 & \infty \\ \infty & \infty & \infty & - & \infty & 8 \\ \infty & \infty & \infty & 4 & - & 10 \\ \infty & \infty & \infty & \infty & \infty & - \end{pmatrix}$$

a) Find the value of the minimum path and the path itself from vertex x_1 to vertex x_6 using Dijkstra's algorithm.

b) Order the vertices of the graph according to Fulkerson's algorithm; find the value of the maximum path and the path itself between the vertices x_1 and x_6.

The results of control works on a 4-point grading scale are entered in the teacher's book and taken into account as an integral assessment during the midterm certification.

Standard scale and criteria of the results of the midterm control work assessment are given in the general part of FET of the educational program.

2.3. FULFILLMENT OF THE COMPLEX INDIVIDUAL SELF-WORK TASK

Individual complex task for the students is used for assessment of their skills and abilities acquired in the process of learning the discipline in which the course project or course paper is not stipulated.

Standard scale and criteria of assessment of the individual complex task presentation are given in the general part of FET of the educational program.

2.4. MIDTERM ASSESSMENT (FINAL CONTROL)

Admission for midterm assessment is made according to the results of continuous assessment and progress check. Preconditions for admittance are successful presentation of all reports on practical work, control works and positive integral estimation with respect to the results of continuous assessment and progress check.

2.4.1. Midterm assessment procedure without additional evaluation testing

Midterm assessment is made in the form of a test. Credit on the discipline is based on the results of the previously fulfilled by the student individual tasks on the given discipline.

Criteria of putting the final mark for the components of competences in the process of midterm assessment made in the form of test are given in the general part of FET of the educational program.

2.4.2. Midterm assessment procedure followed by evaluation testing

In definite cases (for example, in case of re-attestation of the discipline) midterm assessment in the form of the test on this discipline can be made as the ticket-based evaluation test. Every ticket includes theoretical questions(TQ) aimed at control of the acquired knowledge, practical tasks (PT) aimed at mastered abilities, and complex tasks (CT) aimed at control of the acquired skills of all declared competences.

The ticket is formed so that the included questions and practical tasks could estimate the level of maturity of **all** declared competences.

2.4.2.1. Standard questions and tasks the discipline testing

Standard questions for the acquired knowledge control:

1. The set. Relations on sets. Equivalence relation.
2. Disjunctive, conjunctive normal forms.
3. Permutations and combinations.

Standard questions and practical tasks for the mastered abilities control:

1. Let U be a universal set, $A \subset B \subset C \subset D \subset U$. Simplify: $\overline{A} \cap \overline{B} \cap \overline{D} \cup A \cap \overline{B} \cap \overline{C} \cup A \cap \overline{B} \cap D \cup A \cap \overline{C} \cup A \cap B \cap C \cap D$.
2. Using the following DNF $\overline{x}y \vee \overline{z}x\overline{y}$ write the Zhegalkin polynomial.
3. Construct the complement of the graph given by its adjacency matrix $\begin{pmatrix} 0 & 1 & 1 & 0 \\ 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{pmatrix}$.
4. There is one lamp in the staircase of a two-story building. Build a scheme so that on each floor you can turn off and light the lamp with your own switch, regardless of the position of the other switch.
5. Build a combinational circuit working according to the given conditions. Find the minimum DNF and KNF of the corresponding Boolean function. The output signal takes on one value in cases when:

a) $a = b = 1, d = 0$;

b) $a = 1, b = c = 0$;

c) $b = d = 0, c = 1$;

d) $a = 0, c = 1$;

e) $a = b = 0, d = 1$.

2.4.2.2. Scales of test assessment of educational achievements

Evaluation of discipline achievements in the form of maturity level of the components *to know, to be able, to master the* declared competences is made according to the four-point assessment scale.

Standard scale and criteria of estimating educational achievements in the process of testing for the components *to know, to be able, to master* are given in the general part of FET of educational program.

3. ASSESSMENT CRITERIA FOR COMPONENTS AND COMPETENCES LEVEL OF MATURITY

3.1. ASSESSMENT OF COMPETENCES COMPONENTS LEVEL OF MATURITY

While estimating the level of competences maturity by selective control in the process of testing it is considered that *the mark obtained for the components of the examined competence is combined with the corresponding component of all competences formed in the frames of the given academic course.*

General assessment of maturity level of all competences is made by aggregation of marks obtained by the student for each component of the formed competences taking into account the results of continuous assessment and progress check in the form of integral mark according to the four-point scale. All control results are put into the assessment sheet by the teacher according to the results of midterm attestation.

The form of the assessment sheet and requirements for its completion are given in the general part of FET of the educational program.

While making the final assessment of the midterm attestation in the form of test standard criteria given in the general part of FET of the educational program are used.