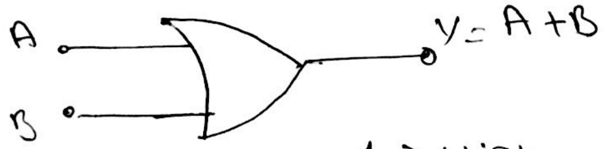
Logic Gates

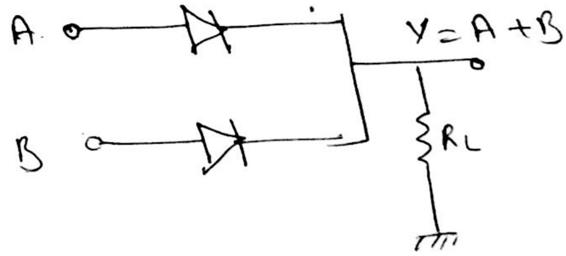
Combinational circuit → A combinational circuit consists of input variables, logic gates and output variables.

The steps involved in the design of combinational circuits are as follows :-

1. State the problems in words.
2. Find the no. of input and output variables
3. Assign letter symbols to the input and output variables
4. Obtain the truth table using the word statement
5. Obtain boolean expressions for each o/p from T-T
6. Simplify the Boolean expressions to minimise the no. of variables by using boolean algebra, Karnaugh map method or Mc-Cluskey method.
7. Draw the logic circuit diagram corresponding to the simplified boolean expression.

OR Gate

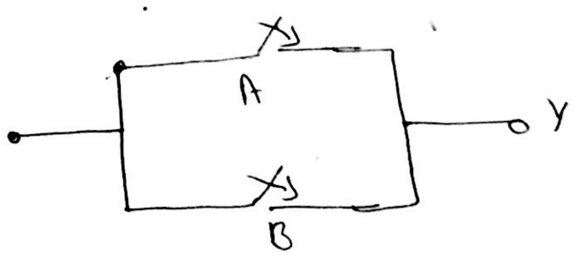




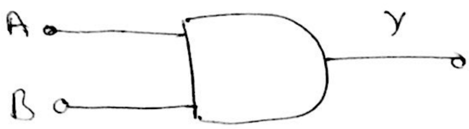
Positive logic system 1 → High, 0 → Low

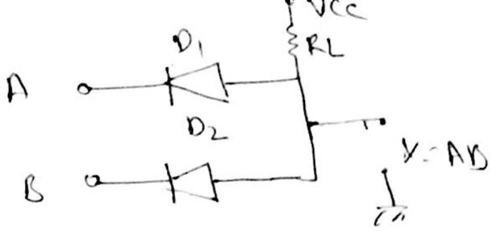
Circuit diagram

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

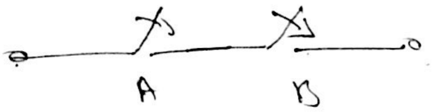


AND Gate





Electrical equivalent



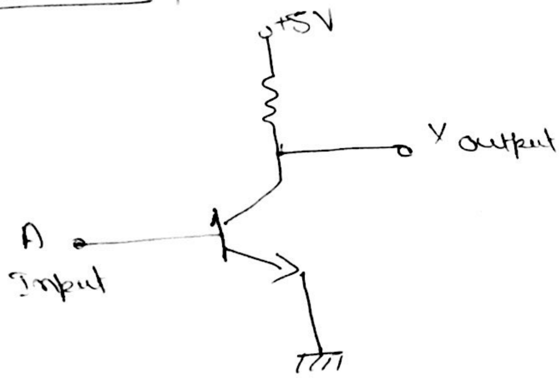
Circuit Diagram

0	0	Y
D_1 conducts	D_2 conducts	0
0	1	
D_1 conducts	D_2 is OFF	0
1	0	
D_1 is OFF	D_2 conducts	0
1	1	
D_1 is OFF	D_2 is OFF	1

