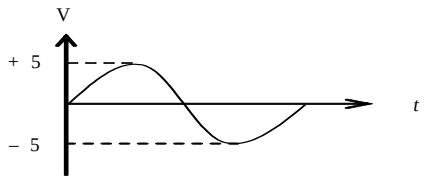
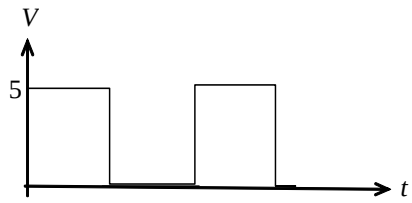
SEMICONDUCTOR DEVICES
3. LOGIC GATES

POINTS TO REMEMBER

1. Voltage signals are of two types
   - o Analog signal
   - o Digital signal
2. In analog circuits, the voltage signals vary continuously with time and such signals are called continuous or analog voltage signals.



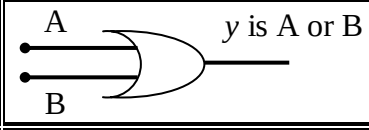
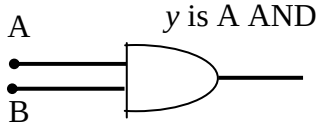
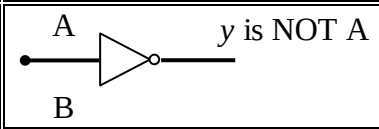
3. The curve gives a voltage signal varying between zero volt and ± 5V.
4. In digital circuit, the pulse wave form does not change with time.
5. It has only two voltage levels, either zero or maximum constant value of voltage.
6. Such signals are called digital voltage signals.



7. The curve represents a voltage signal which has either zero volt or 5V at any instant of time.
8. These two voltage levels are represented by binary numbers O and 1.

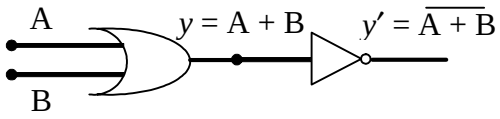
Logic Gates

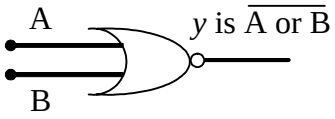
9. Logic gates are used to change one voltage level (input voltage) into another (output voltage) according to some logical statement.
10. Logic gate is a digital circuit which works according to some logical relationship between input and output voltages.
11. A logic gate can have one or more inputs but it has only one output.
12. George Boole invented a different kind of algebra called Boolean Algebra to solve the logical problems.
13. A logical statement has only two values or two states which are represented by binary numbers zero and one.
14. O refers to low/false/off/open/no and 1 refers to high/true/on/close/yes

Gate	Boolean Expression	Read as	Symbol
OR (+)	y = A + B	y is A OR B	
AND (•)	y = A.B	y is A AND B	
NOT (bar or complementation)	y = $\bar{A}$	y is NOT A	

15. **NOR Gate (NOT + OR)**

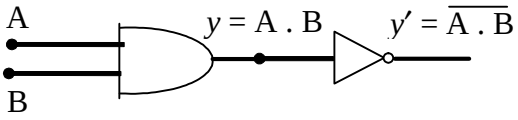
This is the combination of NOT and OR gates.

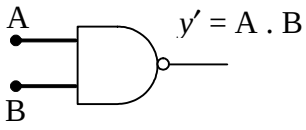




16. **NAND Gate**

This is the combination of NOT and AND gates



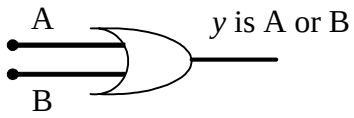


LONG ANSWER QUESTIONS

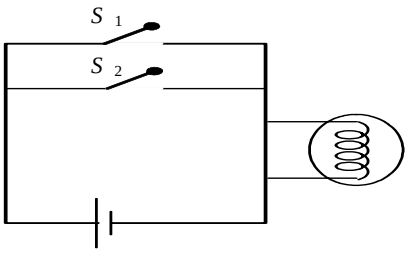
1. Draw an OR gate using two diodes and explain its operation. Write the truth table and logic symbol of OR gate.

A. **OR GATE**

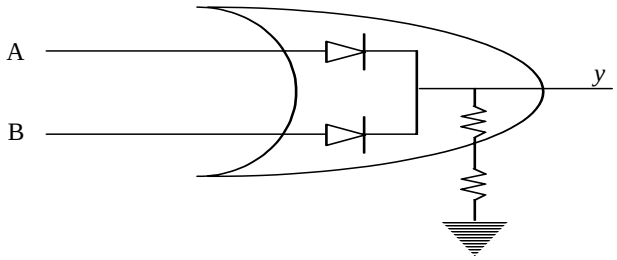
- OR gate has two input terminals and one output terminal
- When both inputs are low,
- Then the output is also low.
- When one of the two inputs is high, or both are
- high, then the output is high



Switch 1	Switch 2	Bulb
Open (O)	Open (O)	No glow(O)
Open (O)	Close (1)	Glow (1)
Close (1)	Open (O)	Glow (1)
Close (1)	Close (1)	Glow (1)



Truth Table



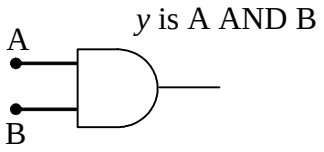
Symbols		Boolean
A	B	y = A + B
O	O	O
O	1	1
1	O	1
1	1	1

- Let a potential 5V represent a logical value 1 and a potential OV represent a logical value O.
- When A = 0 and B = 0, i.e., when A and B is equal to zero volt, then both the diodes are reverse biased and there is no output voltage i.e., y = 0.

