



You must be able to

- state the output of each gate
- write a logic expression from a short problem statement
- complete a truth table from an expression, without simplifying the expression



Method — The six gates

A **logic gate** takes inputs that are **1** (true) or **0** (false) and gives one output. NOT has one input. The other gates have two inputs at IGCSE.

Method — The six gates

Gate	Output is 1 when
NOT	the input is 0
AND	both inputs are 1
OR	at least one input is 1
NAND	AND would be 0 (NOT AND)
NOR	OR would be 0 (NOT OR)
XOR	the two inputs are different

Method — The six gates

AND outputs:

A	B	A AND B
0	0	0
0	1	0
1	0	0
1	1	1

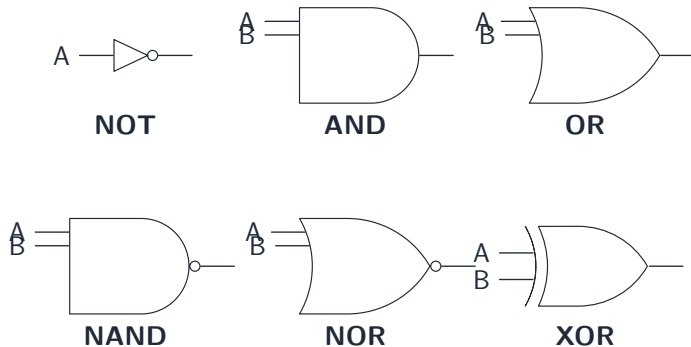
Method — The six gates

NOR outputs (the opposite of OR):

A	B	A NOR B
0	0	1
0	1	0
1	0	0
1	1	0

Method — The six gates

A logic gate takes inputs that are 1 (true) or 0 (false) and gives one output.



The six logic-gate symbols: NOT, AND, OR, NAND, NOR and XOR

Method — Expressions and truth tables

A **logic expression** writes the gates in words, such as $(A \text{ AND } B) \text{ OR } (\text{NOT } C)$. Draw or complete the table for that expression. Do not simplify it first.

Worked example. One row of $X = (A \text{ AND } B) \text{ OR } (\text{NOT } C)$, with $A = 1$, $B = 0$, $C = 0$.

1 $A \text{ AND } B = 1 \text{ AND } 0 = 0$, because AND needs both inputs to be 1.

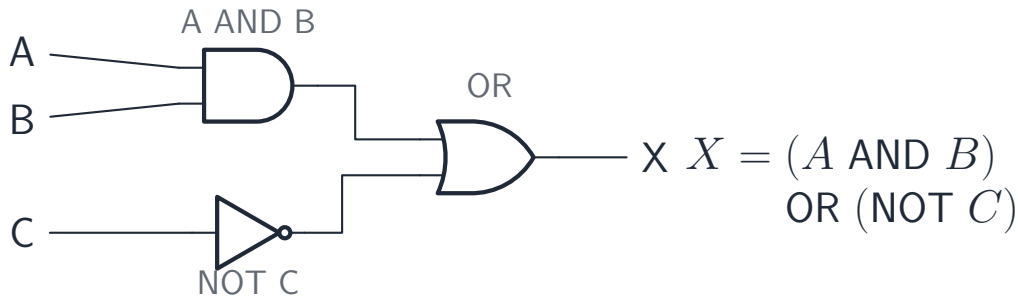
2 $\text{NOT } C = \text{NOT } 0 = 1$.

3 $X = 0 \text{ OR } 1 = 1$.

Give each gate its own column. The final column is the output.

Method — Expressions and truth tables

A logic expression writes the gates in words, such as (A AND B) OR (NOT C) .



The expression (A AND B) OR (NOT C) drawn as an AND gate, a NOT gate and an OR gate

Method — Expressions and truth tables

A logic expression writes the gates in words, such as (A AND B) OR (NOT C) .

3 inputs $\Rightarrow 2 \times 2 \times 2 = 8$ rows

A	B	C
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1

list **every** combination -
count up in binary,
from 000 to 111
the last column flips
every row, the next
every two rows,
the first every four

Eight rows for three inputs, counted in binary from 000 to 111



Practice 2.1 ■ 2 marks

Give the output of NOT A when A is 0, and when A is 1.

