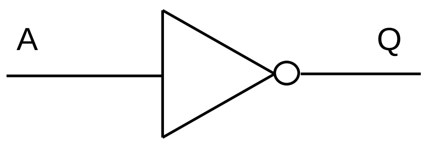
Logic Gates

The term logic gate actually gives a clue as to the function of these devices in an electronic circuit. ‘Logic’ implies some sort of rational thought process taking place and a ‘gate’ in everyday language allows something through when it is opened.

A Logic Gate in an electronic sense makes a ‘logical’ decision based upon a set of rules, and if the appropriate conditions are met then the gate is opened and an output signal is produced.

1.The NOT gate (or inverter)

This is the simplest form of logic gate and has only 1 input and 1 output. So how can it make a decision if it only has 1 input ? Simply the purpose of this gate is to invert the input signal so if a Logic 0 is at the input, the output will be at Logic 1 and vice versa. The symbol for a NOT gate is as follows.

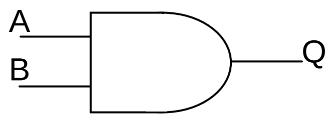


The output of a logic gate can also be summarised in the form of a table, called a ‘Truth Table’. The truth table for a NOT gate is the simplest of all Truth Tables and is shown below.

Input	Output
A	Q
0	1
1	0

2.The AND gate.

We will start with a 2 input AND gate. The symbol for a 2 input AND gate is as follows.

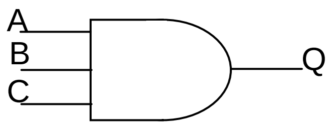


The truth table for the 2 input AND gate is shown below.

Inputs		Output
B	A	Q
0	0	0
0	1	0
1	0	0
1	1	1

We can see that the output is only at a Logic 1 when Input A AND Input B are at a Logic 1.

Now we will consider a 3 input AND gate.
The symbol is:

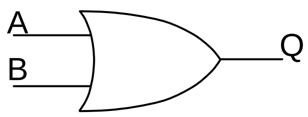


Inputs			Output
C	B	A	Q
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

We can see that the output is only at a Logic 1 when Input A AND Input B AND Input C are at a Logic 1.

3.The OR gate.

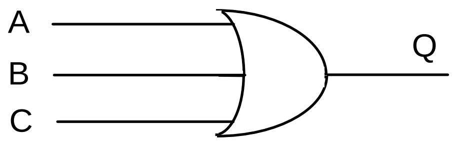
We will start with a 2 input OR gate. The symbol for a 2 input OR gate is as follows.



The truth table for the 2 input OR gate is shown below.

Inputs		Output
B	A	Q
0	0	0
0	1	1
1	0	1
1	1	1

We can see that the output is at a Logic 1 when Input A OR Input B OR both are at a Logic 1.
Now we will consider a 3 input OR gate.
The symbol is:

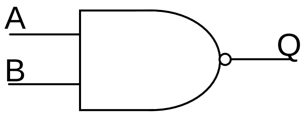


Inputs			Output
C	B	A	Q
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

We can see that the output is at a Logic 1 when either Input A OR Input B OR Input C OR any combination are at a Logic 1.

4. The NAND gate.

We will start with a 2 input NAND gate. The symbol for a 2 input NAND gate is as follows.



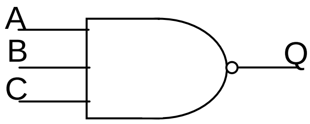
The truth table for the 2 input NAND gate is shown below.

Inputs		Output
B	A	Q
0	0	1
0	1	1
1	0	1
1	1	0

If you compare this truth table with that for the AND gate, you will find that the output Q is the exact opposite to the AND.
The Boolean expression for a 2 input NAND gate is

$$Q = \overline{A.B}$$

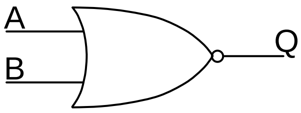
As before the '.' between the A and B means AND, and the 'bar' means invert the output in Boolean Algebra.
Now we will consider a 3 input NAND gate.
The symbol is:



Inputs			Output
C	B	A	Q
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

5.The NOR gate.