- When A = 0 and B = 1, i.e., A = OV and B = 5V then A is reverse biased and B is forward biased. Output is 5V and y = 1.
- When A = 1 and B = 0, i.e., A = 5V and B = OV, then A is forward biased and B is reverse biased. Output is 5V and y = 1.
- When A = 1 and B = 1 i.e., A = 5V and B = 5V then both diodes are forward biased, output is 5V, i.e., y = 5v

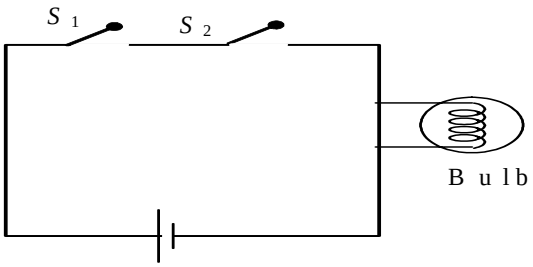
2. Sketch a basis AND circuit with operation .Explain how doping increases the conductivity in semiconductors.

A. **AND Gate:**

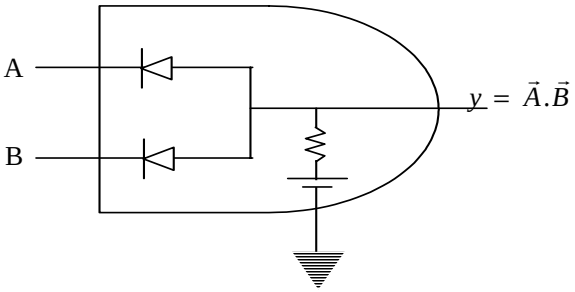


- AND gate has two input terminals and one output terminal.
- When both inputs are low or one of the two inputs is low, the output is low.
- When both inputs are high output is high

Truth Table



Switch 1	Switch 2	Bulb
Open (O)	Open (O)	No glow (O)
Open (O)	Close (1)	No glow (O)
Close (1)	Open (O)	No glow(O)
Close (1)	Close (1)	Glow (1)



Input Symbols		Out Put
A	B	y = A . B
O	O	O
1	O	O
O	1	O
1	1	1

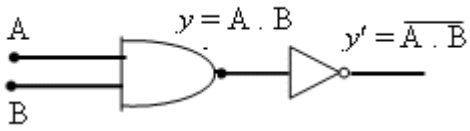
- Let a potential 5V represent a logical value 1 and a potential zero volt represent a logical value zero.
- When A = 0 and B = 0 i.e., when A = 0V and B = OV, both diodes are forward biased hence the potential drop across the resistor is opposed by the cell, hence output y = 0
- When A = 0, B = 1, i.e., when A = OV and B = 5V, then diode A is forward biased and B is reverse biased, then output y = 0.
- When A = 1, B = 0, i.e., when A = 5V and B = OV, then diode A is reverse biased B is forward biased then output y= 0.
- When A = 1 and B = 1, A = 5V and B = 5V, both the diodes are reverse biased and the potential is maximum due to the cell i.e., y = 1.
- The conductivity of a pure semiconductor can be increased by adding impurities.

Doping: Adding impurity to a pure semiconductor is called doping. Generally for 10^8 atoms of a semiconductor one impurity atom increases the conductivity by 1000 times.

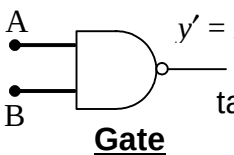
Input		Out put
A	**B**	**y =** $\overline{A+B}$
O	O	1
O	1	O
1	O	O
1	1	O

SHORT ANSWER QUESTIONS

1. Define and NOR their truth tables.

A. 

NAND Gate

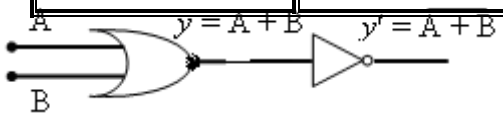


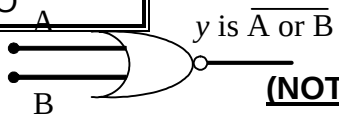
NAND gates. Give

This is the combination of NOT and AND gates

Input		Out put
A	**B**	**y =** $\overline{A \bullet B}$
O	O	1
O	1	1
1	O	1
1	1	O

. **NOR Gate** **(NOT + OR)**





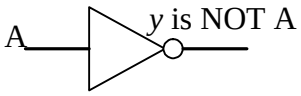
This is the combination of NOT and OR gates.

