

ПРАКТИЧЕСКАЯ РАБОТА ПО ОСНОВАМ АЛГЕБРЫ ЛОГИКИ

Для представления логических данных в компьютере используется аппарат булевой алгебры — формальной математической системы, состоящей из элементов, операций над ними и законов логики. Множество элементов булевой алгебры выбирается бинарным: $\{0, 1\}$: (1-истина, 0-ложь). Переменные, принимающие значения 0 или 1, будем называть булевыми и обозначать прописными буквами латинского алфавита A, B, C, ..., X, Y, Z. Основными операциями булевой алгебры являются:

1. Логическое умножение — конъюнкция (\wedge , &, •, И (AND)).
2. Логическое сложение — дизъюнкция (\vee , +, ИЛИ (OR)).
3. Логическое отрицание — инверсия ($\bar{}$, \neg , НЕ (NOT)).

Кроме того, довольно часто используются следующие логические операции:

4. Логическая неэквивалентность - исключающее ИЛИ (\oplus , неИЛИ (XOR)).
5. Логическая импликация или следование (\rightarrow , ЕСЛИ ... ТО).
6. Логическая эквивалентность (\leftrightarrow , \approx).

В таблице представлена таблица истинности приведенных выше логических операций:

X	Y	$X \wedge Y$	$X \vee Y$	\bar{X}	$X \oplus Y$	$X \rightarrow Y$	$X \leftrightarrow Y$
1	1	1	1	0	0	1	1
1	0	0	1	0	1	0	0
0	1	0	1	1	1	1	0
0	0	0	0	1	0	1	1

Вычисление логических выражений принято выполнять в виде таблиц истинности — таблиц, в которых показано, какие значения принимает логическое выражение при всех возможных наборах его переменных.

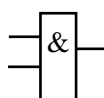
Для составления таблицы необходимо:

- 1) определить количество строк в таблице (вычисляется как 2^n , где n — количество переменных);
- 2) определить количество столбцов (вычисляется как количество переменных плюс количество логических операций);
- 3) установить последовательность выполнения логических операций;
- 4) построить таблицу, указывая названия столбцов и возможные наборы значений исходных переменных.

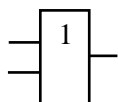
Существует три базовых логических элемента, которые реализуют три основные логические операции:

- 1) логический элемент «И» – логическое умножение – *конъюнктор*;
- 2) логический элемент «ИЛИ» – логическое сложение – *дизъюнктор*;
- 3) логический элемент «НЕ» – инверсию – *инвертор*.

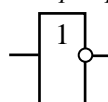
конъюнктор



дизъюнктор



инвертор



Пример 1. Постройте таблицу истинности для выражения:

$$F = (A \vee B) \wedge (\bar{A} \vee \bar{B}).$$

Решение.

- 1) Количество строк = 2^2 (2 переменных) + 1(заголовки столбцов) = 5.
- 2) Количество столбцов = 2 логические переменные (A, B) + 5 логических операций ($\vee, \wedge, -, \vee, -$) = 7.
- 3) Расставим порядок выполнения операций:

$$(A \vee B) \wedge (\bar{A} \vee \bar{B}).$$

1 5 2 4 3
(A ∨ B) ∧ (Ā ∨ B̄)

- 4) Построим таблицу истинности

A	B	$A \vee B$	\bar{A}	\bar{B}	$\bar{A} \vee \bar{B}$	$(A \vee B) \wedge (\bar{A} \vee \bar{B})$
0	0	0	1	1	1	0
0	1	1	1	0	1	1
1	0	1	0	1	1	1
1	1	1	0	0	0	0

Пример 2. Построить логическую схему, соответствующую логическому выражению $F(X, Y) = X \wedge Y \vee \neg(Y \vee X)$. Вычислить значения выражения для $X = 1, Y = 0$.

