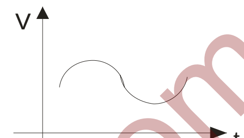
Logic Gates

1. The electronic circuits are of two types. They are analog and digital circuits.
2. **Analog circuits**

   The waveforms are continuous and a range of values of voltages are possible.

   E.g. amplifier, oscillator circuits.

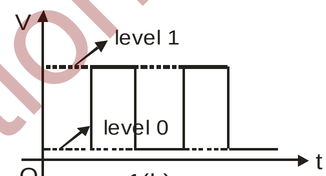


1(a)

3. **Digital circuits**

   The waveforms are pulsated and only discrete values of voltages are possible.

   E.g. logic gates.



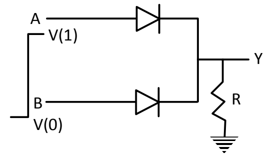
1(b)

4. In the decimal system, there are ten digits. They are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9.
5. In the binary system, there are only two digits 0 and 1.
6. Digital electronics is developed by representing the low and high levels of voltages in pulsated waveform with binary digits 0 and 1 (called bits).
7. The basic building blocks of digital circuits are called as logic gates, since **they perform logic operations**.
8. Generally the level 1 or high level is at 4±1V and level 0 to low level is at 0.2± 0.2V.

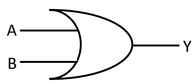
OR Gate

9. An OR gate has two or more inputs with the output.
10. The Boolean expression is Y = A + B (Y equals A or B).
11. The output (Y) of OR gate will be 1 when the inputs A or B or both 1.

a) Two input OR gate



b) Circuit symbol



c) Truth table

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

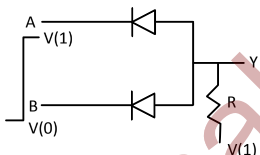
AND Gate

12. An AND gate has two or more inputs with one output.

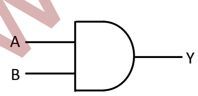
13. The Boolean expression is Y = A, B (Y equals A and B).

14. The output (Y) of AND gate is 1 only when all the inputs are simultaneously 1.

a) Two input AND gate



b) Circuit symbol



c) Truth table

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

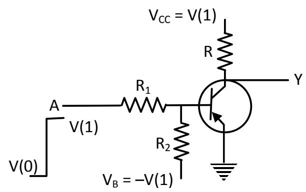
Gate

15. It has a single input and a single output.

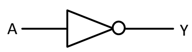
16. The Boolean expression is $Y = \bar{A}$. (Y equals not A).

17. The output of NOT gate is the inverse of the input or it performs negation operation.

a) Transistor NOT gate



b) Circuit symbol



c) Truth table

A	Y
0	1
1	0

NOR Gate

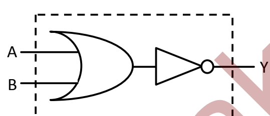
18. It has two or more inputs and one output. A negation (NOT operation) applied after OR gate, gives a NOT-OR gate or simply NOR gate.

19. NOR gate output is inverse of OR GATE output

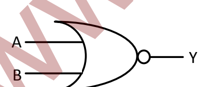
The output of NOR gate is 1 only when all the inputs are simultaneously 0.

20. The Boolean expression is $Y = \overline{A + B}$

a) two input NOR gate



b) circuit symbol



c) truth table

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

NAND Gate

21. It has two or more inputs and one output. A negation (NOT operation) applied after AND gate, gives a NOT-AND gate or simply NAND gate.

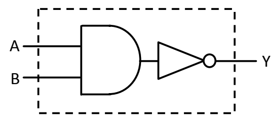
22. NAND gate output is inverse of AND gate output

23. The Boolean expression is $Y = \overline{A \, . \, B}$.

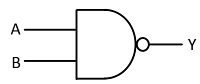
24. The output of NAND gate is 1 only when at least one input is 0.

25. The NOR and NAND gates are considered as universal gates, because we can obtain all the gates like OR, AND and NOT by using either NOR or NAND gates repeatedly.

a) Two input NAND gate



b) Circuit symbol



c) Truth table

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

XOR Gate

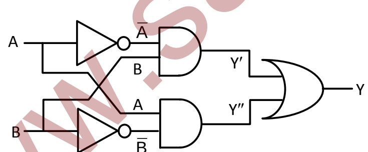
26. XOR gate is obtained by using OR, AND and NOT gate.

27. It is also called exclusive OR gate.

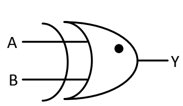
28. The output of two input XOR gate is 1 only when the two inputs are different.

29. The Boolean equation is $Y = A.\bar{B} + B.\bar{A}$

a) Two input XOR gate



b) Circuit symbol



c) Truth table

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

XNOR GATE

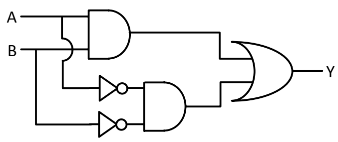
30. XNOR gate is obtained by using OR, AND and NOT gates.

31. It is also called exclusive NOR gate.

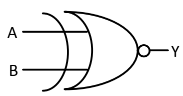
32. The output of a two input XNOR gate is 1 only when both the inputs are same.

33. The Boolean equation is $Y = A.B + \overline{A}\,\overline{B}$ XNOR gate is inverse of XOR gate.

a) Two input XNOR gate



b) Circuit symbol



c) Truth table

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

The basic relations for OR gate

i) A + 0 = A

ii) A + 1 = 1

iii) A + A = A

iv) $A + \overline{A} = 1$

The basic relations for AND gate.

i) A.0 = 0

ii) A.1 = A

iii) A.A = A

iv) $A.\overline{A} = 0$

De-Morgan's Theorems

i) $\overline{A + B} = \overline{A}.\overline{B}$

ii) $\overline{A.B} = \overline{A} + \overline{B}$

iii) $\overline{\overline{A} + \overline{B}} = \overline{\overline{A}} + \overline{\overline{B}} = A.B$

iv) $\overline{\overline{A}.\overline{B}} = \overline{\overline{A}} + \overline{\overline{B}} = A + B$

Example: Verification of theorems with truth table.