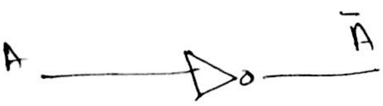
T.T

		Y
0	0	0
0	1	0
1	0	0
1	1	1

Not gate



circuit diagram



T.T

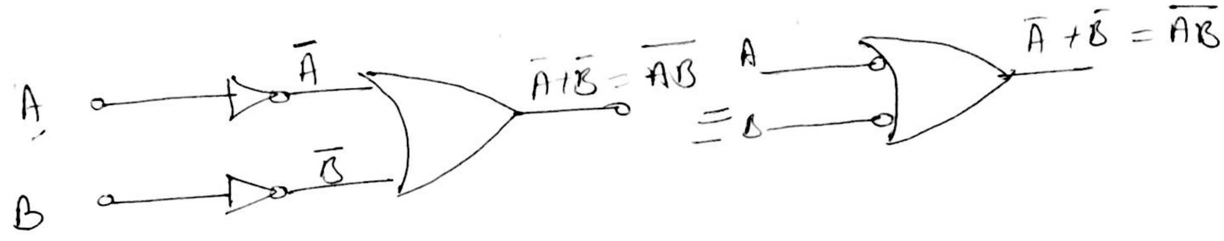
A	Y
0	1
1	0

NAND gate

AND + NOT gate

Now

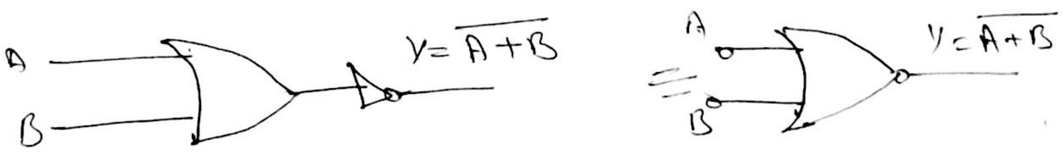
$$\overline{AB} = \overline{A} + \overline{B}$$



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

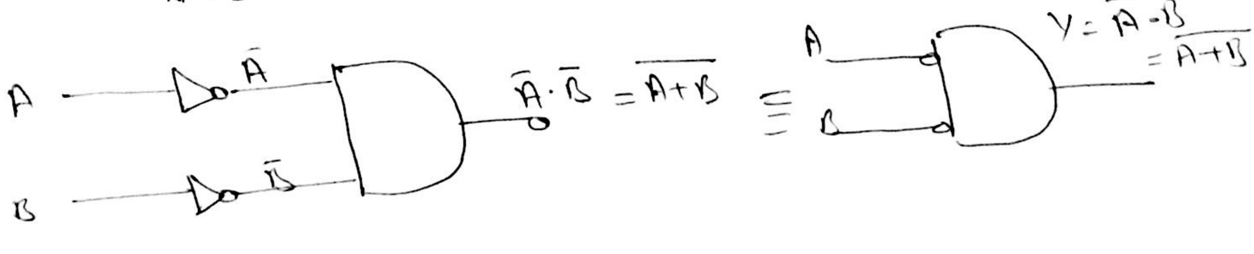
NOR gate

Not gate + OR gate



Now

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

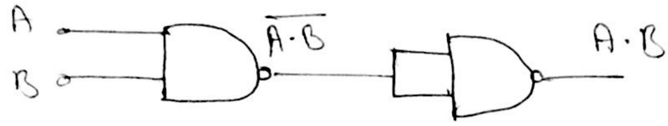


Note:- NAND and NOR gates are called universal gates because both can be used to implement any gate like AND, OR and NOT gate