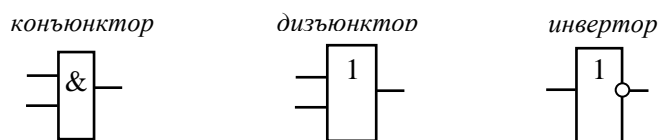
Решение:

1. Количество переменных – две: X и Y.
2. Логических операций – четыре: конъюнкция, дизъюнкция, инверсия, дизъюнкция; последовательность их выполнения: 1 (конъюнкция), 2 (дизъюнкция – в скобках), 3 (инверсия), 4 (дизъюнкция):

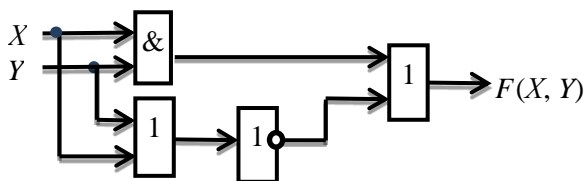
$$1 \quad 4 \quad 3 \quad 2$$

$$X \wedge Y \vee \neg(Y \vee X).$$

3. Этим логическим операциям соответствуют базовые логические элементы соответственно:



4. Схему строим слева направо в соответствии с порядком логических операций:



5. Вычислим значение логического выражения

$$F(X, Y) = 1 \wedge 0 \vee \neg(0 \vee 1) = 0.$$

Задание 1. Найти значения логического выражения:

Вариант	Выражение	Вариант	Выражение
1.	$(1 \vee 1) \vee (1 \vee 0)$	13.	$(1 \wedge 0) \& (1 \vee 0) \& (1 \rightarrow 0)$
2.	$((0 \& 1) \& 1) \wedge 0 \vee 1$	14.	$(1 \& 1 \vee 0) \leftrightarrow (\neg 1 \vee 1)$
3.	$((1 \vee 0) \& (1 \& 1)) \& (0 \vee 1)$	15.	$((1 \vee 0) \wedge (1 \& 0)) \wedge (0 \wedge 1)$
4.	$(0 \vee 1) \rightarrow (1 \& 1)$	16.	$((0 \vee 1) \& 1) \wedge 0 \wedge 1$
5.	$(1 \& 1 \vee 0) \leftrightarrow (\neg 1 \& 1)$	17.	$(1 \vee \neg 0) \& (0 \wedge 1)$
6.	$\neg((1 \rightarrow 0) \leftrightarrow (1 \& 1) \vee 1)$	18.	$((0 \rightarrow 1) \leftrightarrow (1 \wedge 1) \vee 0)$
7.	$(1 \vee 0) \& (1 \vee 0) \& (1 \rightarrow 0)$	19.	$((0 \vee 1) \& 1) \wedge 1 \vee 0$
8.	$\neg(1 \& 1 \vee 0) \leftrightarrow (\neg 1 \vee 1)$	20.	$(1 \& 0 \vee 1) \rightarrow (\neg 1 \& 1)$
9.	$((1 \vee 0) \wedge (1 \& 1)) \wedge (0 \wedge 1)$	21.	$(0 \vee 1) \rightarrow (0 \& 1) \vee 1$
10.	$((0 \vee 1) \& 1) \wedge 0 \vee 1$	22.	$((1 \vee 0) \wedge (1 \& 0)) \wedge (0 \wedge 1)$
11.	$(1 \vee \neg 1) \& (1 \wedge 0)$	23.	$(0 \& \neg 1) \vee (1 \vee 0) \& (1 \rightarrow 0)$
12.	$((1 \rightarrow 0) \leftrightarrow (1 \wedge 1) \vee 1)$	24.	$((0 \vee 1) \& 1) \wedge \neg 0 \& 1$

Задание 2. Для исходной логической функции построить таблицу истинности:

