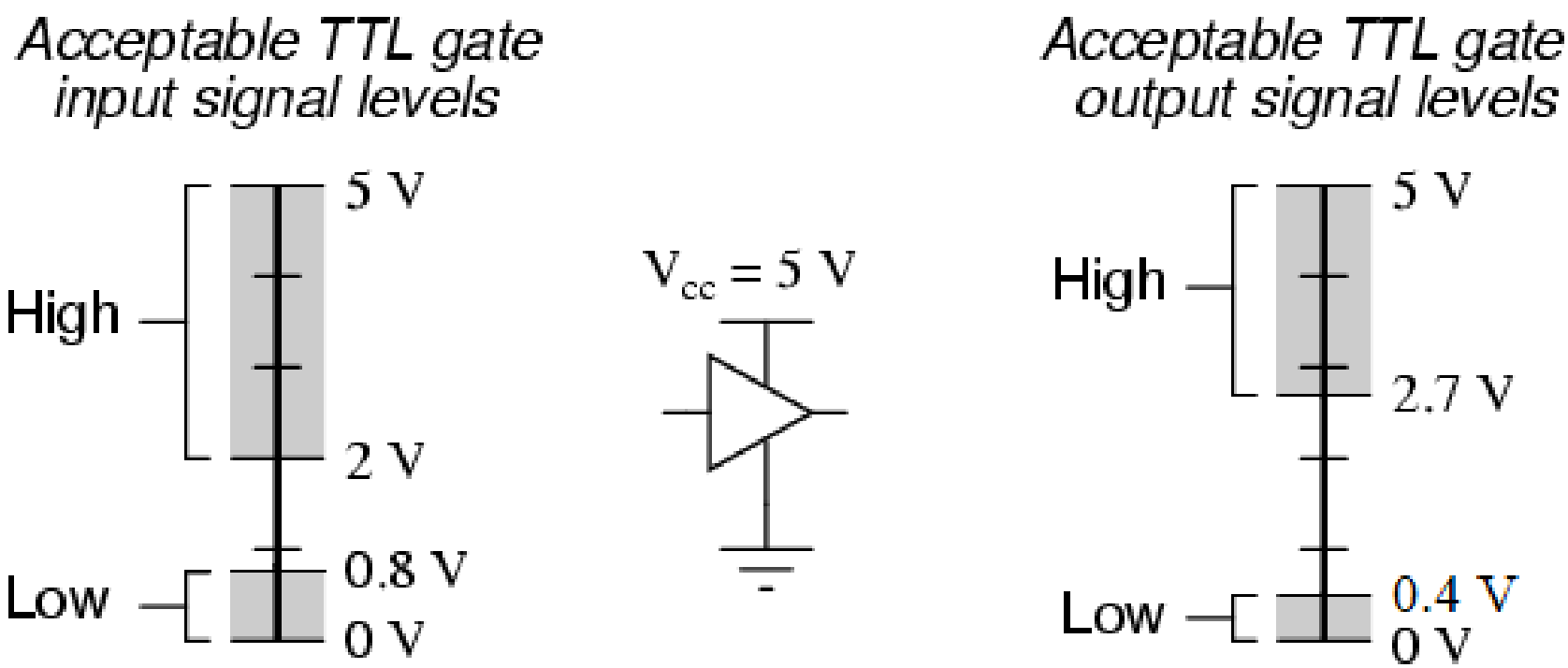
Logic Gates

What are logic gates?

- A logic gate is **a device that acts as a building block for digital circuits**.
- They perform basic logical functions that are fundamental to digital circuits.
- *A logic gate is a simple switching circuit that determines whether an input pulse can pass through to the output in digital circuits.*

- Logic gates works on digital inputs logic ‘0’ or logic ‘1’.
- It is also called as true or false.

TTL voltage levels



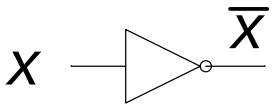
What is Boolean algebra ?

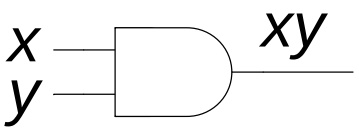
- *Boolean algebra is a type of logical algebra in which symbols represent logic levels.*
- *The digits(or symbols) 1 and 0 are related to the logic levels in this algebra;*
- *in electrical circuits, logic 1 will represent a closed switch, a high voltage, or a device's "on" state.*
- *An open switch, low voltage, or "off" state of the device will be represented by logic 0.*

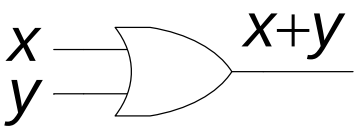
Review of Boolean algebra

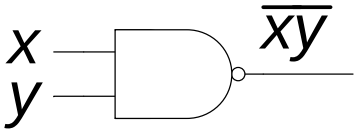
- Not is a horizontal bar above the number
  - $\bar{0} = 1$
  - $\bar{1} = 0$
- OR is a plus
  - 0+0 = 0
  - 0+1 = 1
  - 1+0 = 1
  - 1+1 = 1
- AND is multiplication
  - 0*0 = 0
  - 0*1 = 0
  - 1*0 = 0
  - 1*1 = 1

