MINISTRY OF SCIENCE AND HIGHER EDUCATION
OF THE RUSSIAN FEDERATION
Federal State Autonomous Educational Institution
higher education "NORTH CAUCASUS FEDERAL UNIVERSITY"

METHODOLOGICAL INSTRUCTIONS

for completing laboratory work
in the discipline "Application of mathematical logic in control systems" for the training direction
09.04.03 "Applied Informatics" (focus (profile) "Knowledge Management")

Stavropol, 2026

CONTENT

INTRODUCTION

The content of laboratory work allows you to master practical techniques for compiling truth tables for Boolean formulas, practical techniques for performing equivalent transformations of Boolean and predicate logic formulas, learn to solve logical problems using Boolean methods, apply the tools of the predicate logic language to record and analyze mathematical propositions, conduct evidential reasoning in the course of solving problems; apply mathematical methods to solve professional problems; master the technique of equivalent transformations of logical formulas, methods for recognizing identically true formulas and equivalent formulas, skills for solving basic problems of mathematical logic and methods for solving them.

The methodical instructions for performing laboratory work contain instructions with a clear algorithm for the work process. Each practical work includes brief theoretical material, example problems and a set of tasks.

The methodological instructions can be used for independent work of students.

Laboratory work #1. Elements of mathematical logic

The purpose of the laboratory work:know the basic concepts of propositional algebra, laws of Boolean algebra, be able to compile truth tables for statements, transform formulas using equivalent transformations, solve Boolean equations.

Competencies to be developed:UK-1; UK-4; UK-8

Theoretical part

Mathematical logic is a section of mathematics devoted to the analysis of methods of reasoning, whereby the forms of reasoning are primarily investigated, and not their content, i.e. the formalization of reasoning is investigated? This is a type of formal logic, i.e. a science that studies inferences from the point of view of their formal structure.

The basic undefined concept of mathematical logic is*statement.*Under *statement*understand a sentence that can only take on two meanings "true" or "false". Statements are indicated by small Latin letters:*a,b*, , …,*X*,…. or capital Latin letters A, B, C…

In mathematical logic, the meaning of statements is not considered, only their logical meaning is determined - "true" or "false". The famous German mathematician and logician Ernst Schroeder came up with the idea of proposing the number 0 as a sign for denoting a false judgment, which, of course, led to the designation of truth by the number 1.

Propositional calculus is an introductory section of mathematical logic that examines logical operations on propositions.

A predicate is a logical function of n variables that takes on the values of truth or falsehood.

Predicate calculus is a section of mathematical logic whose object is the further study and generalization of propositional calculus.

The theory of Boolean algebras (Boolean functions) forms the basis of exact methods of analysis and synthesis in the theory of switching circuits in the design of computer systems.

Examples.

1. “The Kola River flows into the Kola Bay” is a statement (true).
2. “The number 32 is a multiple of 3” is a statement (false).
3. “It might snow today” is not a statement.
4. "5*X*-9 = 7" is not a statement (an indefinite statement or statement form).

Using simple statements, you can create more complex ones by combining them simple statements with the conjunctions “and”, “or”, the conjunctions “not”, “should”, etc. Operations on statements can be described using some mathematical apparatus.

Basic logical operations on statements.

*Denial*statements*X*is called a statement that is true then and only when the statement*X*false. Negation is denoted by*x*or -*X*(reads: "Not*X*»).

Logical operations can be specified using*truth tables*, showing the correspondence of truth values of statements. For statements*x*And *x*This table looks like this:

X	$\bar{x}$
1	0
0	1

*Conjunction*two statements*X*And*y*is called a statement that is true then and only when both statements are true*X*And*y*. Conjunction is denoted by:*X-y,* or*X*&*y*(reads: "*X* And*y*"). Tablethe truth for*X-y*has the form:

X	*y*	*X-y*
1	1	1
1	0	0
0	1	0
0	0	0

*Disjunction*two statements*X*And*y*is called a statement that is false then only when both statements*X*And*y*are false. Disjunction is denoted by*X-y*(or *x+y*) (reads: "*X*or *y*"). Tabletruth for*X-y* has the form:

X	*y*	*X-y*
1	1	1
1	0	1
0	1	1
0	0	0

*Implication*two statements*X*And*y*is called a statement that is false then only when the statement*X*true, but*y*- false. The implication is indicated by:*X*- *y*(reads: "*X* attracts*y*" or "from*X*follows*y*"). Statement*X*it's called*by parcel implications*, and the statement*y-slconsequence*. Table of history innosti for*X-y*has the form:

X	*y*	*X-y*
1	1	1
1	0	0
0	1	1
0	0	1

Equivalence(equivalence) of two statements*X*And*y*it's called a statement that is true if and only if the truth values of statements*X*And*y* coincide. Equivalence is denoted by:*X-y,* or*X-y*(reads: "*X*equivalent*y*" or "*X*then and only then when*y*"). Truth table and for*X-y*has the form:

X	*y*	*X-y*
1	1	1
1	0	0
0	1	0
0	0	1

A set of statements with the logical operations of disjunction, conjunction and negation introduced for them by the basic laws of these actions is called ***Boolean algebra***. Boole's algebra is the historically first section of mathematical logic, developed by the Irish logician and mathematician George Boole (1815-1864) - English mathematician and logician. Professor of Mathematics at King's College Cork).in the middle19th century Boole applied algebraic methods to solve logical problems and formulated some fundamental laws of thought in the language of algebra

Laws of Boolean algebra.

Commutative laws:

1.*x-y-y-x*;

2.*x-y-y-x*;

Associative laws:

1. *x*- (*y-z*) - (*x-y*) -*z*;

2. $x\text{-}(y\text{-}z)\text{-}(x\text{-}y)\text{-}z$;

Distributive laws:

1. $x\text{-}(y\text{-}z)\text{-}(x\text{-}y)\text{-}(x\text{-}z)$;
2. $x\text{-}(y\text{-}z)\text{-}(x\text{-}y)\text{-}(x\text{-}z)$;

Idempotent laws:

1. $x\text{-}x\text{-}x$;
2. $x\text{-}x\text{-}x$;

Laws of logical addition and multiplication with 0 and 1:

1. $x\text{-}0\text{-}0$;
2. $x\text{-}0\text{-}x$;
3. $x\text{-}1\text{-}x$;
4. $x\text{-}1\text{-}1$;

Laws of the operation "line":

=

1. $x\text{-}x$;
2. $x\text{-}0\text{-}x$;
3. $x\text{-}\underline{1}\text{-}1$;
4. $x\text{-}x\text{-}\underline{0}$;
5. $x\text{-}x\text{-}1$;

De Morgan's Laws (Augustus de Morgan (1806-1871) - Scottish mathematician and logician; professor of mathematics at University College London):

1. $\overline{x\text{-}y}\text{-}\overline{x}\text{-}\overline{y}$;
2. $\overline{x\text{-}y}\text{-}\overline{x}\text{-}\overline{y}$.

