TYPE A : VERY SHORT ANSWER QUESTIONS

NOTE: " ' " is used instead of" ‾ " .

1.	**Name the person who developed Boolean algebra.**
Ans.	George Boole was developed Boolean algebra.
2.	**What is the other name of Boolean algebra? In which year was the Boolean algebra developed?**
Ans.	Other name of Boolean algebra is 'Switching Algebra'. Boolean algebra was developed in 1854.
3.	**What is the binary decision? What do you mean by a binary valued variable?**
Ans.	✓ The decision which results into either YES (TRUE) or NO (FALSE) is called a Binary Decision. ✓ Variables which can store truth values TRUE or FALSE are called logical variables or binary valued variables.
4.	**What do you mean by tautology and fallacy?**
Ans.	If result of any logical statement or expression is always TRUE or 1, it is called Tautology and if the result is always FALSE or 0 it is called Fallacy.
5.	**What is a logic gate? Name the three basic logic gates.**
Ans.	A Gate is simply an electronic circuit which operates on one or more signals to produce an output signal. Three basic logic gates are as following 1. Inverter (NOT Gate) 2. OR Gate 3. AND Gate
6.	**Which gates implement logical addition, logical multiplication and complementation?**
Ans.	✓ OR gate implements logical addition ✓ AND gate implements logical multiplication ✓ Inverter(NOT gate) implements complementation
7.	**What is the other name of NOT gate?**
Ans.	The other name of NOT gate is Inverter gate.
8.	**What is a truth table? What is the other name of truth table?**
Ans.	Truth Table is a table which represents all the possible values of logical variables/statements along with all the possible results of the given combinations of values.
9.	**Write the dual of : 1 + 1 = 1**
Ans :	The dual of 1 + 1 = 1 is 0. 0 =0
10.	**Give the dual of the following in Boolean algebra :** **(i) X . X' = 0 for each X (ii) X + 0 = X for each X**
Ans.	(i) X + X' = 1 (ii) X . 1 = X
11.	**Which of the following Boolean equation is/are incorrect? Write the correct forms of the incorrect ones :** **(a) A + A' =1 (b) A + 0 = A (c) A . 1 = A** **(d) AA'=1 (e) A+ AB = A (f) A(A+B)' = A** **(g) (A+B)' = A' + B (h) (AB)'=A'B' (i) A + 1 =1 (j) A + A =A** **(k) A + A'B = A +B (l) X +YZ = (X + Y)(X + A)**
Ans.	(a) Correct (b) Correct (c) Correct (d) Incorrect. Correct form is A . A' = 0 (e) Correct (f) Correct (g) Incorrect. Correct form is (A + B)' = A'B' (h) Incorrect. Correct form is (AB), = A' + B' (i) Correct (j) Correct (k) Correct (l) Incorrect. Correct form is X + YZ = (X + Y)(X + Z)
12.	**What is the significance of Principle of Duality?**
Ans.	Principle of Duality is a very important principle used in Boolean algebra. This states that starting with a Boolean relation, another Boolean relation can be derived by : 1. Changing each OR sign (+) to an AND sign(.). 2. Changing each AND sign (.) to an OR sign(+). 3. Replacing each 0 by 1 and each 1 by 0

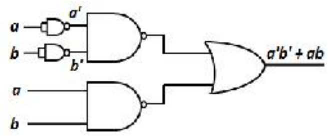
13. **Ans.**	**How many input combination can be there in the truth table of a logic system having (N) input binary variables?** There can be 2^N input combination in the truth table of a logic system having (N) input binary variables.
14. **Ans.**	**Write dual of the following Boolean Expression :** **(a) (x + y') (b) xy + xy' + x'y (c) a + a'b + b' (d) (x + y' + z)(x + y)** (a) xy' (b) (x + y)(x + y')(x' + y) (c) a . (a' + b) . b' (d) xy'z + xy
15. **Ans.**	**Find the complement of the following functions applying De'Morgan's theorem** **(a) F(x,y,z) = x'yz' + x'y'z (b) F(x,y,z) = x(y'z + yz)** (a) x'yz' + x'y'z = (x'yz' + x'y'z)' = (x'yz')'(x'y'z)' = (x'' + y' + z'')(x'' + y'' + z') = (x + y' + z)(x + y + z') (b) x(y'z + yz) = x' + (y'z + yz)' = x' + (y'' + z')(y' + z') = x' + (y + z')(y' + z')
16. **Ans.**	**What is the logical product of several variables called? What is the logical sum of several variables called?** Logical product of several variables is called Minterm and logical sum of several variables is called Maxterm.
17. **Ans.**	**What is the procedure "Break the line, change the sign"?** The procedure "Break the line, change the sign" is called demorganization which is performed by following steps : 1. Complement the entire function 2. Change all ANDs (.) to ORs (+) and all the ORs (+) to ANDs (.) **3.** Complement each of the individual variables.
18. **Ans.**	**What is a logical product having all the variables of a function called?** Logical product having all the variables of a function is called Minterm.
19. **Ans.**	**What is a logical sum having all the variables of a function called?** Logical sum having all the variables of a function is called Maxterm.
20. **Ans.**	**What do you understand by a Minterm and Maxterm?** <u>Minterm</u>: - Minterm is a product of all the literals within the logic system. Each literal may be with or without the bar (i.e. complemented). <u>Maxterm</u>:- Maxterm is a product of all the literals within the logic system. Each literal may be with or without the bar (i.e. complemented).
21. **Ans.**	**Write the minterm and Maxterm for a function F(x,y,z) when x =0, y = 1, z = 0.** Minterm : x'yz' Maxterm: x + y' + z
22. **Ans.**	**Write the minterm and Maxterm for a function F(x,y,z) when x =1, y = 0, z = 0.** Minterm : xy'z' Maxterm: x' + y + z
23. **Ans.**	**Write short hand notation for the following minterms : XYZ, X'YZ', X'YZ** Short hand notation for the minterms XYZ, X'YZ', X'YZ is F = ∑(2, 3, 7)
24. **Ans.**	**Write short hand notation for the following maxterms :** **X + Y + Z, X + Y'+ Z, X'+ Y + Z', X + Y'+ Z'** Short hand notation for the maxterms X + Y + Z, X + Y'+ Z, X'+ Y + Z', X + Y'+ Z' is F = π(0, 2, 3, 5)
25. **Ans.**	**What is the Boolean expression, containing only the sum of minterms, called?** The Boolean expression, containing only the sum of minterms, is called Canonical Sum- of –Product Form of an expression.
26. **Ans.**	**What is the Boolean expression, containing only the product of Maxterms, called?** The Boolean expression, containing only the product of Maxterms, is called Canonical Product- of –Sum Form of an expression.
27. **Ans.**	**What is the other name of Karnaugh map? Who invented Karnaugh maps?** The other name of Karnaugh map is Veitch diagrams. Maurice Karnaugh was invented Karnaugh maps.
28. **Ans :**	**Why are NAND and NOR gates called Universal gates?** Circuits using NAND and NOR are popular as they are easier to design and therefore cheaper. Functions of other gates can easily be implemented using NAND and NOR gates. For this reason they are called universal gates.
29. **Ans.**	**Which gates are called Universal gates and why?** NAND and NOR gates are called Universal gates because NAND and NOR gates are less expensive and easier to design. Also other functions (NOT, AND, OR) can easily be implemented using NAND/NOR gates.

30. State the purpose of reducing the switching functions to the minimal form?

Ans. The switching functions are practically implemented in the form of gates. A minimized Boolean expression means less number of gates which means simplified circuitary. Thus, the purpose of reducing the switching functions to the minimal form is getting circuitary.

31. Draw a logic circuit diagram using NAND or NOR only to implement the Boolean function
F(a,b) = a'b' + ab

Ans.



32. How is gray code different from normal binary code?

Ans. Gray code does not follow binary progression, instead in gray code each successive number differs only in one place.

33. How many variables are reduced by a pair, quad and octet respectively?

Ans. Two, four and eight variables are reduced by a pair, quad and octet respectively.

34. What is inverted AND gate called? What is inverted OR gate called?

Ans. Inverted AND gate is called NAND gate and Inverted OR gate is called NOR gate.

35. When does an XOR gate produce a high output? When does an XNOR gate produce a high output?

Ans. An XOR gate produces a high output when the input combination has odd number of 1's and an XNOR gate produces a high output when the input combination has even number of 1's.

36. Write duals of the following expressions :
(i)1 + x =1 (ii) (a + b).(a' + b') (iii) ab + bc = 1 (iv) (a'c + c'a)(b'd + d'b)

Ans.
(i) 0 . x = 0 (ii) ab + a'b'
(iii) (a + b)(b + c) = 0 (iv) ((a'+ c)(c' + a)) + ((b'+ d)(d' + b))

37. Find the complements of the expressions :
(i)X + YZ + XZ (ii) AB(C'D + B'C)

Ans.

(i) X + YZ + XZ = (X + YZ + XZ)' = (X)'(YZ)'(XZ)' = X'(Y' + Z')(X' + Z')	(ii) AB(C'D + B'C) = (AB)'(C'D + B'C)' = (AB)'((C'D)' + (B'C)') =(AB)'(CD' + BC') =(A' + B')+(C + D')(B + C')

TYPE B : SHORT ANSWER QUESTIONS

1. What do you understand by 'truth table' and 'truth function'? How are these related?

Ans.
- ✓ The statements which can be determined to be True or False are called logical statements or truth functions.
- ✓ The result TRUE or FALSE are called truth values.
- ✓ Both 'truth table' and 'truth function' are related in a way that truth function yields truth values.

2. What do you understand by 'logical function'? What is its alternative name? Give examples for logical functions.

Ans. Logic statements or truth functions are combined with the help of Logical Operators like AND, OR and NOT to form a Logical function. Its alternative name is Compound statement.
Examples for logical functions are as Following :
- ✓ He prefers tea not coffee.
- ✓ He plays guitar and she plays sitar.
- ✓ I watch TV on Sundays or I go for swimming.

3. What is meant by tautology and fallacy? Prove that 1 + Y is a tautology and 0 . Y is a fallacy.

Ans. If result of any logical statement or expression is always TRUE or 1, it is called Tautology and if the result is always FALSE or 0 it is called Fallacy.
We will prove 1 + Y is a tautology with the help of truth table which is given below :

1	Y	R
1	0	1
1	1	1

From truth table it is prove that 1 + Y is a tautology.
We will prove 0 . Y is a fallacy with the help of truth table which is given below :

0	Y	R
0	0	0
0	1	0

From truth table it is prove that 0 . Y is a fallacy.

4. What is a truth table? What is its significance?

Ans. Truth Table is a table which represents all the possible values of logical variables/ statements along with all the possible results of the given combinations of values. With the help of truth table we can know all the possible combinations of values and results of logical statements.

5. In the Boolean Algebra, verify using truth table that X + XY = X for each X , Y in {0 , 1}.

Ans.

X	Y	XY	X + XY
0	0	0	0
0	1	0	0
1	0	0	1
1	1	1	1

Both the columns X and X + XY are identical, hence proved.

6. In the Boolean Algebra, verify using truth table that (X + Y)’ = X’Y’ for each X , Y in {0 , 1}.

Ans.

X	Y	X + Y	(X + Y)’	X’	Y’	X’Y’
0	0	0	1	1	1	1
0	1	1	0	1	0	0
1	0	1	0	0	1	0
1	1	1	0	0	0	0

Both the columns (X + Y)’ and X’Y’ are identical, hence proved.

7. Give truth table for the Boolean Expression (X + Y’)’.

Ans.

X	Y	Y’	X + Y’	(X + Y’)’
0	0	1	1	0
0	1	0	0	1
1	0	1	1	0
1	1	0	1	0

8. Draw the truth table for the following equations :

(a) M = N (P + R)

Ans. **(a)M = N (P + R)**

N	P	R	P + R	N (P + R)
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	1	0
1	0	0	0	0
1	0	1	1	1
1	1	0	1	1
1	1	1	1	1

(b) M = N + P + NP’

N	P	R	P’	NP’	N + P + NP’
0	0	0	1	0	0
0	0	1	1	0	0
0	1	0	0	0	1
0	1	1	0	0	1
1	0	0	1	1	1
1	0	1	1	1	1
1	1	0	0	0	1
1	1	1	0	0	1

9. Using truth table, prove that AB + BC + CA’ = AB + CA’.

Ans.

A	B	C	A’	AB	BC	CA’	AB + BC + CA’	AB + CA’
0	0	0	1	0	0	0	0	0
0	0	1	1	0	0	1	1	1
0	1	0	1	0	0	0	0	0
0	1	1	1	0	1	1	1	1
1	0	0	0	0	0	0	0	0
1	0	1	0	0	0	0	0	0
1	1	0	0	1	0	0	1	1
1	1	1	0	1	1	0	1	1

Both the columns AB + BC + CA’ and AB + CA’ are identical, hence proved.

10. What are the basic postulates of Boolean algebra?

Ans.	Following are the basic postulates of Boolean algebra: 1) If X not equal to 0 then X equal to 1; and If X not equal to 1 then X equal to 0 2) OR Relations (Logical Addition) (i) 0 + 0 = 0 (ii) 0 + 1 = 1 (iii) 1 + 0 = 1 (iv) 1 + 1 = 1 3) AND Relations (Logical Multiplication) (i)0 . 0 = 0 (ii) 0 . 1 = 0 (iii) 1 . 0 = 0 (iv) 1 . 1 = 0 4) Complement Rules (i)0' = 1 (ii) 1'= 0
11. **Ans.**	**What does duality principle state? What is its usage in Boolean algebra?** The principle of duality states that starting with a Boolean relation, another Boolean relation can be derived by : 1. Changing each OR sign(+) to an AND sign(.). 2. Changing each AND sign(.) to an OR sign(+). 3. Replacing each 0 by 1 and each 1 by 0. Principle of duality is use in Boolean algebra to complement the Boolean expression.
12. **Ans.**	**State the principle of duality in Boolean algebra and give the dual of the Boolean expression :** **(X + Y).(X' +Z').(Y + Z)** The principle of duality states that starting with a Boolean relation, another Boolean relation can be derived by : 1 .Changing each OR sign(+) to an AND sign(.). 2. Changing each AND sign(.) to an OR sign(+). 3. Replacing each 0 by 1 and each 1 by 0. The dual of (X + Y).(X' +Z').(Y + Z) is XY + X'Z' + YZ
13. **Ans.**	**State the distributive laws of Boolean algebra. How do they differ from the distributive laws of ordinary algebra?** Distributive laws of Boolean algebra state that (i) X(Y + Z) = XY + XZ (ii) X + YZ = (X + Y)(X + Z) 1^{st} law X(Y + Z) = XY + XZ holds good for all values of X, Y and Z in ordinary algebra whereas X + YZ = (X + Y)(X + Z) holds good only for two values (0, 1) of X, Y and Z.

