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UNIT II: Boolean Algebra and Karnaugh Maps (TUTORIAL SHEET)

Q1. Simplify the following Boolean expressions to minimum number of literals:

(a)* $xy + xy'$

(b)* $(x + y)(x + y')$

(c)* $xyz + x'y + xyz'$

(d)* $(A + B)'(A' + B')'$

(e) $(a + b + c')(a'b' + c)$

(f) $a'bc + abc' + abc + a'bc'$

Q2. Draw the logic diagrams to implement the original and minimized expression for Q1.

Q3. Find the dual and the complement of following expressions:

(a)* $xy' + x'y$

(b) $(a + c)(a + b')(a' + b + c')$

(c) $z + z'(v'w + xy)$

Q4. List the truth table of following functions:

(a)* $F = xy + xy' + y'z$

(b) $F = bc + a'c'$

Q5. Implement the Boolean function:

$$F = xy + x'y' + y'z$$

Using:

OR-AND implementation

AND-OR implementation

NAND implementation

NOR implementation

Q6. Obtain truth table for following values, and express each function in SOP and POS form:

(a)* $(b + cd)(c + bd)$

(b) $(cd + b'c + bd')(b + d)$

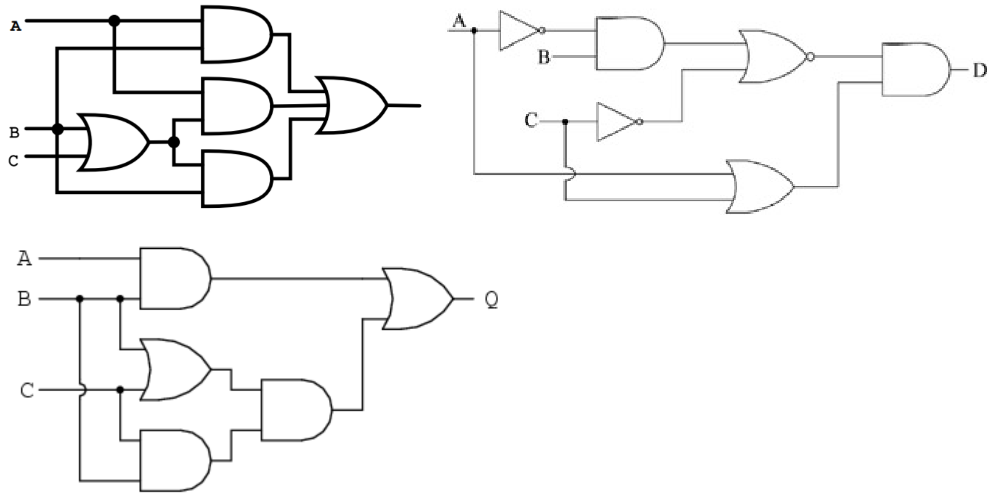
(c) $(c' + d)(b + c')$

(d) $bd' + acd' + ab'c + a'c'$

Q7. Show that the dual of exclusive-OR is equal to its complement.

Q8. Show that a positive logic NAND gate is a Negative logic NOR gate and vice-versa.

Q9: Obtain the Boolean expression and simplify the equation for the following Logic gates:



Q10. Simplify the following Boolean functions, using three variable K-map:

(a) $F(x, y, z) = \Sigma(0, 2, 4, 5)$ (b) $F(x, y, z) = \Sigma(0, 2, 4, 5, 6)$

(c) $F(x, y, z) = \Sigma(0, 1, 2, 3, 5)$ (d) $F(x, y, z) = \Sigma(1, 2, 3, 7)$

Q11. Simplify the following Boolean functions, using four variable K-map:

(a)* $F(w, x, y, z) = \Sigma(1, 4, 5, 6, 12, 14, 15)$

(b) $F(A, B, C, D) = \Sigma(2, 3, 6, 7, 12, 13, 14)$

(c) $F(w, x, y, z) = \Sigma(1, 3, 4, 5, 6, 7, 9, 11, 13, 15)$

(d)* $F(A, B, C, D) = \Sigma(0, 2, 4, 5, 6, 7, 8, 10, 13, 15)$

Q12. Simplify the following Boolean functions, using four variable K-map:

(a)* $A'B'C'D' + AC'D' + B'CD' + A'BCD + BC'D$

(b)* $x'z + w'xy' + w(x'y + xy')$

(c) $A'B'C'D + AB'D + A'BC' + ABCD + AB'C$

(d) $A'B'C'D' + BC'D + A'C'D + A'BCD + ACD'$

Q13. Find prime implicants of following functions, using K-map:

(a)* $F(w, x, y, z) = \Sigma(0, 2, 4, 5, 6, 7, 8, 10, 13, 15)$

(b)* $F(A, B, C, D) = \Sigma(0, 2, 3, 5, 7, 8, 10, 11, 14, 15)$

(c) $F(A, B, C, D) = \Sigma(2, 3, 4, 5, 6, 7, 9, 11, 12, 13)$

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Q14. Find essential prime implicants of following functions, using K-map:

