Digital Logic

The Gatebook

May 2018

1 Boolean Algebra

1. When a 2-input NAND gate has all its input lines and output line inverted, it becomes:
   (A) AND gate
   (B) OR gate
   (C) EXOR gate
   (D) NOR gate

2. Which of the following statements is/are true?
   (A) AND gate resembles switches in parallel while OR gate resembles switches in series connection.
   (B) AND gate resembles switches in series while OR gate resembles switches in parallel connection.
   (C) AND gate resembles switches in series while NOR gate resembles switches in parallel connection.
   (D) AND gate resembles switches in parallel while NOR gate resembles switches in series connection.

3. Simplify following boolean expressions:

   (i) $a(a+\overline{b}+c+d+\overline{e}+\overline{f})$

   (ii) $\overline{(\overline{a}+b)(\overline{a}+)}c$

   (iii) $\overline{a}(\overline{a\overline{b}+\overline{(a+c)}})$

   (iv) $\overline{\overline{(a+d)}+\overline{(\overline{b}+c)}}$

   (v) $\overline{\overline{a.b.\overline{c}}+\overline{\overline{c}.d}}$

   (vi) $\overline{\overline{a}+d}.\overline{b+\overline{c}}.\overline{\overline{c}+d}$

4. When all inputs to a logic circuit are low, still the output is high, then the gate can be:
   (A) either Ex-NOR or Ex-OR
   (B) either Ex-OR or NAND
   (C) either Ex-NOR or NAND
   (D) either Ex-OR or NOT

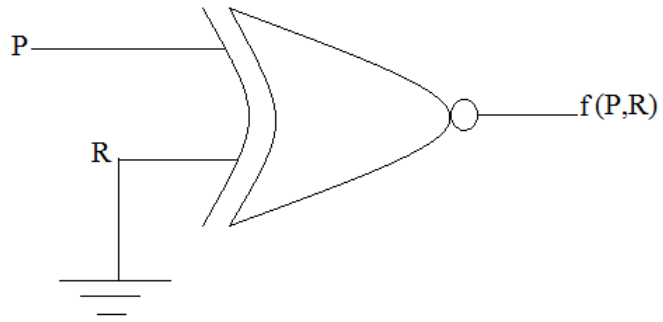
5. The minimum number of NOR gates required to realize this Boolean function is:
   $\overline{A}B + \overline{A}CDB + A\overline{C}B + ABC$
   (A) 3
   (B) 4
   (C) 2
   (D) None of the above

6. The number of Boolean functions that can be generated by n variables is represented by F. F is equal to:
   (A) $2^{2^{n-1}}$
   (B) 2^n
   (C) $2^{\frac{n}{2}}$
   (D) 2^{n^2}
   (E) $2^{2^{log_2 2^n}}$

7. Boolean expression for the output of Ex-NOR with input A and B is:
   (A) $(A\overline{B} + \overline{A}B)$
   (B) $(\overline{A\overline{B}} + AB)$
   (C) $(\overline{A} + B)(A + \overline{B})$
   (D) $(\overline{A} + \overline{B})(A + B)$

8. For an n-variable boolean function the maximum number of prime implicants is:
   (A) 2^{n-1}
   (B) $\frac{n}{2}$
   (C) $2n$
   (D) 2^n

9. The output of following logic gate is:



(A) R
(B) P
(C) 0
(D) $\overline{R}$
(E) None of the above

10. Minimum number of NOR gates required to realize following Boolean function is:
$f(A, B, C) = AB + \overline{C}$
(A) 3
(B) 4
(C) 5
(D) 6
(E) None of the above

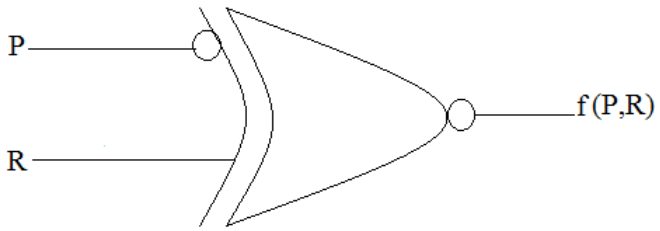
11. In Boolean algebra $X.X.X$ is equivalent to:
(A) $3X$
(B) X^3
(C) X
(D) $\overline{X}$