2. Explain the operation of a NOT gate and give its truth table.

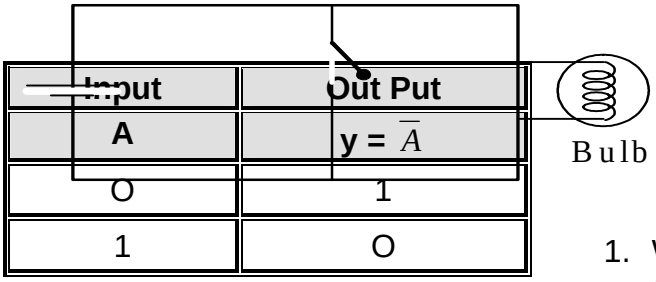
A. **NOT Gate**

- NOT gate has one input and one output terminal.
- If the input is low, output is high and if the input is high, output is low. This is called inverter.

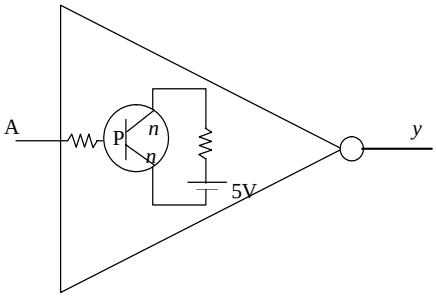
Truth Table



Switch	bulb
open (O)	glow (1)
Closed (1)	No glow (O)



Input	Out Put
A	**y =** $\overline{A}$
O	1
1	O



1. When A = 0, base current is zero, the base emitter is not forward biased and collector current is zero. Hence the output is equal to the voltage connected to the collector, i.e., 5V, therefore y = 1.

2. If A = 1, the base emitter is forward biased and the output voltage across the resistor is 5V and y is nearly 0, i.e.,if A = 1, y = 0.

VERY SHORT ANSWER QUESTIONS

1. Which gates are called universal gates?

A. NAND gate and NOR gate are known as the basic building blocks of logic gates or universal gates because any logic gate can be constructed by using only NAND gates or only NOR gates.

2. Write the truth table of NAND gate. How does it differ from AND gate.

A. NAND AND

Input		Out put
A	**B**	**y =** $\overline{A \bullet B}$

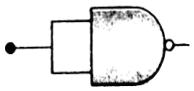
O	O	1
O	1	1
1	O	1
1	1	O

Input Symbols		Out Put
A	B	y = A . B
O	O	O
1	O	O
O	1	O
1	1	1

SOLVED PROBLEMS

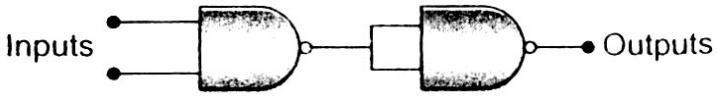
1. Construct NOT gate from NAND gate

A. By connecting both the input terminals of NAND gate together, the output is same as that of a NOT gate.



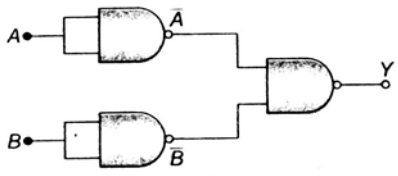
2. Construct AND gate from NAND gate

A.



3. Construct OR gate from NAND gate

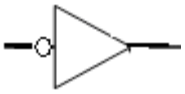
A.



A	$\bar{A}$	B	$\bar{B}$	$\bar{A}.\bar{B}$	$\overline{\bar{A}.\bar{B}}$	A + B
0	1	0	1	1	0	0
1	0	0	1	0	1	1
0	1	1	0	0	1	1
1	0	1	0	0	1	1

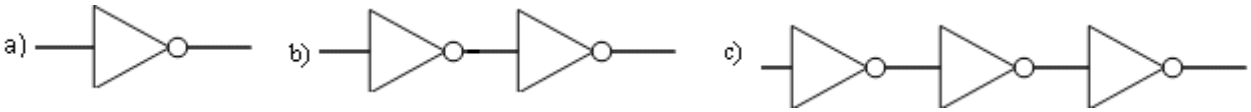
Assess yourself

1 In NOT gate if the bubble is placed on the input side as shown in figure then what does it represent?



A. NOT gate.

2. If the input to an inverter is A, what will be the output in the following cases?



A. a) $\overline{A}$ b) A c) $\overline{A}$

3 If the two inputs of NOR gate are shorted as shown in figure then what does it represent?



A. NOT gate.

4 Are the two gates shown in figure equal? If so why?



A. Both are NOT gates.

5. If ‘n’ number of NOT gates is cascaded in series and input given is 1 find the output a) when n is an odd number, b) when n is an even number.

A. a) Output is 0 when n odd. b) Output is 1 when n even.