*Addition modulo two (*alternative disjunction,logical addition, exclusive "OR", strict disjunction) of two statements*X*And*y* is called a statement that is true if and only if both statements*X*And *y*take on different meanings. Disjunction is denoted by*X-y* (read: "or*X*,or*y*"). Truth table for*X-y*has the form:

X	*y*	*X-y*
1	1	0
1	0	1
0	1	1
0	*0*	*0*

Pierce's Arrow -This is the negation of disjunction. The Pierce arrow is denoted by X ↓ Y. It is read as "neither X nor Y".
Introduced by Charles Peirce in 1880-1881. The truth table for the Peirce arrow is:

X	*y*	*X-y*
1	1	0
1	0	0
0	1	0
0	0	1

Schaeffer's stroke -This is the negation of conjunction.

Introduced into consideration by Henry Schaeffer in 1913 (in some sources it is called Chulkov's Dotted Line)

The Schaeffer stroke denotes$\underline{x|y}$ is given by the following the following truth table:

X	*y*	x|y
1	1	0
1	0	1
0	1	1
0	0	1

Lab assignment

1. Study the theoretical material of this laboratory work.
2. Indicate in which cases the statement is true and in which cases it is false:

(*A*-*B*) --*B*-*A*-

Are the following statements equivalent:

-*x*-*y*---*x*-*z*-And*x*--*y*-*z*-

Solve the Boolean equation:

-*z*-*x*---*z*(*y*-*x*)--*x*- (*y*-*z*)

Indicate in which cases the statement is true and in which cases it is false:

-(*A*-*B*) -*A*- --*A*-*B*-

Are the following statements equivalent:

x-*y*-*z*-And(*xy*) --*xz*-

Solve the Boolean equation:

-*z*-*y*---*z*-*x*--*x*-*y*

3v

2.6. Indicate in which cases the statement is true and in which cases it is false:

--(*A*-*B*) -*A*- --*A*-*B*-

Equipment and materials:to complete this lab work A computer with the Windows 7 operating system and software products installed is required: MS Office package.

Safety instructions:to perform laboratory work Students who are familiar with the rules of working in the laboratory and have undergone safety training are allowed to attend.

Contents of the report:The laboratory report must be completed in in the MS Word editor and formatted according to the requirements. Formatting requirements: Times New Roman font, one and a half spacing, left margins - 3 cm, right - 1.5 cm, top and bottom - 2 cm. Paragraph indent - 1.25. The text should be aligned by width. The report should contain a title page with the topic of the lab work, the purpose of the work and a description of the process of completing your work. At the end of the report, conclusions on the work done are provided. The report must include screenshots of the work done and a description of them. Each figure must be centered on the page, have a caption (Figure 1 - Creating a subsystem) and a link to it in the text.

Test questions:

1. What is meant by a statement in mathematical logic?
2. What actions are performed on statements?
3. What is called Boolean algebra?
4. Laws of Boolean algebra.

List of literature recommended for use on this topic:

1. Peremitina T. O. Mathematical logic and theory of algorithms: a tutorial UDC: 510.6 + 510.51, BBK: 22.12ya73 Tomsk: TUSUR, 2016, S-132. URL:

http://biblioclub.ru/index.php?page=book_red&id=480886&sr=1

2 Mathematical logic and theory of algorithms: a tutorial. Authors Makokha A.N., Shaposhnikov A.V., Berezhnoy V.V. UDC: 94(5) (075.8) BBK: 22.12 ya73. Stavropol: SKFU, 2017.C– 418. URL:

http://biblioclub.ru/index.php?page=book_red&id=467015&sr=1

Lab work #2. Reducing formulas to perfect normal forms according to truth tables

The purpose of the laboratory work:know what DNF and KNF are, be able to give Boolean algebra formulas to SDNF and SKNF and minimize them using the laws of Boolean algebra.

Competencies to be developed:UK-1; UK-4; UK-8

Theoretical part

Definition: A formula is called identically true (tautology) if for any set of variables it takes the value AND.

Definition: A formula is called identically identically false if for any set of variables it takes the value L.

In propositional algebra, two normal forms are used: disjunctive and conjunctive normal forms of formulas (DNF and CNF).

Disjunctive normal form (DNF) is the disjunction of simple conjunctions.

The conjunctive normal form (CNF) of a formula is a formula that is equivalent to the original formula of propositional logic and written as a conjunction of elementary disjunctions of variables.

Every formula that is not identically equal to A can be reduced to a SDNF that is unique up to a permutation of disjunctive terms.

Every formula that is not identically equal to AND can be reduced to a CNF, which is unique up to a permutation of conjunctive terms.

A perfect disjunctive normal form (PDNF) of a formula is an equivalent formula that is a disjunction of elementary conjunctions and has the properties

1. Each logical term of the formula contains all the statements included in it. formula.
2. All logical components of the formula are different
3. No logical term contains a statement and its negation.
4. No logical term of the formula contains the same statement. twice.

Algorithm for obtaining the SCNF from the truth table: 1) Mark those rows in the last column of which there are 0:

2) Write out for each marked line the disjunction of all variables as follows: if the value of some variable in a given row =0, then the disjunction includes this variable itself, if =1, then its negation:

3) Connect all the obtained disjunctions into a conjunction. Lab assignment

1. Study the theoretical material of this laboratory work.
2. Construct a truth table, find the SNDF, find the minimum DNF for statements:

1. $\overline{z}y\overline{\quad}z\overline{x}$
2. $\overline{(A \cdot B)} \cdot \overline{A}$
3. $A \cdot B$

Equipment and materials:to complete this lab work A computer with the Windows 7 operating system and software products installed is required: MS Office package.

Safety instructions:to perform laboratory work

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Contents of the report:The laboratory report must be completed in in the MS Word editor and formatted according to the requirements. Formatting requirements: Times New Roman font, one and a half spacing, left margins - 3 cm, right - 1.5 cm, top and bottom - 2 cm. Paragraph indent - 1.25. The text should be aligned by width. The report should contain a title page with the topic of the lab work, the purpose of the work and a description of the process of completing your work. At the end of the report, conclusions on the work done are provided. The report must include screenshots of the work done and a description of them. Each figure must be centered on the page, have a caption (Figure 1 - Creating a subsystem) and a link to it in the text.

Test questions:

1) What is DNF?
2) What is the difference between DNF and SDNF?
3) How to compose a DNF using a truth table?

List of literature recommended for use on this topic:

1. Peremitina T. O. Mathematical logic and theory of algorithms: a tutorial UDC: 510.6 + 510.51, BBK: 22.12ya73 Tomsk: TUSUR, 2016, S- 132. URL: http://biblioclub.ru/index.php?page=book_red&id=480886&sr=1

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Lab work #3. Solving logical problems

The purpose of the laboratory work:be able to solve problems using algebra formulas logic.
Competencies to be developed:UK-1; UK-4; UK-8
Theoretical part

- Are the statements equivalent:

1. $\overline{a}$-bAnd$\overline{a}$-b

2. b-aAnd$\overline{b}$-$\overline{c}$-$\overline{a}$

3. a-$\overline{b}$And$\overline{b}$-a

- Based on conversational practice, we know that, given statements A and B,

it is possible to construct statements: not A (it is not true that A); A and B; A or B; if A, then B (from A follows B); A if and only if B (A is equivalent to B, A is identical to B)

These statements, unlike the elementary ones, can naturally be called complex, since they are already endowed with a structure. However, they, like the simple ones, can only take on two possible values: And or L.