14. **Prove the idempotence law of Boolean algebra with the help of truth table.**

Ans. **Idempotence law state that (a) X + X = X (b) X . X = X**

(a) X + X = X

To prove this law, we will make a following truth table :

X	X	R
0	0	0
1	1	1

0 + 0 = 0 and 1 + 1 = 1

From truth table it is prove that X + X = X

(b) X . X = X

To prove this law, we will make a following truth table :

X	X	R
0	0	0
1	1	1

0 . 0 = 0 and 1 . 1 = 1

From truth table it is prove that X . X = X

15. **Prove the complementarity law of Boolean algebra with the help of a truth table.**

Ans. **Complementarity law state that (a) X + X' = 1 (b) X . X'= 0**

(a) X + X' = 1

To prove this law, we will make a following truth table :

X	X'	R
0	1	1
1	0	1

0 + 1 = 1 and 1 + 0 = 1

From truth table it is prove that X + X' = 1

(b) X . X'= 0

To prove this law, we will make a following truth table :

X	X'	R
0	1	0
1	0	0

0 . 1 = 0 and 1 . 0 = 0

From truth table it is prove that X . X'= 0

16. **Give the truth table proof for distributive law of Boolean algebra.**

Ans. Distributive law state that (a) X(Y +Z) = XY + XZ (b) X + YZ = (X + Y)(X + Z)

(a) X(Y +Z) = XY + XZ

To prove this law, we will make a following truth table :

X	Y	Z	Y + Z	XY	XZ	X(Y + Z)	XY + XZ
0	0	0	0	0	0	0	0
0	0	1	1	0	0	0	0
0	1	0	1	0	0	0	0
0	1	1	1	0	0	0	0

1	0	0	0	0	0	0	0
1	0	1	1	0	1	1	1
1	1	0	1	1	0	1	1
1	1	1	1	1	1	1	1

From truth table it is prove that X(Y +Z) = XY + XZ

(b) X + YZ = (X + Y)(X + Z)

X	Y	Z	YZ	X + YZ	XZ	X + Y	X + Z	(X + Y)(X + Z)
0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	1	0
0	1	0	0	0	0	1	0	0
0	1	1	1	1	0	1	1	1
1	0	0	0	1	0	1	1	1
1	0	1	0	1	1	1	1	1
1	1	0	0	1	0	1	1	1
1	1	1	1	1	1	1	1	1

From truth table it is prove that X + YZ = (X + Y)(X + Z)

17. Give algebraic proof of absorption law of Boolean algebra.

Ans. Absorption law states that (i) X + XY = X and (ii) X(X + Y) = X

(i) X + XY = X

LHS = X + XY = X(1 + Y)

= X . 1 [∵ 1 + Y = 1]

= X = RHS. Hence proved.

(ii) X(X + Y) = X

LHS = X(X + Y) = X . X + XY

= X + XY

= X(1 + Y)

= X . 1

= X = RHS. Hence proved.

18. Prove algebraically that (X + Y)(X + Z) = X + YZ.

Ans. L.H.S. = (X + Y)(X + Z) = XX + XZ + XY + YZ

= X + XZ + XY + YZ (XX = X Indempotence law)

= X + XY + XZ + YZ = X(1 + Y) + Z(X + Y)

= X.1 + Z(X + Y) (1 + Y = 1 property of 0 and 1)

= X + XZ + YZ) (X . 1 = X property of 0 and 1)

= X(1 + Z) + YZ

= X.1 + YZ (1 + Z = 1 property of 0 and 1)

= X.1 + YZ (X . 1 = X property of 0 and 1)

= L.H.S. Hence proved.

19. Prove algebraically that X + X'Y = X + Y.

Ans. L.H.S. = X + X'Y

= X.1 + X'Y (X . 1 = X property of 0 and 1)

= X(1 + Y) + X'Y (1 + Y = 1 property of 0 and 1)

= X + XY + X'Y

= X + Y(X + X')

= X + Y.1 (X + X' =1 complementarity law)

= X + Y (Y . 1 = Y property of 0 and 1)

= R.H.S. Hence proved.

20. What are DeMorgan's theorems? Prove algebraically the DeMorgan's theorem.

Ans. DeMorgan's theorems state that (i) (X + Y)'= X'.Y' (ii) (X.Y)'= X' + Y'

(i) (X + Y)'= X'.Y'

Now to prove DeMorgan's first theorem, we will use complementarity laws.

Let us assume that P = x + Y where, P, X, Y are logical variables. Then, according to complementation law

P + P' =1 and P . P'= 0

That means, if P, X, Y are Boolean variables hen this complementarity law must hold for variables P. In other words, if P i.e., if (X + Y)'= X'.Y'then

(X + Y) + (XY)'must be equal to 1. (as X + X'= 1)

(X + Y) . (XY)'must be equal to 0. (as X . X'= 0)

Let us prove the first part, i.e.,

$(X + Y) + (XY)' = 1$

$(X + Y) + (XY)' = ((X + Y) + X').((X + Y) + Y')$ (ref. $X + YZ = (X + Y)(X + Z)$)

$= (X + X' + Y).(X + Y + Y')$

$= (1 + Y).(X + 1)$ (ref. $X + X'=1$)

$= 1.1$ (ref. $1 + X =1$)

$= 1$

So first part is proved.

Now let us prove the second part i.e.,

$(X + Y) . (XY)' = 0$

$(X + Y) . (XY)' = (XY)' . (X + Y)$ (ref. $X(YZ) = (XY)Z$)

$= (XY)'X + (XY)'Y$ (ref. $X(Y + Z) = XY + XZ$)

$= X(XY)' + X'YY'$

$= 0 .Y + X' . 0$ (ref. $X . X'=0$)

$= 0 + 0 = 0$

So, second part is also proved, Thus: $X + Y = X' . Y'$

(ii) $(X.Y)' = X' + Y'$

Again to prove this theorem, we will make use of complementary law i.e.,

$X + X' = 1$ and $X . X' = 0$

If XY's complement is X + Y then it must be true that

(a) $XY + (X' + Y') = 1$ and (b) $XY(X' + Y') = 0$

To prove the first part

L.H.S $= XY + (X'+Y')$

$= (X'+Y') + XY$ (ref. $X + Y = Y + X$)

$= (X'+Y' + X).(X'+Y' + Y)$ (ref. $(X + Y)(X + Z) = X + YZ$)

$= (X + X'+Y').(X' + Y +Y')$

$= (1 +Y').(X' + 1)$ (ref. $X + X'=1$)

$= 1.1$ (ref. $1 + X =1$)

$= 1 =$ R.H.S

Now the second part i.e.,

$XY.(\overline{X} + \overline{Y}) = 0$

L.H.S $= (XY)'.(X'+Y')$

$= XYX' + XYY'$ (ref. $X(Y + Z) = XY + XZ$)

$= XX'Y + XYY'$

$= 0.Y + X.0$ (ref. $X . X'=0$)

$= 0 + 0 = 0 =$ R.H.S.

$XY.(X' + Y') = 0$ and $XY + (X' + Y') = 1$

$(XY)' = X' + Y'$. Hence proved.

21. Use the duality theorem to derive another boolean relation from :

$A + A'B = A + B$

Ans. $A.(A' + B) = A.B$

22. What would be the complement of the following: (a) $A'(BC' + B'C)$ (b) $xy + y'z + z'z$?

Ans.

(a) $A'(BC' + B'C) = (A'(BC' + B'C))'$

$= ((A')'(BC' + B'C)')$

$= ((A')'((BC')' + (B'C)')$

$= ((A)((B' C) + (BC'))$

$= A + (B'+ C)(B +C')$

(b) $xy + y'z + z'z = (xy + y'z + z'z)'$

$= (xy)'(y'z)'(z'z)'$

$= (x' + y')(y'' + z')(z'' + z')$

$= (x' + y)(y + z')(z + z')$

23. Prove (giving reasons) that $[(x + y)' + (x + y)']' = x + y$

Ans. $[(x + y)' + (x + y)']' = ((x + y)')'.((x + y)')'$ (Using De Morgan's first theorem i.e., $(A + B)' = A'.B'$)

$= (x + y).(x + y)$ ($\because X' = X$)

$= x + y$ ($X.X = 1$)

24. Find the complement of the following Boolean function : $F_1 = AB' + C'D'$

Ans. $(AB' + C'D')' = (AB')'.(C'D')'$ (De Morgan's first theorem)

$= (A' + B'').(C'' + D'')$ (DeMorgan's second theorem i.e., $(A.B)' = A' + B'$)

= (A’ + B’).(C + D) ((X’)’= X)

25. **Prove the following :**

(i) A(B + B’C + B’C’) = A **(ii) A + A’B’ = A + B'**

(iii) (x + y + z).(x’ + y + z) = y + z **(iv) A’B’C + A’BC + AB’C = A’C + B’C**

Ans. **(i) A(B + B’C + B’C’) = A**

A	B	C	[illegible]	[illegible]	B’C	B’C’	B + B’C + B’C’	A(B + B’C + B’C’)
0	0	0	1	1	0	1	1	0
0	0	1	1	0	1	0	1	0
0	1	0	0	1	0	0	1	0
0	1	1	0	0	0	0	1	0
1	0	0	1	1	0	1	1	1
1	0	1	1	0	1	0	1	1
1	1	0	0	1	0	0	1	1
1	1	1	0	0	0	0	1	1

Both the columns A(B + B’C + B’C’)and A are identical, hence proved.

(ii) A + A’B’ = A + B'

A	B	C	A’	B’	A’B’	A + A’B’	A + B'
0	0	0	1	1	1	1	1
0	0	1	1	1	1	1	1
0	1	0	1	0	0	0	0
0	1	1	1	0	0	0	0
1	0	0	0	1	0	1	1
1	0	1	0	1	0	1	1
1	1	0	0	0	0	1	1
1	1	1	0	0	0	1	1

Both the columns **A + A’B’** and **A + B'** are identical, hence proved.

(iii) (x + y + z).(x’ + y + z) = y + z

x	y	z	X’	x + y + z	x’+ y + z	(x + y + z).(x’ + y + z)	y + z
0	0	0	1	0	1	0	0
0	0	1	1	1	1	1	1
0	1	0	1	1	1	1	1
0	1	1	1	1	1	1	1
1	0	0	0	1	0	0	0
1	0	1	0	1	1	1	1
1	1	0	0	1	1	1	1
1	1	1	0	1	1	1	1

Both the columns (x + y + z).(x’ + y + z) and y + z are identical, hence proved.

(iv) A’B’C + A’BC + AB’C = A’C + B’C

A	B	C	A’	B’	A’B’C	A’BC	AB’C	A’C	B’C	A’B’C + A’BC + AB’C	A’C + B’C
0	0	0	1	1	0	0	0	0	0	0	0
0	0	1	1	1	1	0	0	1	1	1	1
0	1	0	1	0	0	0	0	0	0	0	0
0	1	1	1	0	0	1	0	1	0	1	1
1	0	0	0	1	0	0	0	0	0	0	0
1	0	1	0	1	0	0	1	0	1	1	1
1	1	0	0	0	0	0	0	0	0	0	0
1	1	1	0	0	0	0	0	0	0	0	0

Both the columns A’B’C + A’BC + AB’C and A’C + B’C are identical, hence proved.

26. **What do you mean by canonical form of a Boolean expression? Which of the following are canonical?**

(i) ab + bc **(ii) abc + a’bc’+ ab’c’** **(iii) (a + b)(a’ +b’)**

(iv) (a + b + c)(a + b’+ c)(a’ + b +c’) **(v) ab + bc + ca**

Ans. Boolean Expression composed entirely either of Minterms or maxterms is referred to as canonical form of a Boolean expression.

	(i)Non canonical (ii) canonical (iii) canonical (iv) canonical (v) Non canonical
27.	**Give an example for each of the following :** **(i) a boolean expression in the sum of minterm form** **(ii) a boolean expression in the non canonical form.**
Ans.	For a function F(X, Y, Z) (i) Sum of minterms expression is XYZ + X'Y'Z + X'Y'Z + XYZ' (ii) Non canonical form of Sum-of-products XY + Y'Z + ZX'+ X'Y'
28.	**What are the fundamental products for each of the input words ABCD = 0010. ABCD = 1101, ABCD = 1110?**
Ans.	The fundamental products for each of the input words ABCD = 0010. ABCD = 1101, ABCD = 1110 are as following : A'B'CD' + ABC'D + ABCD'
29.	**A truth table has output 1's for each of these inputs :** **(a)ABCD = 0011 (b) ABCD = 0101 (c) ABCD = 1000, what are the fundamental products?**
Ans.	The fundamental products are A'B'CD + A'BC'D + AB'C'D'
30.	**Construct a boolean function of three variables p, q and r that has an output 1 when exactly two of p, q, r are having values 0, and an output 0 in all other cases.**

Ans.

p	q	r	F
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0

F = p'q'r + p'qr'+ pq'r'

31.	**Write the Boolean expression for a logic network that will have a 1 output when** **X = 1, Y = 0, Z = 0; X = 1, Y = 0, Z = 1; X = 1, Y = 1, Z = 0; and X = 1, Y = 1, Z = 1.**
Ans.	X = 1, Y = 0, Z = 0 XY'Z' X = 1, Y = 0, Z = 1 XY'Z X = 1, Y = 1, Z = 0 XYZ' X = 1, Y = 1, Z = 1 XYZ The Boolean expression is F = XY'Z'+ XY'Z + XYZ' + XYZ
32.	**Derive the Boolean algebra expression for a logic network that will have outputs 0 only output when** **X = 1, Y =1, Z = 1; X = 0, Y = 0, Z = 0; X = 1, Y = 0, Z = 0.** **The outputs are to be 1 for all other cases.**

Ans.

X	Y	Z	F
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	0

F = (X + Y + Z)(X' + Y + Z)(X' + Y' +Z')

33.	**A Boolean function F defined on three input variables X, Y and Z is 1 if and only if number of 1(one) inputs is odd (e.g., F is 1 if x = 1, Y = 0, Z = 0). Draw the truth table for the above functions and express it in canonical sum-of-products form.**
Ans.	The output is 1, only if one of the inputs is odd. All the possible combinations when one of inputs is odd are X = 1, Y = 0, Z = 0 X = 0, Y = 1, Z = 0

	X = 0, Y = 0, Z = 1 For these combination output is 1, otherwise output is 0. Preparing the truth table for it, we get

X	Y	Z	F	Product Terms/ Minterms
0	0	0	0	X'Y'Z'
0	0	1	1	X'Y'Z
0	1	0	1	X'YZ'
0	1	1	0	X'YZ
1	0	0	1	XY'Z'
1	0	1	0	XY'Z
1	1	0	0	XYZ'
1	1	1	0	XYZ

Adding all the minterms for which output is 1, we get

X'Y'Z + X'YZ' + XY'Z'= F

This is desired Canonical Sum-of-Products form.