12. The number of minterms in an expression for n-input Ex-NOR gate can be given by:
(A) $2^{\frac{n^2}{2}}$
(B) $\frac{2^n}{2}$
(C) $\frac{n^2}{2}$
(D) n

13. The simplified SOP (Sum Of Product) form of the Boolean expression (P + Q' + R') . (P + Q' + R) . (P + Q + R') is:
(A) (P'.Q + R')

(B) (P + Q'.R')
(C) (P'.Q + R)
(D) (P.Q + R)

14. A logic gate is shown below:



What logic gate does it resemble?
(A) NOR gate
(B) NAND gate
(C) EXNOR gate
(D) EXOR gate

15. Which of the following expression represents the Boolean function shown in k-map below:

A	B	f(A,B)
0	0	1
0	1	D
1	0	1
1	1	D

(A) OR gate
(B) AND gate
(C) $\overline{B}$
(D) 1

16. Given the following truth table, write the expressions for F1 and F2, simplify each expression, and draw one circuit to implement both functions with only two input AND, OR and NOT gates.

w	x	y	z	F_1	F_2
0	0	0	0	0	0
0	0	0	1	1	1
0	0	1	0	0	0
0	0	1	1	1	1
0	1	0	0	0	0
0	1	0	1	0	0
0	1	1	0	0	0
0	1	1	1	0	0
1	0	0	0	0	0
1	0	0	1	1	0
1	0	1	0	0	0
1	0	1	1	1	0
1	1	0	0	1	1
1	1	0	1	1	1
1	1	1	0	1	1
1	1	1	1	1	1

17. Consider the K-map shown below.

AB \ CD	00	01	11	10
00		1		
01		1	1	1
11	1	1	1	
10			1	

Which or the following represents the number of Essential Prime implicants in the K-map shown above:
(A) 1
(B) 2
(C) 3
(D) 4
(E) 5
(F) 6

18. The K-map for a Boolean function is shown in figure. The number of essential prime implicants and implicants for this function is:

WX \ YZ	00	01	11	10
00	1		1	1
01	1			
11				1
10	1	1		1

(A) 1,5
(B) 2,5
(C) 3,6
(D) 4,8
(E) 5,8
(F) 6,6

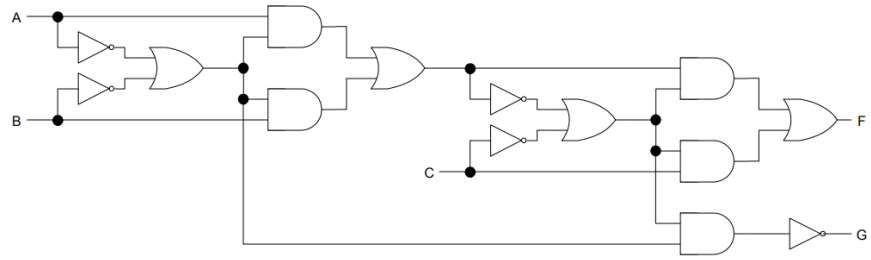
19. The products terms in the minimized sum-of-product expression obtained through the following K-map contain following number of literals in total, (where, "D" denotes don't care states):