Вариант	Выражение	Вариант	Выражение
1.	$(X \rightarrow Y) \vee (Y \rightarrow Z)$	13.	$((X \vee Y) \wedge X) \rightarrow Y$
2.	$((A \& C) \& \neg B) \vee (B \& A)$	14.	$(\neg A \& B \vee C) \leftrightarrow \neg(B \vee A)$
3.	$((X \wedge Y) \vee X) \text{ XOR } Y$	15.	$B \wedge A \vee B \wedge A \text{ XOR } C$
4.	$((B \vee A) \& A) \wedge (C \vee \neg C)$	16.	$(B \& B) \rightarrow ((A \& A) \wedge (C \& \neg C))$
5.	$X \rightarrow (Y \rightarrow Z) \& \bar{X}$	17.	$(A \vee B \wedge \bar{C}) \& A$
6.	$((B \wedge C) \& (\neg A \wedge A)) \& (C \vee \neg B)$	18.	$((\neg A \rightarrow B) \leftrightarrow (C \wedge C) \vee B)$
7.	$(X \vee Y) \rightarrow (\bar{X} \wedge \bar{Y}).$	19.	$\bar{A} \vee B \wedge C \rightarrow (\bar{C} \wedge \bar{B}).$
8.	$(C \& \neg A) \vee (\neg B \& A)$	20.	$(C \vee \neg A) \vee (\neg B \vee A)$
9.	$((X \rightarrow Y) \wedge X) \rightarrow Y$	21.	$(X \rightarrow \bar{Y}) \wedge (Y \rightarrow Z)$
10.	$((C \vee \neg B) \& (A \& C)) \& (A \vee B)$	22.	$((B \vee B) \wedge (C \& C)) \wedge (A \wedge C)$
11.	$X \rightarrow (X \vee Y) .$	23.	$(A \wedge B \vee C) \text{ XOR } A$
12.	$(A \vee B) \& (A \vee C) \& (B \rightarrow C)$	24.	$(A \& B \vee A) \leftrightarrow (C \& \neg C)$

Задание 3. Построить логическое выражение по таблице истинности.

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Задание 4. Построить логическую схему функции $F(A,B)$:

Вариант	$F(A,B)$	Вариант	$F(A,B)$
1.	$\neg(A \& B) \vee (\neg(B \vee A))$	13.	$\neg A \vee B \vee \neg(\neg B \vee A)$
2.	$\neg(A \vee B) \wedge (A \& \neg B)$	14.	$(\neg A \& \neg B) \vee (\neg A \& B)$
3.	$(A \vee B) \wedge (A \vee \neg B)$	15.	$(\neg A \& B) \vee (A \& \neg B)$
4.	$\neg((\neg A \vee B) \wedge (\neg B \vee A))$	16.	$\neg(A \& (B \vee A) \wedge \neg B)$
5.	$(\neg A \vee B) \wedge (\neg B \vee \neg A)$	17.	$\neg A \& B \vee \neg(A \vee B) \vee A$
6.	$(\neg A \vee B) \wedge \neg(A \vee \neg B)$	18.	$\neg(A \& B) \vee (\neg(B \vee C))$
7.	$\neg(\neg A \& \neg B) \vee (A \vee B)$	19.	$\neg(A \vee B) \wedge (A \& \neg B)$

8.	$(\neg A \vee B) \vee \neg(A \& B)$	20.	$(A \vee B) \vee (A \vee \neg B)$
9.	$(A \& B) \vee ((A \vee B) \wedge \neg A)$	21.	$\neg(\neg A \& C) \vee (B \& \neg C)$
10.	$\neg((\neg A \vee B) \& A) \wedge \neg B$	22.	$(\neg A \vee B) \vee (B \vee C) \vee (A \& C)$
11.	$\neg(A \vee \neg B) \vee \neg(A \vee B)$	23.	$\neg(A \vee B) \wedge (A \vee \neg B)$
12.	$\neg A \& \neg B \vee \neg(A \vee B)$	24.	$\neg(A \wedge B) \vee (A \& \neg B)$