34. **Output 1s appear in the truth table for these input conditions: ABCD = 0001, ABCD = 0110, and ABCD = 1110. What is the sum-of-products equation?**

Ans. ABCD = 0001 = A'B'C'D

ABCD = 0110 = A'BCD'

ABCD = 1110 = ABCD'

The sum-of-products equation is as following :

F = A'B'C'D + A'BCD' + ABCD'

35. **Convert the following expression to canonical Sum-of=Product form :**

(a) X + X'Y + X'Z' (b) YZ + X'Y (c) AB' (B'+C')

Ans. **(a) X + X'Y + X'Y'**

= X(Y + Y')(Z + Z') + X'Y(Z + Z') + X'Z'(Y + Y')

= (XY + XY')(Z + Z') + X'YZ + X'YZ' + X'YZ' + X'Y'Z'

= Z(XY + XY') + Z'(XY + XY') + X'YZ + X'YZ' + X'YZ' + X'Y'Z'

= XYZ + XY'Z + XYZ' + XY'Z' + X'YZ + X'YZ' + X'YZ' + X'Y'Z'

By removing duplicate terms we get canonical Sum-of=Product form :

XYZ + XY'Z + XYZ' + XY'Z' + X'YZ + X'YZ' + X'Y'Z'

F = ∑(1, 2, 3, 4, 5, 6, 7)

F = $m_1 + m_2 + m_3 + m_4 + m_5 + m_6 + m_7$

(b) YZ + X'Y

= YZ(X + X') + X'Y(Z + Z')

= XYZ + X'YZ + X'YZ + X'YZ'

By removing duplicate terms we get canonical Sum-of=Product form :

XYZ + X'YZ + X'YZ'

F = ∑(2, 3, 7)

F = $m_2 + m_3 + m_7$

(c) AB'(B' + C')

Try by yourself.

36. **Express in the Product of Sums form, the Boolean function F(x, y, z), and the truth table for which is given below :**

X	Y	Z	F
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	1

Ans. Add a new column containing Maxterms. Now the table is as follows :

X	Y	Z	F	Maxterms
0	0	0	1	X + Y + Z
0	0	1	0	X + Y + Z’
0	1	0	1	X + Y’ + Z
0	1	1	0	X + Y ‘+ Z’
1	0	0	1	X’ + Y + Z
1	0	1	0	X ‘+ Y + Z’
1	1	0	1	X’ + Y ‘+ Z
1	1	1	1	X’+ Y’ + Z'

Now by multiplying Maxterms for the output 0s, we get the desiered product of sums expression which is

(X + Y + Z’)(X + Y’ + Z’)(X’ + Y + Z’)

37. **Given the truth table of a function F(x, y, z). Write S-O-P and P-O-S expression from the following truth table :**

X	Y	Z	F
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

Ans. Add a new column containing Minterms and Maxterms. Now the table is as follows :

X	Y	Z	F	Minterms	Maxterms
0	0	0	0	X’Y’Z’	X + Y + Z
0	0	1	0	X’Y’Z	X + Y + Z’
0	1	0	0	X’YZ’	X + Y’ + Z
0	1	1	1	X’YZ	X + Y ‘+ Z’
1	0	0	1	XY’Z’	X’ + Y + Z
1	0	1	0	XY’Z	X ‘+ Y + Z’
1	1	0	0	XYZ’	X’ + Y ‘+ Z
1	1	1	1	XYZ	X’+ Y’ + Z'

Now by adding all the minterms for which output is 1, we get desired sum-of-products expression which is

X’YZ + XY’Z’ + XYZ

Now by multiplying Maxterms for the output 0s, we get the desired product of sums expression which is

(X + Y + Z)(X + Y + Z’)(X + Y’ + Z)(X ‘+ Y + Z’)(X’ + Y ‘+ Z)

38. **Convert the following expressions to canonical Product-of-Sum form**

(a) (A + C)(C + D) **(b) A(B + C)(C’ +D’)** **(c) (X + Y)(Y + Z)(X + Z)**

Ans. **(a) (A + C)(C + D)**

= (A + BB’ + C + DD’)(AA’ + BB’ + C + D)

= (A + B + C + D)(A + B’ + C + D’)(A + B + C + D)(A’ + B’ + C + D)

By removing duplicate terms we get canonical Product-of-Sum form:

(A + B + C + D)(A + B’ + C + D’)(A’ + B’ + C + D)

F = π(0, 5 , 12)

F = $M_0 + M_5 + M_{12}$

(b) A(B + C)(C’ + D’)

Try by yourself.

(c) (X + Y)(Y + Z)(X + Z)

= (X + Y + ZZ’)(XX’ + Y + Z)(X + YY’ + Z)

= (X + Y + Z)(X + Y + Z’)(X + Y + Z)(X’ + Y + Z)(X + Y + Z)(X + Y’ + Z)

By removing duplicate terms we get canonical Product-of-Sum form:

(X + Y + Z)(X + Y + Z’)(X’ + Y + Z)(X + Y’ + Z)

F = π(0, 1 , 2, 4)

F = $M_0 + M_1 + M_2 + M_4$

39. **Simplify the following Boolean expression :**

(i) AB + AB’+ A’C + A’C’ (ii) XY + XYZ’ + XYZ’ + XZY (iii) XY(X’YZ’+ XY’Z’+ XY’Z’)

Ans. **(i) AB + AB’ + A’C + A’C’**

= A(B + B’) + A’(C + C’) (B + B’ =1, C + C’ = 1)

= A + A’ (A + A’ = 1)

= 1

(ii) XY + XYZ’ + XYZ’ + XZY

= XY(Z’) + XY(Z’ + Z) (Z + Z’ =1)

= XY(Z’) + XY

= XY(Z’ + 1) (Z’ + 1 = 1)

= XY

(iii) XY(X’YZ’ + XY’Z’ + XY’Z’)

= XY[Z’(X’Y + XY’ + XY’)]

= XY[Z’(X’Y + XY’(1 + 1)]

= XY[Z’(X’Y + XY’)]

= XYZ’(X’Y + XY’)

40. **Develop sum of products and product of sums expressions for F_1 and F_2 from the following truth table :**

Inputs			Outputs	
X	Y	Z	F_1	F_2
0	0	0	0	0
0	0	1	0	1
0	1	0	1	1
0	1	1	1	0
1	0	0	1	0
1	0	1	0	0
1	1	0	0	1
1	1	1	1	1

Ans. Add a new column containing Minterms. Now the table is as follows :

Inputs			Outputs		Minterms	Maxterms
X	Y	Z	F_1	F_2		
0	0	0	0	0	X’Y’Z’	X + Y + Z
0	0	1	0	1	X’Y’Z	X + Y + Z’
0	1	0	1	1	X’YZ’	X + Y’ + Z
0	1	1	1	0	X’YZ	X + Y ‘+ Z’
1	0	0	1	0	XY’Z’	X’ + Y + Z
1	0	1	0	0	XY’Z	X ‘+ Y + Z’
1	1	0	0	1	XYZ’	X’ + Y ‘+ Z
1	1	1	1	1	XYZ	X’+ Y’ + Z'

Now by adding all the minterms for which output is 1 in F1, we get desired sum-of-products expression which is X’YZ’ + X’YZ + XY’Z’ + XYZ

Now by adding all the minterms for which output is 1 in F2, we get desired sum-of-products expression which is X’Y’Z + X’YZ’ + XYZ’ + XYZ

Now by multiplying Maxterms for the output 0s in F1, we get the desired product of sums expression which is (X + Y + Z)(X + Y + Z’)(X’ + Y + Z’)(X’ + Y ‘+ Z)

Now by multiplying Maxterms for the output 0s in F2, we get the desired product of sums expression which is (X + Y + Z)(X + Y’ + Z’)(X’ + Y + Z)(X’ + Y + Z’)

41. **Obtain a simplified expression for a Boolean function F(X, Y, Z), the Karnaugh map for which is given bellow :**

X \ YZ	00	01	11	10
0		1	1	
1		1	1	

Ans.

X \ YZ	[00]Y'Z'	[01]Y'Z	[11]YZ	[10]YZ'
[0]X'	0_{0}	1_{1}	1_{3}	0_{2}
[1]X	0_{4}	1_{5}	1_{7}	0_{6}

Completing the given K-map We have 1 group which is Quad i.e.,

$m_1 + m_3 + m_5 + m_7$

= X'Y'Z + X'YZ + XY'Z + XYZ
= X'Z(Y' + Y) + XZ(Y' + Y)
= X'Z + XZ
= Z(X' + X)
=Z

Simplified Boolean expression for given K-map is F(X, Y, Z) = Z.

42. Using the Karnaugh technique obtain the simplified expression as sum of products for the following map.

X \ YZ	00	01	11	10
0			1	1
1			1	1

Ans.

X \ YZ	[00]Y'Z'	[01]Y'Z	[11]YZ	[10]YZ'
[0]X'	0_{0}	0_{1}	1_{3}	1_{2}
[1]X	0_{4}	0_{5}	1_{7}	1_{6}

Completing the given K-map We have 1 group which is Quad i.e.,

$m_2 + m_3 + m_6 + m_7$

= X'YZ + X'YZ' + XYZ + XYZ'
= X'Y(Z + Z') + XY(Z + Z')
= X'Y + XY
= Y(X' + X)
= Y

Simplified Boolean expression as sum of products for given K-map is F(X, Y, Z) = Y.

43. Obtain the simplified expression in the sum of products form, for the Boolean function F(X, Y, Z), Karnaugh map for which is given below :

X \ YZ	00	01	11	10
0				1
1	1			1

Ans.

X \ YZ	[00]Y'Z'	[01]Y'Z	[11]YZ	[10]YZ'
[0]X'	0_{0}	0_{1}	0_{3}	1_{2}
[1]X	1_{4}	0_{5}	0_{7}	1_{6}

Completing the given K-map We have 2 Pairs i.e.,

Pair-1 is $m_3 + m_6$ and Pair-2 is $m_4 + m_6$

= X'YZ' + XYZ' + XY'Z' + XYZ'
= YZ'(X' + X) + XZ'(Y' + Y)
= YZ' + XZ'

Simplified Boolean expression as sum of products for given K-map is F(X, Y, Z) = YZ' + XZ'.

44. Minimize the following function using a Karnaugh map : F(W, X, Y, Z) = ∑(0, 4, 8, 12).

Ans.

WX \ YZ	[00]Y'Z'	[01]Y'Z	[11]YZ	[10]YZ'
[00]W'X'	1_{0}	0_{1}	0_{3}	0_{2}
[01]W'X	1_{4}	0_{5}	0_{7}	0_{6}
[11]WX	1_{12}	0_{13}	0_{15}	0_{14}
[10]WX'	1_{8}	0_{9}	0_{11}	0_{10}

Mapping the given function in a K-map, we get 1 Quad i.e.,

$m_0 + m_4 + m_8 + m_{12}$

= W'X'Y'Z' + W'XY'Z' + WXY'Z' + WX'Y'Z'
= W'Y'Z'(X' + X) + WY'Z'(X + X')
= W'Y'Z' + WY'Z'
= Y'Z'(W' + W)
= Y'Z'

Simplified Boolean expression for given K-map is ,

F(W, X, Y, Z) = Y'Z'

45. Draw and simplify the Karnaugh Maps of X, Y, Z for :

(a) $m_0 + m_1 + m_5 + m_7$ (b) F = ∑(1, 3, 5, 4, 7) (c) $m_0 + m_2 + m_4 + m_6$

Ans. **(a) $m_0 + m_1 + m_5 + m_7$**

X \ YZ	[00]Y'Z'	[01]Y'Z	[11]YZ	[10]YZ'
[0]X'	1_{0}	1_{1}	0_{3}	0_{2}
[1]X	0_{4}	1_{5}	1_{7}	0_{6}

Mapping the given function in a K-map, we get 2 Pairs i.e.,
Pair-1 is $m_0 + m_1$ and Pair-2 is $m_5 + m_7$
= X'Y'Z' + X'Y'Z + XY'Z + XYZ
= X'Y'(Z' + Z) + XZ(Y' + Y)
= X'Y' + XZ
Simplified Boolean expression for given K-map is F(X, Y, Z) = X'Y' + XZ.

(b) F = ∑(1, 3, 5, 4, 7)

X \ YZ	[00]Y'Z'	[01]Y'Z	[11]YZ	[10]YZ'
[0]X'	0_{0}	1_{1}	1_{3}	0_{2}
[1]X	1_{4}	1_{5}	1_{7}	0_{6}

Mapping the given function in a K-map, we get 1 Pair and 1 Quad i.e.,
Pair is $m_4 + m_5$ and Quad is $m_1 + m_3 + m_5 + m_7$
= X'Y'Z + X'YZ + XY'Z + XYZ + XY'Z' + XY'Z
= X'Z(Y' + Y) + XZ(Y' + Y) + XY'(Z' + Z)
= X'Z + XZ + XY'
= Z(X' + X) + XY'
= Z + XY'
Simplified Boolean expression as for given K-map is F(X, Y, Z) = Z + XY'.

(c) $m_0 + m_2 + m_4 + m_6$

X \ YZ	[00]Y'Z'	[01]Y'Z	[11]YZ	[10]YZ'
[0]X'	1_{0}	0_{1}	0_{3}	1_{2}
[1]X	1_{4}	0_{5}	0_{7}	1_{6}

Mapping the given function in a K-map, we get 2 Pairs i.e.,
Pair-1 is $m_0 + m_4$ and Pair-2 is $m_2 + m_6$
= X'Y'Z' + XY'Z' + X'YZ' + XYZ'
= Y'Z'(X' + X) + YZ'(X' + X)
= Y'Z' + YZ'
= Z'(Y' + Y)
= Z'
Simplified Boolean expression for given K-map is F(X, Y, Z) = Z'.

46. **Using K-map, derive minimal product of sums expression for the F(X, Y, Z) whose truth table is given below :**

X	Y	Z	F
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

Ans.

X \ YZ	[00]Y+Z	[01]Y+Z'	[11]Y'+Z'	[10]Y'+Z
[0]X	0_{0}	1_{1}	1_{3}	0_{2}
[1]X'	0_{4}	1_{5}	1_{7}	0_{6}

Completing the K-map by putting 0's where F produces 0, we get 2 Pairs i.e.,
Pair-1 is $M_0 . M_4$ and Pair-2 is $M_2 . M_6$
Reduced expression are as follows :
For Pair-1, (Y + Z) (as X is eliminated : X changes to X')
For Pair-2, (Y' + Z) (X changes to X; hence eliminated)
Hence final P-O-S expression will be
F(X , Y, Z) = (Y + Z) (Y' + Z)

47. **Using map, simplify the following expression, using sum-of-products form :**
(a) A'B'C'+ AB'C'+ ABC + A'B'C
(b) ABCD + A'B'C'D + A'BCD + A'B'CD + ABCD'

Ans. **(a) A'B'C'+ AB'C'+ ABC + A'B'C**

A \ BC	[00]B'C'	[01]B'C	[11]BC	[10]BC'
[0]A'	1_{0}	1_{1}	0_{3}	0_{2}
[1]A	1_{4}	0_{5}	1_{7}	0_{6}

Mapping the given function in a K-map, we get 2 Pairs i.e.,
Pair-1 is $m_0 + m_1$ and Pair-2 is $m_0 + m_4$
= A'B'C' + A'B'C + A'B'C' + AB'C' + ABC
= A'B'(C' + C) + B'C'(A' + A) + ABC
= A'B' + B'C' + ABC
Simplified Boolean expression as sum of products for given K-map is

F(A, B, C) = A'B' + B'C' + ABC.