1	0	0	1
0	d	0	0
0	0	d	1
1	0	0	1

(A) 1
(B) 2
(C) 3
(D) 4

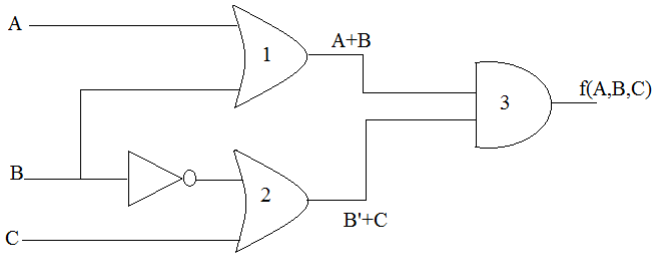
(E) 5

20. Convert the following logic diagram shown below to
(i) a NAND logic diagram
(ii) a NOR logic diagram



21. Consider a Boolean function $f(a,b,c,d) = \sum m\{0,1,2,6,8,9,10,13,14,15\}$. Which of the following Boolean expressions represents $f(a,b,c,d)$ without having any static-1 hazard?
(A) $\overline{b}.\overline{c} + abd + c\overline{d}$
(B) $\overline{a}.\overline{b}.\overline{c} + a\overline{b}.\overline{c} + abd + c\overline{d} + a\overline{c}d$
(C) $\overline{b}.\overline{c} + abd + c\overline{d} + a\overline{c}d + abc$
(D) $\overline{b}.\overline{c} + abd + a\overline{b}.\overline{d} + c\overline{d} + a\overline{c}d + abc + \overline{a}.\overline{b}.\overline{d}$
(E) $\overline{b}.\overline{c} + abd + c\overline{d} + a\overline{c}d + \overline{b}.\overline{d} + abc$

22. Consider a logic circuit shown below.



hazard circuit.png
Answer the folowing questions:
(i) Is there any static hazard?
(ii) If yes what is its type,i.e. static-0 or static-1 hazard?
(iii) Write a Boolean expression representing $f(a,b,c,d)$ without having any static hazard?
(iv) Is there any other type of hazard other than static hazard in this digital circuit?

23. Simplify each of the statements below using boolean laws and identities.

(i) $(A+B)(A+C)(\overline{A}+\overline{B})$
(ii) $F(E+F+G)$
(iii) $(AB+\overline{A}B+A\overline{B}+\overline{AB})$
(iv) $(A+B)(\overline{A}+\overline{B})$
(v) $(B+\overline{C}+\overline{A}B)(BC+A\overline{B}+AC)$
(vi) $(AB+A\overline{B})$
(vii) $(\overline{A}BC+AC)$
(viii) $\overline{(AB+\overline{A}B+BC)}$
(ix) $\overline{(AB+\overline{A}C+B\overline{C})}$
(x) $\overline{(A+B+C)}D+AD+B$

24. Logical Ex-OR operation is equivalent to which of the following set operation?
(A) Union
(B) Intersection
(C) Set difference
(D) Symmetric set difference
(E) Symmetric Division

25. Prove/disprove following identities:
(I) $(AB\overline{C}+B\overline{C}.\overline{D}+BC+\overline{C}D)=(B+\overline{C}D)$
(ii) $(WY+\overline{W}Y\overline{Z}+WXZ+\overline{W}X\overline{Y})=(WY+\overline{W}X\overline{Z}+\overline{X}Y\overline{Z}+X\overline{Y}Z)$
(iii) $(A\overline{D}+\overline{A}B+\overline{C}D+\overline{B}C)=(\overline{A}+\overline{B}+\overline{C}+\overline{D})(A+B+C+D)$

26. Simplify the following Boolean expressions to expressions containing a minimum number of literals:
(i) $\overline{A\overline{C}+\overline{A}BC+\overline{B}C}$
(ii) $\overline{(A+B+C).(abc)}$
(iii) $(\overline{A.\overline{B}.D+\overline{A}.\overline{C}.D+BD})$
(IV) $\overline{(\overline{A}+B).\overline{A}+\overline{C}}+\overline{A.\overline{B}.C}$

27. Which of the following is not equivalent to following Boolean expression:
$\overline{D}+(\overline{A}B\overline{C}+A\overline{B}.\overline{C})D+AC\overline{D}+\overline{(\overline{A}\oplus 0).A}$

(A) D
(B) $\overline{D}$
(C) 0
(D) $(B+\overline{B})$

28. Minimum number of two input NAND gates required to implement the function, $F = (\overline{A} + \overline{B}).(C + D)$, is:
(A) 2
(B) 3
(C) 4
(D) 5
(E) 6

29. The number of min-terms after minimizing the following Boolean expression is:
$[D' + AB' + A'C + AC'D + A'C'D]'$
(A) 1
(B) 2
(C) 3
(D) 4