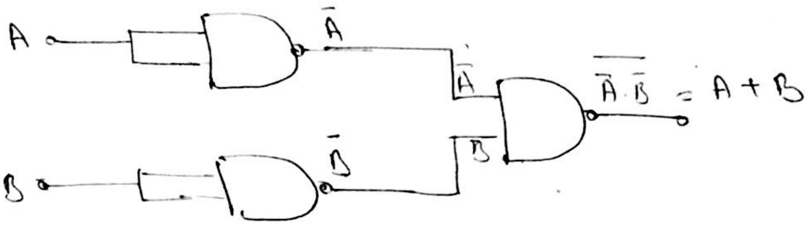
① Using NAND gate

Inverter (NOT) gate

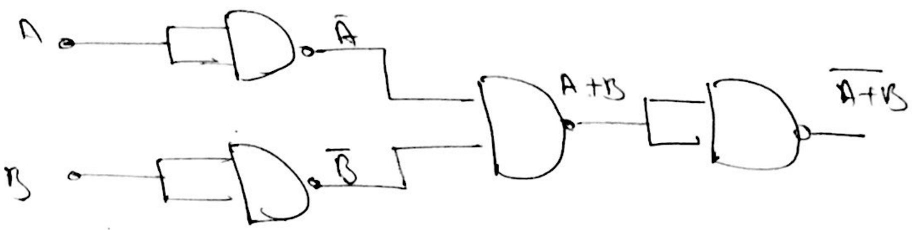
AND gate



OR gate

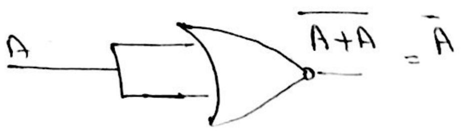


NOR gate

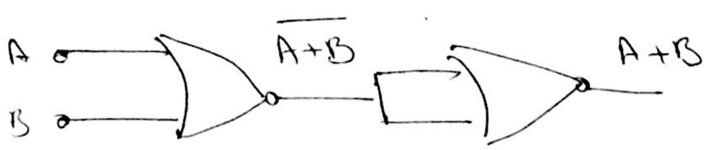


② Using NOR gate

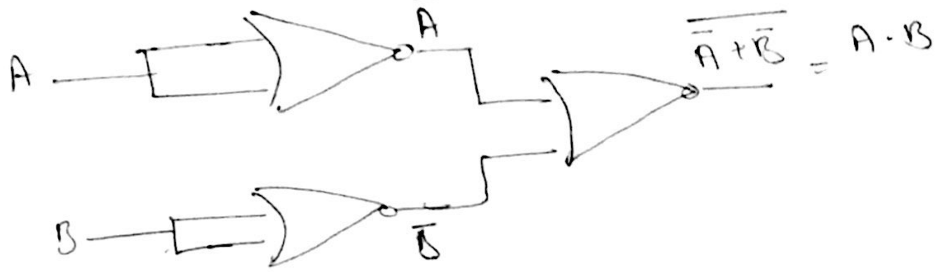
NOT gate



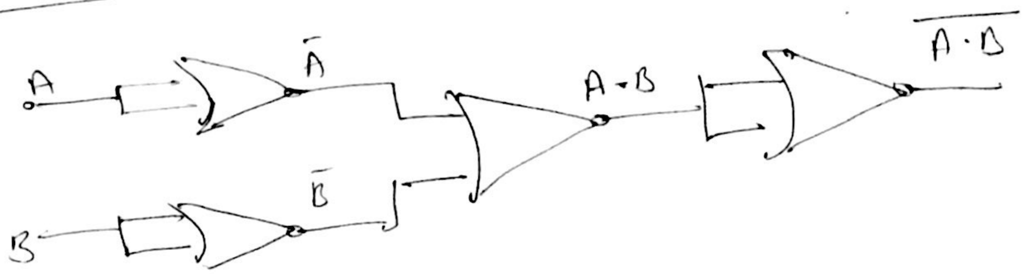
OR gate



AND gate



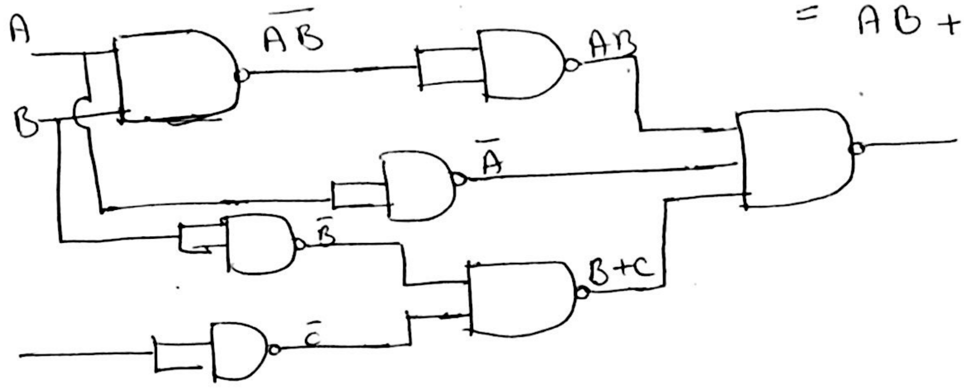
NAND gate



Q $Y = \overline{AB} + A + \overline{B+C}$ using NAND gates

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

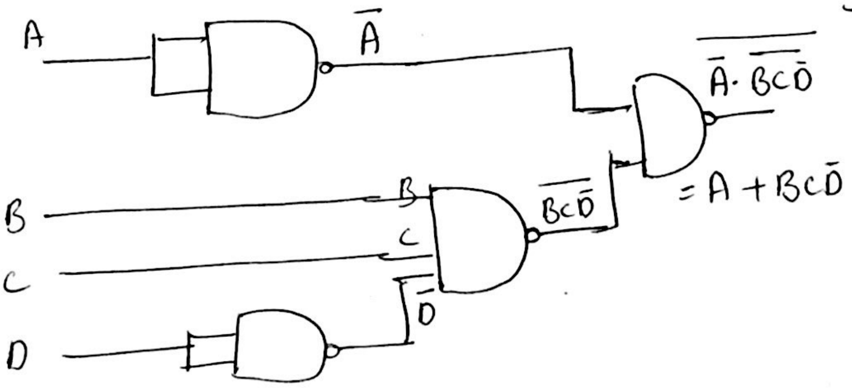
$= \overline{AB} + A + \overline{(B+C)}$