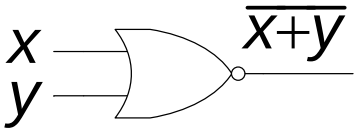
Basic logic gates

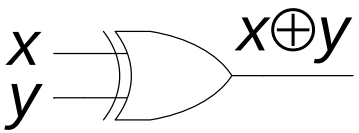
- NOT 

- AND 

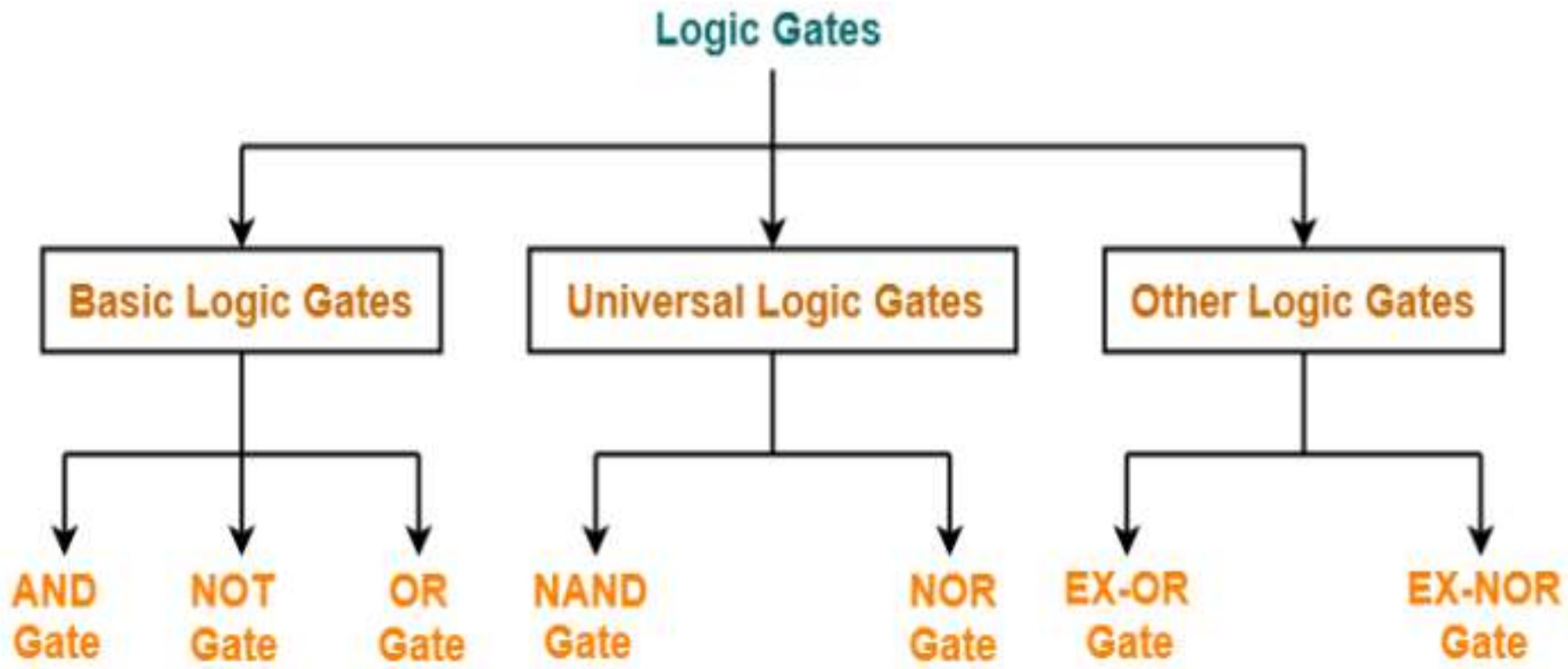
- OR 

- NAND 

- NOR 

- XOR 

- Logic gates are the basic building blocks of any digital circuit.
- Logic gates are classified as-



Types of Logic Gates

Basic logic gates

- There are following three basic logic gates-

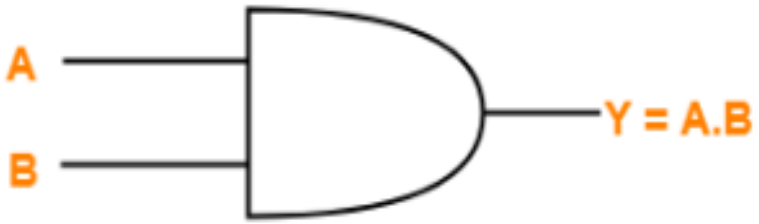
1. AND Gate
2. OR Gate
3. NOT Gate

AND Gate

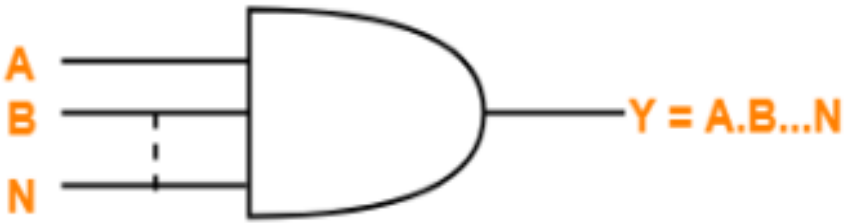
- The output of AND gate is high ('1') if all of its inputs are high ('1').
- The output of AND gate is low ('0') if any one of its inputs is low ('0').