(a) $F(w, x, y, z) = \Sigma(0, 2, 5, 7, 8, 10, 12, 13, 14, 15)$

(b) $F(A, B, C, D) = \Sigma(0, 2, 3, 5, 7, 8, 10, 11, 14, 15)$

(c)* $F(A, B, C, D) = \Sigma(1, 3, 4, 5, 10, 11, 12, 13, 14, 15)$

Q15. Find simplified expression using don't care conditions, using K-map:

(a) $F(x, y, z) = \Sigma(0, 1, 4, 5, 6)$
$d(x, y, z) = \Sigma(2, 3, 7)$

(b)* $F(A, B, C, D) = \Sigma(0, 6, 8, 13, 14)$
$d(A, B, C, D) = \Sigma(2, 4, 10)$

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BRAIN TEASERS:

Q16. A safe has 5 locks:v,w,x,y,all of which must be unlocked for the safe to open.?

The keys to the locks are distributed among ve executives in the following manner:

Mr. A has keys for locks v& x

Mr. B has keys for locks v& y

Mr. C has keys for locks w& y

Mr. D has keys for locks x& z

Mr. E has keys for locks v& z

i. Determine the minimal no. of executives required to open the safe.

ii. Find all the combinations of executives that can open the safe, write an expression f(A,B,C,D,E) which species when the safe can be opened as a function of which executives are present.

iii. Who is the `essential executive' without whom the safe cannot be opened.

Q17. You are presented with a set of requirements under which an insurance policy will be issued. The applicant must be:

a. A married female 25 years old or over, or
b. A female under 25, or
c. A married male under 25 who has not been involved in a car accident, or
d. A married male who has involved in a car accident, or
e. A married male 25 years or over who has not been involved in a car accident.

The variables w, x, y, and z assume the truth value 1 in the following cases:

- w = 1 if applicant has been involved in a car accident
- x = 1 if applicant is married
- y = 1 if applicant is a male
- z = 1 if applicant is under 25

You are asked to find an algebraic expression which assumes the value 1 whenever the policy should be issued. Simplify algebraically the above expression and suggest a simpler set of requirements. Finally design a logic circuit for the derived expression.

Q18. Five soldiers, A, B, C, D, and E, volunteer to perform an important military task if the following conditions are satisfied.

1. Either A or B or both must go.
2. Either C or E, but not both, must go.
3. Either both A and C go or neither goes.
4. If D goes then E must also go.
5. If B goes then A and D must also go.

Define variables A, B, C, D, E such that an unprimed variable will mean that the corresponding soldier has been selected to go. Determine the expression that specifies the combinations of volunteers that can get the assignment.

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UNIT II: Boolean Algebra and Karnaugh Maps (GATE PROBLEMS)

Q1. A function F(A, B, C) defined by three Boolean variables A, B and C when expressed as sum of products is given by

$$F = \overline{A}.\overline{B}.\overline{C} + \overline{A}.B.\overline{C} + A.\overline{B}.\overline{C}$$

The product of sums (POS) form of the function F is ______

Q2. For an n - variable Boolean function maximum number of prime implicants is

(a) 2n -1 (b) n/2 (c) 2^n (d) $2^{(n-1)}$ _____________

Q3. The Boolean expression $(X+Y)(X+\overline{Y})+((X\overline{Y}) + \overline{X}$ simplifies to

(a) X (b) Y (c) XY (d) X+Y

Q4. The Boolean function A + BC is a reduced form of

a. AB + BC
b. (A + B)(A + C)
c. A'B + AB'C
d. (A + C)B

Q5. For the identity, AB + A'C + BC = AB + A'C, the dual form is

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

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

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

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

Q6. The logical expression Y = A + A'B is equivalent to

a. AB
b. A'B
c. A' + B
d. A + B

Q7. The minimized form of the logical expression

$(\overline{A}\,\overline{B}\,\overline{C}+\overline{A}B\overline{C}+\overline{A}BC+AB\overline{C})$ is

(a) $\overline{A}\,\overline{C}+B\overline{C}+\overline{A}B$ (b) $A\overline{C}+\overline{B}C+\overline{A}B$

(c) $\overline{A}C+\overline{B}C+\overline{A}B$ (d) $A\overline{C}+\overline{B}C+A\overline{B}$