We will start with a 2 input NOR gate. The symbol for a 2 input NOR gate is as follows.



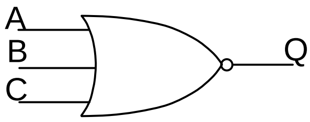
The truth table for the 2 input NOR gate is shown below.

Inputs		Output
B	A	Q
0	0	1
0	1	0
1	0	0
1	1	0

If you compare this truth table with that for the OR gate, you will find that the output Q is the exact opposite of the OR.
The Boolean expression for a 2 input NOR gate is

$$Q = \overline{A + B}$$

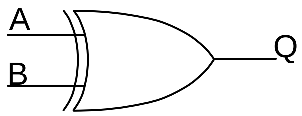
As before the '+' between the A and B means OR and the 'bar' means invert the result in Boolean Algebra.
Now we will consider a 3 input NOR gate.
The symbol is:



Inputs			Output
C	B	A	Q
0	0	0	1
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	0

6.The XOR gate.

The EXOR gate has 2 inputs and is a specialised version of the OR gate. The symbol for a 2 input XOR gate is as follows.



The truth table for the 2 input XOR gate is shown below.

Inputs		Output
B	A	Q
0	0	0
0	1	1
1	0	1
1	1	0

Comparison with the 2 input OR gate will reveal that Q is a Logic 1 when either A or B is a Logic 1, but not when A and B are Logic 1.

The Boolean expression for a 2 input EXOR gate is

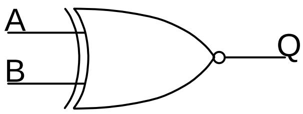
$$Q = A \oplus B$$

$$alternatively \quad Q = \overline{A}.B + A.\overline{B}$$

The '$\oplus$' between the A and B means Exclusive OR, however the alternative form will prove to be more useful later on in the course when simplifying Boolean expressions.

7.The XNOR gate.

The XNOR gate has 2 inputs and is the inverted form of the EXOR gate. The symbol for a 2 input XNOR gate is as follows.



The truth table for the 2 input XNOR gate is shown below.

Inputs		Output
B	A	Q
0	0	1
0	1	0
1	0	0
1	1	1

If you compare this truth table with that for the EXOR gate, you will find that the output Q is the exact opposite to the EXOR.

The Boolean expression for a 2 input XNOR gate is

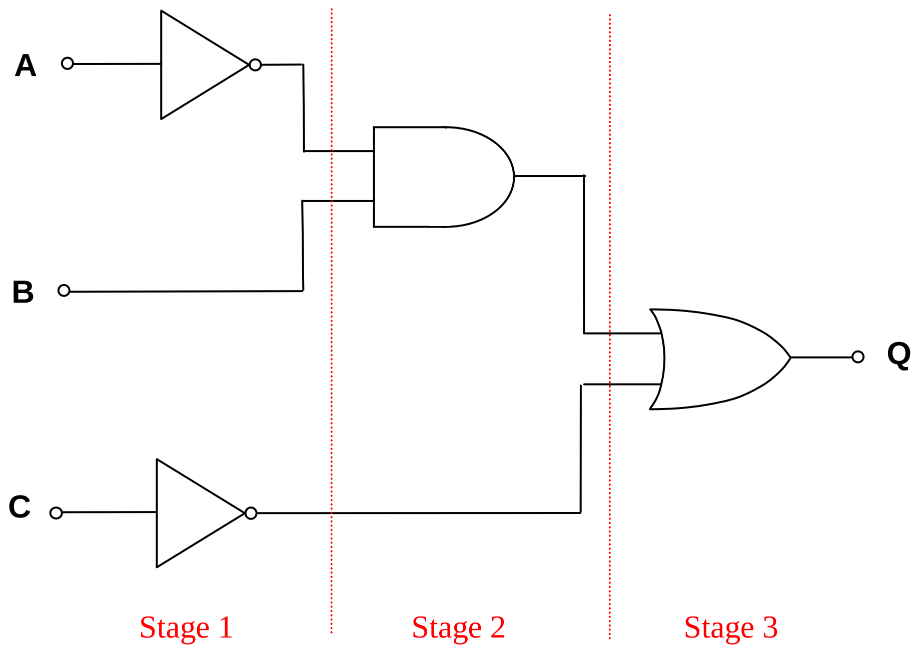
$$Q = \overline{A \oplus B}$$

$$alternatively \quad Q = \overline{A}.\overline{B} + A.B$$

The '$\oplus$' between the A and B means Exclusive OR, and the 'bar' means that the result is inverted. Once again however the alternative form will prove to be more useful later on in the course when simplifying Boolean expressions.

