LOGIC GATES

PRESENTED BY NABANITA DAS

LOGIC GATES

- Logic gates are the basic building blocks of any digital system. It is an electronic circuit having one or more than one input and only one output. The relationship between the input and the output is based on a **certain logic**. Based on this, logic gates are named as AND gate, OR gate, NOT gate etc.

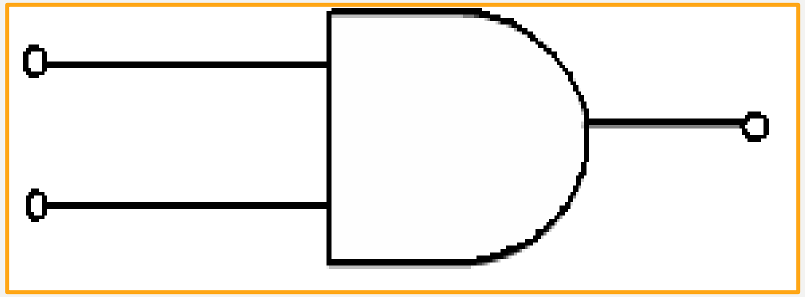
TRUTH TABLES

- Truth table: a unique representation of a Boolean function.
- If two functions have identical truth tables, the functions are equivalent and vice-versa.
- Truth tables can be used to prove equality theorems.
- However, the size of a truth table grows exponentially with the number of variables involved, hence unwieldy.

AND GATE

- AND gate can have two or more inputs and performs what is know as multiplication.
- The output of AND gate is high when all inputs are high other wise all outputs are low.

Logical Symbol



It's logical expression is, X=A.B

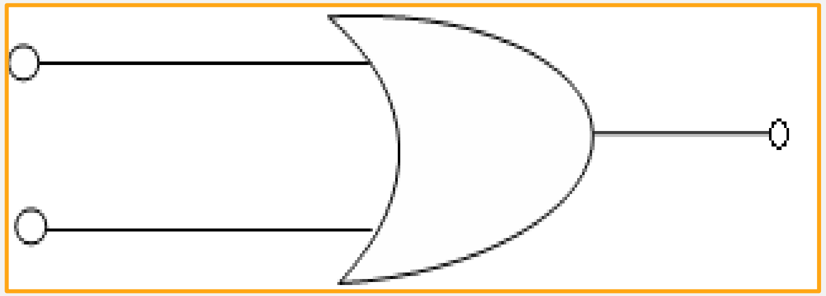
Truth Table

Inputs		Output
A	B	X
0	0	0
0	I	0
I	0	0
I	I	I

OR GATE

- OR gate can have two or more inputs and performs what is known as logical addition.
- The output of OR gate is Low when all inputs are low, otherwise all outputs are high.

Logical Symbol



Truth Table

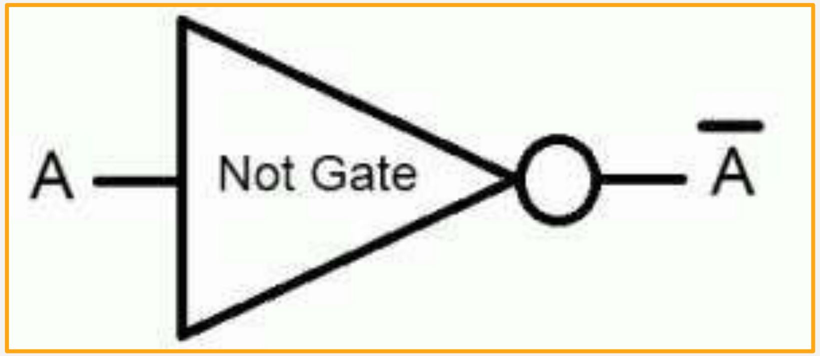
Inputs		Output
A	B	X
0	0	0
0	I	I
I	0	I
I	I	I

It's logical expression is, $X=A+B$

NOT GATE

- The inverter (NOT circuit) performs the operation called inversion or complementation.
- The NOT operation changes one logic level to the opposite logical level. When the input is Low, the output is high. When the input is high, the output is low.