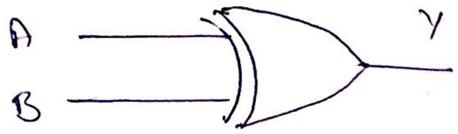
Q $Y = A + BC\bar{D}$

Sol $= \overline{\cancel{\bar{A} \cdot (BC\bar{D})}}$

$= \overline{\bar{A}} \cdot \overline{BC\bar{D}}$



Exclusive-OR (EX-OR) gate



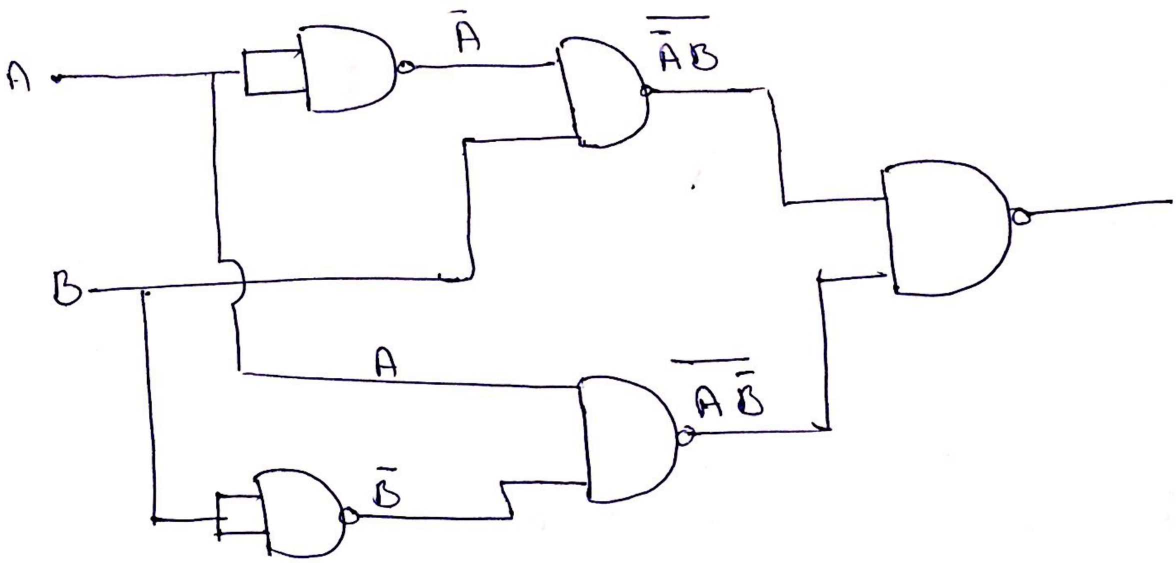
$Y = A \oplus B$

$= \bar{A}B + A\bar{B} \rightarrow$ SOP form

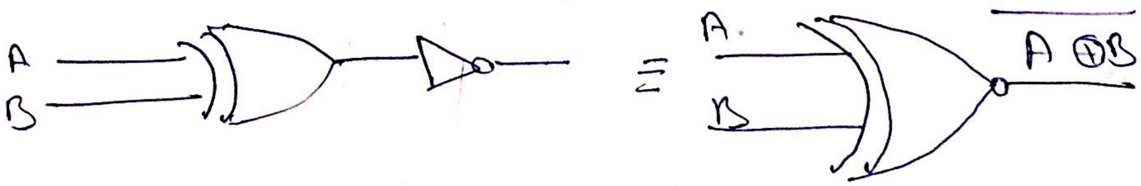
$(A+B)(\bar{A}+\bar{B})$ $\rightarrow$ POS form

Inputs		output
A	B	
0	0	0
0	1	1
1	0	1
1	1	0

$Y = \overline{\overline{\bar{A}B} \cdot \overline{A\bar{B}}}$



Exclusive-NOR (EX-NOR) gate

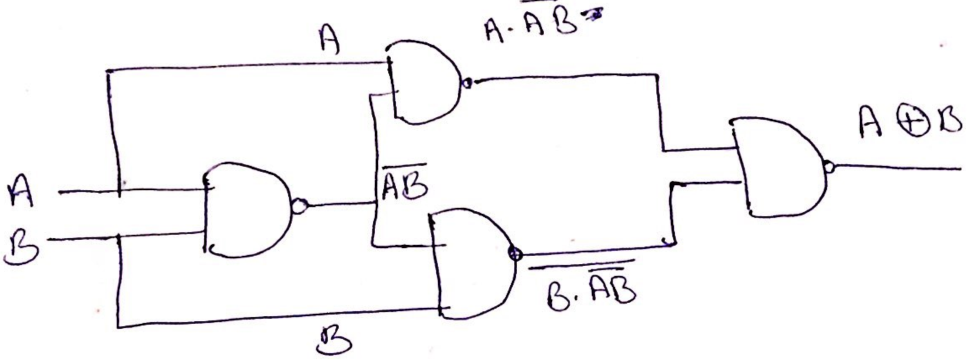


$A \odot B$

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