Among the following statements, indicate the composite ones; highlight the simple ones in them, designating each of them with a letter; write down each composite statement using logical operations:

1."Spring has come, and the rooks have arrived." Solution to the problem:

Let us denote by A- "spring has come"; and by B- "the rooks have arrived". Then the statement C - "Spring has come, and the rooks have arrived" we will write like this: C = A-B. Answer: C= A-B.

2."The number 6 is divisible by 2 and the number 6 is divisible by 3."

3. "It is not true that 4 is divisible by 3." Let us denote by a simple statement "4 is divisible by 3". Present the first statement as a logical formula.

4. It is not true that the Sun moves around the Earth.

5. The Earth is shaped like a ball.

6. In a math lesson, high school students answered the teacher's questions and wrote independent work.

7. If the sum of the digits of a number is divisible by 3, then the number is divisible by 3.

8. A number is divisible by 3 if and only if the sum of the digits of the number is divisible by 3.

9. The number 376 is even and three-digit.

10. 1) "In the summer I will go to the village or on a tourist trip."
2) "In the summer I will go to the village, or on a tourist trip, or to a sanatorium."
3) "If I go to the village in the summer, I won't go on a tourist trip."
4) "If I don't go to the village or to a sanatorium in the summer, then I'll go to "a tourist trip."
5) "If I go to the village or to a sanatorium in the summer, then I will not go to "a tourist trip."

- Solve problems using Boolean algebra.

1. During the process of drawing up the lesson schedule, teachers expressed their wishes. The Russian language teacher wants to teach the first or second lesson, the math teacher wants to teach the first or third lesson, and the physical education teacher wants to teach the second or third lesson. How many possible schedule options are there and what are they?

Solution. Let's introduce the designations: A - 1st lesson of Russian, B - 2nd lesson of Russian language,$\overline{A}$-1st lesson of mathematics, C – 3rd lesson of mathematics,$\overline{B}$-2nd lesson of physical education,$\overline{C}$- 3rd lesson of physical education. Let's make a logical formula based on the problem statement: (AvB) & ($\overline{A}$v C) & (B v$\overline{C}$). The truth table for it will look like this:

A	B	C	$\overline{A}$	$\overline{B}$	$\overline{C}$	AvB	$\overline{A}$ v C	$\overline{B}$ v $\overline{C}$	(AvB) & ($\overline{A}$ v C)	(AvB) & ($\overline{A}$ v C) & ($\overline{B}$ v $\overline{C}$)
0	0	0	1	1	1	0	1	1	0	0
0	0	1	1	1	0	0	1	1	0	0
0	1	0	1	0	1	1	1	1	1	1
0	1	1	1	0	0	1	1	0	1	0
1	0	0	0	1	1	1	0	1	0	0
1	0	1	0	1	0	1	1	1	1	1
1	1	0	0	0	1	1	0	1	0	0
1	1	1	0	0	0	1	1	0	0	0

Answer: Analyzing the table, we come to the conclusion that the schedule can be presented in two versions:

1 lesson math
Lesson 2 Russian language
or
Lesson 3 Physical education
.
Lab assignment

1 lesson Russian
language 2 lesson
physical education
Lesson 3
mathematics.

1. Study the theoretical material of this laboratory work.
2. Construct a truth table.

1. Only one of the suspects participated in the crime. It is known that if Ivanov did not participate or Petrov participated, then Sidorov participated; if Ivanov did not participate, then Sidorov did not participate. Who participated in the crime?

2. Anya, Vika and Sergey decided to go to the cinema. The teacher, who knew the children well, made suggestions: Anya will go to the cinema only when Vika and Sergey go; Anya and Sergey will go to the cinema together or both will stay at home; for Sergey to go to the cinema, Vika must go. When the children went to the cinema, it turned out that the teacher had made a slight mistake: out of his three statements, only two were true. Which of the children went to the cinema?

3. Excursions to three cities A, B and C are planned. The head of the company said: "It is not true that if there is an excursion to city B, then there will be no excursion to city C. If there is an excursion to city C, then there will be no excursion to city A." To which cities will the excursion be conducted?

Equipment and materials:to complete this lab work A computer with the Windows 7 operating system and software products installed is required: MS Office package.

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Lab #4. Actions on sets

The purpose of the laboratory work:know what is meant by a set, be able to perform operations on sets and know the laws of operations on sets.

Competencies to be developed:UK-1; UK-4; UK-8

Theoretical part

*By unification*two sets A and B are called a set of the form: AB = {a / a- A or a- B} (Fig. 1, a).

*Intersection*two sets A and B are called a set of the form: AB={a / a- A and a- B} (Fig. 1, b).

If sets A and B have no common elements, then AB=-. *A*

b

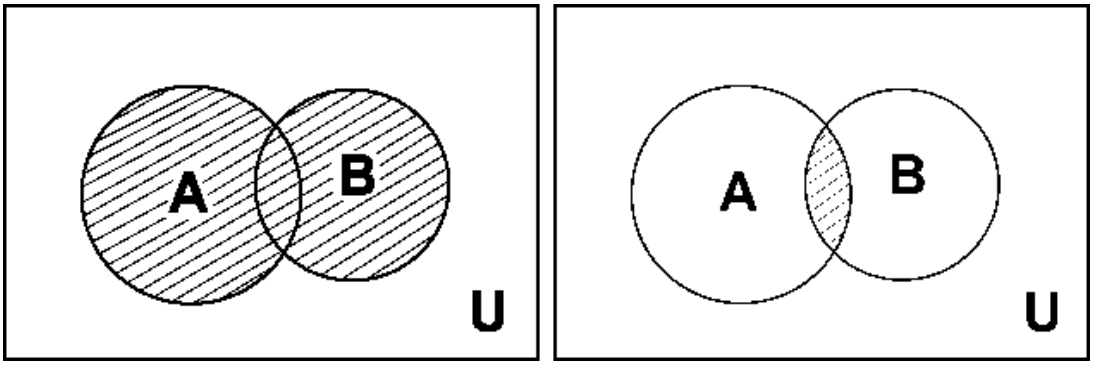

Fig. 1.2.

Properties of the operations of union and intersection 1. AB = B-A, AB = B-A (commutativity);

2. (AB)-C = A-(B-C), (AB)-C = A-(B-C) (associativity). Union and intersection are related by the laws of distributivity: A-(BC)= (AB) - (A-C); A-(BC)= (AB) - (A-C).

By property 3 of the inclusion operation, the equality of the right and left parts of the equality being proved follows.

For the operation of union of sets, the empty set is neutral, and for the operation of intersection of sets, the universal set U is neutral. The difference between sets A and B is defined as follows: A\B = {a / aA and aB} (Fig. 1.3, a).