Logical Symbol



Truth Table

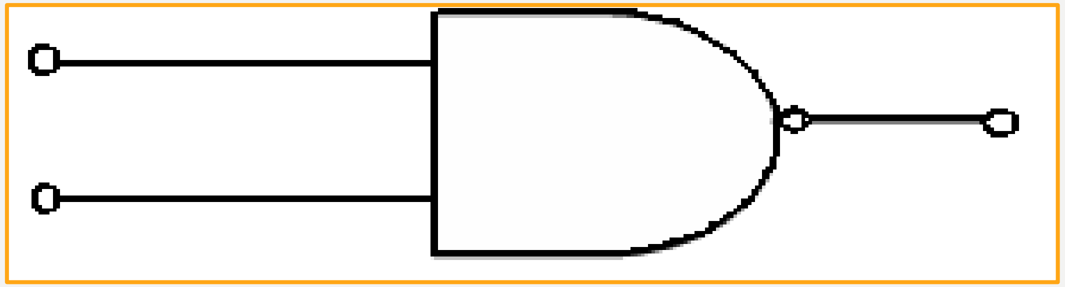
Input	Output
0	I
I	0

- It's logical expression is, A=A'

NAND GATE

- The NAND gate is the one of the popular logic element because it can be used as a universal gate; that is NAND gate can be used in combination to perform the AND, OR, and inverter operations.
- NAND Gate is constructed by attaching NOT Gate at the output of AND Gate, hence NAND Gate is called NOT- AND Gate.
- The output of NAND gate is low when all inputs are high, otherwise all outputs are high.

Logical Symbol



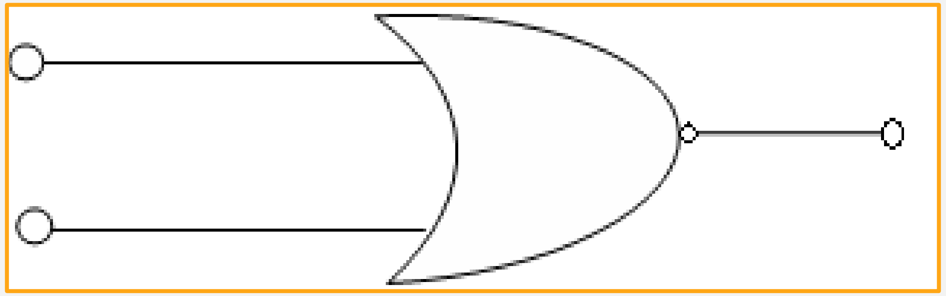
Inputs		Output
A	B	X
0	0	I
0	I	I
I	0	I
I	I	0

It’s logical expression is, X= (AB)’

NOR GATE

- The NOR gate, like the NAND gate, NOR gate is also useful logical element because it can also be used as a universal gate.
- NOR gate can be used in combination to perform the AND, OR and Inverter operations.
- NOR Gate is the combination of NOT gate at the output of OR gate, hence NOR gate is type of NOT-OR gate.
- The Output of NOR gate is high when all inputs are low otherwise the output is low.

Logical Symbol



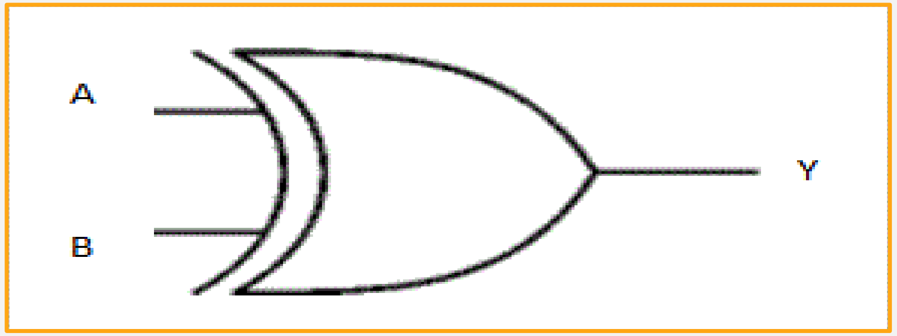
It's expression is, X=(A+B)'

Inputs		Output
A	B	X
0	0	I
0	I	0
I	0	0
I	I	0

EXCLUSIVE-OR

- The exclusive-OR gate has a graphical symbol similar to that of the OR gate, except for the additional curved line on the input side.
- If both inputs are Low or both are High then it produces the output Low or 0. otherwise it produce the High.

Logical Symbol



Inputs		Output
A	B	X
0	0	0
0	I	I
I	0	I
I	I	0

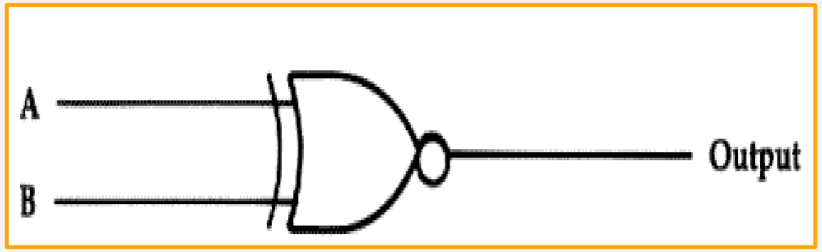
It's logical expression is X=AB'+A'B

$X = A \oplus B$

EXCLUSIVE-NOR

- The exclusive-NOR gate is the complement of the exclusive-OR gate, as indicated by small circle on the output side of the graphic symbol.
- If both inputs are Low or both are High then it produces the output High or 1. otherwise it produce the Low output.