Logic Symbol-

The logic symbol for AND Gate is as shown below-



2-Input AND Gate



N-Input AND Gate

Truth Table-

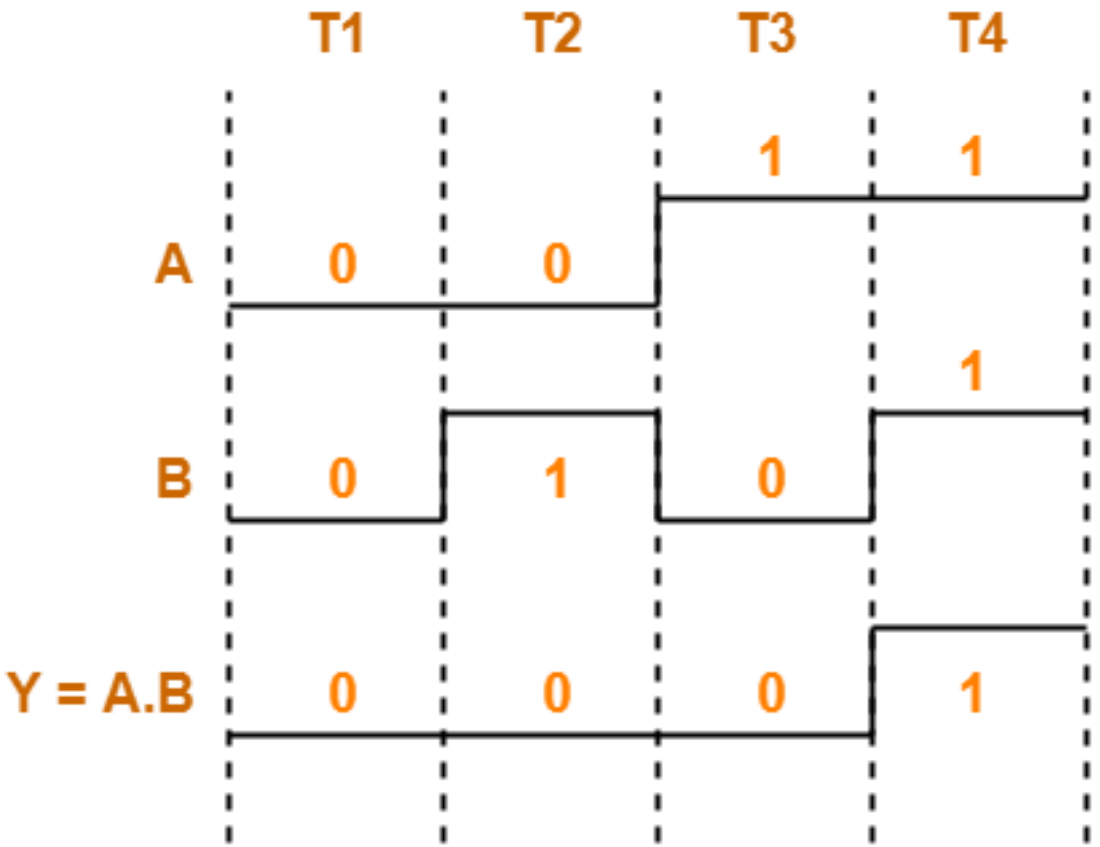
The truth table for AND Gate is as shown below-

A	B	Y = A.B
0	0	0
0	1	0
1	0	0
1	1	1

Truth Table

Timing Diagram-

The timing diagram for AND Gate is as shown below-



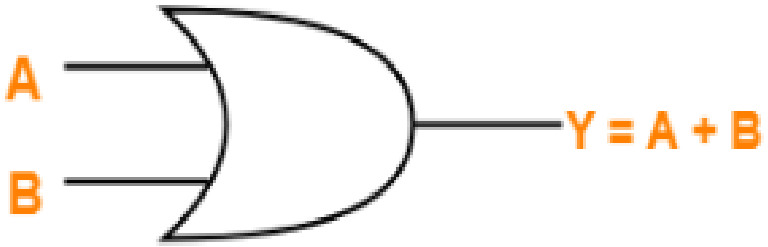
AND Gate Timing Diagram

2. OR Gate-

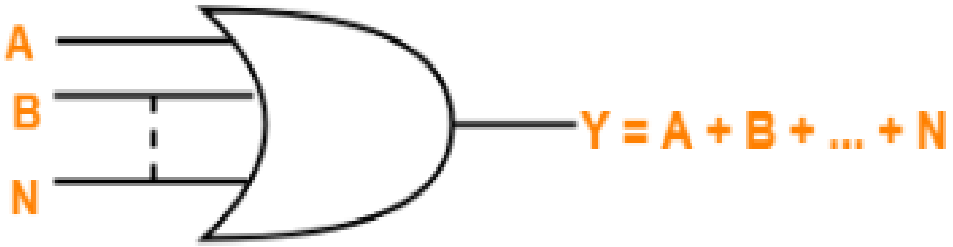
- The output of OR gate is high ('1') if any one of its inputs is high ('1').
- The output of OR gate is low ('0') if all of its inputs are low ('0').