(b) ABCD + A'B'C'D + A'BCD + A'B'CD + ABCD'

AB \ CD	[00]C'D'	[01]C'D	[11]CD	[10]CD'
[00]A'B'	1_{0}	1_{1}	1_{3}	0_{2}
[01]A'B	0_{4}	0_{5}	1_{7}	0_{6}
[11]AB	0_{12}	0_{13}	0_{15}	1_{14}
[10]AB'	0_{8}	0_{9}	0_{11}	0_{10}

Mapping the given function in a K-map, we get 2 Pairs i.e.,
Pair-1 is $m_0 + m_1$ and Pair-2 is $m_0 + m_4$
You notice that there is a single 1 in a m_{14} because it has no adjacent 1 so it is not possible to make a pair.
= A'B'C'D' + A'B'C'D + A'B'CD + A'BCD + ABCD'
= A'B'C'(D' + D) + A'CD(B' + B) + ABCD'
= A'B'C' + A'CD + ABCD'
Simplified Boolean expression as sum of products for given K-map is
F(A, B, C, D) = A'B'C' + A'CD + ABCD'.

48. A truth table has output is for these inputs ;
ABCD = 0011, ABCD = 0110, ABCD = 1001, and ABCD = 1110. Draw the Karnaugh map showing the fundamental products.

Ans.

AB \ CD	[00]C'D'	[01]C'D	[11]CD	[10]CD'
[00]A'B'	0_{0}	0_{1}	1_{3}	0_{2}
[01]A'B	0_{4}	0_{5}	0_{7}	1_{6}
[11]AB	0_{12}	0_{13}	0_{15}	1_{14}
[10]AB'	0_{8}	1_{9}	0_{11}	0_{10}

ABCD = 0011 = A'B'CD = m_3 and ABCD = 0110 = A'BCD' = m_6
ABCD = 1001 = AB'C'D = m_9 and ABCD = 1110 = ABCD' = m_{14}
Mapping the given outputs in a K-map, we get 1 Pairs i.e.,
$m_5 + m_{14}$
You notice that there are a single 1 in a m_3 and m_9 because it have no adjacent 1 so it is not possible to make a pair.
= A'B'CD + A'BCD' + ABCD' + AB'C'D
= A'B'CD + BCD'(A' + A) + AB'C'D'
= A'B'CD + BCD' + AB'C'D
Simplified Boolean expression as sum of products for given K-map is
F(A, B, C, D) = A'B'CD + BCD' + AB'C'D.

49. A truth table has four input variables. The first eight outputs are 0s, and the last eight outputs are 1s. Draw the Karnaugh map.

Ans.

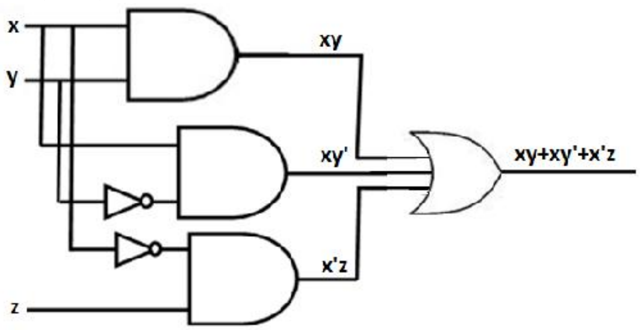
AB \ CD	[00]C'D'	[01]C'D	[11]CD	[10]CD'
[00]A'B'	0_{0}	0_{1}	0_{3}	0_{2}
[01]A'B	0_{4}	0_{5}	0_{7}	0_{6}
[11]AB	1_{12}	1_{13}	1_{15}	1_{14}
[10]AB'	1_{8}	1_{9}	1_{11}	1_{10}

Last eight outputs are 1s i.e.,
$m_8 + m_9 + m_{10} + m_{11} + m_{12} + m_{13} + m_{14} + m_{15}$
= ABC'D' + ABC'D + ABCD + ABCD' + AB'C'D' + AB'C'D + AB'CD + AB'CD'
= ABC'(D' + D) + ABC(D + D') + AB'C'(D' + D) + AB'C(D + D')
= ABC' + ABC + AB'C' + AB'C
Simplified Boolean expression for given K-map is
F(A, B, C, D) = ABC' + ABC + AB'C' + AB'C.

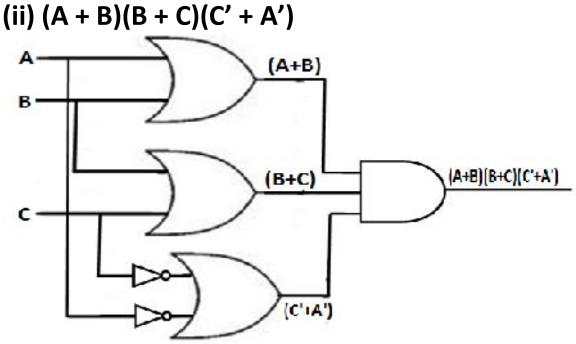
50. Draw logic circuit diagrams for the following :
(i) xy + xy' + x'z (ii) (A + B)(B + C)(C' + A') (iii) A'B + BC (iv) xyz + x'yz'

Ans.

(i) xy + xy' + x'z

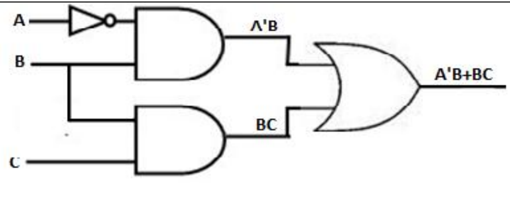


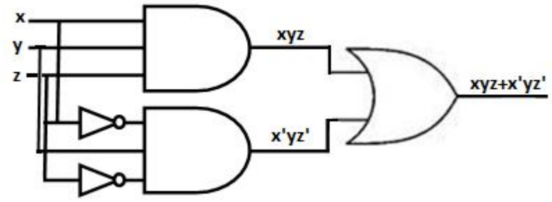
(ii) (A + B)(B + C)(C' + A')



(iii) A'B + BC

(iv) xyz + x'yz'





51. **Design a circuit (3 input) which gives a high input, when there is even number of low inputs.**

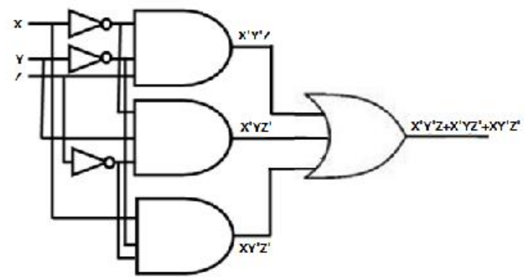
Ans. Following truth table gives a high input, when there is even number of low inputs :

X	Y	Z	F
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0

From truth table we get following function :

F = X’Y’Z + X’YZ’ + XY’Z’

Logic circuit for the function F is as following :



52. **Design a circuit (3 input) which gives a high input only when there is even number of low or high inputs.**

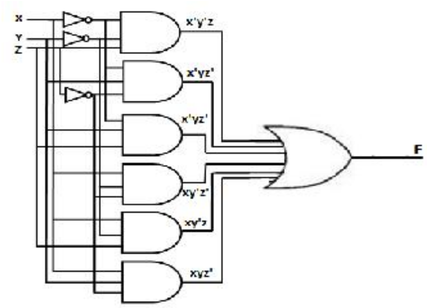
Ans. Following truth table gives a high input, only when there is even number of low or high inputs:

X	Y	Z	F
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0

From truth table we get following function :

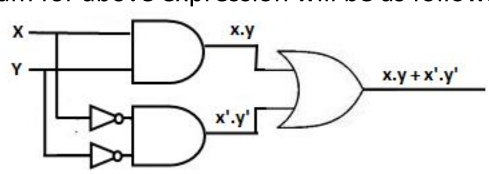
F = X’Y’Z + X’YZ’ + X’YZ + XY’Z’ + XY’Z + XYZ’

Logic circuit for the function F is as following :



53. **Design a logic circuit to realize the Boolean function f(x, y) = x . y + x’ . y’**

Ans. The circuit diagram for above expression will be as follows:

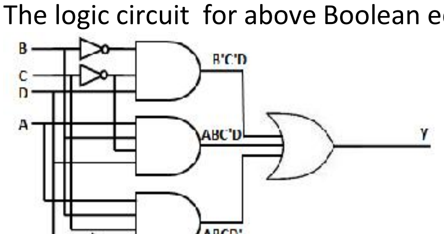


54. **Draw the logic circuit for this Boolean equation : y = A’B’C’D + AB’C’D + ABC’D + ABCD’**

Ans.

= A’B’C’D + AB’C’D + ABC’D + ABCD’
= B’C’D(A’+A) + ABC’D + ABCD’
= B’C’D + ABC’D + ABCD’

The logic circuit for above Boolean equation will be as follows:



55. **Draw logic circuit for the following using k-maps :**

(i) F(A, B, C, O) = ∑(1, 3, 5, 9, 10) **(ii) F(A, B, C) = π(0, 2, 4, 5)**

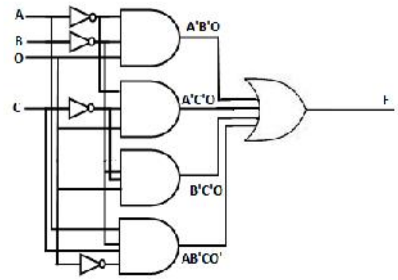
(iii) F(A, B, C) = ∑(1, 2, 4, 6, 7) **(iv) F(A, B, C) = π(1, 3, 5, 7)**

Ans. **(i) F(A, B, C, O) = ∑(1, 3, 5, 9, 10)**

AB \ CO	[00]C'O	[01]C'O	[11]CO	[10]CO'
[00]A'B'	0_{0}	1_{1}	1_{3}	0_{2}
[01]A'B	0_{4}	1_{5}	0_{7}	0_{6}
[11]AB	0_{12}	0_{13}	0_{15}	0_{14}
[10]AB'	0_{8}	1_{9}	0_{11}	1_{10}

There are three pairs that reduces as given below:
Pair-1($m_1 + m_3$) reduces to A'B'O
Pair-2($m_1 + m_5$) reduces to A'C'O
Pair-3($m_1 + m_9$) reduces to B'C'O
And single 1 in m_{10} is AB'CO'
Simplified Boolean expression for given K-map is
F(A,B,C,O) = A'B'O + A'C'O + B'C'O + AB'CO'

The logic circuit will be as follows:

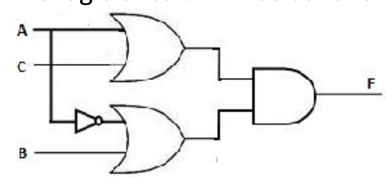


(ii) F(A, B, C) = π(0, 2, 4, 5)

A \ BC	[00]B+C	[01]B+C'	[11]B'+C'	[10]B'+C
[0]A	0_{0}	1_{1}	1_{3}	0_{2}
[1]A'	0_{4}	0_{5}	1_{7}	1_{6}

There are two pairs that reduces as given below:
Pair-1($M_0.M_2$) reduces to (A + C)
Pair-2($M_4.M_5$) reduces to (A' + B)
Simplified Boolean expression for given K-map is
F(A,B,C) = (A + C). (A' + B)

The logic circuit will be as follows:

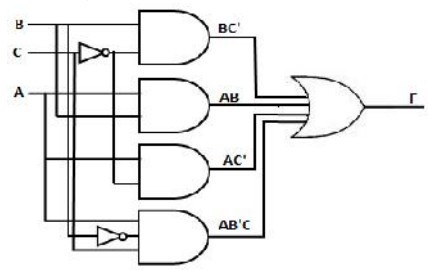


(iii) F(A, B, C) = ∑(1, 2, 4, 6, 7)

A \ BC	[00]B'C'	[01]B'C	[11]BC	[10]BC'
[0]A'	0_{0}	1_{1}	0_{3}	1_{2}
[1]A	1_{4}	0_{5}	1_{7}	1_{6}

There are three pairs that reduces as given below:
Pair-1($m_2 + m_6$) reduces to BC'
Pair-2($m_6 + m_7$) reduces to AB
Pair-2($m_4 + m_6$) reduces to AC'
And single 1's in m_1 is AB'C
Simplified Boolean expression for given K-map is
F(A,B,C) = BC' + AB + AC' + AB'C

The logic circuit will be as follows:

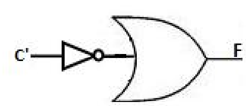


(iv) F(A, B, C) = π(1, 3, 5, 7)

A \ BC	[00]B+C	[01]B+C'	[11]B'+C'	[10]B'+C
[0]A	1_{0}	0_{1}	0_{3}	1_{2}
[1]A'	1_{4}	0_{5}	0_{7}	1_{6}

There is Quad that reduces as given below:
Pair-1($M_1.M_3.M_5.M_7$) reduces to C'
Simplified Boolean expression for given K-map is C'.

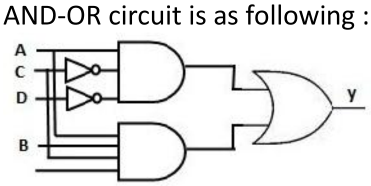
The logic circuit will be as follows:



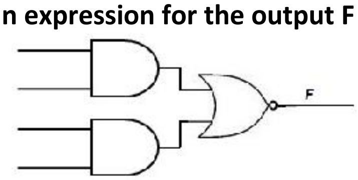
56. **Draw the AND-OR circuit for : y = AB'C'D' + ABC'D' + ABCD**

Ans. Reduced expression for given expression is as follows :
= AB'C'D' + ABC'D' + ABCD
= AC'D'(B' + B) + ABCD
= AC'D' + ABCD

AND-OR circuit is as following :



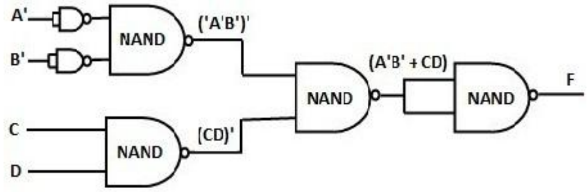
57. **Derive a Boolean expression for the output F at the network shown below :**



Ans. **Boolean expression for the output F is (A'B' + CD)'**

58. **Convert the above circuit into NAND-to-NAND logic circuit.**

Ans. The given Boolean expression can be written as
= (NOT((NOT A) NAND (NOT B)) NAND (C NAND D))



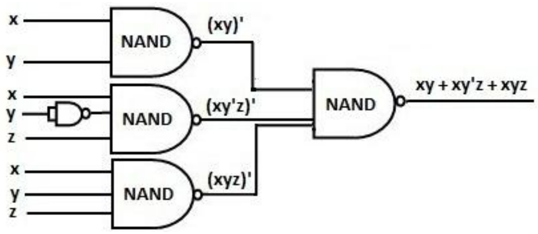
59. **Why are NAND and NOR gates more popular?**

Ans. NAND and NOR gates are more popular as these are less expensive and easier to design. Also other functions (NOT, AND, OR) can easily be implemented using NAND/NOR gates. Thus NAND, NOR gates are also referred to as Universal Gates.

