

1.3 Logic gates and circuits

Name: _____ Class: _____ Date: _____

Total: 20 marks

KEY WORDS logic gate • truth table • logic circuit

Objective

Build the skills to answer exam questions on **computer logic** – logic gates, truth tables and logic circuits.

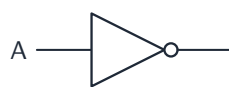
You must be able to:

- draw and name the AND, OR, NOT, NAND, NOR, XOR and XNOR **logic gates**
- complete a **truth table** for a gate or a circuit
- work out a circuit's output by labelling each gate's output
- draw a **logic circuit** from a Boolean expression

1 Key knowledge and worked examples

Study these first. Each one shows the method for a question type used later.

■ Key knowledge: the gates



NOT



AND



OR



NAND



NOR

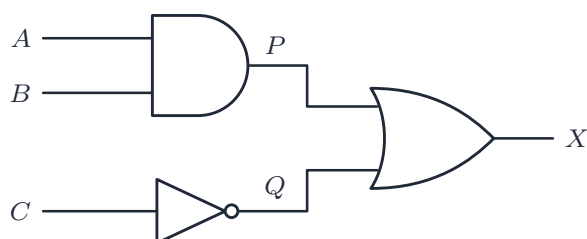


XOR

A	B	AND	OR	XOR	NAND	NOR	XNOR
0	0	0	0	0	1	1	1
0	1	0	1	1	1	0	0
1	0	0	1	1	1	0	0
1	1	1	1	0	0	0	1

- NOT flips its one input. A small circle on an output means NOT.
- XOR: 1 when the inputs differ. XNOR: 1 when they are the same.

■ **Worked example: a circuit's truth table**



$$X = (A \text{ AND } B) \text{ OR } (\text{NOT } C)$$

A	B	C	P	Q	X
0	0	0	0	1	1
0	0	1	0	0	0
0	1	0	0	1	1
0	1	1	0	0	0
1	0	0	0	1	1
1	0	1	0	0	0
1	1	0	1	1	1
1	1	1	1	0	1

1. Three inputs: $2^3 = 8$ rows, counting up in binary.
2. Label each gate's output (P , Q) and fill one column at a time.
3. X is 1 when P or Q is 1.

2 Practice

2.1 Complete the truth table for $X = A \text{ NAND } B$. [2]

2.2 State the output of: (i) 1 XOR 1; (ii) NOT(0 OR 1); (iii) (1 AND 0) OR 1. [3]

2.3 A circuit gives $X = \text{NOT } A \text{ AND } B$. Complete its truth table. [2]

3 Exam-style questions

3.1 Which gate gives 1 only when both inputs are 0? [1]

- ☐ A AND
☐ B NAND
☐ C NOR
☐ D XOR

3.2 How many rows does the truth table of a 4-input circuit have? [1]

- ☐ A 4
- ☐ B 8
- ☐ C 12
- ☐ D 16

3.3 For the circuit in the worked example, which inputs make $X = 0$? [1]

- ☐ **A** whenever $C = 0$
B $C = 1$ and A, B not both 1
C $A = 1$ and $B = 1$
D never

3.4 A greenhouse fan F must turn on when it is hot ($H = 1$) and the door is closed ($D = 0$), or when the humidity is high ($M = 1$).

(a) Write a Boolean expression for F . [2]

(b) Draw the logic circuit for your expression. [3]

(c) Complete the truth table for F , with a column for each intermediate output. [4]

(d) State how many input combinations turn the fan on. [1]

Solutions

Each answer shows the steps, then the **result**.

2.1

- rows 00, 01, 10 give **1**
- row 11 gives **0**

2.2

- (i) **0**
- (ii) NOT 1 = **0**
- (iii) 0 OR 1 = **1**

2.3

A	B	NOT A	X
0	0	1	0
0	1	1	1
1	0	0	0
1	1	0	0

- NOT A column
- X is 1 only for $A = 0$, $B = 1$

3.1 C

- NOR: NOT (A OR B)

3.2 D

- $2^4 = 16$

3.3 B

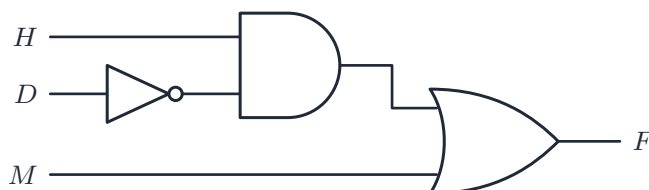
- $Q = 0$ needs $C = 1$, and $P = 0$ needs A AND $B = 0$

3.4

(a)

- $F = (H \text{ AND NOT } D) \text{ OR } M$

(b)



- NOT gate on D

- AND gate with inputs H and NOT D
- OR gate with inputs the AND output and M , output F

(c)

H	D	M	NOT D	H AND NOT D	F
0	0	0	1	0	0
0	0	1	1	0	1
0	1	0	0	0	0
0	1	1	0	0	1
1	0	0	1	1	1
1	0	1	1	1	1
1	1	0	0	0	0
1	1	1	0	0	1

- 8 rows in binary order
- NOT D column
- AND column
- F column

(d)

- **5**