

Logic Gates: AND, OR, NOT (Inverter)

Using AND

An AND gate can have more than two inputs

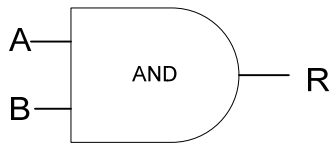
- If at least one input is a 0, then the output is a 0.
- When all inputs are 1, the output is a 1.

All of these symbols are equivalent:

$A \text{ AND } B \rightarrow A \wedge B \rightarrow A \cdot B \rightarrow AB$

Truth Table (AND)

A	B	$A \cdot B$	A	B	R
0	0	0	0	0	0
0	1	0	0	1	0
1	0	0	1	0	0
1	1	1	1	1	1



Using OR

An OR gate can have more than two inputs

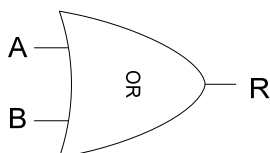
- If at least one input is a 1, then the output is a 1.
- If **all** the inputs are 0, the output is a 0.

All of these symbols are equivalent

$A \text{ OR } B \rightarrow A \vee B \rightarrow A + B$

Truth Table (OR)

A	B	$A + B$	A	B	R
0	0	0	0	0	0
0	1	1	0	1	1
1	0	1	1	0	1
1	1	1	1	1	1



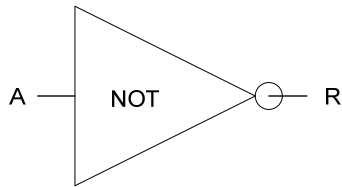
Using NOT (Invert)

All of these symbols are equivalent

NOT $\rightarrow \sim \rightarrow \bar{\quad}$

Truth Table (NOT)

C	$\sim C = R$
0	1
1	0



Sample Examples:

1) $R = \sim AC + B$

3 Variables (A, B, C)
3 initial columns
8 rows to include all possibilities

Question:

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

A	B	C	$\sim A$
0	0	1	1
0	0	0	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

A	B	C	$\sim A$	$\sim A \cdot C$
0	0	0	1	0
0	0	1	1	1
0	1	0	1	0
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

A	B	C	$\sim A$	$\sim A \cdot C$	$\sim AC + B$
0	0	1	0	0	0
0	0	1	1	1	1
0	1	0	1	0	1
0	1	1	1	1	1
1	0	0	0	0	0
1	0	1	0	0	0
1	1	0	0	0	1
1	1	1	0	0	1

2) $R = (A+C)(\sim C+A)$

A	C	$\sim C$	A+C	$\sim C+A$	R
0	0	1			
0	1	0			
1	0	1			
1	1	0			

A	C	$\sim C$	A+C	$\sim C+A$	R
0	0	1	0		
0	1	0	1		
1	0	1	1		
1	1	0	1		

A	C	$\sim C$	A+C	$\sim C+A$	R
0	0	1	0	1	
0	1	0	1	0	
1	0	1	1	1	
1	1	0	1	1	

A	C	$\sim C$	A+C	$\sim C+A$	$R = (A+C)(\sim C+A)$
0	0	1	0	1	0
0	1	0	1	0	0
1	0	1	1	1	1
1	1	0	1	1	1

Try these Examples:

Remember, the dot (\cdot) will only be included if critical
 Two letters next to each other $AB = A \cdot B$ which means AND

Note: Order of operations matters

The order is: Parenthesis ($()$)
 NOT \sim
 AND \cdot ex: AB or $A \cdot B$
 OR $+$ ex: $A+B$

- 1) $R = \sim A + \sim BC$ If $A = 0, B = 1, C = 1$, then what is R ?
- 2) $R = \sim A \cdot \sim B + A$ If $A = 1, B = 0$, then what is R ?
- 3) $R = \sim A \cdot (\sim B + A)$ If $A = 1, B = 0$, then what is R ?
 Be careful question 2 and 3 are not the same. Order of operations matters.
- 4) $R = (\sim B + C)A$ If $A = 0, B = 1, C = 1$ then what is R ?
 Order of operations matters here.
- 5) $R = ((A + \sim B)(B + C))$ If $A = 1, B = 1, C = 0$ then what is R ?
 Order of operations matters here.

Solutions:

1) $R = \sim A + \sim BC$

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

A	B	C	$\sim A$	$\sim B$	$\sim BC$	$\sim A + \sim BC$
0	0	0	1	1	0	1
0	0	1	1	1	1	1
0	1	0	1	0	0	1
0	1	1	1	0	0	1
1	0	0	0	1	0	0
1	0	1	0	1	1	1
1	1	0	0	0	0	0
1	1	1	0	0	0	0

2) $R = \sim A \cdot \sim B + A$

If $A = 1, B = 0$, then what is R ?
 $R = 1$

A	B	$\sim A$	$\sim B$	$\sim A \cdot \sim B$	$\sim A \cdot \sim B + A$
0	0	1	1	1	1
0	1	1	0	0	0
1	0	0	1	0	1
1	1	0	0	0	1

3) $R = \sim A \cdot (\sim B + A)$

If $A = 1, B = 0$, then what is R ?
 $R = 0$

A	B	$\sim A$	$\sim B$	$(\sim B + A)$	$\sim A \cdot (\sim B + A)$
0	0	1	1	1	1
0	1	1	0	0	0
1	0	0	1	1	0
1	1	0	0	1	0

4) $R = (\sim B + C)A$

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

A	B	C	$\sim B$	$(\sim B + C)$	$(\sim B + C)A$
0	0	0	1	1	0
0	0	1	1	1	0
0	1	0	0	0	0
0	1	1	0	1	0
1	0	0	1	1	1
1	0	1	1	1	1
1	1	0	0	0	0
1	1	1	0	1	1

5) $R = ((A+\sim B)(B+C))$

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

A	B	C	$\sim B$	$(A + \sim B)$	$(B + C)$	$((A + \sim B)(B + C))$
0	0	0	1	1	0	0
0	0	1	1	1	1	1
0	1	0	0	0	1	0
0	1	1	0	0	1	0
1	0	0	1	1	0	0
1	0	1	1	1	1	1
1	1	0	0	1	1	1
1	1	1	0	1	1	1