Logical symbol



It’s logical expression is $X = AB + A'B'$

$$X = A \odot B$$

Inputs		Output
A	B	X
0	0	1
0	1	0
1	0	0
1	1	1

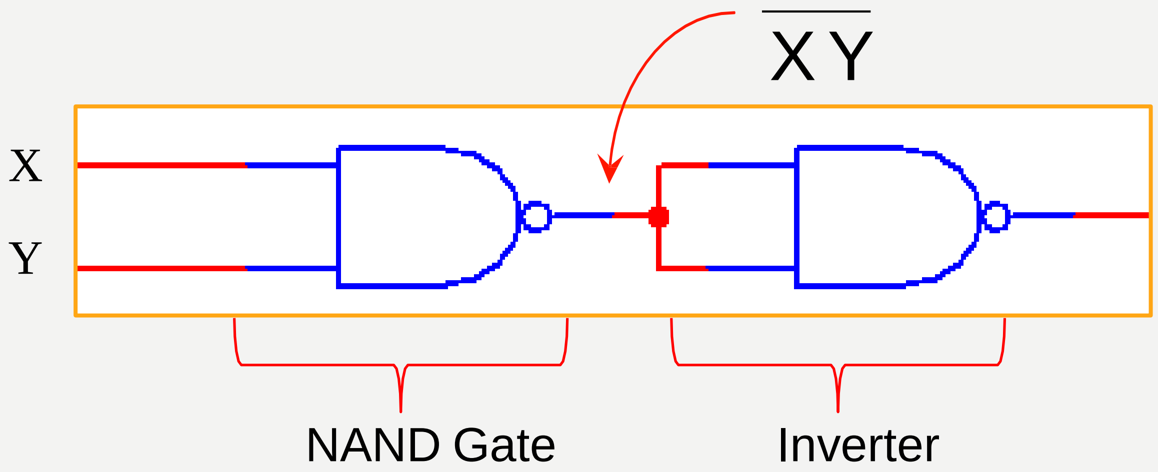
What are a universal gate & why NAND & NOR are known as universal gates?

- A gate which can be use to create any Logic gate is called Universal Gate.
- NAND and NOR are called Universal Gates because all the other gates can be created by using these gates.
- Any Boolean function can be implemented using AND, OR and NOT gates. In the same way AND, OR and NOT gates can be implemented using NAND gates only.
- Like NAND gates, NOR gates are so-called "universal gates" that can be combined to form any other kind of logic gate. A NOR gate is logically an inverted OR gate.