Logic Symbol-

The logic symbol for OR Gate is as shown below-



2-Input OR Gate



N-Input OR Gate

Truth Table-

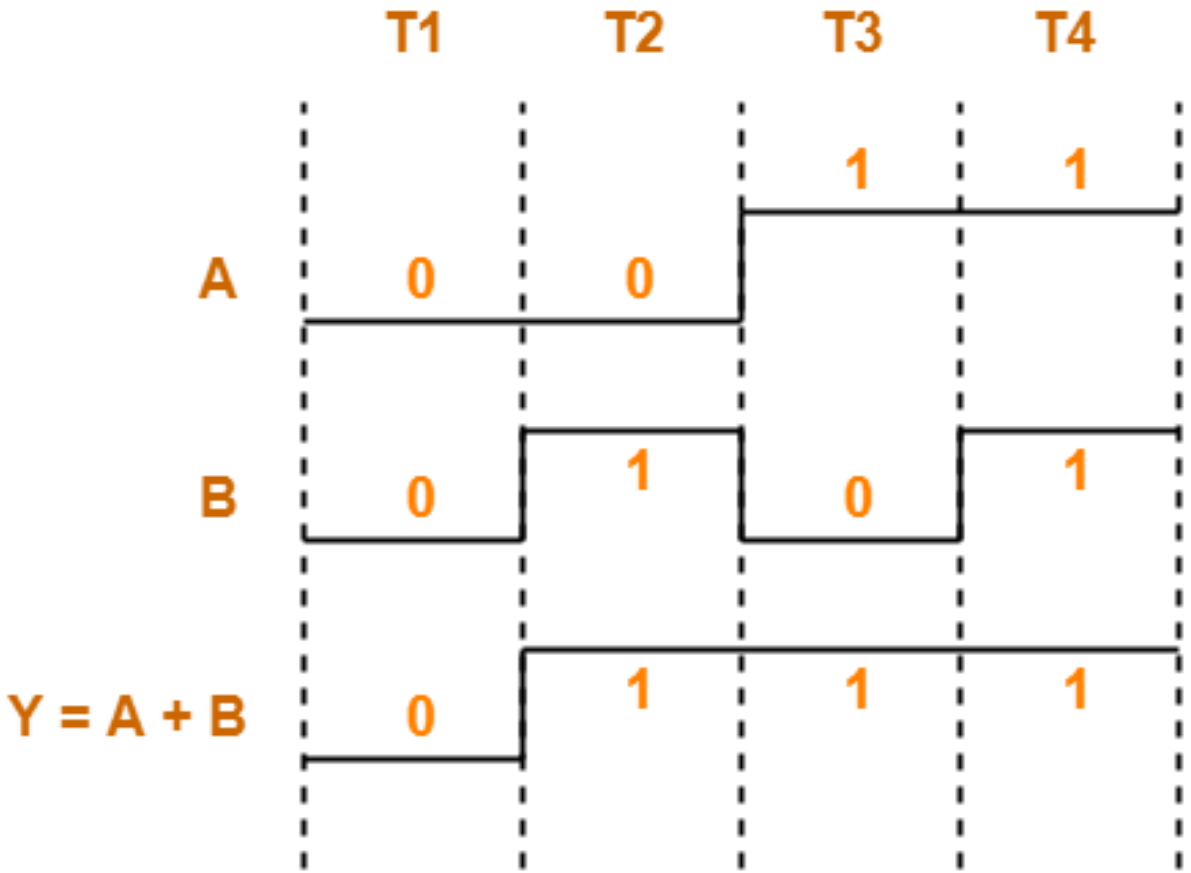
The truth table for OR Gate is as shown below-

A	B	Y = A + B
0	0	0
0	1	1
1	0	1
1	1	1

Truth Table

Timing Diagram-

The timing diagram for OR Gate is as shown below-



OR Gate Timing Diagram

3. NOT Gate-

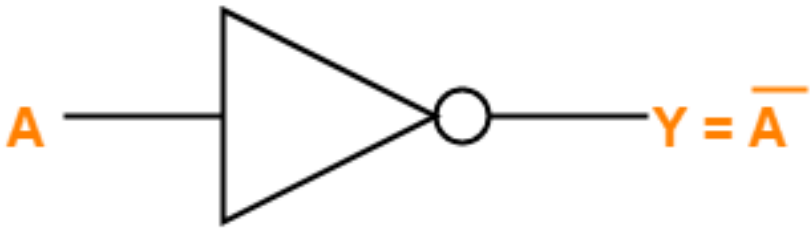
- The output of NOT gate is high ('1') if its input is low ('0').
- The output of NOT gate is low ('0') if its input is high ('1').

