Logic Gates and Truth Tables

Logic gates are part of the electrical circuits that make up computers. They can be found in memory, on the motherboard and inside the CPU – particularly in the Arithmetic Logic Unit element of the CPU

Transistors and diodes are used in electrical circuits to create switches. These can be either ON or OFF. They can be combined using the four types of logic gate to create more complex electronic circuits. These logic gates control the flow of electricity around the device and determine what the device does in any situation.

In the Truth Tables, the inputs are A and B. Each can have the value True or False.
The output is Q. This can be True or False.

Logic gates are used to process up to two inputs. These generate a single output.

There are four logic gates you need to know:

- AND
- OR
- XOR (exclusive OR)
- NOT

We use logic gates to take up to two input values, which can be either True or False. From the gate, we get a single output, which can be either True or False again.

So, for example, we can say:

IF age > 15 AND height > 1.55 THEN

When we write this, we're saying: **IF** someone is aged more than 15 **AND** their height is greater than 1.55 metres **THEN** the output will be True – so we might let them on the dangerous ride at the amusement park for example.

Or we might say,

IF age < 21 OR shoeSize > 42 THEN

So, we're saying **IF** the person is under 21 **OR** if their shoe size is more than a 42 THEN the output is True.

Truth Tables

When we create logic gates with AND, OR, XOR and NOT, we use Truth Tables to understand the possible range of outputs.

Each Boolean statement in a Truth table can be True or False. With two statements, A and B, there are four possible combinations of Boolean outputs.

Truth Table – AND

For an AND logic gate, **both** Boolean inputs need to be True for the result to be True.

Input A	Input B	Output Q
True	True	True – both A and B are True
True	False	False – only A is True so both are not
False	True	False – only B is True so both are not
False	False	False – neither A or B are True

Truth Table – OR

For an OR logic gate, **one or more** Boolean inputs need to be True for the result to be True.

Input A	Input B	Output Q
T	T	T – both A and B are True, so at least one is
T	F	T – A is True, so at least one is
F	T	T – B is True, so at least one is
F	F	False – neither A or B are True

T or F are often used in Truth Tables rather than writing out True or False

Truth Table – XOR

An XOR gate is an Exclusive OR gate. This means that one, **but only one**, of the inputs must be True to get an output of True. This means that if both the inputs are True that the output is False.

A	B	Q	
1	1	0	both are 1, so more than one is, so the output is False – which is 0
1	0	1	one, and only one, input is True, so the output is True
0	0	1	one, and only one, input is True, so the output is True
0	0	0	neither input is True, so the output is False

In exam truth tables you will often see a numerical value rather than T or F. These are the Binary values that digital devices actually use.
- True = 1
- False = 0

Truth Table – NOT

A NOT gate simply reverses the input value. So an input of True becomes an output value of False; an input False becomes True. NOT gates only have one input.

Input A	Output Q
True	False
False	True

NOT logic gates are really simple, but it's easy to end up confused…

Activities:

a) For the AND truth table, what rows produce an OUTPUT of True?

b) For the OR truth table, how many rows produce an OUTPUT of True?

c) For the XOR truth table, how can an output be True?

d) For the XOR truth table, how many rows produce an OUTPUT of True?

e) What does XOR stand for? What does this actually mean?

f) Describe what the NOT gate does

g) Complete the table by writing one or more of AND, OR, XOR or NOT in the left column:

	Returns True if both inputs are True
	Has only one input
	Returns True if one or both inputs are True
	Has exactly two False outputs
	Has exactly one True output
	Has the most True outputs