30. Consider the following Boolean expression for F:
F(P, Q, R, S) = PQ + P'QR + P'QR'S
The minimal sum-of-products form of F is
(A) PQ + QR + QS
(B) P + Q + R + S
(C) P' + Q' + R' + S'
(D) P'R + P'R'S + P

31. Consider the operations f(X, Y, Z) = X'YZ + XY' + Y'Z' and g(X', Y, Z) = X'YZ + X'YZ' + XY Which one of the following is correct?
(A) Both f and g are functionally complete
(B) Only f is functionally complete
(C) Only g is functionally complete
(D) Neither f nor g is functionally complete

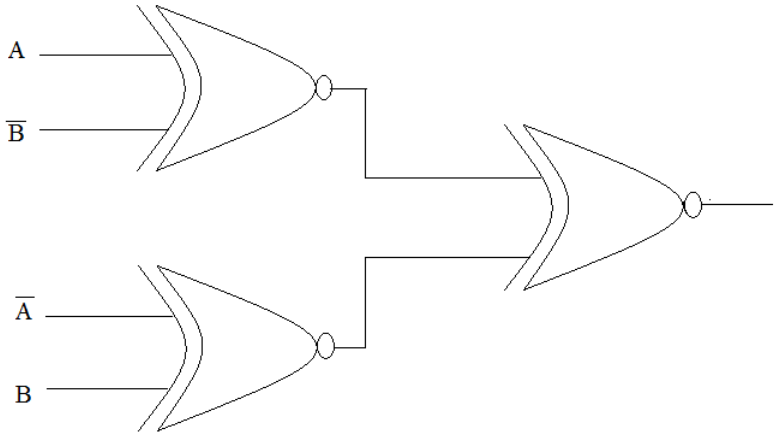
32. Given the function F = P' + QR, where F is a function in three Boolean variables P, Q and R and P' = !P, consider the following statements.
S1: F = $\sum$ (4, 5, 6)
S2: F = $\sum$ (0, 1, 2, 3, 7)
S3: F = $\prod$ (4, 5, 6)
S4: F = $\prod$ (0, 1, 2, 3, 7)
Which of the following is true?
(A) S1-False, S2-True, S3-True, S4-False
(B) S1-True, S2-False, S3-False, S4-True
(C) S1-False, S2-False, S3-True, S4-True
(D) S1-True, S2-True, S3-False, S4-False

33. Let f(A, B) = A' + B. Simplified expression for function f(f(x + y, y)z) is :
(A) x' + z
(B) xyz
(C) xy' + z
(D) None of the above

34. Define the connective * for the Boolean variables X and Y as: X * Y = XY + X' Y'. Let Z = X * Y.
Consider the following expressions P, Q and R.
P: X = Y*Z
Q: Y = X*Z
R: X*Y*Z=1
Which of the following is TRUE?
(A) Only P and Q are valid
(B) Only Q and R are valid.
(C) Only P and R are valid.
(D) All P, Q, R are valid.

35. A Boolean function f of two variables X and Y is defined as follows:
f(0, 0) = f(0, 1) = f(1, 0) = 1; f(1, 1) = 0
Assuming complements of X and Y are not available, a minimum cost solution for realizing using only 2-input NOR gates and 2-input OR gates (each having unit cost) would have a total cost of:
(A) 1 unit
(B) 2 unit
(C) 3 unit
(D) 4 unit
(E) 5 unit

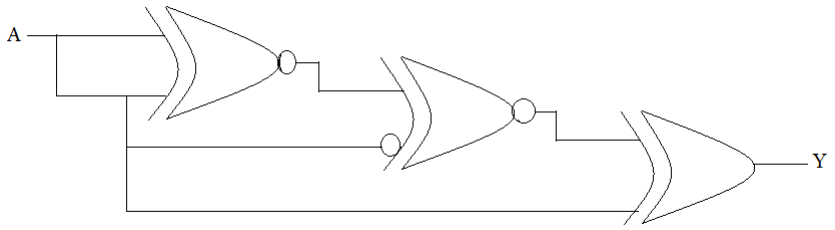
36. The output of the circuit shown is equal to:



