



## CIE IGCSE Computer Science



## 10.1 Logic Gates

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### **Logic Gates**

## Your notes

## **Logic Gates**

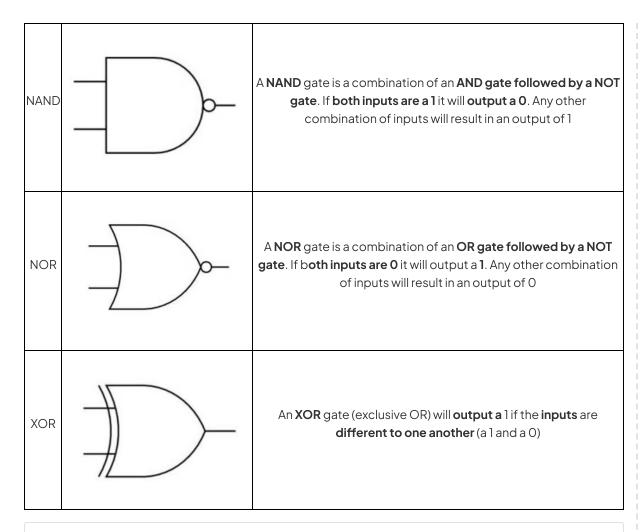
- A logic gate is a building block of a digital circuit. Logic gates perform a logical operation on one or more binary inputs to produce a binary output
- An **electrical signa**l entering the logic gate is represented by a 1
- No electrical signal is represented by a 0
- There are **several types of logic gates**, each performing a **specific logical operation**
- Logic gates can be combined to carry out meaningful functions such as performing calculations or checking if data meets certain conditions

A table showing the symbol used to represent each logic gate

Gate	Symbol	Description
NOT		The <b>NOT</b> gate takes a s <b>ingle binary input</b> and outputs the <b>opposite</b> of the input
AND		The <b>AND</b> gate takes <b>two inputs</b> and produces one output  Only <b>two positive inputs</b> (1 and 1) will result in a positive <b>output of</b> 1  If either of the inputs is a 0 the output will be a 0
OR		The OR gate takes <b>two inputs</b> and produces one output  If <b>either of the inputs is positive</b> (1) the <b>output will be 1</b>



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## Exam Tip

• You will need to either draw a diagram of a logic circuit using these symbols, or you will have to interpret an existing diagram. This is why it is important to remember the symbol of each gate and the logic rules for each one



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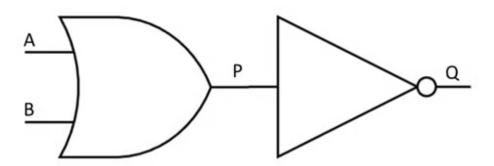
### **Logic Circuits**

## Your notes

## **Logic Circuits**

- Logic gates can be **combined** to produce different outputs
- The combination of two or more logic gates forms a logic circuit
- A logic diagram is a **visual representation** of combinations of logic gates within a logic circuit

#### An example of Logic Circuit



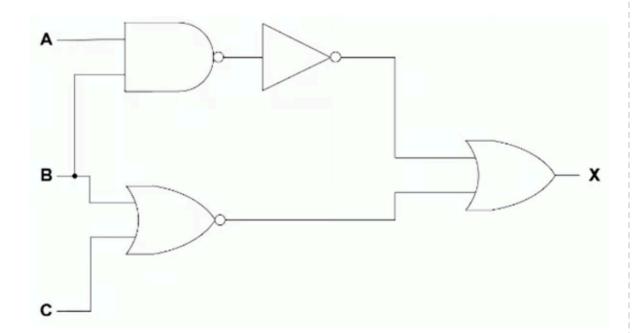
- In this diagram, the inputs are represented by A and B
- P is the output of the OR gate on the left and becomes the input of the NOT gate. This is called an intermediary output
- Q is the final output of the logic circuit

## Exam Tip

- You may be asked to draw a logic circuit from a logic statement or a boolean expression. Circuits must be drawn **without simplification**
- Logic circuits will be limited to a maximum of three inputs and one output

An example of Logic Circuit







- This logic circuit contains three inputs (A, B and C)
- It contains a **NAND** gate, a **NOT** gate, a **NOR** gate and finally an **OR** gate
- X is the final output
- This logic circuit can be represented as a logic expression as
   X=((NOT(A NAND B)) OR (B NOR C))



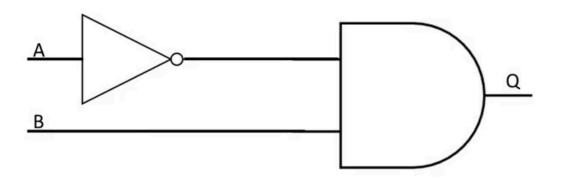
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### Worked example

A sprinkler system switches on if it is not daytime (input A) and the temperature is greater than 40 (input

Draw a logic circuit to represent the problem statement above

[2]





## Exam Tip

• You may need to draw a logic circuit from a problem statement (as in the example above), from a truth table or from a boolean expression