Difference does not have the property of commutativity; this operation is also not associative.

Using the concept of a universal set, we can define a complement*A* to the set A, as a difference of the form:*A*=U \ A (Fig. 1.3, b).

Example: Let the universal set be the set of integers numbers Z and let A be the set of all even numbers. Then*A*- this is the set of all odd numbers.

The operations of union, intersection and complement of sets are related to each other by De Morgan's laws:

A-B-A-B, = *A-B-A-B*.

If a -*A-B*, Thata - AB. This means that either a-*A*, ora-*B*, i.e.a-

A-B. Hence,*A-B-A-B*.

On the other hand, if a-*A-B*, then ora-*A*, ora-*B*. This means thata-

A- B , i.e. a -*A-B*. Thus,*A-B-A-B*.

From these two inclusions follows the first law of De - Morgan. The second law is proved in a similar way.

A *b*

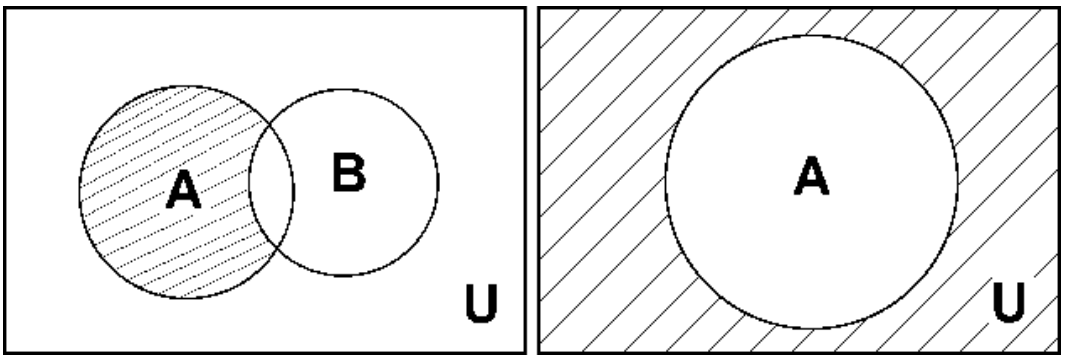

Fig. 1.3.

Examples of problem solutions.

1. Find*A-B;A-B;A-B;B-A;A* *B.* *A*-7;-8;9 ;*B*- -7;8;10-

Solution:

A-B--7;8;9---7;8;10---7;8;9;10-
A-B--7;8;9---7;8;10---7;8-
A-B--7;8;9---7;8;10 --------- 7;7-;-7;8-;-7;10-;-8;7-;-8;8-;-8;10-;-9;7-;-9;8-;-9;10--
B-A--7;8;10---7;8;9----7;7-;-7;8-;-7;9-;-8;7-;-8;8-;-8;10-;-10;7-;-10;8-;-10;9--
A.B.--7;8;9- -7;8;10---------- 9-.

2. Prove the equality and write its dual:

(*A-B*)(*B-C*)(*C-A*) -*ABC-A.B.-AC-B.C.*

Solution:

Let's transform the left side:

(*A-B*)(*B-C*)(*B-A*) --*A.B.-C*-(*B-A*) -*A.B.-A.B.-CB-CA*-

-*ABC-A.B.-AC-B.C.*

Thus, the left side is equal to the right side, i.e. the equality is true.

In order to form an equality dual to the given one, we use the principle of duality. Let us replace the sign in the given equality-on-and vice versa. To avoid changing the order of actions, we will put the brackets differently. We will get the dual equality: *A.B.-B.C.-CA-A-B--CA-BA-CB-C*--- -- --

Lab assignment

1. Study the theoretical material of this laboratory work.
2. Find*A-B;A-B;A-B;B-A;A.B..A*-4;6;8 ;*B*- - - -6;10;14-
3. Prove the equality and write its dual:

-*A-B--B-C--C-D--AC-B.C.-BD*

4. Sets M, P, T are given. What will the set be?*S*- (*M*-*P*) *T*, If *M*- {3; 7; 8; 6; 0};*P*- {*x*|*x*-*R*; 0 -*x*-6};*T*- {*x*|*x*-*R*; 3 -*x*-7} .

Find it. Draw it using Euler circles.

Equipment and materials:to complete this lab work A computer with the Windows 7 operating system and software products installed is required: MS Office package.

Safety instructions:to perform laboratory work Students who are familiar with the rules of working in the laboratory and have undergone safety training are allowed to attend.

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Test questions:

1. What is meant by a set?
2. Methods of defining sets.
3. What set is called empty? Universal?
4. Actions on sets.
5. Laws of actions on sets.

List of literature recommended for use on this topic:

1. Peremitina T. O. Mathematical logic and theory of algorithms: a tutorial UDC: 510.6 + 510.51, BBK: 22.12ya73 Tomsk: TUSUR, 2016, S- 132. URL: http:// biblioclub.ru/index.php?page=book_red&id=480886&sr=1

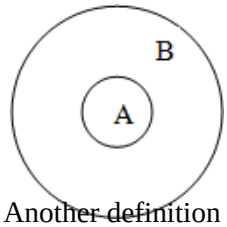
2 Mathematical logic and theory of algorithms: a tutorial. Authors Makokha A.N., Shaposhnikov A.V., Berezhnoy V.V. UDC: 94(5) (075.8) BBK: 22.12 ya73. Stavropol: SKFU, 2017.C– 418. URL: http://biblioclub.ru/index.php?page=book_red&id=467015&sr=1

Lab #5. Power of a Finite Set

The purpose of the laboratory work:be able to solve problems using Euler circles.
Competencies to be developed:UK-1; UK-4; UK-8 Theoretical part

A set A is called a subset of a set B if any element of set B is an element of set B. Graphically it

looks like this

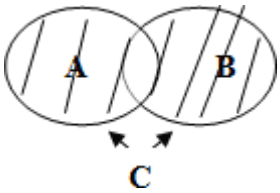


Another definition of equal sets can be given. Two sets are called equal if they are mutual subsets.

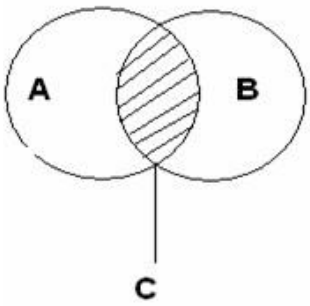
$$A \subset B \text{ и } B \subset A \Rightarrow A = B$$

Let's consider operations on sets and their graphical illustration

1. The union of sets A and B is depicted as:

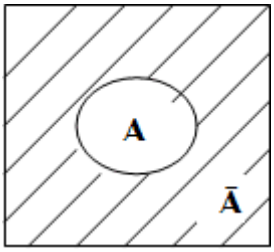


2. The intersection of two sets A and B is depicted as:



In any meaningful problem, we usually consider subsets of some "largest" set U, which is called the universal set. The universal set is the largest set that contains all the sets considered in the problem.