(A) $\overline{A}B + A\overline{B}$
(B) 0
(C) 1
(D) $(\overline{A \oplus B}) \oplus (A \oplus B)$

37. If $X = 1$, in the given logic expression shown below:
$(X + Z\{\overline{Y} + (\overline{Z} + X\overline{Y}))(\overline{X} + \overline{Z}(X + Y))\} = 1$,
then which of the following statements is true:
(A) $Y = \overline{Z}$
(B) $Y = Z$
(C) $Z = 0$
(D) $Z = 1$

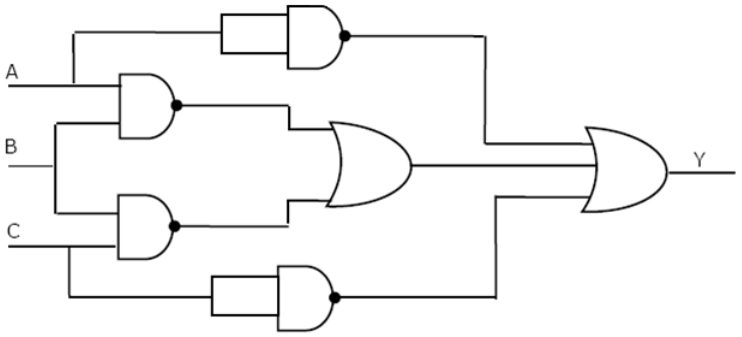
38. For the circuit shown below, output Y can be represented by:



(A) $\overline{A}$
(B) 0
(C) 1
(D) A

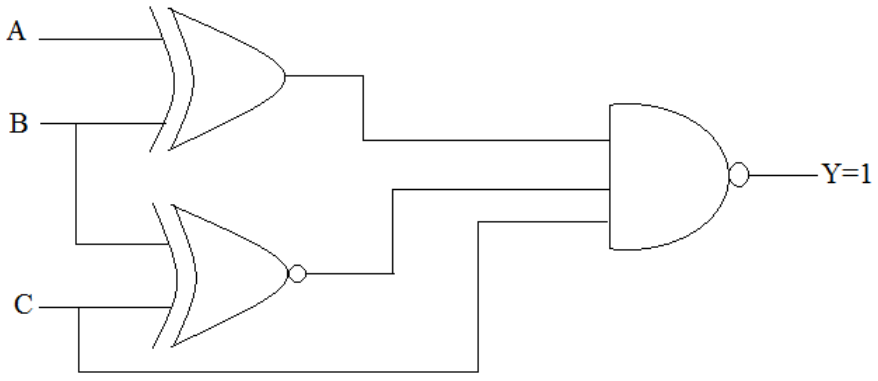
39. The boolean expression $AC + B\overline{C}$ is equivalent to:
(A) $AC + \overline{A}C + B\overline{C}$
(B) $AC + \overline{B}C + B\overline{C} + \overline{A}.\overline{B}C$
(C) $AC + B\overline{C} + \overline{B}C + ABC$
(D) $ABC + \overline{A}B\overline{C} + AB\overline{C} + A\overline{B}C$

40. For the circuit shown below, output Y can be represented by:



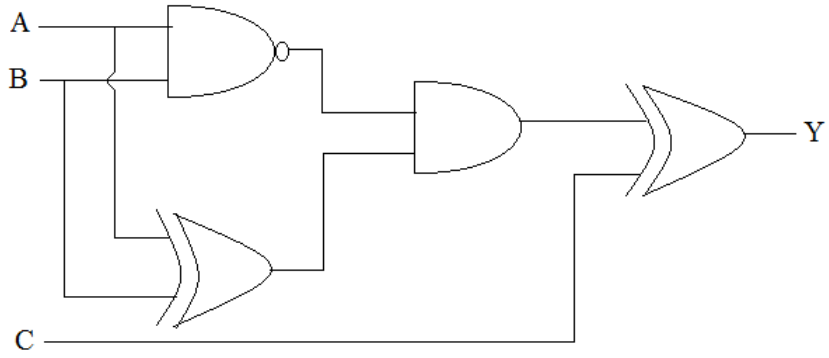
(A) $\overline{A + B + C}$
(B) $\overline{A} + \overline{B} + \overline{C}$
(C) 1
(D) $\overline{AB} + \overline{BC} + \overline{AC}$