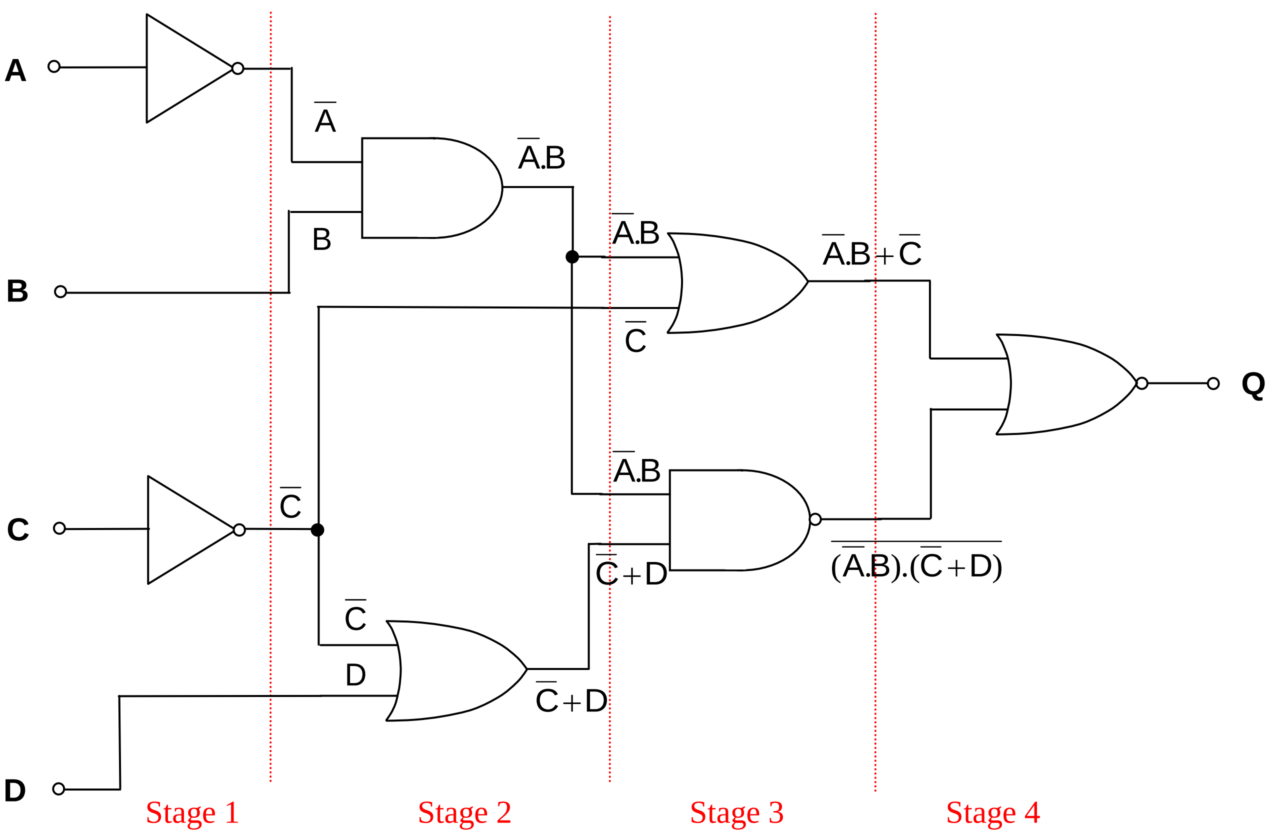
Example 1 :Draw the Boolean expression

$$Q=\overline{A}.B+\overline{C}$$

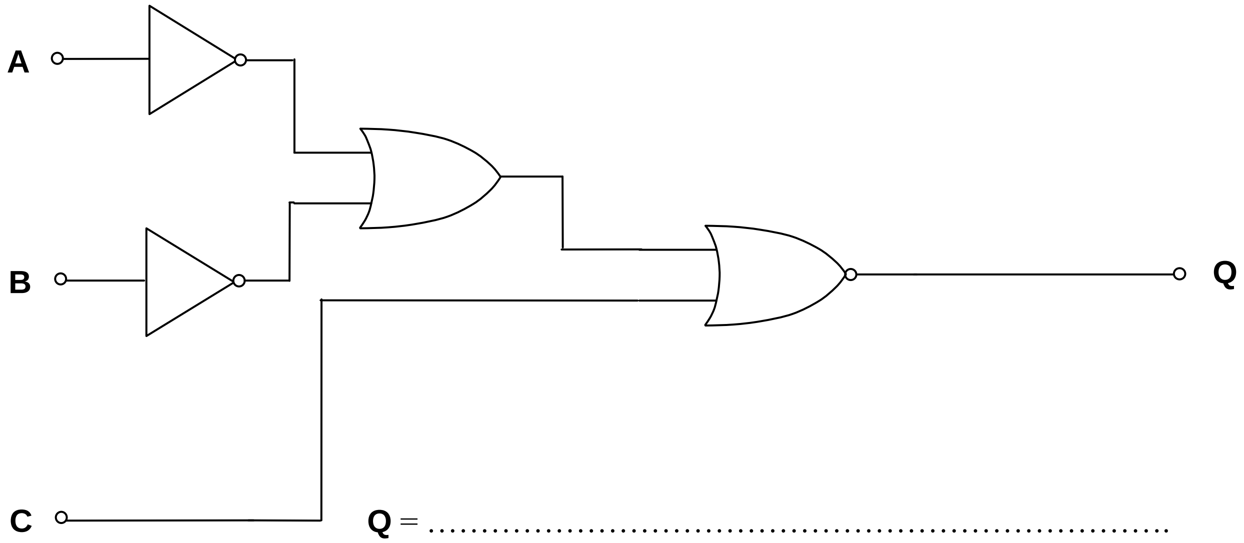


Example 2 :Draw the Boolean expression

$$Q=\overline{(\overline{A}.B+\overline{C})+\overline{(\overline{A}.B).(\overline{C}+D)}}$$