From here-

- It is clear that NOT gate simply inverts the given input.
- Since NOT gate simply inverts the given input, therefore it is also known as **Inverter Gate.**

Logic Symbol-

The logic symbol for NOT Gate is as shown below-



Truth Table-

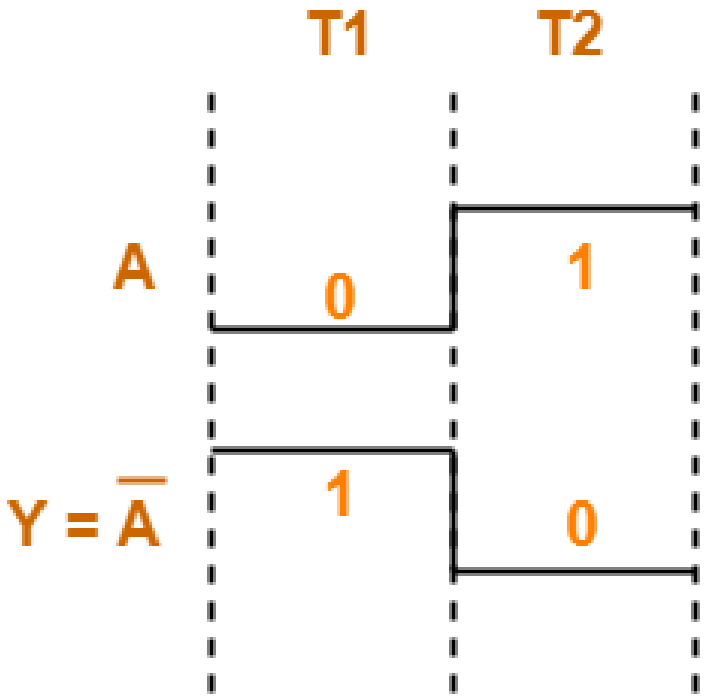
The truth table for NOT Gate is as shown below-

A	Y = A'
0	1
1	0

Truth Table

Timing Diagram-

The timing diagram for NOT Gate is as shown below-



NOT Gate Timing Diagram

What are **Universal Gates ?**

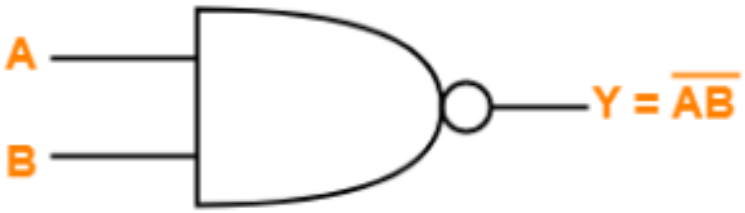
- They are called as “**Universal Gates**” because-
- They can realize all the binary operations.
- All the basic logic gates can be derived from them.

1. NAND Gate-

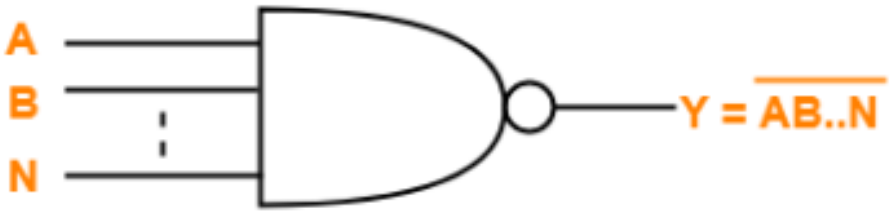
- A NAND Gate is constructed by connecting a NOT Gate at the output terminal of the AND Gate.
- The output of NAND gate is high ('1') if at least one of its inputs is low ('0').
- The output of NAND gate is low ('0') if all of its inputs are high ('1').

