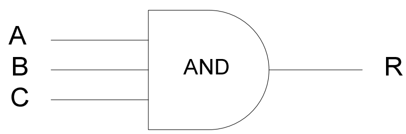
Interpreting Logic Gates

Logic gates are the mechanism used to convert Boolean logic into the circuitry the computer needs to solve such problems.

We have learned about three(3) different gates.

The AND Gate takes two or more inputs. Remember that the AND operator examines all the inputs. If they are all True (1) the result is True (1). If any of the inputs are False(0) the Result is False(0)



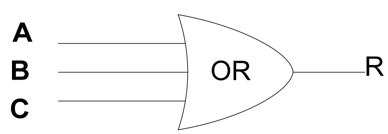
The equation for this AND gate is:

R = ABC

The Truth Table for this AND gate is:

A	B	C	ABC
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

The OR Gate takes two or more inputs. Remember that the OR operator examines all the inputs. If any of the inputs are True(1) the Result is True(1).



The equation for this OR gate is:

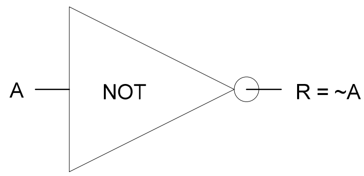
R = A+B+C

The Truth Table for this OR gate is:

A	B	C	A+B+C
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

The last gate we have discussed is the NOT gate and this gate simply inverts whatever data enters it. If the input is True(1) the output is False(0). If the input is False(0) the output is True(1).

Interpreting Logic Gates



The equation for this NOT gate is:

R = ~A

The Truth Table for this NOT gate is:

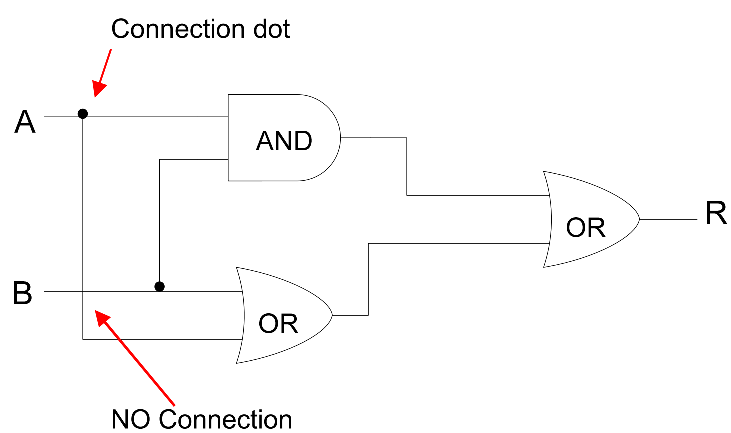
A	~A
0	1
1	0

These are the building blocks of computer circuitry. By combining them in the correct order all of the fancier circuitry is build.

<u>Logic Networks</u>

Gates are interconnected together to form circuits that perform more complex functions care called Logic Networks.

- o Wires connect gates
- o When two wires cross a dot represents a connection



This network represents the following Boolean statement. R = AB + (A+B)

How do I know this?

Examining the diagram we can assume that if the inputs are on the left, and the output on the right then the "current" in this circuit moves from left to right.

What do we encounter first?

A AND B enters at the top (AB)
B OR A enters at the bottom (B+A)

So thus far R → AB (B+A)

The outputs from both of these gates goes into an OR gate

Interpreting Logic Gates

So AB (B+A) ➔ R = AB + (B+A)

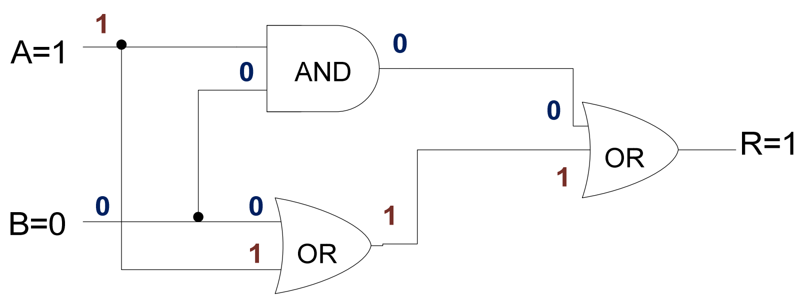
OR(+)

The Truth Table is:

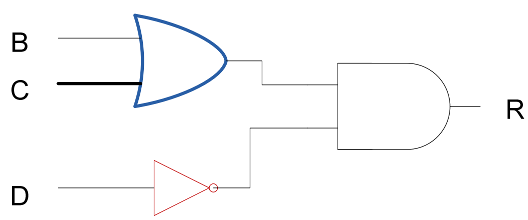
A	B	AB	(A+B)	AB+(A+B)
0	0	0	0	0
0	1	0	1	1
1	0	0	1	1
1	1	1	1	1

Using the Truth Table above, If A = 1, B = 0, What is R? We can read across the third line of the table and see that R = 1.