60. **Draw the logical circuits for the following using NAND gates only :**
(i) xy + xy'z + xyz (ii) ABC + AB'C' + ABC

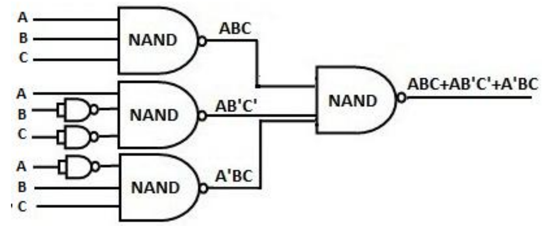
Ans. **(i) xy + xy'z + xyz**

The given Boolean expression can be written as
= (x NAND y) NAND (x NAND (NOT y) NAND z) NAND (x NAND y NAND z)



(ii) ABC + AB'C' + ABC

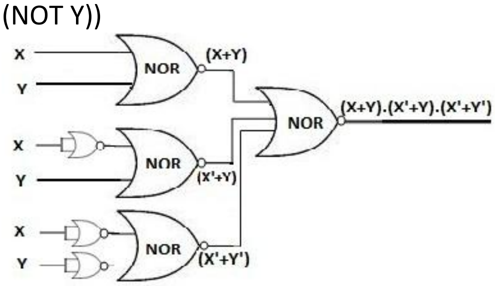
The given Boolean expression can be written as
= (A NAND B NAND C) NAND (A NAND (NOT B) NAND (NOT C)) NAND (A NAND B NAND C)



61. **Draw the logical circuits for the following using NOR gates only :**
(i)(X + Y) . (X'+ Y) . (X'+Y') (ii) (X + Y + Z) . (X + Y' +Z')

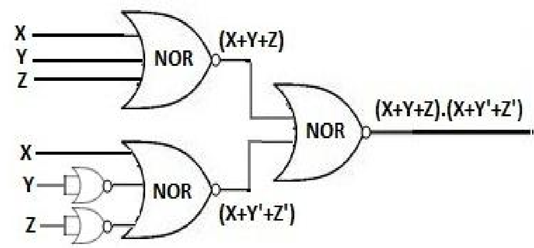
Ans. **(i)(X + Y) . (X'+ Y) . (X'+Y')**

The given Boolean expression can be written as
= (X NOR Y) NOR ((NOT X) NOR Y) NOR ((NOT X) NOR (NOT Y))



(ii) (X + Y + Z) . (X + Y' +Z')

The given Boolean expression can be written as
= (X NOR Y NOR Z) NOR (X NOR (NOT Y) NOR (NOT Z))



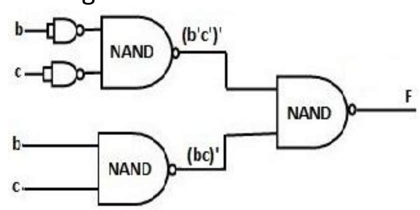
62. **Draw the logical circuit for the following function using NAND gates only F(a, b, c) = ∑(0, 3, 4, 7)**

Ans.

a \ bc	[00]b'c'	[01]b'c	[11]bc	[10]bc'
[0]a'	1 (0)	0 (1)	1 (3)	0 (2)
[1]a	1 (4)	0 (5)	1 (7)	0 (6)

There are two pairs that reduces as given below:
Pair-1(m_0 + m_4) reduces to b'c'
Pair-2(m_3 + m_7) reduces to bc
Simplified Boolean expression for given K-map is
F(A,B,C) = b'c' + bc

The logic circuit will be as follows:



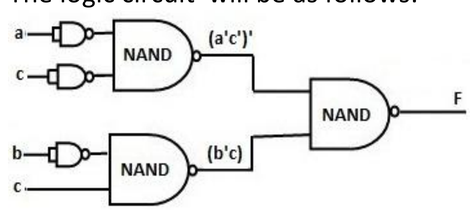
63. **Draw the simplified logic diagram using only NAND gates to implement the three input function F denoted by the expression : F = ∑(0, 1, 2, 5).**

Ans.

a \ bc	[00]b'c'	[01]b'c	[11]bc	[10]bc'
[0]a'	1 (0)	1 (1)	0 (3)	1 (2)
[1]a	0 (4)	1 (5)	0 (7)	0 (6)

There are two pairs that reduces as given below:
Pair-1(m_0 + m_2) reduces to a'c'
Pair-2(m_1 + m_5) reduces to b'c
Simplified Boolean expression for given K-map is
F(A,B,C) = a'c' + b'c

The logic circuit will be as follows:



64. **Give an example for each of the following :**

(i) a boolean expression in the sum of minterm form
(ii) a boolean expression in the non canonical form.

Ans. For a function F(X, Y, Z)

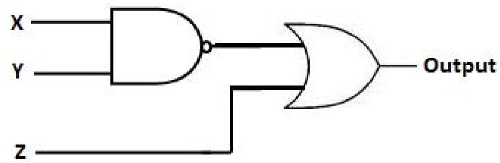
(i) Sum of minterms expression is

$$XYZ + \overline{X}\overline{Y}Z + X\overline{Y}Z + XY\overline{Z}$$

(ii) Non canonical form of Sum-of-products

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

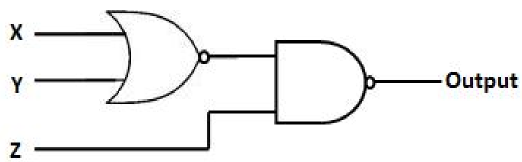
65. **What function is implemented by the circuit shown**



(a) x'y' + z (b) (x' + y')z (c) x'y'z (d) x' + y' + z (e) none of these

Ans. **(e) is correct answer**

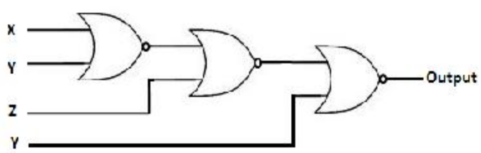
66. **What function is implemented by the circuit shown**



(a) x + y + z (b) x + y + z' (c) x'y'z (d) x' + y' + z' (e) none of these

Ans. **(b) is correct answer**

67. **What function is implemented by the circuit shown**

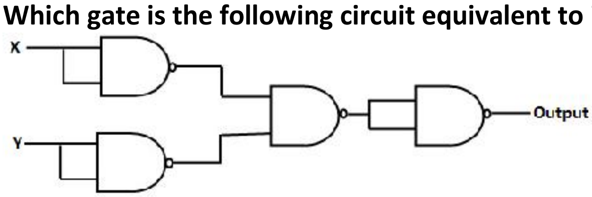


(a) xz' + y (b) xz + y (c) x'z + y' (d) x'y' + y'z' (e) x'y' + y'z

(e) is correct answer

Ans.

68. **Which gate is the following circuit equivalent to ?**



(a) AND (b) OR (c) NAND (d) NOR (e) None of these

Ans. **(c) is correct answer**

69. **Which of the following functions equals the function : f = x + yz'?**

(a)x(y' + z) (b) (y + x)(z' + x) (c) (y + x')(x' + z') (d) None of these

Ans. **(b) is correct answer**

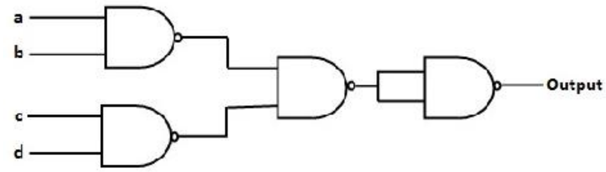
70. **Any possible binary logic function can be implemented using only.**

(a) AND (b) OR (c) NOT (d) AA (anyone is sufficient) (e) NAND

Ans. **Try by Yourself.**

71. **The function in the following circuit is:**

Ans.



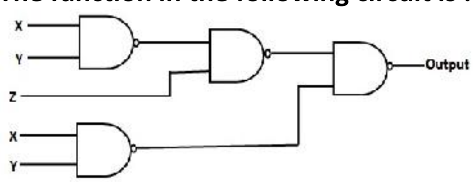
(a) abcd (b) ab + cd (c) (a + b)(c + d) (d) a + b + c + d (e) (a' + b')+(c' + d')

(e) is correct answer

72. **Given F = A'B + (C' + E)(D + F'), use de Morgan's theorem to find F'.**
(a) ACE' + BCE' + D'F (b) (A + B')(CE' + D'F) (c) A + B + CE'D'F
(d) ACE' + AD'F + B'CE' + B'CE' + B'D'F (e)NA

Ans. A'B + (C' + E)(D + F')= (A'B)' + ((C' + E)(D + F'))'
= (AB') + (C' + E)'(D + F')'
= (AB') + (C + E')(D' + F)
= (A + B')(CE' + D'F)
So , F' = (A + B')(CE' + D'F)

73. **The function in the following circuit is :**



(a) x' + y' + z' (b) x + y + z (c) x'z' + y'z' (d) xy + z (e) z

Ans. **(c) is correct.**

74. **Try Harder Simplify the following: {[(AB)'C]D]}'**
(a) (A' + B')C + D (b) (A + B')C' + D' (c) A' + (B' + C')D (d) A' + B' + C' + D' (e) A + B + C + D

Ans. **Try by Yourself.**

75. **Give the relationship that represents the dual of the Boolean property A + 1 = 1?**
[Note. * = AND, + = OR and ' = NOT]
(a) A . 1 = 1 (b) A . 0 = 0 (c) A + 0 = 0 (d) A . A = A (e) A . 1 = 1

Ans. The relationship that represents the dual of the Boolean property A + 1 = 1 is A . 0 = 0

76. **Simplify the Boolean expression (A + B + C)(D + E)' + (A + B + C)(D + E) and choose the best answer.**
(a) A + B + C (b) D + E (c) A'B'C' (d) D'E' (e) None of these

Ans. (A+B+C)(D+E)' + (A+B+C)(D+E)= (A+B+C)((D+E)+(D+E)') (Distributive Law)
= (A+B+C).(1) (X+X'=1)
= A+B+C
So, simplification of the Boolean expression (A + B + C)(D + E)' + (A + B + C)(D + E) yields A+B+C

77. **Which of the following relationship represents the dual of the Boolean property x + x'y = x + y?**
(a) x'(x + y) = x'y' (b) x(x'y) = xy (c) x * x' + y = xy (d) x'(xy') = x'y' (e) x(x' + y) = xy

Ans. The relationship x * x' + y = xy represents the dual of the Boolean property x + x'y = x + y

78. **Given the function F(X, Y, Z) = XZ + Z(X' + XY), the equivalent most simplified Boolean representation for F is :**
(a)Z + YZ (b) Z + XYZ (c) XZ (d) X + YZ (e) None of these

Ans. XZ + Z(X'+ XY)= XZ + X'Z + XYZ (distributive Law)
= Z(X+X') + XYZ (distributive Law)
= Z(1) + XYZ (Complementarity Law)
= Z+XYZ (Identity Law)
The equivalent most simplified Boolean representation for F is Z+XYZ

79. **Simplification of the Boolean expression (A + B)'(C + D + E)' + (A + B)' yields which of the following results?**
(a) A + B) (b) A'B' (c) C + D + E (d) C'D'E' (e) A'B'C'D'E'

Ans. (A + B)'(C + D + E)' + (A + B)'=(A+B)'((C+D+E)+1) (Distb. Law)
=(A+B)'.1 (Identity Law)
=(A+B)' (Identity Law)
=A'B' (DeMorgan's Law)
So, simplification of the Boolean expression (A + B)'(C + D + E)' + (A + B)' yields A'B

80. **Given that F = A'B' + C + D' + E', Which of the following represents the only correct expression for F'?**

(a) F’ = A + B + C + D + E (b) F’ = ABCDE (c) F’ = AB(C + D + E)
(d) F’ = AB + C’ + D’ + E’ (e) F’ = (A + B)CDE

Ans. F = A'B'+ C'+ D'+ E'
Taking complement on both sides:
F’ = (A'B'+ C'+ D'+ E')’
=(A’B’)’.(C’)’(D’)’(E’)’
=(A+B).C.D.E
So, (A + B)CDE represents correct expression for F’

81. An equivalent representation for the Boolean expression A’ + 1 is
(a) A (b) A’ (c) 1 (d) 0

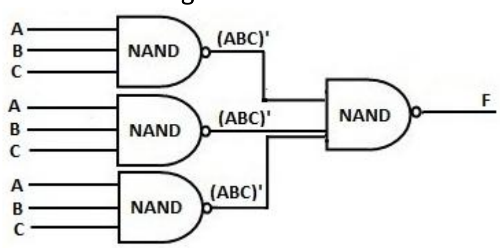
Ans. An equivalent representation for the Boolean expression A’ + 1 is 1

82. Simplification of the Boolean expression AB + ABCD + ABCDE + ABCDEF yields which of the following results?
(a)ABCDEF (b) AB (c) AB + CD + EF (d) A + B + C + D + E + F (e) A + B(C + D(E + F))

Ans. AB + ABC + ABCD + ABCDE + ABCDEF
=(AB +ABC) + (ABCD +ABCDE) + ABCDEF (Commutative Law Law)
=AB + ABCD +ABCDEF (Absorption Law)
=AB +(ABCD +ABCDEF) (Commutative Law Law)
=AB +ABCD (Absorption Law)
=AB
So, simplification of the Boolean expression AB + ABCD + ABCDE + ABCDEF yields AB

83. Given the following Boolean function F = A*BC* + A*BC + AB*C
(a) Develop an equivalent expression using only NAND operations, and the logic diagram.
(b) Develop an equivalent expression using only NOR operations, and the logic diagram.

Ans. **(a) Develop an equivalent expression using only NAND operations, and the logic diagram.**
The given Boolean expression can be written as
= (A NAND B NAND C) NAND (A NAND B NAND C) NAND (A NAND B NAND C)
The logic diagram is as following :



(b) Develop an equivalent expression using only NOR operations, and the logic diagram.
Try by Yourself.

84. For the logic function of F(A, B, C, D) = ∑(0, 1, 3, 4, 5, 7, 8, 10, 12, 14, 15).
(a) Show the truth table (b) Write the SOP form (c) Write the POS form (d) Simplify by K-map.

Ans. **(a)Show the truth table**
Truth table for the given function is as following :

A	B	C	D	F	Minterms	Maxterms
0	0	0	0	1	A’B’C’D’	A+B+C+D
0	0	0	1	1	A’B’C’D	A+B+C+D’
0	0	1	0		A’B’CD’	A+B+C’+D
0	0	1	1	1	A’B’CD	A+B+C’+D’
0	1	0	0	1	A’BC’D’	A+B’+C+D
0	1	0	1	1	A’BC’D	A+B’+C+D’
0	1	1	0		A’BCD’	A+B’+C’+D
0	1	1	1	1	A’BCD	A+B’+C’+D’
1	0	0	0	1	AB’C’D’	A’+B+C+D
1	0	0	1		AB’C’D	A’+B+C+D’
1	0	1	0	1	AB’CD’	A’+B+C’+D
1	0	1	1		AB’CD	A’+B+C’+D’
1	1	0	0	1	ABC’D’	A’+B’+C+D

1	1	0	1		ABC’D	A’+B’+C+D’
1	1	1	0	1	ABCD’	A’+B’+C’+D
1	1	1	1	1	ABCD	A’+B’+C’+D’

(b) Write the SOP form

Adding all the minterms for which output is 1, we get

A’B’C’D’ + A’B’C’D + A’B’CD + A’BC’D’ + A’BC’D + A’BCD + AB’C’D’ + AB’CD’ + ABC’D’ + ABCD’ + ABCD

This is desired Canonical Sum-of-Product form.