41. For the logic circuit shown below, the required input combination, as (A,B,C), for which the output Y is set to 1, is:



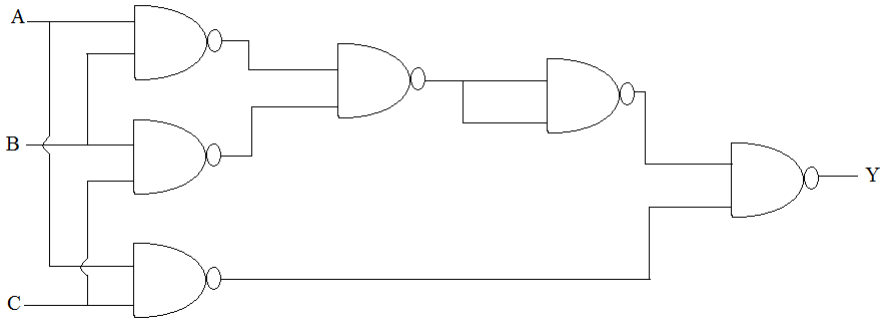
(A) (1,1,1)
(B) (1,0,1)
(C) (0,1,1)
(D) (1,0,0)
(E) (0,1,0)

42. Which of the following correctly represents the relation between A, B, C and Y, shown in the circuit below:



(A) $Y = (A \oplus B).C$
(B) $Y = (A \oplus B) \oplus C$
(C) $Y = (A + B).C$
(D) $Y = A + B \oplus C$

43. The output Y in the circuit shown below, is always 1 when:

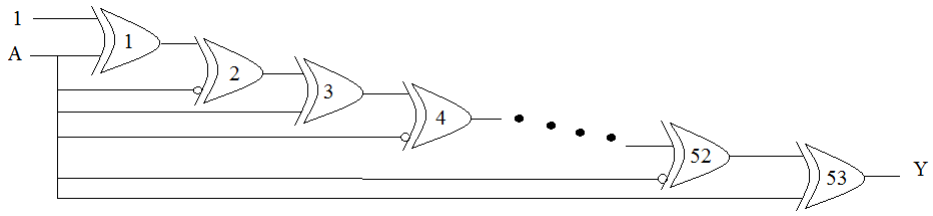


(A) Odd number of inputs are 1
(B) Even number of inputs are 0
(C) At least 2 of the inputs are 1
(D) At least 1 of the inputs are 1
(E) All of the inputs must be 1

44. What happens when a bit-string is Ex-ORed with itself n-times as shown:
$[(B \oplus (B \oplus (B \oplus (B$....n times]
(A) complements when n is even
(B) complements when n is odd

(C) divides by 2^n always
(D) remains unchanged when n is even

45. For the figure shown below what should be the expression for Y:



(A) 0
(B) 1
(C) A
(D) $\overline{A}$

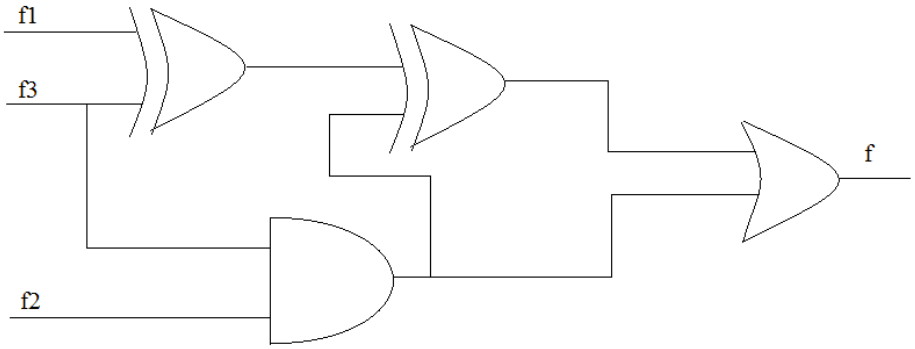
46. The four variable function f is given as collection of sum-of-product tersm as follows:
f(A,B,C,D) = {2,3,8,10,11,12,14,15}
Which of the following correctly represents the pair (P,Q) where P represents the minimized expression for this function and Q stands for minimum number of NAND gates required to realize this function, considering variables are available only in their nonprime form:
(A) $A\overline{D} + AC + \overline{B.C}$, 6
(B) $A\overline{C} + AD + \overline{B}C$, 8
(C) $A\overline{D} + AC + \overline{B}C$, 8
(D) $A\overline{C} + AD + \overline{B}C$, 6