The set of all elements of the universal set U that do not belong to the set A is called the complement of the set A to U and is denoted by $\bar{A}$



PowerThe number of elements of a finite set is called the number of its elements. For a finite set Athroughm (A) denotes the number of elements in the set A.

The following properties follow from the definition: $m(A) + m(\bar{A}) = m(E)$

$A = B \Rightarrow m(A) = m(B)$

For any finite sets the following statements are also true: $M(A-B)=m(A) + m(B) – m(A \cap B)$

$m(A-B-C) = m(A) + m(B) + m(C)– m(A \cap B) - m(A \cap C) – m(B \cap C) – m(A \cap B \cap C)$.

Lab assignment

1. Study the theoretical material of this laboratory work.
2. Solve the problems.

Problem № 1. There are 35 students in a class. Each of them uses at least one of the types of public transport: metro, bus and trolleybus. All three types of transport are used by 6 students, the metro and bus - 15 students, the metro and trolleybus - 13 students, the trolleybus and bus - 9 students. How many students use only one type of transport?

Problem № 2. Each of the 35 sixth-graders is a reader of at least one of two libraries: the school and the district library. Of these, 25 people take books from the school library, 20 from the district library. How many sixth-graders: 1. Are readers of both libraries; 2. Are not readers of the district library; 3. Are not readers of the school library; 4. Are readers only of the district library; 5. Are readers only of the school library?

Problem № 1. Of the company's employees, 16 have visited France, 10 have visited Italy, 6 have visited England; 5 have visited England and Italy; 6 have visited England and France; 5 have visited all three countries. How many people have visited both Italy and France, if the company employs 19 people in total, and each of them has visited at least one of the named countries?

Problem №2. There are 70 students in three groups. Of these, 27 are in the drama club, 32 are in the choir, and 22 are into sports. There are 10 students from the choir in the drama club, 6 athletes in the choir, and 8 athletes in the drama club; 3 athletes attend both the drama club and the choir. How many students do not sing in the choir, are not into sports, and do not attend the drama club? How many students are only into sports?

Equipment and materials:to complete this lab work A computer with the Windows 7 operating system and software products installed is required: MS Office package.

Safety instructions:to perform laboratory work Students who are familiar with the rules of working in the laboratory and have undergone safety training are allowed to attend.

Contents of the report:The laboratory report must be completed in in the MS Word editor and formatted according to the requirements. Formatting requirements: Times New Roman font, one and a half spacing, left margins - 3 cm, right - 1.5 cm, top and bottom - 2 cm. Paragraph indent - 1.25. The text should be aligned by width. The report should contain a title page with the topic of the lab work, the purpose of the work and a description of the process of completing your work. At the end of the report, conclusions on the work done are provided. The report must include screenshots of the work done and a description of them. Each figure must be centered on the page, have a caption (Figure 1 - Creating a subsystem) and a link to it in the text.

Test questions:

1. What is meant by a set?
2. Methods of defining sets.
3. What set is called empty? Universal?
4. Actions on sets.
5. Laws of actions on sets.

List of literature recommended for use on this topic:

1. Peremitina T. O. Mathematical logic and theory of algorithms: a tutorial UDC: 510.6 + 510.51, BBK: 22.12ya73 Tomsk: TUSUR, 2016, S- 132. URL: http:// biblioclub.ru/index.php?page=book_red&id=480886&sr=1

2 Mathematical logic and theory of algorithms: a tutorial. Authors Makokha A.N., Shaposhnikov A.V., Berezhnoy V.V. UDC: 94(5) (075.8) BBK: 22.12 ya73. Stavropol: SKFU, 2017.C– 418. URL: http://biblioclub.ru/index.php?page=book_red&id=467015&sr=1

Lab #6. Boolean algebra functions

The purpose of the laboratory work:be able to solve problems using algebra functions logic.
Competencies to be developed:UK-1; UK-4; UK-8
Theoretical part
Let's consider logical variables$x1,x2, \ldots,xn$,accepting only two values: "1" or "0".

Boolean function $f(x1,x2, \ldots,xn)$ is an arbitrary function whose arguments are logical variables and which takes only one of two values: “1” or “0”.

The number of Boolean functions of one argument is 22= 4, these are the functions:

$$f1(x) = 0, f2(x) = 1, f3(x) = x \text{ And } f4(x) = \bar{x}.$$

There are only 2 Boolean functions with two arguments.4= 16, and the number of Boolean functions$n$

arguments equal$22n$.

Every formula of Boolean algebra composed of elementary statements$x1, x2, \ldots,xn$corresponds to a boolean function$f(x1,x2, \ldots,xn)$, the arguments of which take the truth values of the corresponding elementary statements: "1" or "0". Two
equivalent formulas of Boolean algebra define the same Boolean function, since the truth values of these formulas coincide for the same values of the variables included in them. For Boolean functions, one can compile tables of values - any Boolean function$n$arguments can be specified as a table of$2n$lines.

For example, a table of values of some functions 2-x arguments, corresponding to the basic logical operations (negation of one argument, conjunction, disjunction, implication and equivalence) looks like this:

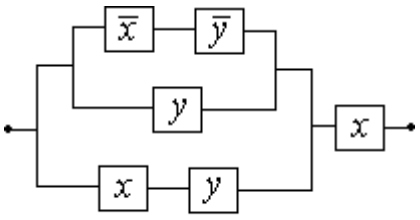
$x1$	$x2$	$\bar{x}1$	$x1$-$x2$	$x1$-$x2$	$x1$-$x2$	$x1$-$x2$
1	1	0	1	1	1	1
1	0	0	0	1	0	0
0	1	1	0	1	1	0
0	0	1	0	0	1	1

The value of the Boolean function$f(x1,x2)$ for known values of arguments, it is set according to the table row corresponding to the given values$x1$And$x2$. For example, for the function$f(x1,x2) = x1$-$x2$meaning$f(1, 0) = 0$, and the value$f(1, 1) = 1$.

Each relay-contact circuit (RCC) composed of switches$x1,x2, \ldots,xn$, you can associate it with a Boolean function called its*function conductivity:*

$$f(x1,x2,...,xn) - \begin{cases} -1, & \text{If} \quad \text{RKS is closed,} \\ -0, & \text{If} \quad \text{RKS is open.} \end{cases}$$

The conductivity function of the RCS is specified using the logic formula corresponding to this RCS. For example, the RCS shown in Fig. 2,

has a function 

conductivity

Рис. 2

f(*x*,*y*) --((*x*-*y*) -*y*)- (*x*-*y*)--*x*-*y*-*x*, the table of values of which has view:

X	*y*	*f*(*x*, *y*)
1	1	1
1	0	0
0	1	0
0	0	0

Any function of n variables can be represented by a Zhegalkin polynomial and this representation is unique.

Lab assignment

1. Study the theoretical material of this laboratory work.

2. Solve the problems.

Construct a function dual to the given one:*A*-*V* To which of the Post classes does the function belong?*X*-*at*

Construct a function dual to the given one:*A*-*V* To which of the Post classes does the function belong?*X*-*at*

Construct a function dual to the given one:*A* To which of the Post classes does the function belong?*hu*

Construct a function dual to the given one:*X*

Equipment and materials:to complete this lab work A computer with the Windows 7 operating system and software products installed is required: MS Office package.

Safety instructions:to perform laboratory work Students who are familiar with the rules of working in the laboratory and have undergone safety training are allowed to attend.

Contents of the report:The laboratory report must be completed in in the MS Word editor and formatted according to the requirements. Formatting requirements: Times New Roman font, one and a half spacing, left margins - 3 cm, right - 1.5 cm, top and bottom - 2 cm. Paragraph indent - 1.25. The text should be aligned by width. The report should contain a title page with the topic of the lab work, the purpose of the work and a description of the process of completing your work. At the end of the report, conclusions on the work done are provided. The report must include screenshots of the work done and a description of them. Each figure must be centered on the page, have a caption (Figure 1 - Creating a subsystem) and a link to it in the text.

Test questions:

1. What is meant by a set?
2. Methods of defining sets.
3. What set is called empty? Universal?
4. Actions on sets.
5. Laws of actions on sets.

List of literature recommended for use on this topic:

1. Peremitina T. O. Mathematical logic and theory of algorithms: a tutorial UDC: 510.6 + 510.51, BBK: 22.12ya73 Tomsk: TUSUR, 2016, S- 132. URL: http://biblioclub.ru/index.php?page=book_red&id=480886&sr=1

2 Mathematical logic and theory of algorithms: a tutorial. Authors Makokha A.N., Shaposhnikov A.V., Berezhnoy V.V. UDC: 94(5) (075.8) BBK: 22.12 ya73. Stavropol: SKFU, 2017.C– 418. URL: http://biblioclub.ru/index.php?page=book_red&id=467015&sr=1

Lab #7. Representation of Boolean functions in the form

Zhegalkin polynomial

The purpose of the laboratory work:be able to represent a Boolean function given by table or formula, in the form of a Zhegalkin polynomial, using transformations of expressions according to the laws of Boolean algebra, determine whether a given function is linear.

Competencies to be developed:UK-1; UK-4; UK-8

Theoretical part

Polynomials of Boolean algebra are constructed by analogy with ordinary polynomials. Multiplication is replaced by conjunction, and addition by alternative disjunction (addition modulo two).

A Zhegalkin polynomial is an alternative disjunction, each member of which is a conjunction of variables or variables, or 1. Any function can be represented by a Zhegalkin polynomial and this representation is unique. A function is linear if the Zhegalkin polynomial does not contain a conjunction of variables.

Samples solutions: Write Boolean function down

f- x,y,z-- (*x-y*) --~~*z*~~-*x*-in the form of a Zhegalkin polynomial. Determine whether linear function.

Solution:

Let's transform the equality using Boolean algebra formulas.

(*x-y*) --$\bar{z}$-*x*--` (*xy-x-y*) --~~*z*~~-*x*-1-- ¯

- (*x*~~*y-x*~~-*y*)-*z*-~~*x*~~-1-- (*xy-x-y*) -1- ¯ –

-*xy*~~*z*~~-*xyx-xy-*~~*xz*~~-*x-x-yz*-*yx-y-xy-x*- – ¯ – –

-*y*-~~*1*~~-*xz-y*-1--*xy-xy-xz*--*y*-1-~~*z*~~-*y-x*- –

-*y*-~~*1*~~-*xyz-xz-xz-yz-z-x*-1-*xyz-yz-z-x*-1

The function is not linear, since the Zhegalkin polynomial contains conjunctions of variables.

Answer: the function is not linear; the Zhegalkin polynomial corresponding to this function is:

f-x;y;z--xyz-yz-z-x-1

Lab assignment

1. Study the theoretical material of this laboratory work.
2. Solve the problems.

1. Check the correctness of the formulas using truth tables:

$\bar{X}$=*X*-1;*X-x*-0; *x-y-hu-X-y*;*x-y-hu-X*-1;*x-y-X-y*-1; *x-y-hu-X-y*-1 ; *xy*|*hu*-1 .

2. Select the rule for excluding alternative disjunction*A-V*: 3. Find a linear one among Zhegalkin polynomials.

Equipment and materials:to complete this lab work A computer with the Windows 7 operating system and software products installed is required: MS Office package.

Safety instructions:to perform laboratory work Students who are familiar with the rules of working in the laboratory and have undergone safety training are allowed to attend.

Contents of the report:The laboratory report must be completed in

in the MS Word editor and formatted according to the requirements. Formatting requirements: Times New Roman font, one and a half spacing, left margins - 3 cm, right -
1.5 cm, top and bottom - 2 cm. Paragraph indent - 1.25. The text should be aligned by width. The report should contain a title page with the topic of the lab work, the purpose of the work and a description of the process of completing your work. At the end of the report, conclusions on the work done are provided. The report must include screenshots of the work done and a description of them. Each figure must be centered on the page, have a caption (Figure 1 - Creating a subsystem) and a link to it in the text.

Test questions:

1. Definition of the Zhegalkin polynomial.
2. Which Zhegalkin polynomial is called linear?

List of literature recommended for use on this topic:

1. Peremitina T. O. Mathematical logic and theory of algorithms: a tutorial UDC: 510.6 + 510.51, BBK: 22.12ya73 Tomsk: TUSUR, 2016, S- 132. URL: http://biblioclub.ru/index.php?page=book_red&id=480886&sr=1

2 Mathematical logic and theory of algorithms: a tutorial. Authors Makokha A.N., Shaposhnikov A.V., Berezhnoy V.V. UDC: 94(5) (075.8) BBK: 22.12 ya73. Stavropol: SKFU, 2017.C– 418. URL: http://biblioclub.ru/index.php?page=book_red&id=467015&sr=1

Laboratory work #8. Post classes

The purpose of the laboratory work:know the definitions of Post classes, the theorem on functional completeness of the system of Boolean functions, to be able to determine to which Post class a given Boolean function belongs.

Competencies to be developed:UK-1; UK-4; UK-8

Theoretical part

The American mathematician Emil Post introduced the following closed classes of Boolean functions:

- Functions that preserve the constant 0 or
- 1; Self-dual functions;
- Monotone functions;
- Linear function.

He proved that any closed class of Boolean functions that does not coincide with is entirely contained in one of these five so-called precomplete classes, but none of the five is entirely contained in the union of the other four. Thus, Post's criterion for the completeness of a system comes down to finding out whether the entire system is entirely contained in one of the precomplete classes. If for each class in the system there is a function that is not included in it, then such a system will be complete, and any other Boolean function can be obtained using the functions included in it. Post proved that the set of closed classes of Boolean functions is a countable set.

Note that there are functions that do not belong to any of Post's classes. Any such function by itself forms a complete system. Examples include the Sheffer stroke or the Pierce arrow.

in order to write down a complete system of functions, it is necessary to check the existing functions for all Post classes, and then write down the missing function based on the theorem "for a system of Boolean functions to be complete, it is necessary that it contain:

- At least one function that does not store 0.
- At least one function that does not preserve 1.
- At least one nonlinear function.
- At least one non-monotonic function.
- At least one non-self-dual function. Lab assignment

1. Study the theoretical material of this laboratory work.
2. Determine to which Post classes the Boolean functions belong: 1c.