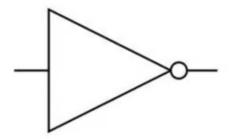
### **Truth Tables**

# Your notes

### **Truth Tables**

#### NOT gate

- A NOT gate has **one input** and will invert it to produce an **opposite output**. This is shown in the truth table below
- A is the input
- Z is the output



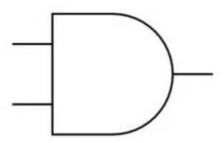
Input	Output
Α	Z
0	1
1	0

#### **AND** gate

An AND gate has two inputs





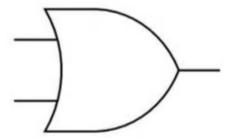


Input		Output
Α	В	Z
0	0	0
0	1	0
1	0	0
1	1	1

The AND gate truth table shows the only combination of inputs which will result in a positive output is 1
 and 1

### OR gate

• An OR gate has **two inputs** 



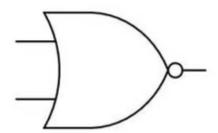
Input		Output
Α	В	Z
0	0	0
0	1	1
1	0	1
1	1	1



• The truth table shows an OR gate produces an output of 1 if any of the inputs are a 1

### NOR gate

■ A NOR gate has **two** inputs



Input		Output	
Α	В	Z	
0	0	1	
0	1	0	
1	0	0	
1	1	0	

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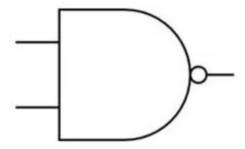
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■ The truth table shows a NOR gate works oppositely **to an OR gate** – the only input combination which results in a 1 is two 0s

## Your notes

#### **NAND** gate

• A NAND gate has **two** inputs



In	put	Output
Α	ш	Z
0	0	1
0	1	1
1	0	1
1	1	0

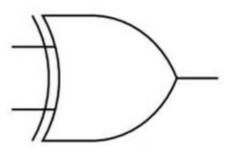
■ The truth table shows a NAND gate works in the **opposite way to an AND gate** – the only input combination which does not result in a 1 is two positive inputs (1+1)

#### **XOR** gate

An XOR gate has two inputs







Input		Output
A	В	Z
0	0	0
0	1	1
1	0	1
1	1	0

• The truth table shows how an XOR gate works. It will only output a 1 if the two inputs are **different to one** another



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### Worked example

#### A truth table for a two input (A and B) logic gate

A	В	X
0	0	0
0	1	1
1	0	1
1	1	1

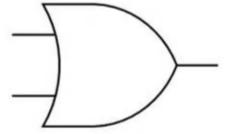
Identify what logic gate the truth table is representing

[1]

OR [1]

What symbol is used to represent this logic gate?

[1]



[1]

Truth tables can also be used to help work out the possible outputs of a logic circuit containing more than one gate

### Exam Tip

• You will only be asked to create truth tables for logic circuits with three inputs. The number of rows you should have in a three input truth table is 8 (not including the headings)

## Your notes

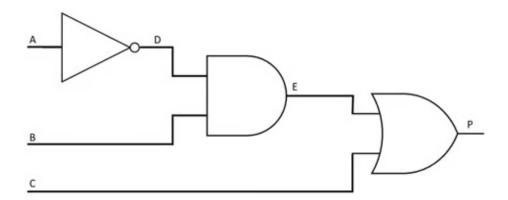
 When creating a truth table for multiple inputs, begin by entering the possible input combinations into the leftmost columns

## Your notes

#### A truth table for a three input (A, B and C) logic gate

Α	В	С	Z
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

- The column on the **right** contains the final **output** of the logic circuit (Z)
- Column(s) in between the inputs and the final output can be used to help work out the final output by containing intermediary outputs
- Intermediary outputs are the output of gates found within the logic circuit
- In the logic circuit diagram below, D and E are intermediary outputs



• The fourth column labelled D represents the output of NOTA

A B	C D (NOT A)	Е	Z
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0	0	0	1	
0	0	1	1	
0	1	0	1	
0	1	1	1	
1	0	0	0	
1	0	1	0	
1	1	0	0	
1	1	1	0	



- The next intermediary output is E which is the equivalent of ((NOTA) AND B) this notation is called a logic expression
- The Eintermediary output can be worked out by performing the AND logical operation on columns B and D

Α	В	С	D (NOT A)	E ((NOT A) AND B)	Z
0	0	0	1	0	
0	0	1	1	0	
0	1	0	1	1	
0	1	1	1	1	
1	0	0	0	0	
1	0	1	0	0	
1	1	0	0	0	
1	1	1	0	0	

• The final output (Z) can be worked out by performing the OR logical operation on columns E and C



Α	В	С	D (NOT A)	E ((NOT A) AND B)	Z (((NOTA) AND B) OR C)
0	0	0	1	0	0
0	0	1	1	0	1
0	1	0	1	1	1
0	1	1	1	1	1
1	0	0	0	0	0
1	0	1	0	0	1
1	1	0	0	0	0
1	1	1	0	0	1



## Exam Tip

• In the examit is likely truth tables will just contain columns for the inputs and the final output. You can still work out intermediary outputs to help you find the final output answers