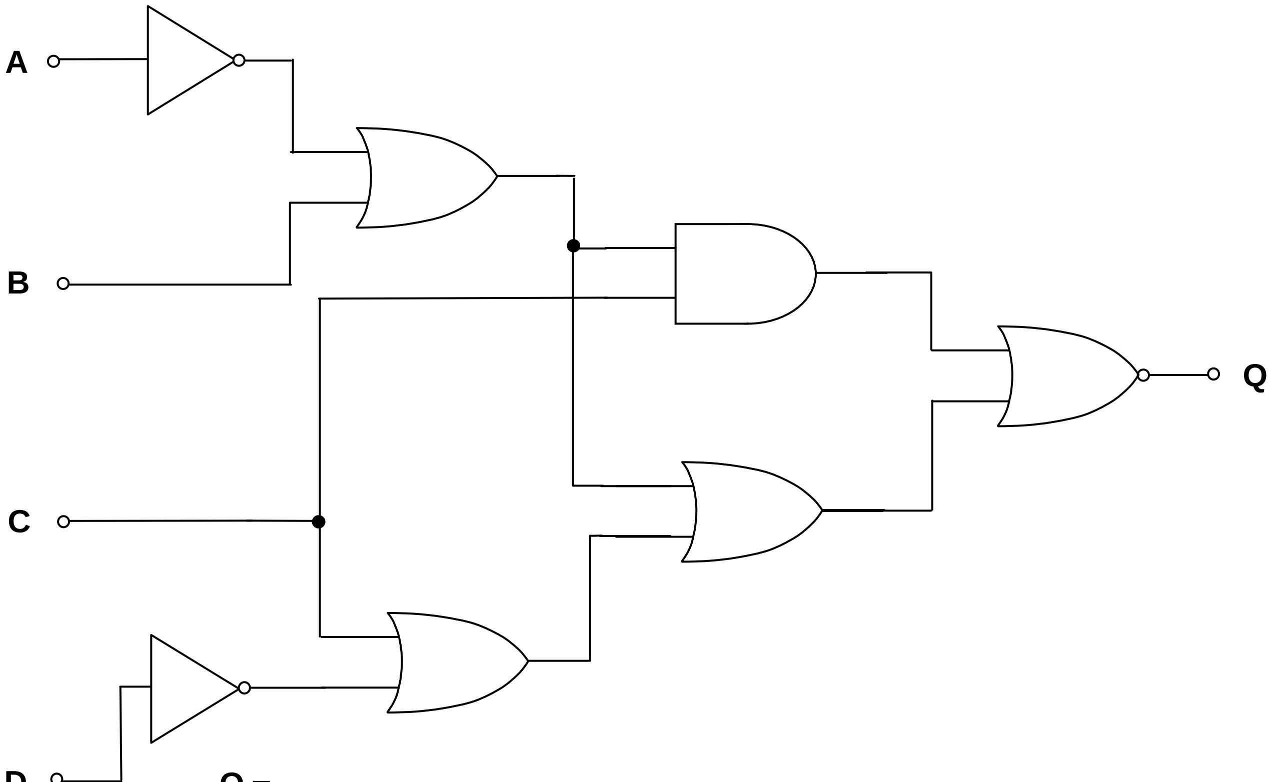


Example 3: write the Boolean Expression for the output of the following logic systems.