1.- *x*--*y*- -*x*-*z*-

2. -*z*-*x*---*z*(*y*-*x*)- 2c.

1. *x*-*y*-*z*-

2. -*z*-*y*---*z*-*x*- 3v

1. *x*-*y*-*z*-

2. -*z*-*y*---*z*-*x*- 4v.

1. -*z*-*y*---*z*-*x*-

2. -z-y---z-x-

5v

1 .-x-y---z-x-

2. -z-y---z-x-

6v

1 .--x-y--z--y

2. (xy) --xz-

7v.

1. (xy) --xz-

2. -z-y---z(y-x)-

8th century.

1. -z-x---yx-

2. -z-x---z(y-x)-

9v

1. x-y-z- -

3.-x-y---z-x-

10th century

1. x-y-z-

3. x-y-z-

11th century

1. x-y-z-

2. (xy) --xz-

12th century

1. -z-x---yx-

2. -z-y---z(y-x)-

13th century

1. -z-y---z(y-x)-

2.

14th century

1.- x-y ---x-z-

2. -z-y---z(z-x)-

15th century

1. (xy) - xz

2. $\overline{-z\,y---z(y-x)}$ | .

Equipment and materials:to complete this lab work A computer with the Windows 7 operating system and software products installed is required: MS Office package.

Safety instructions:to perform laboratory work Students who are familiar with the rules of working in the laboratory and have undergone safety training are allowed to attend.

Contents of the report:The laboratory report must be completed in in the MS Word editor and formatted according to the requirements. Formatting requirements: Times New Roman font, one and a half spacing, left margins - 3 cm, right - 1.5 cm, top and bottom - 2 cm. Paragraph indent - 1.25. The text should be aligned by width. The report should contain a title page with the topic of the lab work, the purpose of the work and a description of the process of completing your work. At the end of the report, conclusions on the work done are provided. The report must include screenshots of the work done and a description of them. Each figure must be centered on the page, have a caption (Figure 1 - Creating a subsystem) and a link to it in the text.

Test questions:

1. What classes of Lent exist?
2. Definitions of functions belonging to different Post classes. List of literature recommended for use on this topic:

1. Peremitina T. O. Mathematical logic and theory of algorithms: a tutorial UDC: 510.6 + 510.51, BBK: 22.12ya73 Tomsk: TUSUR, 2016, S- 132. URL: http://biblioclub.ru/index.php?page=book_red&id=480886&sr=1

2 Mathematical logic and theory of algorithms: a tutorial. Authors Makokha A.N., Shaposhnikov A.V., Berezhnoy V.V. UDC: 94(5) (075.8) BBK: 22.12 ya73. Stavropol: SKFU, 2017.C– 418. URL: http://biblioclub.ru/index.php?page=book_red&id=467015&sr=1

Laboratory work #9. Application of logic algebra: relay-contact diagrams

The purpose of the laboratory work:know the laws of Boolean algebra, be able to compose RKS for statements, record statements based on RKS data.

Competencies to be developed:UK-1; UK-4; UK-8

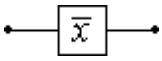
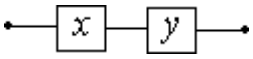
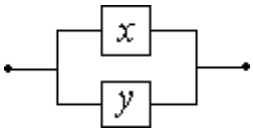
Theoretical part

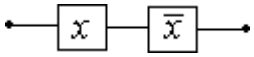
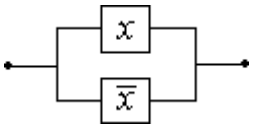
Relay-contact diagram(*RKS*) or*switching circuit*is a schematic representation of a device consisting of the following elements:

1) switches (contacts, relays, lamps, etc.);
2) connecting conductors;
3) inputs-outputs (RCS poles).

Let us consider the simplest RCS containing one switch*R*. If the switch*R*match the statement*X*: "Switch*R*closed", then the true value*X*(*X*=1) will correspond to the closed state of the switch, in which the RKS conducts current, i.e. the pulse arriving at the input can be removed at the output. The value*X*= 0 will correspond to the open state of the RCS (current is not conducted). Each RCS, consisting of several switches, can be associated with a statement expressed by a certain formula*A*, so that the true value of the formula (*A*=1) will correspond to the closed state of the RCS, and the value *A*= 0 – open state. Examples of such correspondences are given in the table.

The simplest RCS and the corresponding logic formulas.

RKS	Formula	Values
Switch*X*: 	The simplest statement:*X*	*X* = 1, If switch closed; *X*= 0 if switch open
Switch*x* 	Negation the simplest statements: $\bar{x}$	$\bar{x}$ = 0, If switch closed; $\bar{x}$ = 1 if switch open
Series connection:  (the circuit is closed when both switches are closed)	Conjunction statements: *x*-*y*	*x*-*y*-1- - -*x*-1, -*y*-1, *x*-*y*-0 - -*x*-0, -*y*-0.
Parallel connection:  (circuit is open when both switches are open)	Disjunction statements: *x*-*y*	*x*-*y*-0 - -*x*-0, -*y*-0, *x*-*y*-1- -*x*-1, -*y*-1.

A circuit that is always open 	$x \cdot \bar{x}$	$x \cdot x \cdot \bar{0}$
A circuit that is always closed 	$x \cdot \bar{x}$	$x \cdot x \cdot \bar{1}$

More complex switching circuits can be constructed from the simplest RCS by connecting them in series and parallel.

It has been proven that any Boolean algebra formula can be transformed into a form containing only the operations of negation, conjunction, and disjunction. This allows logical formulas to be represented using RCS, and RCS to be specified by formulas.

For example, according to the formulas of fundamental equivalences

$\bar{}$

$x \cdot y \cdot \bar{x} \cdot \bar{y}$ And $x \cdot y - (x \cdot y) - (y \cdot x)$,

Consequently, the logical operations of implication and equivalence correspond to the RCS shown in Fig. 1.

Using equivalent transformations of a logical formula corresponding to a certain RCS, one can *simplify RCS*, i.e. bring it to a form containing a smaller number of switches.

.

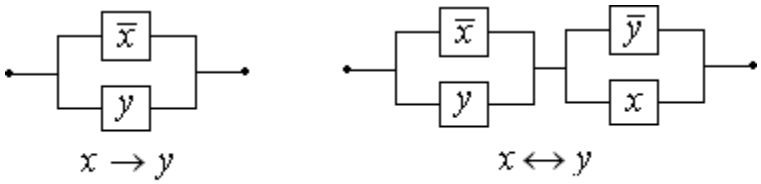


Рис. 1

Lab assignment

1. Study the theoretical material of this laboratory work.
2. Set the relay-contact diagram formula corresponding to the truth table:

x	y	z	
1	1	1	1
1	0	1	1
1	1	0	0
1	0	0	0
0	1	1	0
0	0	1	1
0	1	0	0
0	0	0	1

3. Define the formula of logic algebra using a relay-contact diagram:

$\bar{z} \cdot x - z(y \cdot \bar{x}) - x - (y \cdot \bar{z})$

Equipment and materials:to complete this lab work A computer with the Windows 7 operating system and software products installed is required: MS Office package.