(c) Write the POS form

By multiplying Maxterms for the output 0s, we get

(A+B+C’+D)(A+B’+C’+D)(A’+B+C+D’)(A’+B+C’+D’)(A’+B’+C+D’)

This is desired Canonical Product-of-Sum form.

(d) Simplify by K-map

AB \ CD	[00]C'D'	[01]C'D	[11]CD	[10]CD'
[00]A'B'	1 $_0$	1 $_1$	1 $_3$	0 $_2$
[01]A'B	1 $_4$	1 $_5$	1 $_7$	0 $_6$
[11]AB	1 $_{12}$	0 $_{13}$	1 $_{15}$	1 $_{14}$
[10]AB'	1 $_8$	0 $_9$	0 $_{11}$	1 $_{10}$

Mapping the given function in a K-map, we get 2 pairs and 2 Quads.

Pair-1(m_{14} + m_{15}) reduces to ABC as D removed.

Pair-2(m_3 + m_7) reduces to ACD’ as B removed.

Quad-1(m_0 + m_4 + m_8 + m_{12}) reduces to C’D’ as A and B removed.

Quad-1(m_1 + m_3 + m_5 + m_7) reduces to A’D as B and C removed.

Simplified Boolean expression for given K-map is

F(A,B,C) = ABC + ACD’ + C’D’ + A’D

85. **(a) Implement the following Boolean expression using only NAND gates.**

F = (A’+ B +C’)(A + B)(A’ + C)

(b) Construction a NOR function by only NAND gates.

Ans. Try by Yourself.

TYPE C : LONG ANSWER QUESTION

1(a) **State and verify De Morgan’s law in Boolean Algebra.**

Ans. DeMorgan’s theorems state that (i) (X + Y)’= X’.Y’ (ii) (X.Y)’= X’ + Y’

(i) (X + Y)’= X’.Y’

Now to prove DeMorgan’s first theorem, we will use complementarity laws.

Let us assume that P = x + Y where, P, X, Y are logical variables. Then, according to complementation law

P + P’ =1 and P . P’= 0

That means, if P, X, Y are Boolean variables hen this complementarity law must hold for variables P. In other words, if P i.e., if (X + Y)’= X’.Y’then

(X + Y) + (XY)’must be equal to 1. (as X + X’= 1)

(X + Y) . (XY)’must be equal to 0. (as X . X’= 0)

Let us prove the first part, i.e.,

(X + Y) + (XY)’ = 1

(X + Y) + (XY)’= ((X + Y) +X’).((X + Y) +Y’) (ref. X + YZ = (X + Y)(X + Z))

= (X + X’+ Y).(X + Y +Y’)

= (1 + Y).(X + 1) (ref. X + X’=1)

= 1.1 (ref. 1 + X =1)

= 1

So first part is proved.

Now let us prove the second part i.e.,

(X + Y) . (XY)’= 0

(X + Y) . (XY)’ = (XY)’ . (X + Y) (ref. X(YZ) = (XY)Z)

= (XY)’X + (XY)’Y (ref. X(Y + Z) = XY + XZ)

= X(XY)’ + X’YY’

= 0 .Y + X’ . 0 (ref. X . X’=0)

= 0 + 0 = 0

So, second part is also proved, Thus: X + Y = X’ . Y’

(ii) (X.Y)’= X’ + Y’

Again to prove this theorem, we will make use of complementary law i.e.,

X + X’= 1 and X . X’= 0

If XY’s complement is X + Y then it must be true that

(a) XY + (X’+ Y’) = 1 and (b) XY(X’+ Y’) = 0

To prove the first part

L.H.S = XY + (X’+Y’)
= (X’+Y’) + XY (ref. X + Y = Y + X)
= (X’+Y’ + X).(X’+Y’ + Y) (ref. (X + Y)(X + Z) = X + YZ)
= (X + X’+Y’).(X’ + Y +Y’)
= (1 +Y’).(X’ + 1) (ref. X + X’=1)
= 1.1 (ref. 1 + X =1)
= 1 = R.H.S

Now the second part i.e.,

XY.($\overline{X} + \overline{Y}$) = 0
L.H.S = (XY)’.(X’+Y’)
= XYX’ + XYY’ (ref. X(Y + Z) = XY + XZ)
= XX’Y + XYY’
= 0.Y + X.0 (ref. X . X’=0)
= 0 + 0 = 0 = R.H.S.

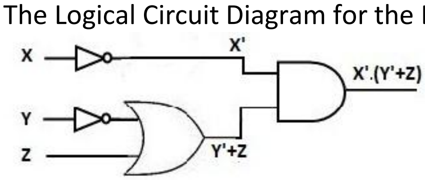
XY.(X’ + Y’)= 0 and XY + (X’ +Y’) = 1

(XY)’= X’ + Y’. Hence proved.

1(b). **Draw a Logical Circuit Diagram for the following Boolean Expression**

X’.(Y’ + Z)

Ans. The Logical Circuit Diagram for the Boolean Expression is as following:



1(c) **Convert the following Boolean expression into its equivalent Canonical Sum of Product Form (SOP).**

(X’ + Y + Z’).(X’ + Y + Z).(X’ + Y’ + Z’)

Ans. Given (X’ + Y + Z’).(X’ + Y + Z).(X’ + Y’ + Z’)

(1 + 0 + 1) (1 + 0 + 0) (1 + 1 + 1)

= $M_4.M_5.M_6.M_7$

= π(4, 5, 6, 7)

⇨ SOP is equal to(excluding position of minterms)

= ∑(0, 1, 2, 3)

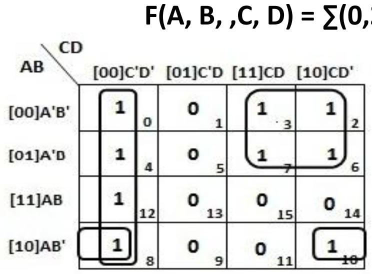
= $m_0 + m_1 + m_2 + m_3$

= X’Y’Z + X’Y’Z + X’YZ’ + X’YZ

1(d) **Reduce the following Boolean expression using K-map**

F(A, B, ,C, D) = ∑(0,2,3,4,5,6,7,8,10,12)

Ans.



There are 1 Pair and 2 Quads that reduce as given below:

Pair($m_8 + m_{10}$) reduces to AB’D’

Quad-1($m_0 + m_4 + m_{12} + m_8$) reduces to C’D’

Quad- 2($m_2 + m_3 + m_6 + m_7$) reduces to A’C

Simplified Boolean expression for given K-map is

F(A,B,C,D) = AB’D’ + C’D’ + A’C

2(a). **State De Morgan’s Theorems and verify the same using truth table.**

Ans. De Morgan’s First theorem. It states that (X+Y)’=X’.Y’

Truth Table for first theorem.

X	Y	X’	Y’	X+Y	(X+Y)’	X’.Y’
0	0	1	1	0	1	1
0	1	1	0	1	0	0

De Morgan’s Second theorem. It states that (X.Y)’=X’+Y’

Truth Table for second theorem.

X	Y	X’	Y’	X.Y	(X.Y)’	X’+Y’
0	0	1	1	0	1	1
0	1	1	0	0	1	1

1	0	0	1	1	0	0
1	1	0	0	1	0	0

From Truth Table it is proved that (X+Y)’ = X’.Y’

1	0	0	1	0	1	1
1	1	0	0	1	0	0

From Truth Table it is proved that (X.Y)’ = X’ + Y’

2(b). **Write the equivalent Canonical Product of Sum Expression for the following Sum of Product Expression : F(X, Y, Z) = $\sum(0, 2, 4, 5)$**

Ans. Given SOP expression : F(X, Y, Z) = $\sum(0, 2, 4, 5)$

Equivalent POS expression : $\pi(1, 3, 6, 7)$

Equivalent POS expression will be = $M_1.M_3.M_6.M_7$

M1 = (0 + 0 + 1)’S Maxterm = (X + Y + Z)

M3 = (0 + 1 + 1)’S Maxterm = (X + Y’ + Z’)

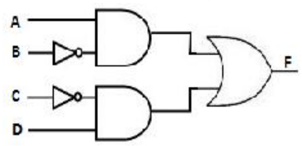
M6 = (1 + 1 + 0)’S Maxterm = (X’ + Y’ + Z)

M7 = (1 + 1 + 1)’S Maxterm = (X’ + Y’ + Z’)

∴ Equivalent POS will be

F(X, Y, Z) = (X + Y + Z). (X + Y’ + Z’). (X’ + Y’ + Z). (X’ + Y’ + Z’)

2(c). **Write the equivalent Boolean expression for the following Logic Circuit.**



Ans. The equivalent Boolean expression for the given Logic Circuit is: F = AB’ + C’D

2(d). **Reduce the following Boolean expression using K-map :**

F(A, B, C, D) = $\prod(5, 6, 7, 8, 9, 12, 13, 14, 15)$

Ans.

AB \ CD	[00]C+D	[01]C+D'	[11]C'+D'	[10]C'+D
[00]A+B	1 (0)	1 (1)	1 (3)	1 (2)
[01]A+B'	1 (4)	0 (5)	0 (7)	0 (6)
[11]A'+B'	0 (12)	0 (13)	0 (15)	0 (14)
[10]A'+B	0 (8)	0 (9)	1 (11)	1 (10)

There are 1 Pair and 2 Quads that reduce as given below:

Pair(M_5 . M_7) reduces to (A + B’ + D’)

Quad-1(M_6 . M_7 . M_{14} . M_{15}) reduces to (B’ + C’)

Quad- 2(M_8 . M_9. M_{12} . M_{13}) reduces to (A’ + C)

Simplified Boolean expression for given K-map is

F(A,B,C,D) = (A + B’ + D’). (B’ + C’). (A’ + C)

3(a). **State DeMorgan’s Laws. Verify them using truth tables.**

Ans. De Morgan’s First theorem. It states that (X+Y)’=X’.Y’

Truth Table for first theorem.

X	Y	X’	Y’	X+Y	(X+Y)’	X’.Y’
0	0	1	1	0	1	1
0	1	1	0	1	0	0
1	0	0	1	1	0	0
1	1	0	0	1	0	0

From Truth Table it is proved that (X+Y)’ = X’.Y’

De Morgan’s Second theorem. It states that (X.Y)’=X’+Y’

Truth Table for second theorem.

X	Y	X’	Y’	X.Y	(X.Y)’	X’+Y’
0	0	1	1	0	1	1
0	1	1	0	0	1	1
1	0	0	1	0	1	1
1	1	0	0	1	0	0

From Truth Table it is proved that (X.Y)’ = X’ + Y’

3(b). **Prove (A + B).(A’ + C)=(A + B + C).(A + B + C’).(A’ + B + C).(A’ + B’ + C) algebraically.**

Ans. RHS = (A + B + C).(A + B + C’).(A’ + B + C).(A’ + B’ + C)

= (A + B)(C + C’).(A’ + C)(B + B’)   (∵ C + C’=1, B + B’=1)

= (A + B).(A’ + C)

= LHS

3(c). **Obtain a simplified form for a Boolean expression :**

F(X, Y, Z, W) = $\sum(0, 1, 4, 5, 7, 8, 9, 12, 13, 15)$ using K-map method.

Ans.

XY \ ZW	[00]Z'W'	[01]Z'W	[11]ZW	[10]ZW'
[00]X'Y'	1 (0)	1 (1)	0 (3)	0 (2)
[01]X'Y	1 (4)	1 (5)	1 (7)	0 (6)
[11]XY	1 (12)	1 (13)	1 (15)	0 (14)
[10]XY'	1 (8)	1 (9)	0 (11)	0 (10)

There are 1 Pair and 1 Octet that reduce as given below:

Pair($m_7 + m_{15}$) reduces to YZW

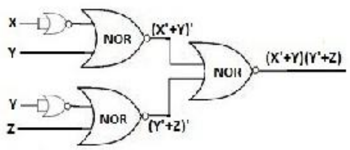
Octet($m_0 + m_1 + m_4 + m_5 + m_8 + m_9 + m_{12} + m_{13}$) reduces to Z’

Simplified Boolean expression for given K-map is

F(X,Y,Z,W) = YZW + Z’

3(d). **Draw the circuit diagram for the Boolean function F(X, Y, Z) = (X’ + Y)(Y’ + Z) using NOR gates only.**

Ans. **The circuit diagram for the given Boolean function is as following:**



3(e). **Express in the POS form, the Boolean function F(A, B, C), the truth table for which is given below :**

A	B	C	F
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

Ans. The desired Canonical Product-of-Sum form is as following;

F = π(0, 2, 4, 6) = (A + B + C)(A + B' + C)(A' + B + C)(A' + B' + C)

4(a). **State the distributive law. Verify the law using truth table.**

Ans. Distributive law state that (a) X(Y +Z) = XY + XZ (b) X + YZ = (X + Y)(X + Z)

(a) X(Y +Z) = XY + XZ

To prove this law, we will make a following truth table :

X	Y	Z	Y + Z	XY	XZ	X(Y + Z)	XY + XZ
0	0	0	0	0	0	0	0
0	0	1	1	0	0	0	0
0	1	0	1	0	0	0	0
0	1	1	1	0	0	0	0
1	0	0	0	0	0	0	0
1	0	1	1	0	1	1	1
1	1	0	1	1	0	1	1
1	1	1	1	1	1	1	1

From truth table it is prove that X(Y +Z) = XY + XZ

(b) X + YZ = (X + Y)(X + Z)

X	Y	Z	YZ	X + YZ	XZ	X + Y	X + Z	(X + Y)(X + Z)
0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	1	0
0	1	0	0	0	0	1	0	0
0	1	1	1	1	0	1	1	1
1	0	0	0	1	0	1	1	1
1	0	1	0	1	1	1	1	1
1	1	0	0	1	0	1	1	1
1	1	1	1	1	1	1	1	1

From truth table it is prove that X + YZ = (X + Y)(X + Z)

4(b). **Prove x + x'y = x + y algebraically.**

Ans. LHS = x + x'y

= (x + x')(x + y) (X + YZ = (X + Y)(X + Z) Distributive law)

= x + y (∵x + x' =1)

= RHS

4(c). **Write the dual of the Boolean expression (x + y).(x' + y')**

Ans. The dual of the given Boolean expression is xy + x'y'

4(d). **Minimize F(w, x, y, z) using Karnaugh map**

F(w, x, y, z) = ∑(0, 4, 8, 12)

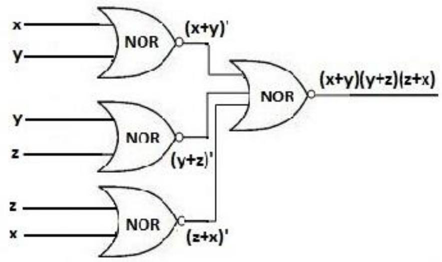
Ans.

wx \ yz	[00]y'z'	[01]y'z	[11]yz	[10]yz'
[00]w'x'	1 (0)	0 (1)	0 (3)	0 (2)
[01]w'x	1 (4)	0 (5)	0 (7)	0 (6)
[11]wx	1 (12)	0 (13)	0 (15)	0 (14)
[10]wx'	1 (8)	0 (9)	0 (11)	0 (10)

There is 1 Quad($m_0 + m_4 + m_8 + m_{12}$) that reduces to y'z'
Simplified Boolean expression for given K-map is
F(w, x, y, z) = y'z'

4(e). **Represent the Boolean expression (x + y)(y + z)(z + x) with the help of NOR gates only.**

Ans.



