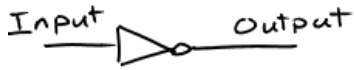


**NOT Gate (Inverter)**

- Takes the input, and changes the logic level on output

Standard Symbol



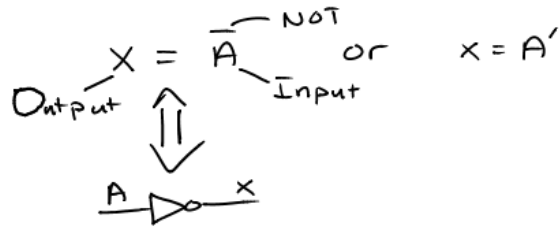
Truth Table

- Provides the possible input scenarios, and the corresponding output

NOT

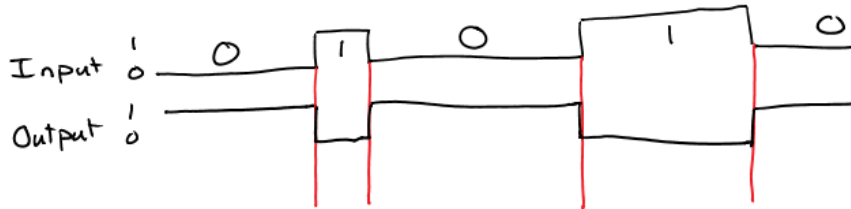
Input	Output
0	1
1	0

Logic Expression



Waveforms

- Divide the input waveform into segments where the logic level changes, and apply the truth table to each segment



**AND Gate**

- All inputs must be 1 for the output to be 1  
- Must have at least two inputs, but can have more than two

Symbol



Truth Table

A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

A	B	C	X
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

Logic Expression

$$X = A \cdot B \quad \text{or } X = AB$$

└ Boolean Multiplication

OR Gate

- If one or more of the inputs is 1, then the output is 1
- Must be at least two inputs, but there can be more

Truth Table

A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

A	B	C	X
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

Logic Expression

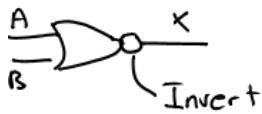
$$X = A + B$$

OR (Boolean Addition)

**NOR Gate**

- Invert the output of the OR Gate
- Must be at least two inputs, but there can be more

Symbol



Bubble

Right => Invert on output  
Left => Invert the inputs first

Truth Table

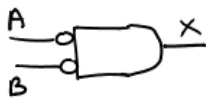
A	B	X
0	0	1
0	1	0
1	0	0
1	1	0

Logic Expression

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

Equivalent Gate to the NOR

- Negative-AND



A	B	$\bar{A}$	$\bar{B}$	X
0	0	1	1	1
0	1	1	0	0
1	0	0	1	0
1	1	0	0	0

$$\text{NOR} \quad \equiv \quad \text{Negative-AND}$$

$$\overline{A + B} \quad \equiv \quad \bar{A} \bar{B}$$

**NAND Gate**

- Invert the output of the AND Gate
- Must be at least two inputs, but there can be more

Symbol



Truth Table

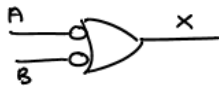
A	B	X
0	0	1
0	1	1
1	0	1
1	1	0

Logic Expression

$$X = \overline{AB}$$

Equivalent Gate to the NOR

- Negative-OR



A	B	$\bar{A}$	$\bar{B}$	X
0	0	1	1	1
0	1	1	0	1
1	0	0	1	1
1	1	0	0	0