Logic Symbol-

The logic symbol for NAND Gate is as shown below-



2-Input NAND Gate



N-Input NAND Gate

Truth Table-

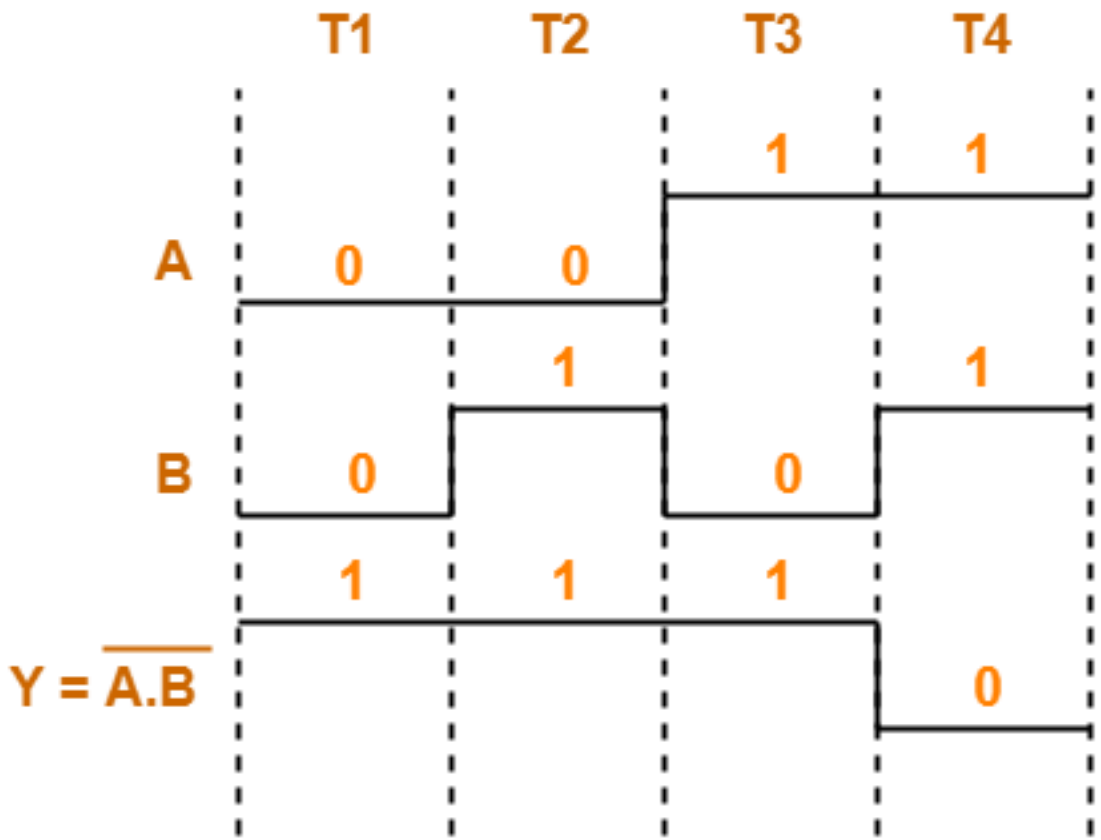
The truth table for NAND Gate is as shown below-

A	B	Y = (A.B)'
0	0	1
0	1	1
1	0	1
1	1	0

Truth Table

Timing Diagram-

The timing diagram for NAND Gate is as shown below-



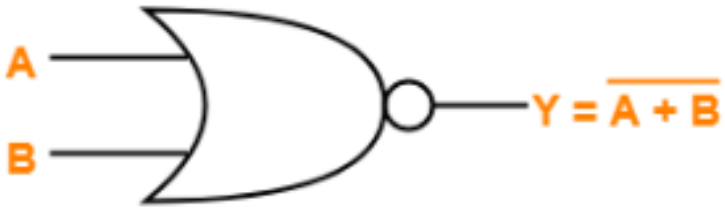
NAND Gate Timing Diagram

2. NOR Gate-

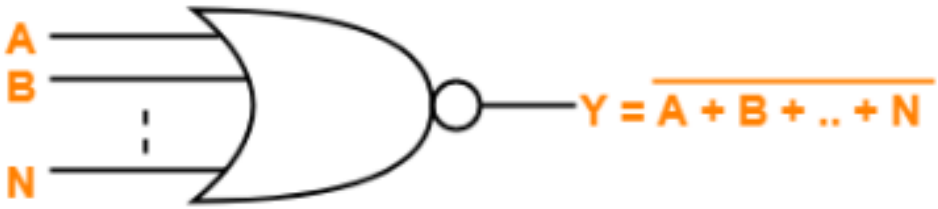
- A NOR Gate is constructed by connecting a NOT Gate at the output terminal of the OR Gate.
- The output of OR gate is high ('1') if all of its inputs are low ('0').
- The output of OR gate is low ('0') if any of its inputs is high ('1').