NAND GATE AS UNIVERSAL GATE

NAND Gate as an AND Gate

Logical symbol

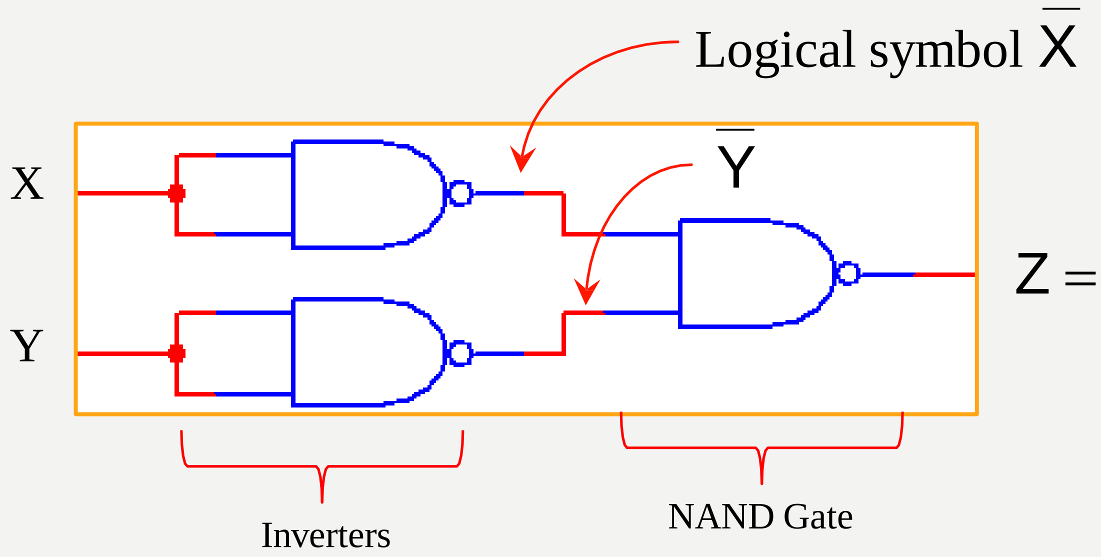


$$Z = \overline{\overline{XY}} = XY$$

Truth Table

Inputs		Output
X	Y	Z
0	0	0
0	1	0
1	0	0
1	1	1

NAND Gate as an OR Gate



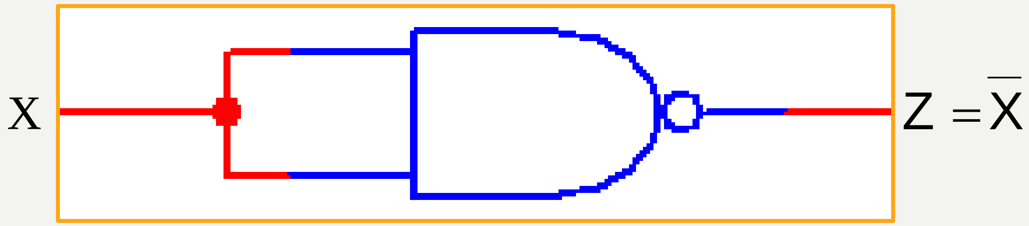
$$Z = \overline{\overline{X}\,\overline{Y}} = \overline{\overline{X}} + \overline{\overline{Y}} = X + Y$$