4(f). **Write sum of products form of function F(x, y, z). The truth table representation for the function F is given below :**

x	y	z	F
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

Ans. The desired Canonical Sum-of-Product form is as following;
F = ∑(2, 4, 7) = x'yz' + xy'z' + xyz

5(a). **State and prove DeMorgan's Theorem (Any One) algebracaly.**

Ans: DeMorgan's theorems state that (i) (X + Y)'= X'.Y' (ii) (X.Y)'= X' + Y'

(i) (X + Y)'= X'.Y'

Now to prove DeMorgan's first theorem, we will use complementarity laws.
Let us assume that P = x + Y where, P, X, Y are logical variables. Then, according to complementation law

P + P' =1 and P . P'= 0

That means, if P, X, Y are Boolean variables hen this complementarity law must hold for variables P. In other words, if P i.e., if (X + Y)'= X'.Y'then

(X + Y) + (XY)'must be equal to 1. (as X + X'= 1)
(X + Y) . (XY)'must be equal to 0. (as X . X'= 0)

Let us prove the first part, i.e.,

(X + Y) + (XY)' = 1
(X + Y) + (XY)'= ((X + Y) +X').((X + Y) +Y') (ref. X + YZ = (X + Y)(X + Z))
= (X + X'+ Y).(X + Y +Y')
= (1 + Y).(X + 1) (ref. X + X'=1)
= 1.1 (ref. 1 + X =1)
= 1

So first part is proved.
Now let us prove the second part i.e.,

(X + Y) . (XY)'= 0
(X + Y) . (XY)' = (XY)' . (X + Y) (ref. X(YZ) = (XY)Z)
= (XY)'X + (XY)'Y (ref. X(Y + Z) = XY + XZ)
= X(XY)' + X'YY'
= 0 .Y + X' . 0 (ref. X . X'=0)
= 0 + 0 = 0

So, second part is also proved, Thus: X + Y = X' . Y'

5(b). **Given the following truth table, driven a Sum of Product (SOP) and Product of Sum (POS) form of Boolean**

expression from it :

Ans.

X	Y	Z	G(X, Y, Z)
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

The desired Canonical Sum-of-Product form is as following;

$$G = \sum(1, 2, 5, 7) = X'Y'Z + X'YZ' + XY'Z + XYZ$$

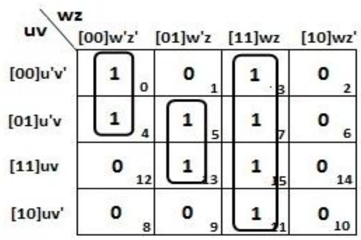
The desired Canonical Product-of-Sum form is as following;

$$G = \pi(0, 3, 4, 6) = (X + Y + Z)(X + Y' + Z')(X' + Y + Z)(X' + Y' + Z)$$

5(c). **Obtain a simplified form for the following Boolean Expression using Karnaugh's Map :**

$F(u, v, w, z) = \sum(0, 3, 4, 5, 7, 11, 13, 15)$.

Ans.



There are 2 Pairs and 1 Quad that reduce as given below:

Pair-1($m_0 + m_4$) reduces to u'w'z'

Pair-2($m_5 + m_{13}$) reduces to vw'z

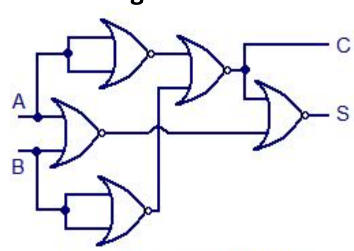
Quad($m_3 + m_7 + m_{11} + m_{15}$) reduces to wz

Simplified Boolean expression for given K-map is

$F(u, v, w, z) = u'w'z' + vw'z + wz$

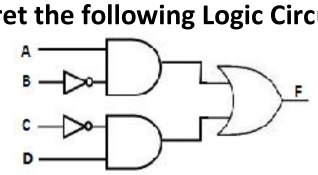
5(d). **Draw the logic circuit for a Half Adder using NOR gates only.**

Ans.



Half adder using NOR logic

5(e). **Interpret the following Logic Circuit as Boolean Expression :**



Ans. The equivalent Boolean expression for the given Logic Circuit is: $F = (W + X')(Y' + Z)$

6(a). **State DeMorgan's Laws. Verify one of the DeMorgan's laws using truth tables.**

Ans. De Morgan's First theorem. It states that $(X+Y)'=X'.Y'$

De Morgan's Second theorem. It states that $(X.Y)'=X'+Y'$

Truth Table for first theorem.

X	Y	X'	Y'	X+Y	(X+Y)'	X'.Y'
0	0	1	1	0	1	1
0	1	1	0	1	0	0
1	0	0	1	1	0	0
1	1	0	0	1	0	0

From Truth Table it is proved that $(X+Y)' = X'.Y'$

6(b). **Prove $X + Y'Z = (X + Y' + Z')(X + Y' + Z)(X + Y + Z)$ algebraically.**

Ans. Try by Yourself.

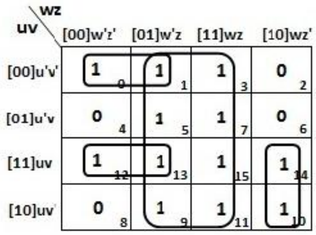
6(c). **Write the dual of the Boolean expression $(U + W)(V'U + W)$**

Ans. The dual of the given Boolean expression is $UW + (V' + U)W$

6(d). **Obtain a simplified form for a Boolean expression :**

$F(u, v, w, z) = \sum(0, 1, 3, 5, 7, 9, 10, 11, 12, 13, 14, 15($ using Karnaugh Map.

Ans.



There are 3 Pairs and 1 Octet that reduce as given below:

Pair-1($m_0 + m_1$) reduces to u'v'w'

Pair-2($m_{12} + m_{13}$) reduces to uvw'

Pair-3($m_{10} + m_{14}$) reduces to uwz'

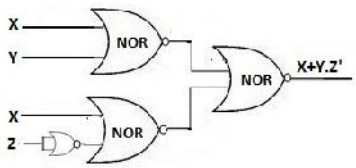
Octet($m_1 + m_3 + m_5 + m_7 + m_9 + m_{11} + m_{13} + m_{15}$) reduces to z

Simplified Boolean expression for given K-map is

F(u, v, w, z) = u'v'w' + uvw' + uwz' + z

6(e). **Represent the Boolean expression X + Y . Z' with the help of NOR gates only.**

Ans.



6(f). **Write the Product of Sum form of the function H(U, V, W), truth table representation of H is as follows :**

U	V	W	H
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

Ans. The desired Canonical Product-of-Sum form is as following;

H = π(1, 3, 4, 6) = (U + V + W')(U + V' + W')(U' + V + W')(U' + V' + W)

7(a). **State and prove the absorption law algebraically.**

Ans. Absorption law states that (i) X + XY = X and (ii) X(X + Y) = X

(i) X + XY = X

LHS = X + XY = X(1 + Y)

= X . 1 [∵ 1 + Y = 1]

= X = RHS. Hence proved.

(ii) X(X + Y) = X

LHS = X(X + Y) = X . X + XY

= X + XY

= X(1 + Y)

= X . 1

= X = RHS. Hence proved.

7(b). **Given the following truth table, derive a sum of product (SOP) and Product of Sum (POS) form of Boolean expression from it :**

A	B	C	G(A, B, C)
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

Ans. The desired Canonical Sum-of-Product form is as following;

G = ∑(1, 2, 5, 7) = A'B'C + A'BC' + AB'C + ABC

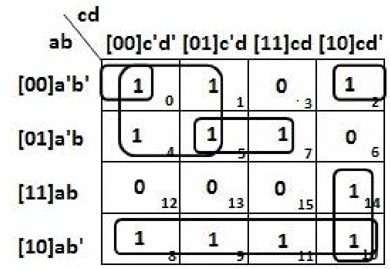
The desired Canonical Product-of-Sum form is as following;

G = π(0, 3, 4, 6) = (A + B + C)(A + B' + C')(A' + B + C)(A' + B' + C)

7(c). **Obtain a simplified form for the following Boolean Expression using Karnaugh's Map :**

F(a, b, c, d) = ∑(0, 1, 2, 4, 5, 7, 8, 9, 10, 11, 14)

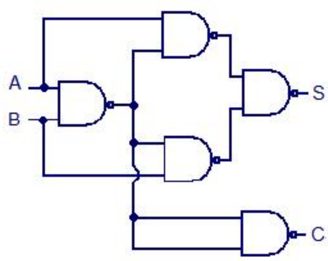
Ans.



There are 3 Pairs and 2 Quads that reduce as given below:
Pair-1($m_0 + m_2$) reduces to a'b'd'
Pair-2($m_5 + m_7$) reduces to a'b'd
Pair-3($m_{12} + m_{14}$) reduces to acd'
Quad-1($m_0 + m_1 + m_4 + m_5$) reduces to a'c'
Quad-2($m_8 + m_9 + m_{10} + m_{11}$) reduces to ab'
Simplified Boolean expression for given K-map is
F(a, b, c, d) = a'b'd' + a'b'd + acd' + a'c' + ab'

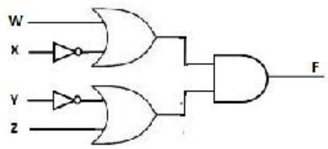
7(d). **Draw the logic circuit for a Half Adder using NAND gates only.**

Ans.



Half adder using NAND logic

7(e). **Interpret the following Logic Circuit as Boolean Expression :**



Ans. The equivalent Boolean expression for the given Logic Circuit is: F = (W + X').(Y' + Z)

8(a). **State Absorption Laws. Verify one of the Absorption Law using truth table.**

Ans. Absorption law states that (i) X + XY = X and (ii) X(X + Y) = X

Truth Table for X + XY = X

X	Y	XY	X + XY
0	0	0	0
0	1	0	0
1	0	0	1
1	1	1	1

From Truth Table it is proved that X + XY = X

8(b). **Verify X.Y' + Y'.Z = X.Y'.Z + X.Y'.Z' + X'.Y'.Z algebraically.**

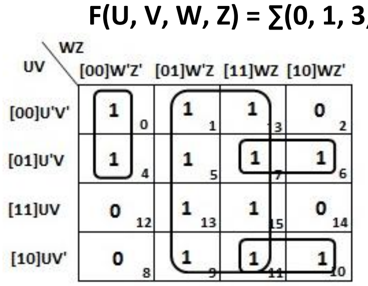
Ans. RHS = X.Y'.Z + X.Y'.Z' + X'.Y'.Z
= X.Y'(Z + Z') + X'.Y'.Z
= X.Y' + X'.Y'.Z
= X.Y' + Y'(X + X'.Z) (X + X' = 1)
= X.Y' + Y'.Z
= LHS

8(c). **Write the dual of the Boolean expression A + B' . C**

Ans. The dual of the given Boolean expression is A.(B' + C)

8(d). **Obtain a simplified form for a boolean expression**
F(U, V, W, Z) = ∑(0, 1, 3, 4, 5, 6, 7, 9, 10, 11, 13, 15) using Karnaugh Map.

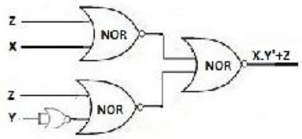
Ans.



There are 3 Pairs and 1 Octet that reduce as given below:
Pair-1($m_0 + m_4$) reduces to U'W'Z'
Pair-2($m_6 + m_7$) reduces to U'VW
Pair-3($m_{10} + m_{11}$) reduces to UV'W
Octet ($m_1 + m_3 + m_5 + m_7 + m_9 + m_{11} + m_{13} + m_{15}$) reduces to Z
Simplified Boolean expression for given K-map is
F(U, V, W, Z) = U'W'Z' + U'VW + UV'W + Z

8(e). **Represent the Boolean expression X . Y' + Z with the help of NOR gates only.**

Ans.



8(f). **Write the Product of Sum form of the function H(U, V, W), truth table representation of H is as follows :**

U	V	W	H
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	0

Ans. The desired Canonical Product-of-Sum form is as following;

H = π(2, 4, 6, 7) = (U + V' + W)(U' + V + W)(U' + V' + W)(U' + V' + W')

9(a). **State the distributive law and verify the law using truth table.**

Ans. Distributive law state that (a) X(Y +Z) = XY + XZ (b) X + YZ = (X + Y)(X + Z)

(a) X(Y +Z) = XY + XZ

To prove this law, we will make a following truth table :

X	Y	Z	Y + Z	XY	XZ	X(Y + Z)	XY + XZ
0	0	0	0	0	0	0	0
0	0	1	1	0	0	0	0
0	1	0	1	0	0	0	0
0	1	1	1	0	0	0	0
1	0	0	0	0	0	0	0
1	0	1	1	0	1	1	1
1	1	0	1	1	0	1	1
1	1	1	1	1	1	1	1

From truth table it is prove that X(Y +Z) = XY + XZ

(b) X + YZ = (X + Y)(X + Z)

X	Y	Z	YZ	X + YZ	XZ	X + Y	X + Z	(X + Y)(X + Z)
0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	1	0
0	1	0	0	0	0	1	0	0
0	1	1	1	1	0	1	1	1
1	0	0	0	1	0	1	1	1
1	0	1	0	1	1	1	1	1
1	1	0	0	1	0	1	1	1
1	1	1	1	1	1	1	1	1

From truth table it is prove that X + YZ = (X + Y)(X + Z)

9(b). **Prove XY + YZ + Y'Z = XY + Z, algebraically.**

Ans. LHS = XY + YZ + Y'Z

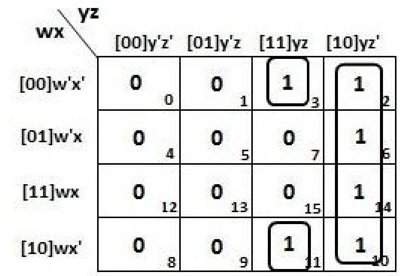
= XY + Z(Y + Y') (Y + Y' = 1)

= XY + Z

9(c). **Obtain the simplified form of a boolean expression using Karnaugh map "**

F(w, x, y, z) = ∑(2, 3, 6, 10, 11, 14)

Ans.