Logic Symbol-

The logic symbol for NOR Gate is as shown below-



2-Input NOR Gate



N-Input NOR Gate

Truth Table-

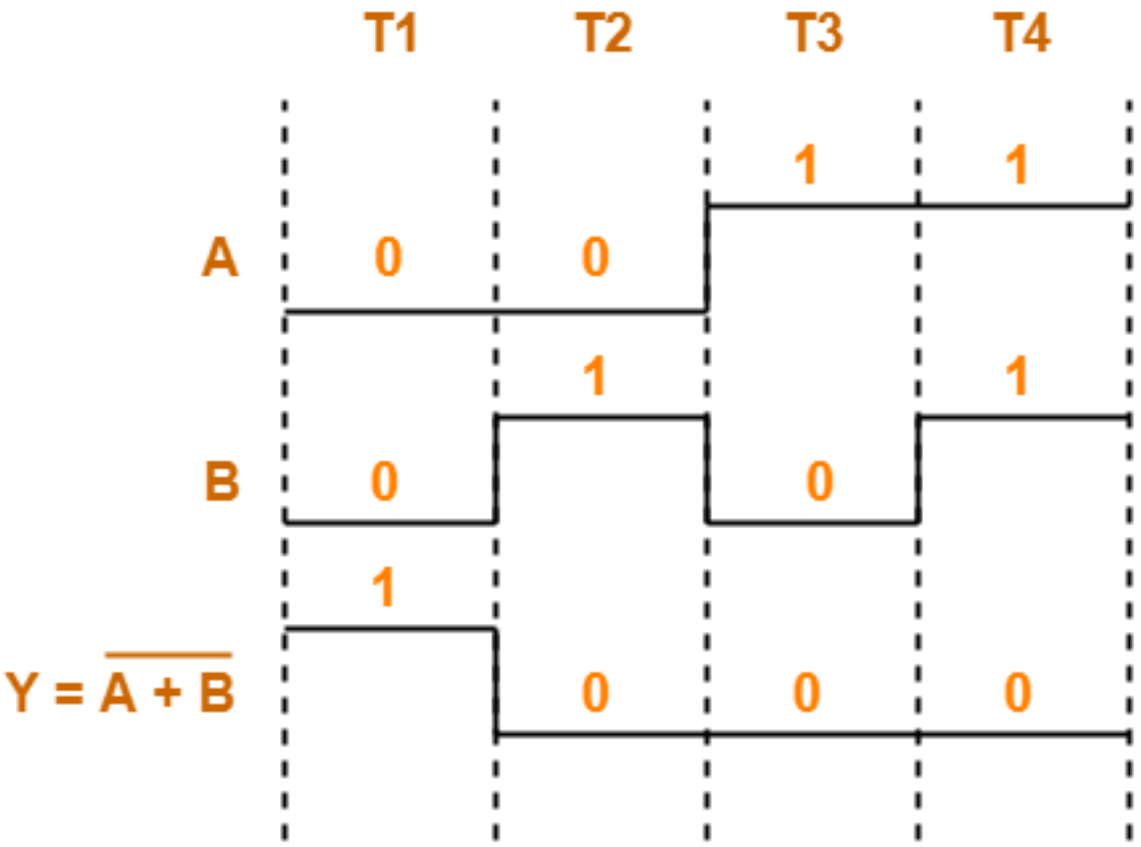
The truth table for NOR Gate is as shown below-

A	B	Y = A + B
0	0	1
0	1	0
1	0	0
1	1	0

Truth Table

Timing Diagram-

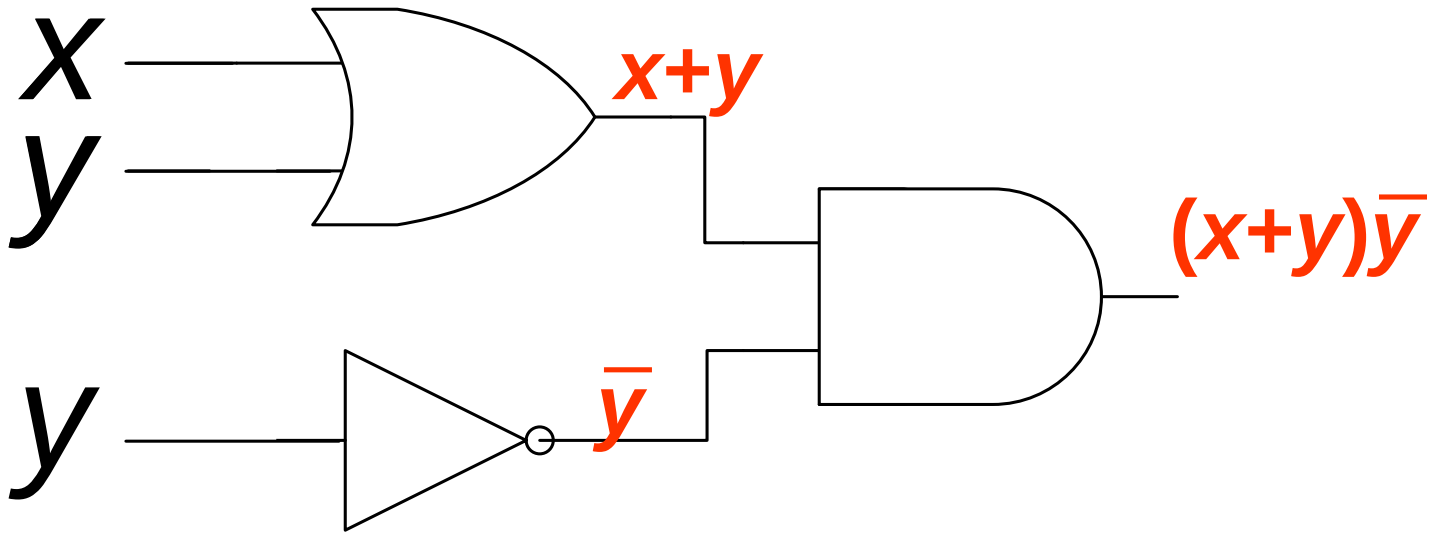
The timing diagram for NOR Gate is as shown below-