Q8. The number of distinct Boolean expressions of 4 variables is

a. 16
b. 256
c. 1024
d. 65536

Q9. The Boolean expression for the truth table shown is

A	B	C	f
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0

(a) $B(A+C)(\overline{A}+\overline{C})$

(b) $B(A+\overline{C})(\overline{A}+C)$

(c) $\overline{B}(A+\overline{C})(\overline{A}+C)$

(d) $\overline{B}(A+C)(\overline{A}+\overline{C})$

Q10. The Boolean function Y = AB + CD is to be realized using only 2 input NAND gates. The minimum number of gates required is

a. 2
b. 3
c. 4
d. 5

Q11. The Boolean expression simplifies to

$$(X+Y)(X+\overline{Y})+\overline{(X\overline{Y})+\overline{X}}$$

(A) X (B) Y

(C) XY (D) X+Y

Q12. For the given Boolean function, which one of the following is the complete set of essential prime implicants?

$$F(w,x,y,z) = wy + xy + \overline{w}xyz + \overline{w}\overline{x}y + xz + \overline{x}\overline{y}\overline{z}.$$

(A) $w, y, xz, \overline{x}\overline{z}$ (B) w, y, xz

(C) $y, \overline{x}\overline{y}\overline{z}$ (D) $y, xz, \overline{x}\overline{z}$

Q13. What is the minimal form of the Karnaugh map shown below? Assume that X denotes a don't care term.

cd \ ab	00	01	11	10
00	1	x	x	1
01	x			1
11				
10	1			x

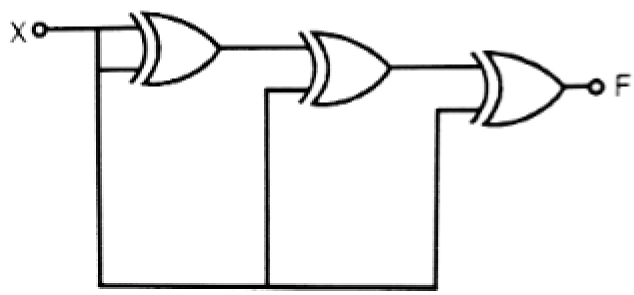
(A) b'd'

(B) b'd' + b'c'

(C) b'd' + a'b'c'd'

(D) b'd' + b'c' + c'd'

Q14. For the circuit shown below, the output F is given by



(a) F = 1 (b) F = 0

(c) F = X (d) F = $\bar{X}$

Q15. Minimum number of 2 input NAND gates required to implement the function given below is

Ans=B

$$F = (\bar{X} + \bar{Y})(Z + W)$$

(a) 3 (b) 4 (c) 5 (d) 6

Q16. Boolean expression for the output of XNOR logic gate with inputs A and B is

a. AB' + A'B
b. (AB)' + AB
c. (A' + B)(A + B')
d. (A' + B')(A + B)

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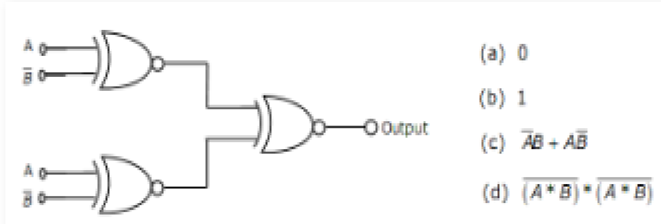
Q17. The output of the circuit shown in figure is equal to



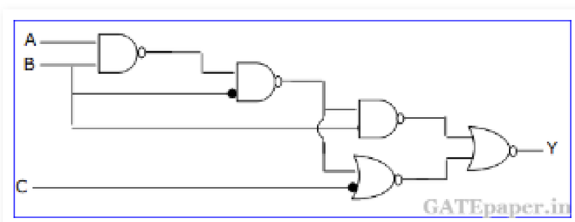
Q18. The minimum number of NAND gates required to implement the Boolean function $A + AB' + AB'C$ is equal to

a. Zero
b. 1
c. 4
d. 7

Q19. The minimum number of 2 input NAND gates required to implement the Boolean function $Z = AB'C$, assuming that A, B and C are available, is

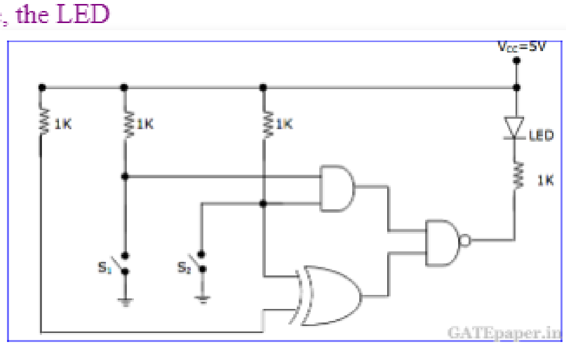
a. Two
b. Three
c. Five
d. Six

Q20. For the logic circuit shown, the simplified Boolean expression for the output Y is



a. $A + B + C$
b. A
c. B
d. C

Q21. In the figure, the LED



a. Emits light when both S_1 and S_2 are closed.
b. Emits light when both S_1 and S_2 are open.
c. Emits light when only of S_1 or S_2 is closed.
d. Does not emit light, irrespective of the switch positions.