Safety instructions:to perform laboratory work

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Test questions:

1. What is called a relay-contact circuit.
2. The simplest RCS and the corresponding logic formulas. List of literature recommended for use on this topic:

1. Peremitina T. O. Mathematical logic and theory of algorithms: a tutorial UDC: 510.6 + 510.51, BBK: 22.12ya73 Tomsk: TUSUR, 2016, S- 132. URL: http://biblioclub.ru/index.php?page=book_red&id=480886&sr=1

2 Mathematical logic and theory of algorithms: a tutorial. Authors Makokha A.N., Shaposhnikov A.V., Berezhnoy V.V. UDC: 94(5) (075.8) BBK: 22.12 ya73. Stavropol: SKFU, 2017.C– 418. URL: http://biblioclub.ru/index.php?page=book_red&id=467015&sr=1

RECOMMENDED REFERENCES

1. Peremitina T. O. Mathematical logic and theory of algorithms: a tutorial UDC: 510.6 + 510.51, BBK: 22.12ya73 Tomsk: TUSUR, 2016, S- 132. URL: http://biblioclub.ru/index.php?page=book_red&id=480886&sr=1

2 Mathematical logic and theory of algorithms: a tutorial. Authors Makokha A.N., Shaposhnikov A.V., Berezhnoy V.V. UDC: 94(5) (075.8) BBK: 22.12 ya73. Stavropol: SKFU, 2017.C– 418. URL: http://biblioclub.ru/index.php?page=book_red&id=467015&sr=1

MINISTRY OF SCIENCE AND HIGHER EDUCATION
OF THE RUSSIAN FEDERATION
FEDERAL STATE AUTONOMOUS EDUCATIONAL
INSTITUTION OF HIGHER EDUCATION "NORTH
CAUCASUS FEDERAL UNIVERSITY"

METHODOLOGICAL INSTRUCTIONS

on the organization of independent work on the subject "Application of mathematical logic in control systems /
Application of mathematical logic in control systems" for the training direction 09.04.03 "Applied informatics"

(focus (profile) "Knowledge Management")

Stavropol
2022

Introduction

At the current stage of the technological process, in the era of computerization, the study of information systems and technologies is relevant in many specialties.

Computer literacy is necessary for every literateisperson. A absolutely component of computer literacy should be recognized as thIenaplrieonpaebr level of proficiency in a certain set of concepts and terms of the language of computer technologies. Such language knowledge is useful for the confident orientation of the user in the world of information and the improvement of his technological capabilities when working with a computer in the future.

1. General characteristics of independent work of a student studying the disciplineApplication of mathematical logic in systems management – formation of a set of general, general professional and professional competencies of the future master's degree in the field of training 09.04.03 "Applied Informatics".

2. Objectives of mastering the discipline:

- formulate logical problems and apply tools mathematical logic to solve them.

3. Formed competencies- UK-1; UK-4; UK-8

4. Schedule for completing independent work

No. p/p	Chapter disciplines	Week semesters	SRS in hours	Forms of the current control academic performance
1	Laboratory work #1. Elements of mathematical logic	1.	7	Interview on questions of the topic
2	Laboratory Job No. 2. Reduction of formulas to perfect normal forms using truth tables	2.	7	Interview on questions of the topic
3	Lab work #3. Solving logical problems	3.	7	Interview on questions of the topic
4	Lab #4. Actions on sets	4.	7	Interview on questions of the topic
5	Lab #5. Power of a Finite Set	5.	7	Interview on questions of the topic
6	Lab #6. Boolean algebra functions	6.	7	Interview on questions of the topic
7	Laboratory Job No. 7. Representation of Boolean functions as a Zhegalkin polynomial	7.	7	Interview on questions of the topic
8	Laboratory work #8. Post classes	8.	7	Interview on questions of the topic
9	Laboratory Job No. 9. Application algebras logic: relay contact circuits	9.	11.5	Interview on questions of the topic
		TOTAL	67.5	

5. Methodological recommendations for studying theoretical material

At the first stage, it is necessary to familiarize yourself with the working program of the discipline, which examines the content of the topics of the lecture course, the relationship of lecture topics with laboratory classes, topics and types of independent work. For each type of independent work, certain reporting forms are provided.

Sample list of interview questions Lab work #1. Elements of mathematical logic

1. What is meant by a statement in mathematical logic?
2. What actions are performed on statements?
3. What is called Boolean algebra?
4. Laws of Boolean algebra.

Lab Work #2. Reducing Formulas to Perfect Normal Forms Using Truth Tables

1. What is DNF?
2. What is the difference between DNF and SDNF?
3. How to compose a DNF using a truth table?

Lab work #3. Solving logical problems

1. What is DNF?
2. What is the difference between DNF and SDNF?
3. How to compose a DNF using a truth table?

Lab #4. Actions on sets

1. What is meant by a set?
2. Methods of defining sets.
3. What set is called empty? Universal?
4. Actions on sets.
5. Laws of actions on sets.

Lab #5. Power of a Finite Set

1. What is meant by a set?
2. Methods of defining sets.
3. What set is called empty? Universal?
4. Actions on sets.
5. Laws of actions on sets.

Lab #6. Boolean algebra functions

1. What is meant by a set?
2. Methods of defining sets.
3. What set is called empty? Universal?
4. Actions on sets.
5. Laws of actions on sets.

Lab #7. Representation of Boolean functions as a Zhegalkin polynomial

1. Definition of the Zhegalkin polynomial.
2. Which Zhegalkin polynomial is called linear?

Laboratory work #8. Post classes

1. What classes of Lent exist?
2. Definitions of functions belonging to different Post classes.

Lab #9. Application of Boolean Algebra: Relay Contact Circuits

1. What is called a relay-contact circuit.
2. The simplest RCS and the corresponding logic formulas.

6. Methodological instructions for preparing for the test

The credit procedure is not carried out as a separate control event; the assessment of the student’s knowledge occurs based on the results of the current control.

7. Methodological materials defining procedures

assessment of knowledge, skills, abilities and (or) experience of activities characterizing the stages of formation of competencies

Current assessment of master's degree students by teacheriss being carried out conducting laboratory work on the subject, based on the results of oral questioning during practical classes and completion of independent work assignments.

For independent study, the master's student must prepare answers to interview questions, complete additional assignments on the topic of the lesson, study additional scientific sources, and make a summary of the article (if provided). The student receives the maximum grade if he actively participates in the work, has a command of the material, can express his thoughts logically and clearly, creatively approaches the solution of the main issues of the topic, and demonstrates independent thinking.

The grounds for reducing the assessment are:

- poor knowledge of the topic and basic terminology;
- lack of ability to apply theoretical knowledge to solve problems practical tasks.