NOR Gate Timing Diagram

Converting between circuits and equations

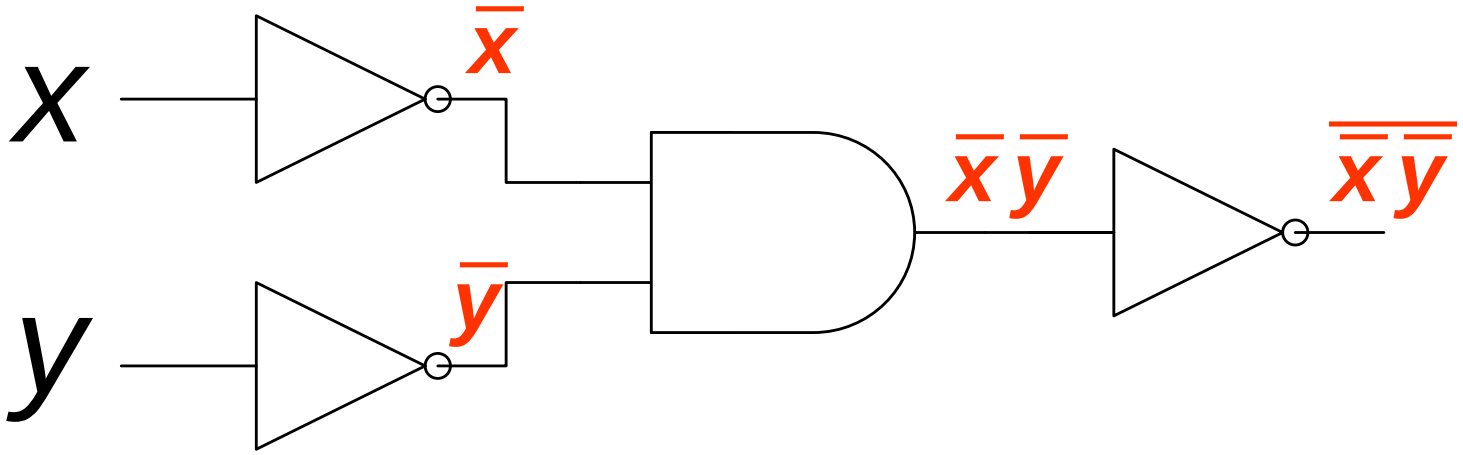
- Find the output of the following circuit



- Answer: $(x+y)\overline{y}$

Converting between circuits and equations

- Find the output of the following circuit

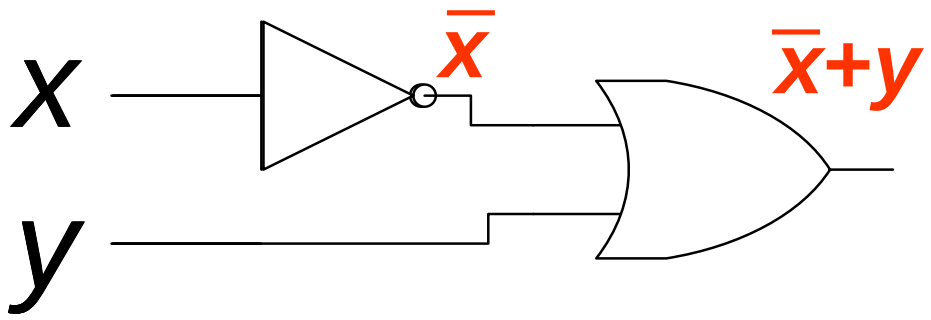


- Answer: $\overline{\bar{x}\bar{y}}$

Converting between circuits and equations

- Write the circuits for the following Boolean algebraic expressions

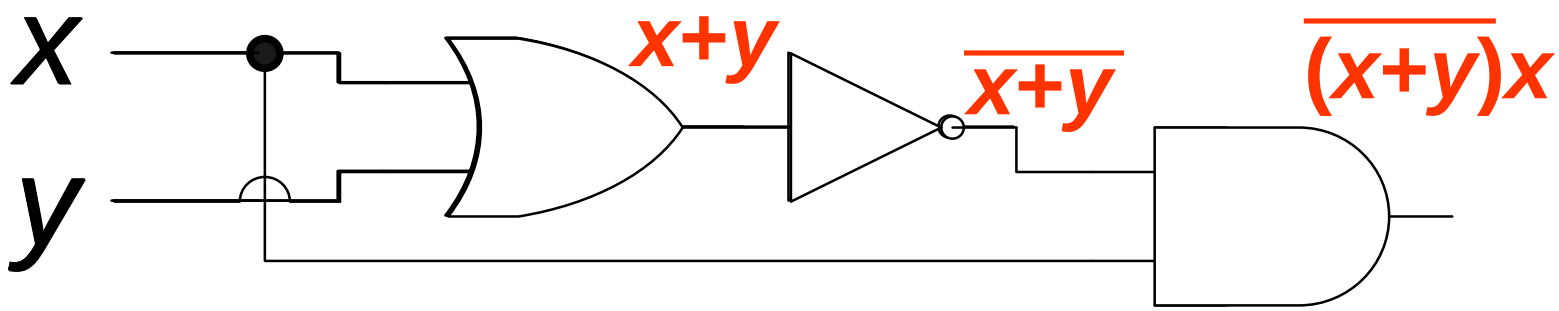
a) $\overline{x}+y$



Converting between circuits and equations

- Write the circuits for the following Boolean algebraic expressions

b) $\overline{(x+y)}x$



Writing xor using and/or/not

- $x \oplus y \equiv (x + y)(\overline{xy})$

x	y	$x \oplus y$
1	1	0
1	0	1
0	1	1
0	0	0