There is another way to find this value. In the diagram below the values are placed on the gate diagram. The input to the gate is identified, then the output is identified and we can determine R without using a truth table. The output from the final OR gate R = 1.



Example 1: What is logic equation represented by this circuit?



There are three gates used in this example. B and C are input to the top OR gate. D enters a NOT gate. The output from the OR gate and the NOT gate become the input to the final AND gate.

When data is input to the gates on the left, what do we know

B, C go into the OR gate (B+C)

D goes into the NOT gate ~D

Interpreting Logic Gates

(B+C) ~D

AND(·)

R = (B+C) · ~D

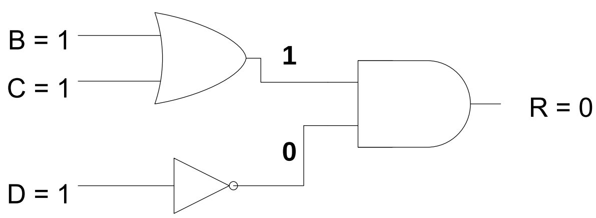
The Truth Table is:

R = (B+C) · ~D

B	C	D	(B+C)	~D	(B+C) · ~D
0	0	0	0	1	0
0	0	1	1	0	0
0	1	0	1	1	1
0	1	1	1	0	0
1	0	0	1	1	1
1	0	1	1	0	0
1	1	0	1	1	1
1	1	1	1	0	0

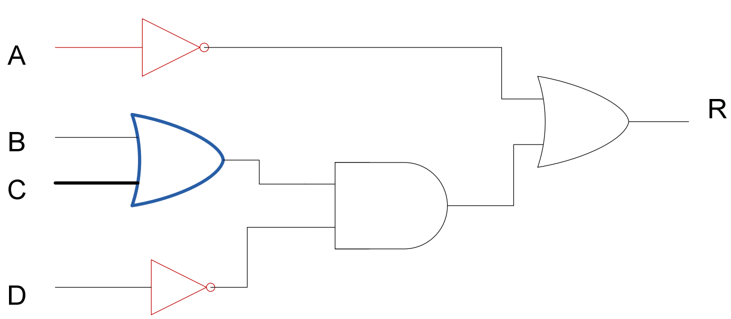
If B = 1, C = 1, D = 1, What is R?
Reading across the last line, we can see that R = 0

Another way to solve this problem is by placing values directly on the circuit diagram. The output from each gate is then determined by the input into it.



Example 2:
This is an expansion of the above circuit.
What equation does the following circuit represent?
Construct the truth table for the following circuit.
If A = 1, B = 1, C = 0 and D = 0, what is R?
If A = 0, B = 0, C = 1 and D = 1, what is R?

Look carefully at the component parts of this diagram.



The topmost NOT gate takes A as input. Its out put is ~A. Below that is an OR gate which takes both B and C as input. Its output is contained in the expression (B+C). At the bottom in another NOT gate which can be represented at ~D.

Interpreting Logic Gates

So far we have

~A (B+C) ~D

The output of the OR gate and the NOT gate are input to an AND gate.
The output of this AND gate is input to the final OR gate whose other input is the topmost NOT gate.

~A (B+C) ~D

AND (·)

OR (+)

So: R = ~A + ((B+C)(~D)) or R = ~A + ((B+C) · ~D)
Truth Table for R = ~A + ((B+C) · ~D)

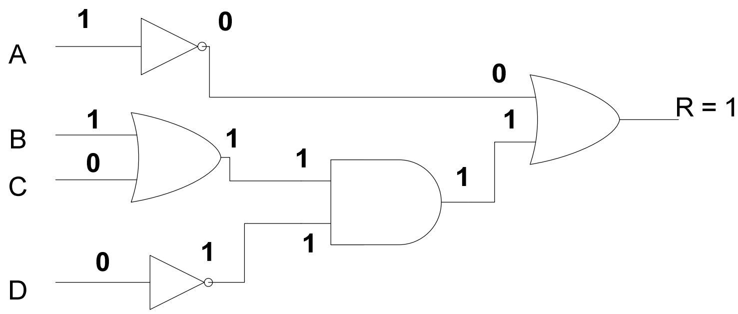
A	B	C	D		(B+C)	~D	(B+C)(~D)	~A+((B+C)(~D))	
0	0	0	0		0	1		1	
0	0	0	1	1	0	0	0	1	
0	0	1	0	1	1	1	1	1	
0	0	1	1	1	1	0	0	1	
0	1	0	0	1	1	1	1	1	
0	1	0	1	1	1	0	0	1	
0	1	1	0	1	1	1	1	1	
0	1	1	1	1	1	0	0	1	
1	0	0	0	0	0	1	0	0	
1	0	0	1	0	0	0	0	0	
1	0	1	0	0	1	1	1	1	
1	0	1	1	0	1	0	0	0	
1	1	0	0	0	1	1	1	1	
1	1	0	1	0	1	0	0	0	
1	1	1	0	0	1	1	1	1	
1	1	1	1	0	1	0	0	0	

If A = 1, B = 1, C = 0 and D = 0, what is R? Using the Truth Table R = 1
If A = 0, B = 0, C = 1 and D = 1, what is R? Using the Truth Table R = 1

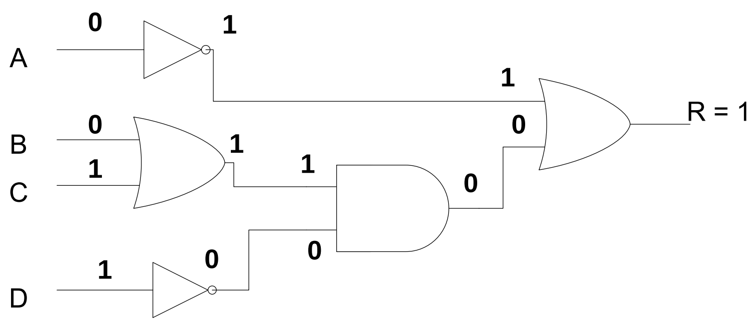
As with the previous example we can use the circuit diagram directly to determine the value of R for each question.

If A = 1, B = 1, C = 0 and D = 0, what is R? Using the circuit R = 1

Interpreting Logic Gates

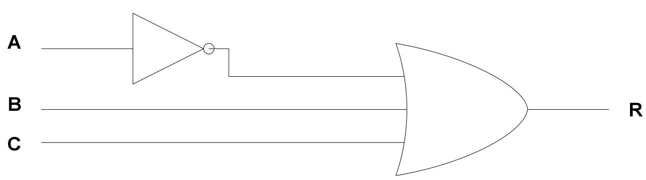


Similarly, If A = 0, B = 0, C = 1 and D = 1, what is R? Using the circuit R = 1

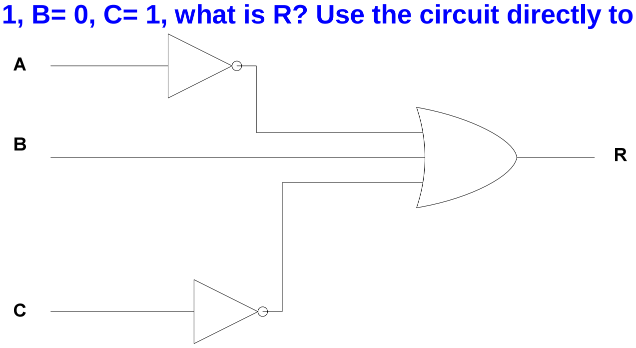


Try These Examples:

1) If A = 0, B= 1, C= 0, what is R? Use the circuit directly to find your answer.

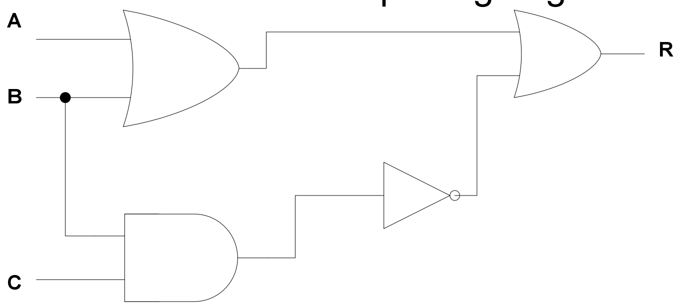


2) If A = 1, B= 0, C= 1, what is R? Use the circuit directly to find your answer.

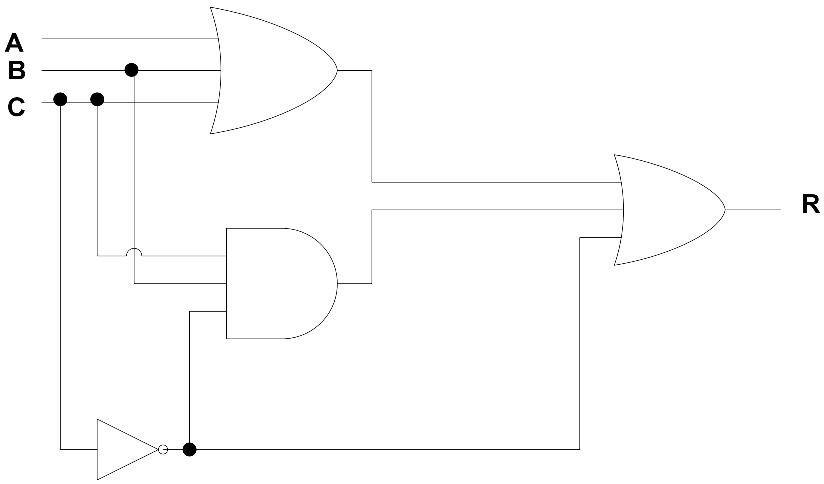


3) If A = 1, B = 0, C = 1, What is R? Use the circuit directly to find your answer.

Interpreting Logic Gates



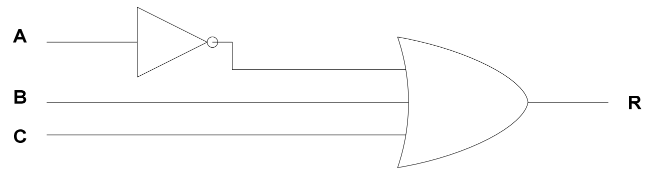
4) If A = 0, B = 1, C = 1, What is R? Use the circuit directly to find your answer.



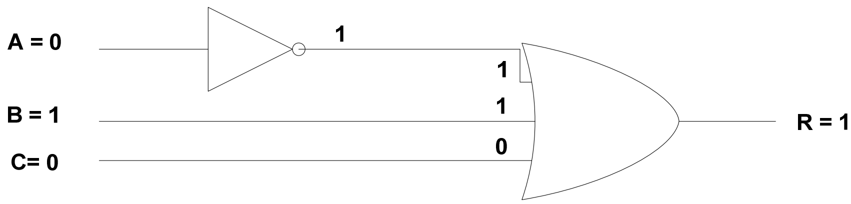
Interpreting Logic Gates

Solutions:

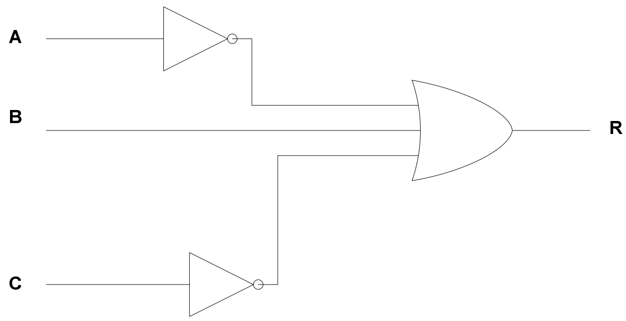
1) If A = 0, B= 1, C= 0, what is R?



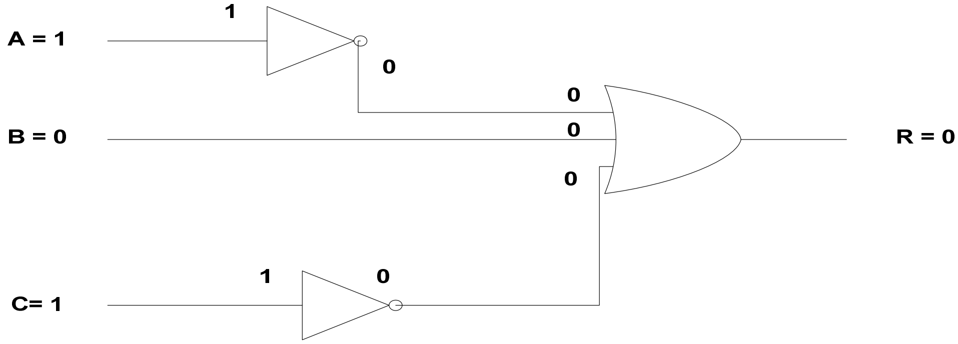
Reading from left to right (and top to bottom), we encounter a NOT gate the result of which along with B and C are entered into an OR gate.



2) If A = 1, B= 0, C= 1, what is R?

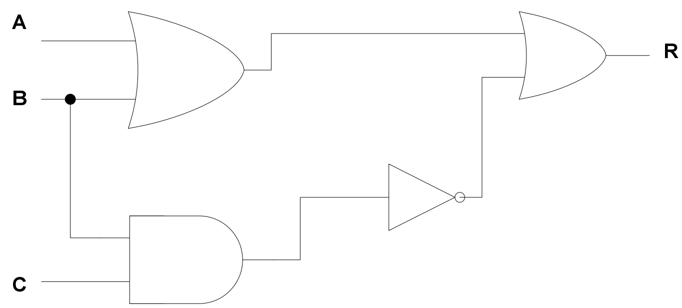


Reading from left to right at the top we encounter a NOT gate which flips the value of A. At the bottom we encounter a NOT gate that flips the value of C. The value of NOT A, NOT C and B all enter an OR gate to give us the answer.

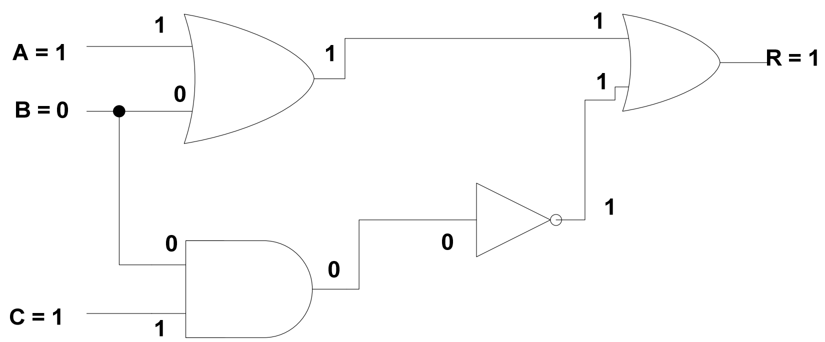


Interpreting Logic Gates

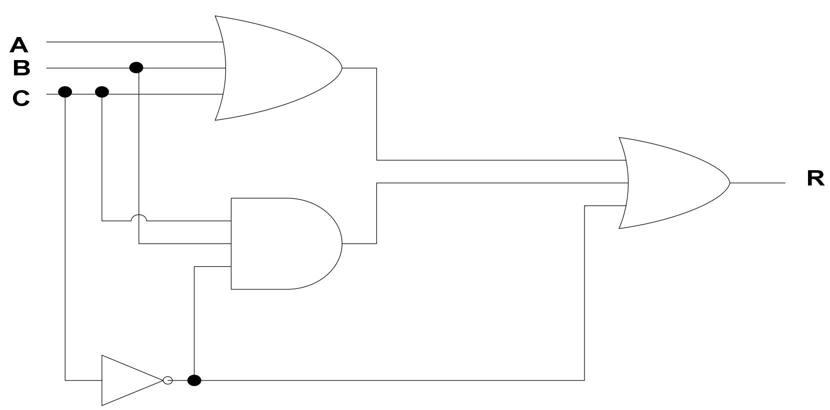
3) If A = 1, B = 0, C = 1, What is R?



This diagram is only slightly more complex as it has four gates instead of three. We proceed in the same way. Identify that the values of A along with those of B enter an OR gate at the upper left. The values of B along with C enter an AND gate at the bottom left. The result of this AND gets flipped by the NOT gate and the results of the NOT along with the OR to into the final OR.



4) If A = 0, B = 1, C = 1, What is R?



This circuit diagram looks more complex than it really is. Like example 3 above it only four gates are present. . However, we grab values from B and C (in fact from C twice) to use them as input to other gates. Work through this carefully. The inputs to the topmost gate (which is an OR) are A, B, and C. The inputs to the AND gate below it are B, C and NOT C. The results from the OR and AND gates go to the final OR gate.

Interpreting Logic Gates