# OCR Computer Science GCSE

## 2.4 – Boolean logic

Advanced Notes

# 2.4.1 Boolean logic

## What is Boolean logic?

Boolean logic is a form of algebra where all values are either TRUE (1) or FALSE (0). It is used in computers to control decision-making and logical operations.

Computers use Boolean logic in:

- Programming conditions
- Logic gates and circuits
- Searching and filtering

## Truth tables

A truth table is used to show the output of Boolean expressions for all possible input combinations. This means that they are useful for debugging and understanding logic conditions.

## Logic gates

A computer's processor is made up of billions of logic gates, components which apply logical operations to one or more Boolean inputs in order to produce a single output.

Within a processor, logic gates are combined to form logic circuits. These can perform more complex operations like binary addition.

### AND

- Returns **TRUE** only if **both inputs** are TRUE
- Symbol: `A AND B`, `A ∧ B`

| A | B | A AND B |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

**OR**

- Returns **TRUE** if **either** input is TRUE
- Symbol: `A OR B, A ∨ B`

| A | B | A OR B |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

**NOT**

- Reverses the input
- Symbol: `NOT A, ¬A`

| A | NOT A |
|---|---|
| 0 | 1 |
| 1 | 0 |

## Combining operators

You can combine logic gates and build expressions like:

`A AND (B OR NOT C)`, $A \wedge (B \vee \neg C)$

### Order of precedence

Algebraic operations have an order of precedence, meaning that some operations must be applied before others. You may have met BODMAS in Mathematics, this is the same idea.

| Operator | Precedence |
|---|---|
| Brackets | Highest<br>.<br>.<br>.<br>.<br>Lowest |
| NOT | |
| AND | |
| OR | |

For example, the expression `B OR NOT C AND A` would actually be carried out in the order `B OR ((NOT C) AND A)`.

## Logic circuit symbols

Each of the three required logic gates has an internationally recognised symbol which you should learn. The symbols have inputs on the left and outputs on the right.

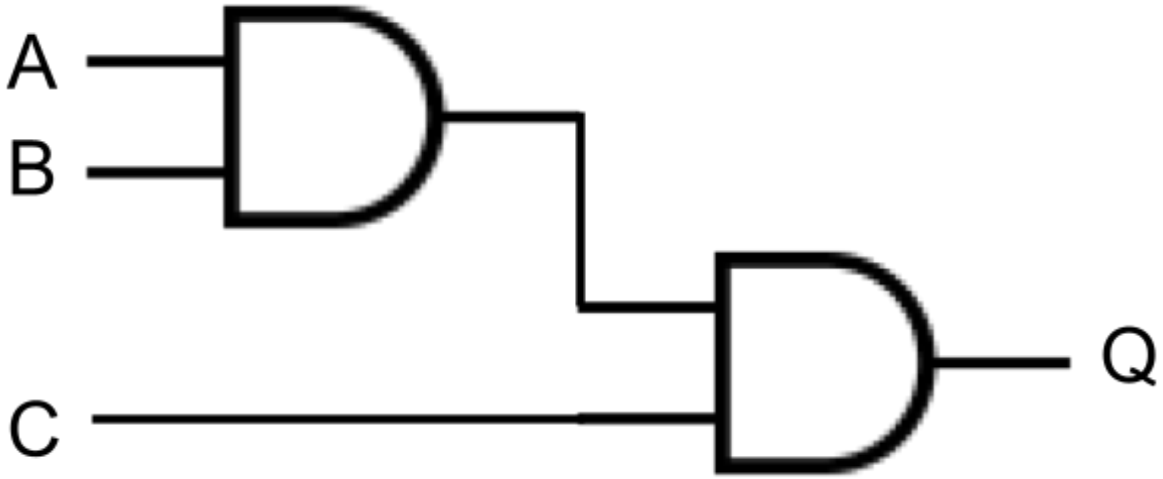
NOT AND OR

These symbols can be combined to form logic circuit diagrams.

## Logic circuit diagrams

Logic gates can be combined to form more complex circuits. You may be asked to draw or interpret a logic circuit involving multiple logic gates.

### Example 1 - combining two AND gates



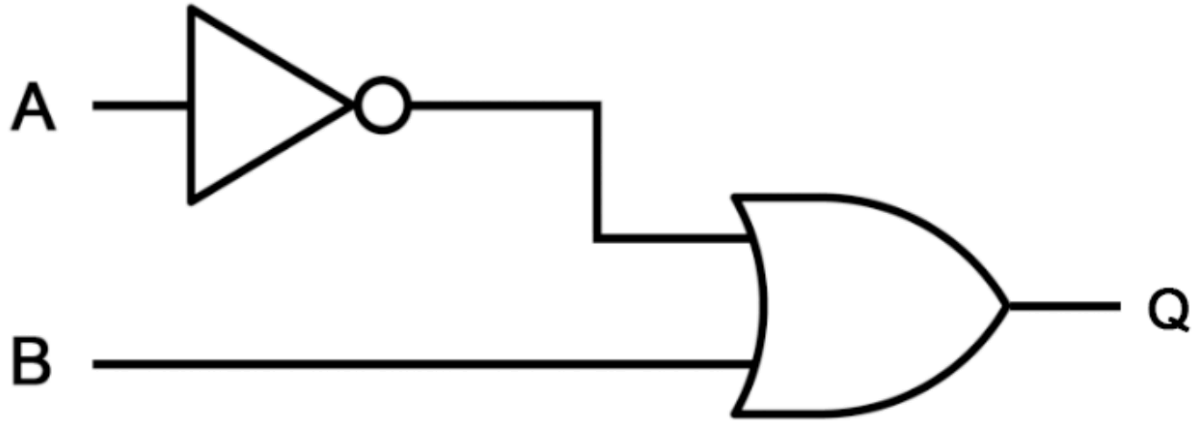

In this example, the output Q is TRUE only if A, B AND C are all TRUE.

The Boolean expression from this logic circuit is A AND B AND C.

You are also expected to be able to fill out truth tables for logic gate diagrams, the following table represents the diagram above:

| A | B | C | Q |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 1 |

**Example 2 - combining NOT and OR gates**




In this example, the output Q is TRUE when either A is FALSE, B is TRUE, or both, in one instance.

You can visualise this in the truth table below:

| A | B | Q |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |