

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.

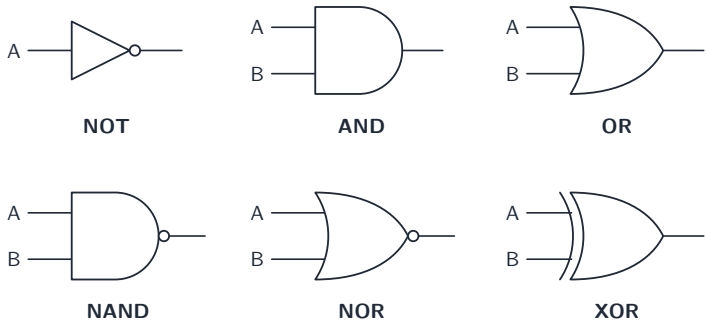
You must be able to:

- 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.

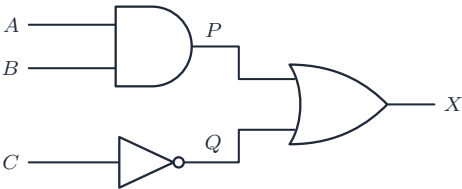
■ **Key knowledge: the gates**



<i>A</i>	<i>B</i>	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**



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

<i>A</i>	<i>B</i>	<i>C</i>	<i>P</i>	<i>Q</i>	<i>X</i>
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

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

2 Practice

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

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

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

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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]

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

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

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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

<i>A</i>	<i>B</i>	NOT <i>A</i>	<i>X</i>
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

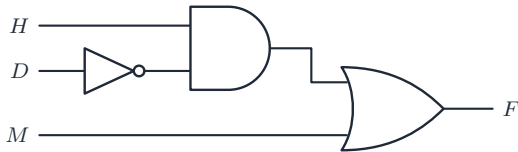
- *Q* = 0 needs *C* = 1, and *P* = 0 needs *A* AND *B* = 0

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)

<i>H</i>	<i>D</i>	<i>M</i>	NOT <i>D</i>	<i>H</i> AND NOT <i>D</i>	<i>F</i>
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**