$Y =$

EX-OR using NAND



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

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

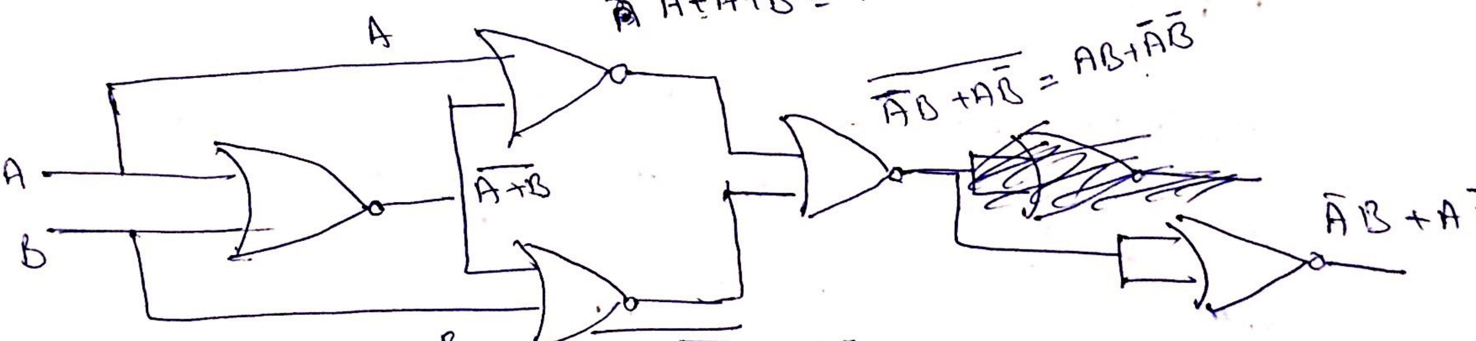
$$= \overline{(\overline{A}+B)(\overline{B}+A)} = \overline{\overline{A}+B} + \overline{\overline{B}+A}$$

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

EX-NOR

EX-OR using NOR gate

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



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

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

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

$$= 0 + AB + \overline{B}\overline{A} + 0$$

$=$