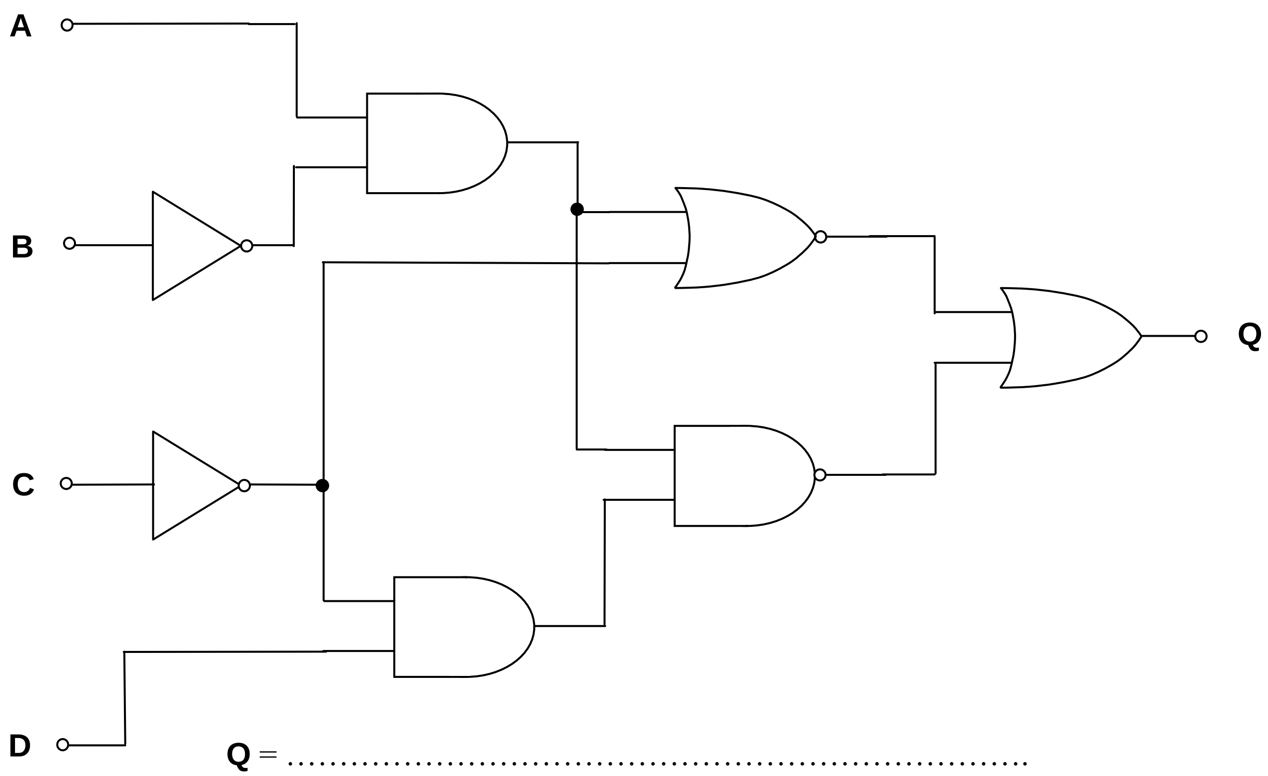
Q = ……………………………………………………………………

Example 4: write the Boolean Expression for the output of the following logic systems.

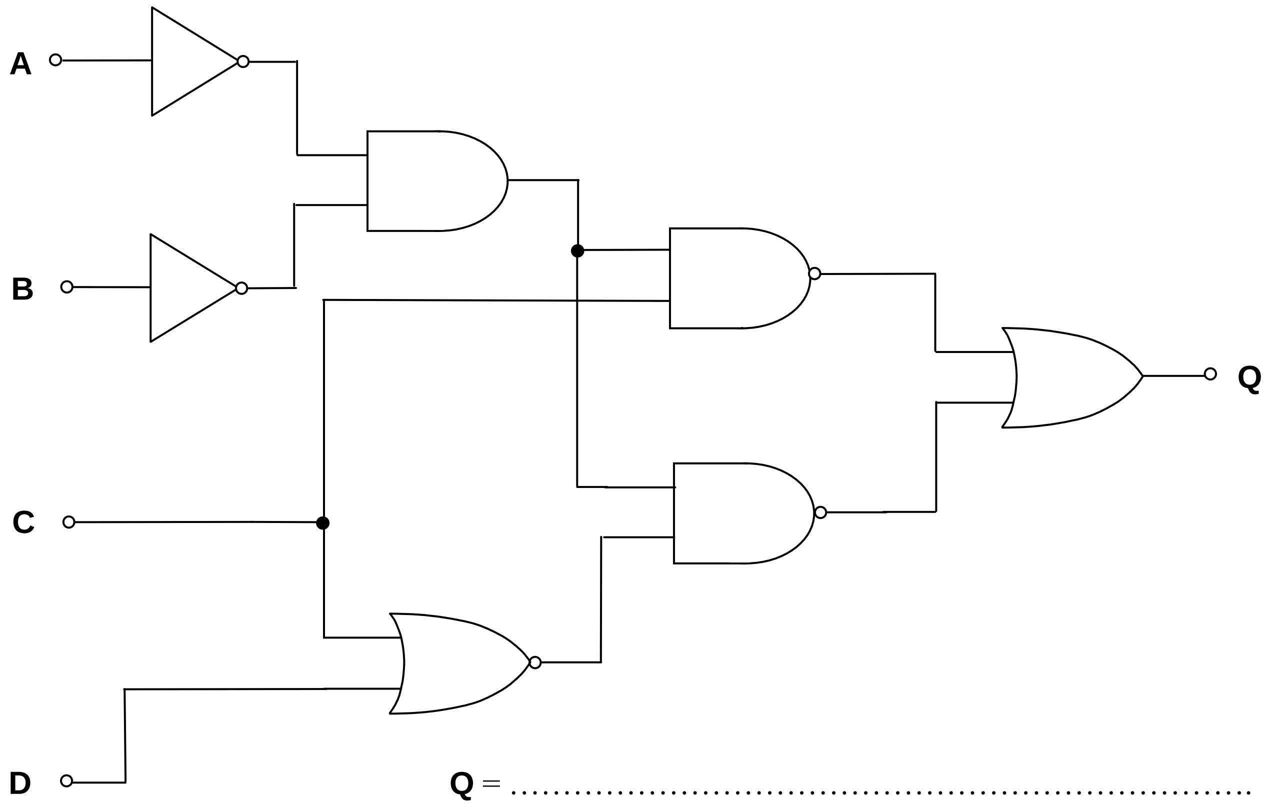


Q = ……………………………………………………………………

Example 5: write the Boolean Expression for the output of the following logic systems.



Q = ……………………………………………………………………



Q = ……………………………………………………………………