Truth Table

Inputs		Output
X	Y	Z
0	0	0
0	1	1
1	0	1
1	1	1

NAND GATE AS A NOT GATE

Logical symbol

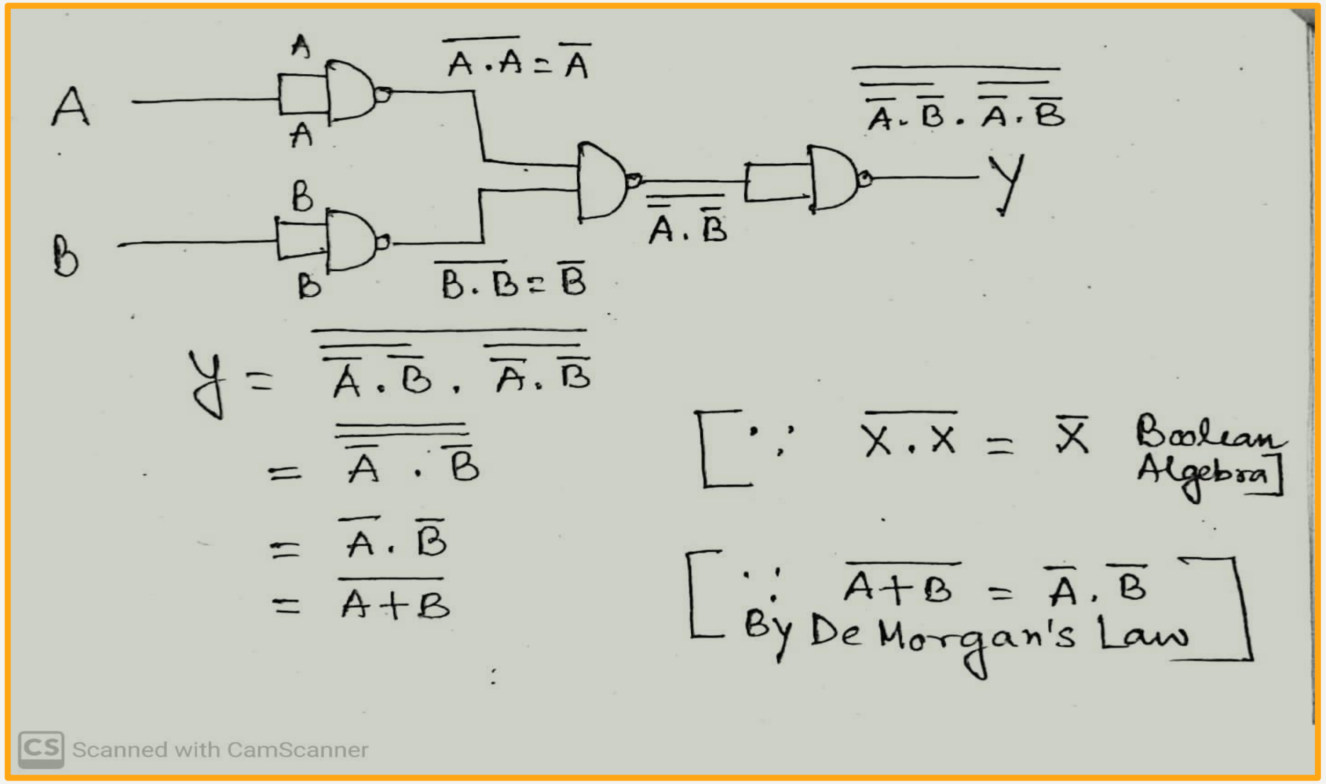


Truth Table

Input	Output
X	Z
0	I
I	0

NAND GATE AS AN NOR GATE

Logical symbol



Truth Table

Inputs		Output
A	B	Z
0	0	1
0	1	0
1	0	0
1	1	0

NAND Gate as an Ex-OR Gate

The boolean expression for output is as below

$$Y = \overline{\overline{(A \cdot \overline{(AB)})} \cdot \overline{(B \cdot \overline{(AB)})}}$$

Let's simplify it using DeMorgan's theorem

$$= \overline{\overline{(A \cdot \overline{(AB)})}} + \overline{\overline{(B \cdot \overline{(AB)})}}$$

(A • B)' = A' +B'

$$= (A \cdot \overline{(AB)}) + (B \cdot \overline{(AB)})$$

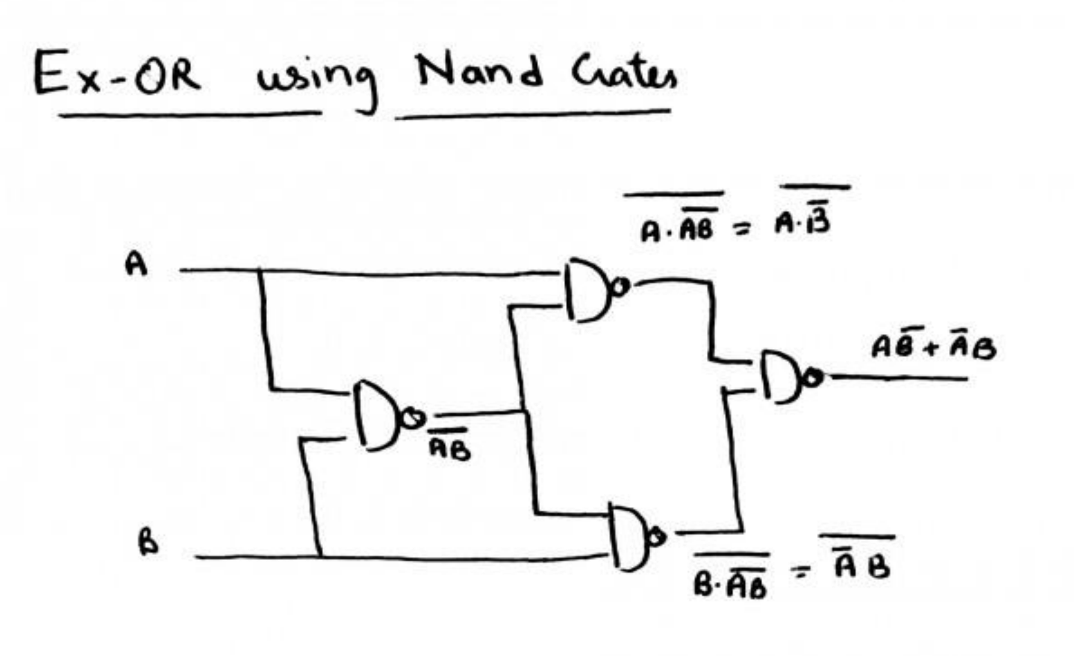
(A')' = A

$$= A \cdot (\overline{A} + \overline{B}) + B \cdot (\overline{A} + \overline{B})$$