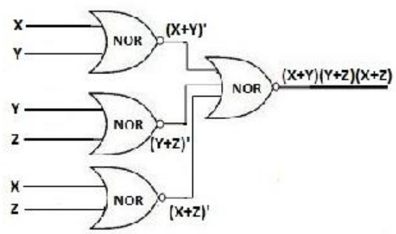


There are 1 Pair and 1 Quad that reduce as given below:
Pair ($m_3 + m_{11}$) reduces to x'yz
Quad ($m_2 + m_6 + m_{10} + m_{14}$) reduces to yz'
Simplified Boolean expression for given K-map is

F(w, x, y, z) = x'yz + yz'

9(d). **Represent the Boolean expression (X + Y)(Y + Z)(X + Z) with help of NOR gate only.**

Ans.



9(e). **Given the following truth table, write the products of sums form of the function F(x, y, z):**

x	y	z	F
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

Ans. The desired Canonical Product-of-Sum form is as following;

F = π(0, 3, 4, 6) = (x + y + z)(x + y' + z')(x' + y + z')(x' + y' + z)

10(a). **State and verify Duality principle.**

The principle of duality states that starting with a Boolean relation, another Boolean relation can be derived by :

1 .Changing each OR sign(+) to an AND sign(.).
2. Changing each AND sign(.) to an OR sign(+).
3. Replacing each 0 by 1 and each 1 by 0.

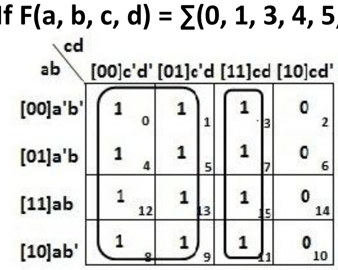
For example postulate II states (a) 0 + 0 = 0 (b) 0 + 1 = 1 (c) 1 + 0 = 1 (d) 1 + 1 = 1
Now according to principle of duality we changed '+' to '.' and 0 to 1.
These become (i) 1 . 1 = 1 (ii) 1 . 0 = 0 (iii) 0 . 1 = 0 (iv) 0 . 0 = 0 ,which are same as postulate III.
So i, ii, iii, iv are duals of a, b, c, d.

10(b). **Prove algebraically x'y'z' + x'y'z + x'yz + x'yz' + xy'z' + xy'z = x' + y'**

Ans. LHS = x'y'z' + x'y'z + x'yz + x'yz' + xy'z' + xy'z
= x'y'(z' + z) + x'y(z + z') + xy'(z' + z)   (z' + z = 1, z + z' = 1)
= x'y' + x'y + xy'
= x'(y' + y) + xy'
= x' + xy'   (y' + y = 1)
= x' + (x')'y'   (x = (x')')
= x' + y'   (a + a'b = a + b   x' + xy' = x' + y')
= RHS

10(c). **If F(a, b, c, d) = ∑(0, 1, 3, 4, 5, 7, 8, 9, 11, 12, 13, 15), obtain the simplified form using K-Map.**

Ans.



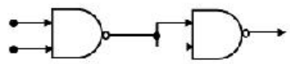
There are 1 Quad and 1 Octet that reduce as given below:
Pair ($m_3 + m_7 + m_{11} + m_{15}$) reduces to cd
Quad ($m_0 + m_1 + m_4 + m_5 + m_8 + m_9 + m_{12} + m_{13}$) reduces to c'
Simplified Boolean expression for given K-map is

F(a, b, c, d) = cd + c'

10(d). **Seven inverters are cascaded one after another. What is the output if the input is 1?**

Ans. 0

10(e). Given the following circuit :



What is the output if
(i) both inputs are FALSE
(ii) one is FALSE and the other is TRUE ?

Ans. (i) FALSE (ii) FALSE

11(a). State and verify Absorption law in Boolean Algebra.

Ans. Absorption law states that (i) X + XY = X and (ii) X(X + Y) = X

Truth Table for X + XY = X

X	Y	XY	X + XY
0	0	0	0
0	1	0	0
1	0	0	1
1	1	1	1

From Truth Table it is proved that X + XY = X

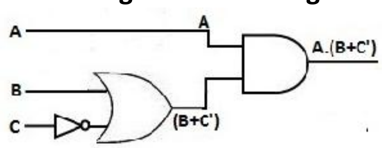
Truth Table for X(X + Y) = X

X	Y	X +Y	X(X + Y)
0	0	0	0
0	1	1	0
1	0	1	1
1	1	1	1

From Truth Table it is proved that X(X + Y) = X

11(b). Draw a Logical Circuit Diagram for the following Boolean Expression : A . (B + C')

Ans.



11(c). Convert the following Boolean expression into its equivalent Canonical Product of Sum Form(POS) :
A.B'.C + A'.B.C + A'.B.C'

Ans. **Given A.B'.C + A'.B.C + A'.B.C'**

(1 0 1) (0 1 1) (0 1 0)

= $m_5 + m_3 + m_2$

= ∑(2, 3, 5)

⇨ **POS is equal to (excluding positions of minterms)**

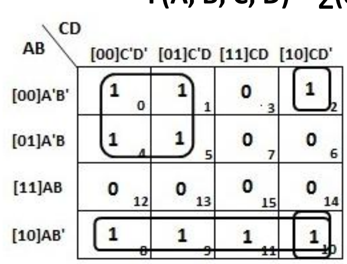
= π(0, 1, 4, 6, 7)

= $M_0.M_1.M_4.M_6.M_7$

= (A + B + C).(A + B + C').(A' + B + C).(A' + B' +C).(A' + B' + C')

11(d). Reduce the following Boolean expression using K-map:
F(A, B, C, D) = ∑(0, 1, 2, 4, 5, 8, 9, 10, 11)

Ans.



There are 1 Pair and 2 Quad that reduce as given below:
Pair ($m_2 + m_{10}$) reduces to B'CD'
Quad-1 (m_0+ m_1 + m_4 + m_5) reduces to A'C'
Quad-2 (m_0+ m_1 + m_4 + m_5) reduces to AB'
Simplified Boolean expression for given K-map is
F(A, B, C, D) = B'CD' +' A'C' + AB'

12(a). State and verify Distributive law in Boolean Algebra.

Ans. Distributive law state that (a) X(Y +Z) = XY + XZ (b) X + YZ = (X + Y)(X + Z)

(a) X(Y +Z) = XY + XZ

To prove this law, we will make a following truth table :

X	Y	Z	Y + Z	XY	XZ	X(Y + Z)	XY + XZ
0	0	0	0	0	0	0	0
0	0	1	1	0	0	0	0
0	1	0	1	0	0	0	0
0	1	1	1	0	0	0	0
1	0	0	0	0	0	0	0
1	0	1	1	0	1	1	1
1	1	0	1	1	0	1	1

1	1	1	1	1	1	1	1

From truth table it is prove that X(Y +Z) = XY + XZ

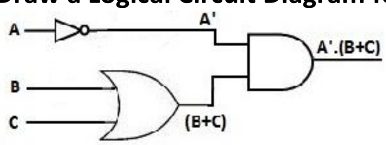
(b) X + YZ = (X + Y)(X + Z)

X	Y	Z	YZ	X + YZ	XZ	X + Y	X + Z	(X + Y)(X + Z)
0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	1	0
0	1	0	0	0	0	1	0	0
0	1	1	1	1	0	1	1	1
1	0	0	0	1	0	1	1	1
1	0	1	0	1	1	1	1	1
1	1	0	0	1	0	1	1	1
1	1	1	1	1	1	1	1	1

From truth table it is prove that X + YZ = (X + Y)(X + Z)

12(b). **Draw a Logical Circuit Diagram for the following Boolean Expression: A’.(B + C)**

Ans.



12(C). **Convert the following Boolean expression into its equivalent Canonical Sum of Product Form(SOP).**

(U’ + V’ + W’).(U + V’ + W’).(U + V + W)

Ans. Given (U’ + V’ + W’).(U + V’ + W’).(U + V + W)

(1 + 1 + 1) (0 + 1 + 1) (0 + 0 + 0)

$= M_0.M_3.M_7$

$= \pi(0, 3, 7)$

⇨ SOP is equal to(excluding position of Maxterms)

$= \sum(1, 2, 4, 5, 6)$

$= m_1 + m_2 + m_4 + m_5 + m_6$

= U’V’W + U’VW’ + UV’W’ + UV’W + UVW’

12(d). **Reduce the following Boolean expression using K-map:**

F(A, B, C, D) = ∑(0, 3, 4, 5, 7, 9, 11, 12, 13, 14)

Ans.

AB \ CD	[00]C'D'	[01]C'D	[11]CD	[10]CD'
[00]A'B'	0 (0)	1 (1)	1 (3)	0 (2)
[01]A'B	1 (4)	1 (5)	1 (7)	0 (6)
[11]AB	1 (12)	1 (13)	0 (15)	1 (14)
[10]AB'	0 (8)	1 (9)	1 (11)	0 (10)

There are 4 Pair and 1 Quad that reduce as given below:

Pair-1($m_4 + m_5$) reduces to A’BC’

Pair-2($m_7 + m_{13}$) reduces to A’CD

Pair-3($m_9 + m_{11}$) reduces to AB’D

Pair-4($m_{12} + m_{14}$) reduces to ABD’

Quad($m_1 + m_5 + m_9 + m_{13}$) reduces to C’D

Simplified Boolean expression for given K-map is

F(A, B, C, D) = A’BC’ +’ A’CD + AB’D + ABD’ + C’D

13(a). **Verify the following algebraically: X’.Y + X.Y’ = (X’ + Y’).(X + Y)**

Ans. RHS = (X’ + Y’).(X + Y)

= (X’ + Y’).X + (X’ + Y’).Y

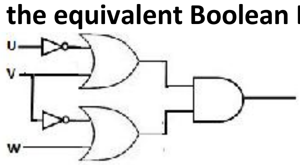
= X’.X + X.Y’ + X’.Y + Y’.Y

= 0 + X.Y’ + X’.Y + 0

= X.Y’ + X’.Y

= LHS (Verified)

13(b). **Write the equivalent Boolean Expression for the following Logic Circuit.**



Ans. The equivalent Boolean Expression for the given Logic Circuit is: F = (U’ + V).(V’ + W)

13(c). **Write the SOP form of a Boolean function G, which is represented in a truth table as follows:**

P	Q	R	G
0	0	0	0

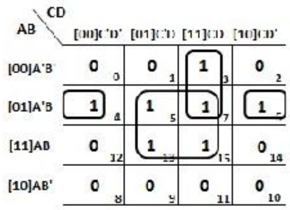
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	1

Ans. The desired Canonical Sum-of-Product form is as following;

G = ∑(2, 3, 4, 6, 7) = P’QR’ + P’QR + PQ’R’ + PQR’ + PQR

13(d). **Reduce the following Boolean expression using K-map: F(A, B, C, D) = ∑(3, 4, 5, 6, 7, 13, 15)**

Ans.



There are 2 Pair and 1 Quad that reduce as given below:

Pair-1(m_3 + m_7) reduces to A’CD

Pair-2(m_4 + m_7) reduces to A’BD’

Quad(m_1+ m_5 + m_9 + m_{13}) reduces to BD

Simplified Boolean expression for given K-map is

F(A, B, C, D) = A’CD +’ A’BD’ + BD

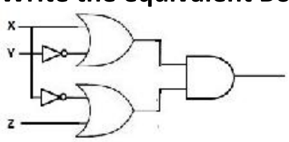
14(a). **Verify X’Y + XY’ + X’Y’ = (X’ + Y’) using truth table.**

Ans.

X	Y	X’	Y’	X’Y	XY’	X’Y’	X’Y + XY’ + X’Y’	X’ + Y’
0	0	1	1	0	0	1	1	1
0	1	1	0	1	0	0	1	1
1	0	0	1	0	1	0	1	1
1	1	0	0	0	0	0	0	0

From Truth Table it is proved that X’Y + XY’ + X’Y’ = (X’ + Y’)

14(b). **Write the equivalent Boolean Expression for the following Logic Circuit.**



Ans. The equivalent Boolean Expression for the given Logic Circuit is: F = (X + Y’).(X’ + Z)

14(c). **Write the POS form of a Boolean function H, which is represented in a truth table as follows:**

A	B	C	H
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

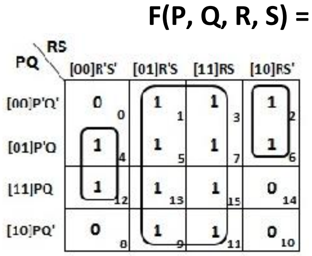
Ans. The desired Canonical Product-of-Sum form is as following;

H = π(0, 5, 6) = (A + B + C).(A’ + B + C’).(A’ + B’ + C)

14(d). **Reduce the following Boolean expression using K-map:**

F(P, Q, R, S) = ∑(1, 2, 3, 4, 5, 6, 7, 9, 11, 12, 13, 15)

Ans.



There are 2 Pair and 1 Octet that reduce as given below:

Pair-1(m_2 + m_6) reduces to QR’S’

Pair-2(m_4 + m_{12}) reduces to P’RS’

Octet (m_1+ m_3 + m_5 + m_7 + m_9+ m_{11} + m_{13} + m_{15}) reduces to S

Simplified Boolean expression for given K-map is

F(P, Q, R, S) = QR’S’ +’ P’RS’ + S

15(a). **State and verify absorption law using truth table.**

Ans. Absorption law states that (i) X + XY = X and (ii) X(X + Y) = X

Truth Table for X + XY = X

X	Y	XY	X + XY

Truth Table for X(X + Y) = X

X	Y	X +Y	X(X + Y)

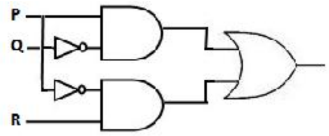
0	0	0	0
0	1	0	0
1	0	0	1
1	1	1	1

From Truth Table it is proved that X + XY = X

0	0	0	0
0	1	1	0
1	0	1	1
1	1	1	1

From Truth Table it is proved that X(X + Y) = X

15(b). Write the equivalent Boolean Expression for the following Logic Circuit.



Ans. The equivalent Boolean Expression for the given Logic Circuit is: F = PQ' + P'R

15(c). Write the POS form of a Boolean function H, which is represented in a truth table as follows:

U	V	W	G
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	1

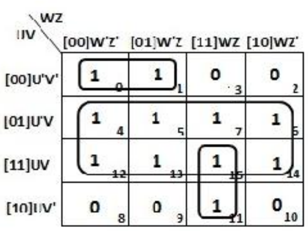
Ans. The desired Canonical Product-of-Sum form is as following;

G = π(2, 3, 6) = (U + V' + W).(U + V' + W').(U' + V' + W)

15(d). Reduce the following Boolean expression using K-map:

H(U, V, W, Z) = ∑(0, 1, 4, 5, 6, 7, 11, 12, 13, 14, 15)

Ans.



There are 2 Pair and 1 Octet that reduce as given below:

Pair-1(m_0 + m_1) reduces to U'V'W'

Pair-2(m_{11}+ m_{15}) reduces to UWZ

Octet (m_4+ m_5 + m_6 + m_7 + m_{12}+ m_{13} + m_{14} + m_{15}) reduces to V

Simplified Boolean expression for given K-map is

F(U, V, W, Z) = U'V'W' +' UWZ + V

NOTE: “ ‘ “ is used instead of“ ¯“ .