Solution 2.1

Worked steps

- NOT 0 = **1** **B1**
- NOT 1 = **0** **B1**

Practice 2.2 ■ 1 mark

State the only input pair that makes an AND gate output 1.

Solution 2.2

Method: The six gates — p.??

Worked steps

- both inputs are 1, written **1 and 1** B1

Practice 2.3 ■ 1 mark

State when an XOR gate outputs 1.

Solution 2.3

Method: The six gates — p.??

Worked steps

- the output is 1 when the inputs are **different** B1

Practice 2.4 ■ 2 marks

Explain what a NAND gate does, and give its output when both inputs are 1.

Solution 2.4

Method: The six gates — p.??

Worked steps

- NAND is NOT AND: it outputs the opposite of AND **B1**
- when both inputs are 1, AND is 1, so NAND is **0** **A1**

Practice 2.5 ■ 4 marks

Complete the outputs of $X = A \text{ NOR } B$.

A	B	X
0	0	
0	1	
1	0	
1	1	

Solution 2.5

Worked steps

■ $0 \text{ NOR } 0 = 1$ (B1)

■ $0 \text{ NOR } 1 = 0$ (B1)

■ $1 \text{ NOR } 0 = 0$ (B1)

■ $1 \text{ NOR } 1 = 0$ (B1)

Practice 2.6 ■ 2 marks

An alarm X sounds when the door is open (A) AND the system is on (B). Write the logic expression for X .

Solution 2.6

Method: Expressions and truth tables — p.??

Worked steps

- both conditions are required, so the gate is AND M1
- $X = A \text{ AND } B$ A1



Exam-style 3.1 ■ 1 mark

The gate that outputs 1 only when both inputs are 1 is:

A OR

B XOR

C AND

D NOR

Solution 3.1

Method: The six gates — p.??

A OR

B XOR

C AND



D NOR

Worked steps

C

- AND is 1 only for inputs 1 and 1 **B1**
- OR is also 1 when one input is 1; XOR is 1 when the inputs differ; NOR is 1 only for 0 and 0

Exam-style 3.2 ■ 4 marks

Complete the truth table for $X = \text{NOT } (A \text{ OR } B)$.

A	B	A OR B	X
0	0		
0	1		
1	0		
1	1		

Solution 3.2

Method: Expressions and truth tables — p.??

Worked steps

- OR column: **0, 1, 1, 1** **B1** **B1** *for 0; for the three 1s*
- X is NOT of that column: **1, 0, 0, 0** **B1** **B1** *for 1; for the three 0s*

Solution 3.2

A	B	A OR B	X
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

Exam-style 3.3 ■ 4 marks

A lamp X is on when switch A is on AND switch B is off.

Exam-style 3.3 (a) ■ 2 marks

Write the logic expression for X. Do not simplify a different expression into this one.

Solution 3.3 (a)

Method: Expressions and truth tables — p.??

Worked steps

- switch B is off, so use NOT B **B1**
- both parts are required: $X = A \text{ AND } (\text{NOT } B)$ **A1**

Exam-style 3.3 (b) ■ 2 marks

Find X when $A = 1$ and $B = 0$. Show the output of each gate.

Solution 3.3 (b)

Worked steps

- $\text{NOT } B = \text{NOT } 0 = 1$ **M1**
- $A \text{ AND } 1 = 1 \text{ AND } 1 = \mathbf{1}$, so $X = 1$ **A1**

Exam-style 3.4 ■ 3 marks

$$X = (A \text{ AND } B) \text{ OR } C.$$

Exam-style 3.4 (a) ■ 1 mark

State how many rows a full truth table for A, B and C must have.

Solution 3.4 (a)

Method: Expressions and truth tables — p.??

Worked steps

- three inputs give $2^3 = 8$ rows **B1**

Exam-style 3.4 (b) ■ 2 marks

Find X when $A = 1$, $B = 1$ and $C = 0$. Show the AND result, then the OR result.

Solution 3.4 (b)

Worked steps

- $A \text{ AND } B = 1 \text{ AND } 1 = 1$ (M1)
- $1 \text{ OR } C = 1 \text{ OR } 0 = \mathbf{1}$, so $X = 1$ (A1)