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

$$= A\overline{B} + B\overline{A} \qquad \cdots (\because X\overline{X} = 0)$$

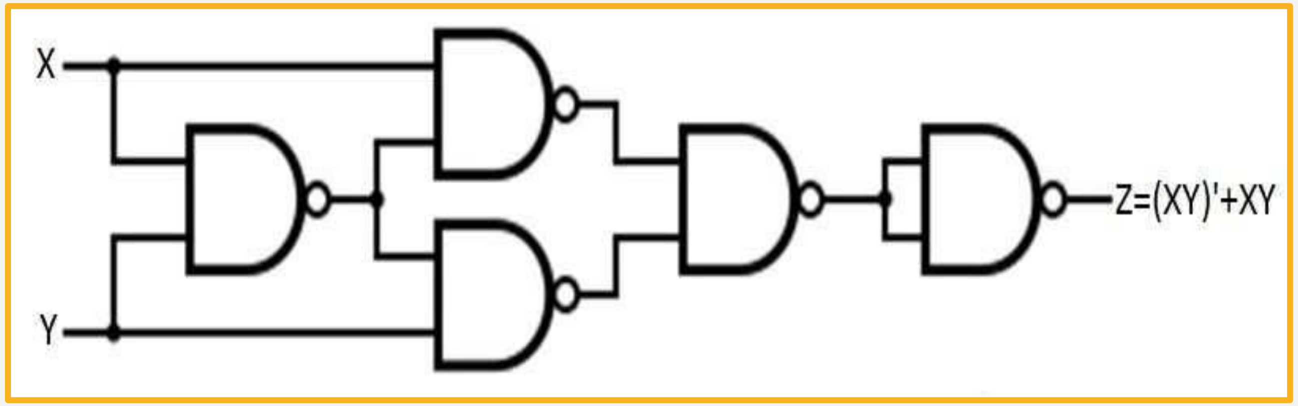
$$= \mathbf{A} \oplus \mathbf{B}$$



INPUTS		OUTPUTS
A	B	$Y = A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

NAND Gate as an Ex-NOR Gate

Logical symbol



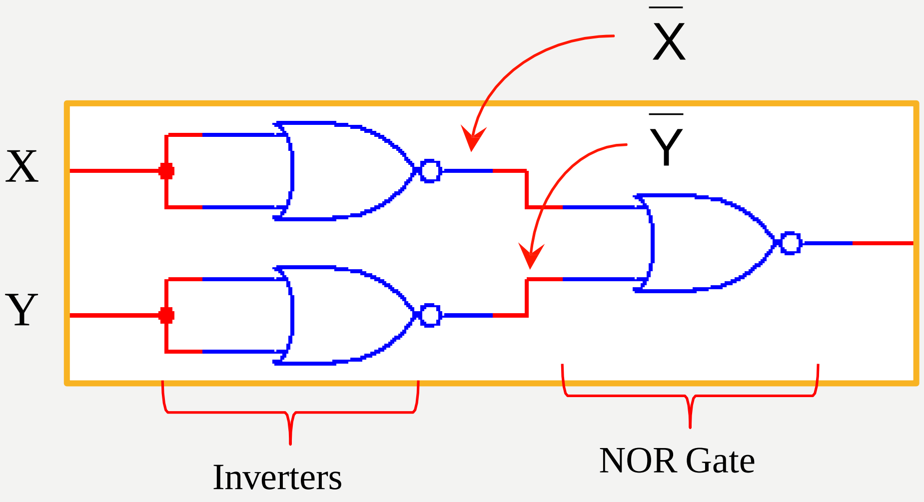
Truth Table

Inputs		Output
X	Y	Z
0	0	I
0	I	0
I	0	0
I	I	I

NOR GATE AS UNIVERSAL GATE

NOR GATE AS AN AND GATE

Logical symbol

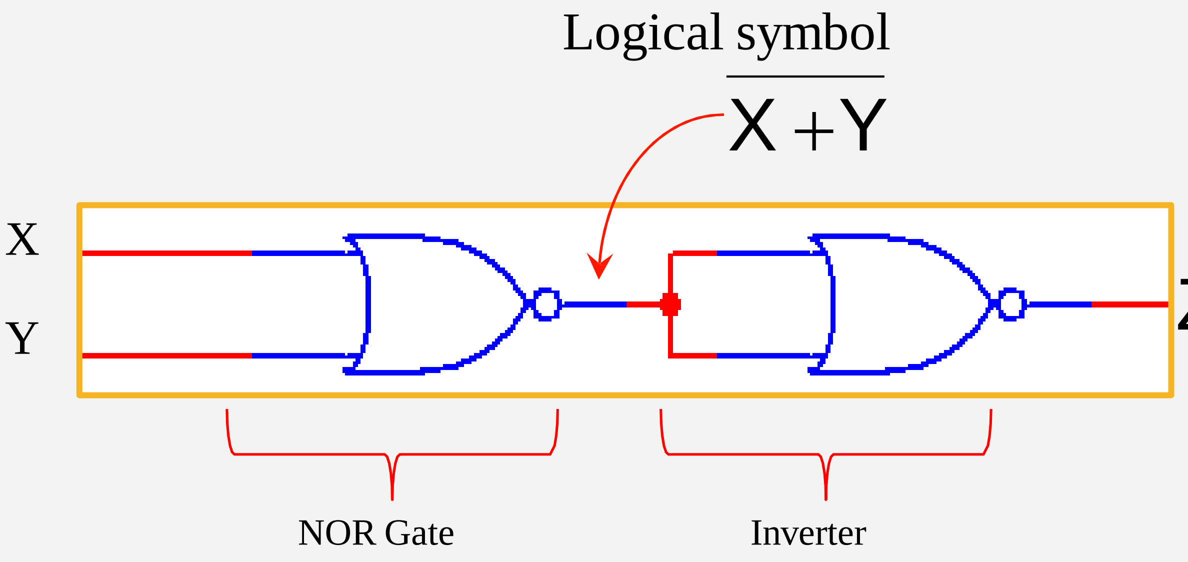


$$Z = \overline{\overline{X} + \overline{Y}} = \overline{\overline{X}}\;\overline{\overline{Y}} = X\,Y$$

Truth Table

Inputs		Output
X	Y	Z
0	0	0
0	1	0
1	0	0
1	1	1

NOR GATE AS AN OR GATE



$$Z = \overline{\overline{X+Y}} = X+Y$$

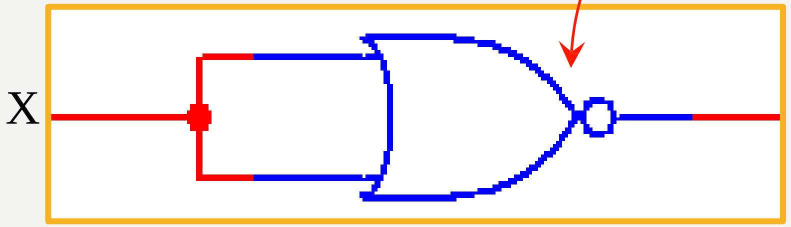
Truth Table

Inputs		Output
X	Y	Z
0	0	0
0	1	1
1	0	1
1	1	1

NOR GATE AS AN NOT GATE

$X + X = X$ (Before Bubble)

Logical symbol



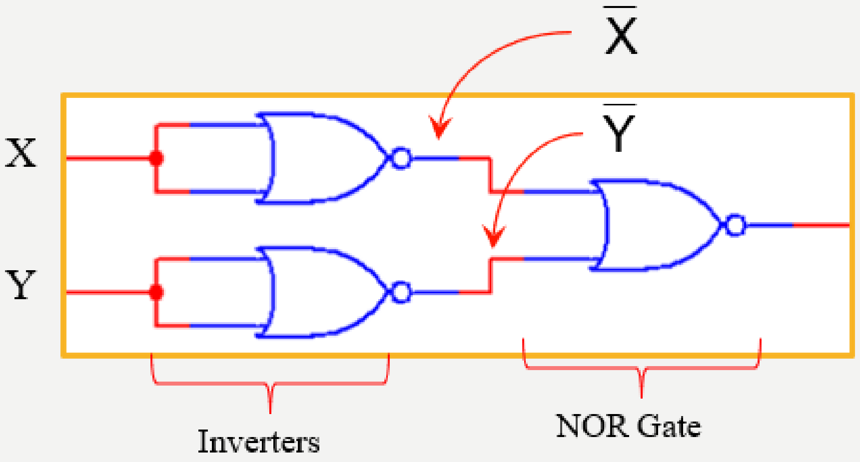
$Z = \overline{X}$

Truth Table

Inputs	Output
X	Z
0	1
1	0

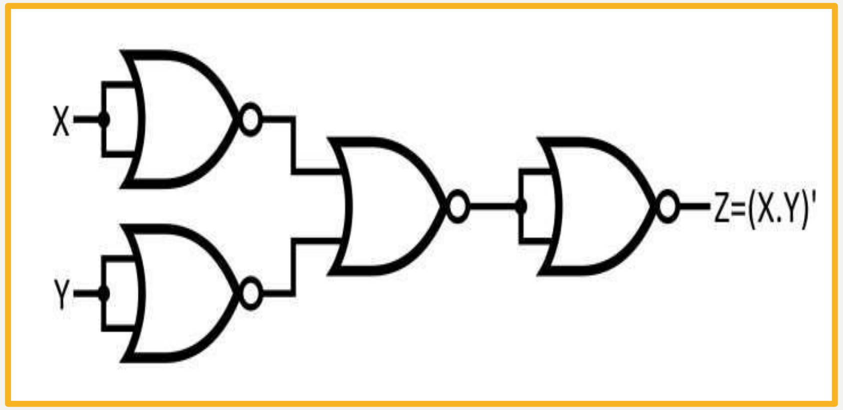
NOR GATE AS AN NAND GATE

Logical symbol of AND



$$Z = \overline{\overline{X} + \overline{Y}} = \overline{\overline{X}}\,\overline{\overline{Y}} = X\,Y$$

Logical symbol of NAND

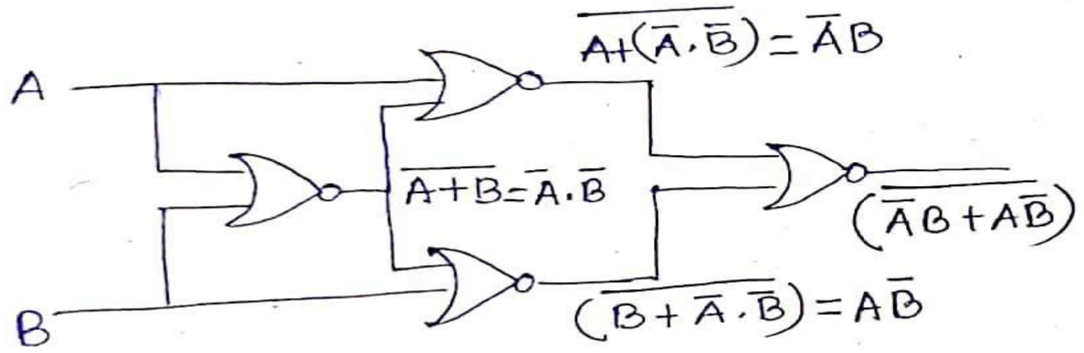


Truth Table

Inputs		Output
X	Y	Z
0	0	I
0	I	I
I	0	I
I	I	0

NOR GATE AS AN EX-NOR GATE

Logical Symbol



Truth Table

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

$Y = \bar{A}\bar{B} + AB$

$= \overline{A \oplus B}$

$= \overline{(A\bar{B} + \bar{A}B)}$

$\overline{A+B} = \bar{A}.\bar{B}$ (∵ De Morgans Law)

$\overline{A+(\bar{A}.\bar{B})} = \bar{A}.(\overline{\bar{A}.\bar{B}})$ (,,)

$= \bar{A}.(\bar{\bar{A}} + \bar{\bar{B}})$ (∵ DeMorgans $\overline{A.B} = \bar{A}+\bar{B}$)

$= \bar{A}.(A+B)$

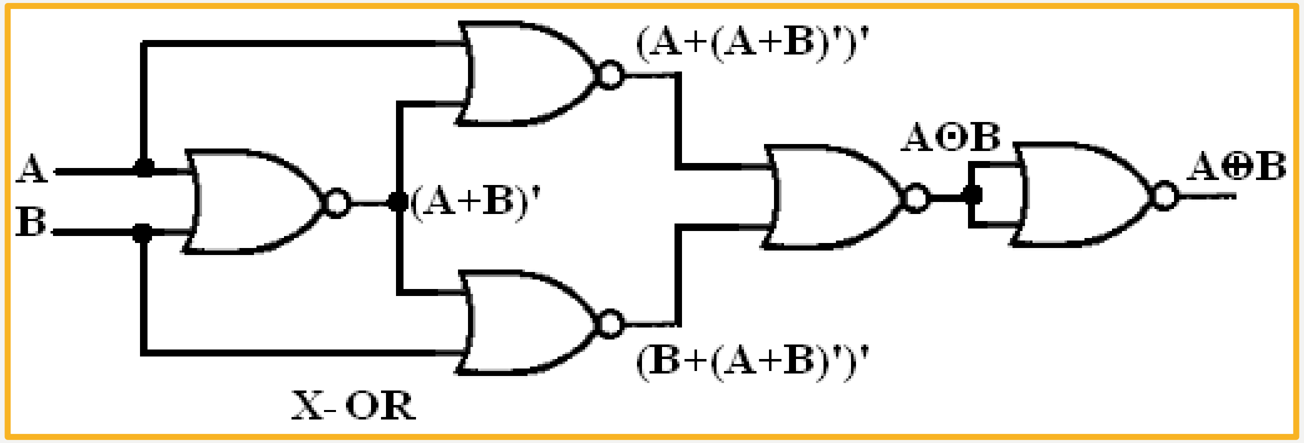
$= \bar{A}A + \bar{A}B$ (∵ $\bar{A}A = 0$)

$= \bar{A}B$

Similarly we get $= A\bar{B}$

NOR GATE AS AN EX-OR GATE

Logical symbol



Truth Table

Inputs		Output
X	Y	Z
0	0	0
0	I	1
I	0	1
I	I	0