47. Let the set of minterms in Ex-OR expression of n variables is A and set of maxterms in the Ex-NOR expression of these n variables is B. Define F to be the set of all functions defined as: $f : A \to B$. Let D be the radix of the number system. What should be the value of D such that at max $2D$ digits are required to represent any number in the range $[0, |F| - 1]$.
(A) 2^n
(B) $2^{\frac{n-1}{2}}$
(C) $2^{2(n-1)}$
(D) 2^{2^n-1}

48. If W, X, Y and Z are defined as functions of A,B,C and D as given below:
$W = C + \overline{A}B + \overline{C}D$
$X = AB\overline{CD} + \overline{ABCD} + A\overline{BCD}$
$Y = CD + (A\overline{C} + A\overline{B} + \overline{AB})$
$Z = C + D + \overline{(AB + \overline{ABC} + A\overline{BD})}$

Then which of the following statement is correct?
(A) $W = Z, X = \overline{Z}$
(B) $W = Z, X = Y$
(C) $W = Y$
(D) $W = Y = \overline{Z}$

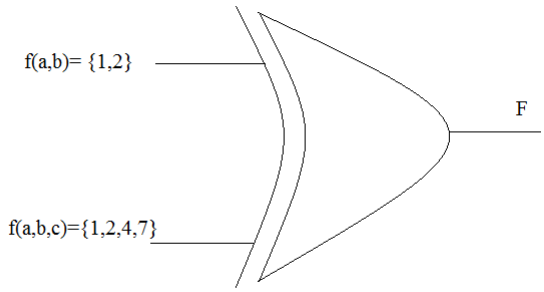
49. Given function f_1, f_2 and f_3 as follows:
$f_1 = \sum m\{2, 3, 4, 5\}$
$f_2 = \sum m\{1, 2, 3, 4, 6\}$
$f_3 = \sum m\{1, 3, 5, 6\}$
and the logic circuit shown below:



which of the following collection of minterms best represents the function f?
(A) $\sum m\{1, 2, 3, 4, 5, 6\}$
(B) $\sum m\{2, 3, 4, 5, 6\}$
(C) $\sum m\{1, 3, 4, 5, 6\}$
(D) $\sum m\{1, 2, 3, 4, 6\}$

50. A Boolean function f can be expressed as follows:
$f = \overline{A}B\overline{D}.\overline{E}.\overline{F} + AB\overline{D}F + A\overline{B}.\overline{E}.\overline{F} + \overline{A}BCE\overline{F} + A\overline{B}.\overline{D}E\overline{F} + \overline{A}.\overline{B}DF$
when simplified, results into $A \oplus B \oplus F$.
Then consider following statements:
(A) There are 13 don't care conditions in f.
(B) The collection of don't cares can be expressed as: $\{1, 3, 9, 11, 18, 20, 22, 28, 38, 53, 55, 56, 61, 63\}$
(C) The collection of don't cares can be expressed as: $\{1, 3, 9, 11, 18, 20, 22, 28, 38, 53, 55, 56, 61, 63\}$
(D) The collection of don't cares can be expressed as: $\{1, 3, 9, 11, 18, 20, 22, 28, 38, 46, 53, 55, 61, 63\}$
(E) The function f does not have any don't care conditions as it completely expresses $A \oplus B \oplus F$.

51. Which of the following set of minterms represents function F shown in the logic circuit below:



(A) $abc + a\overline{b}.\overline{c}$
(B) $a\overline{b}c + abc + \overline{a}.\overline{b}c + \overline{a}bc$
(C) $\overline{a}bc + a\overline{b}.\overline{c} + a\overline{b}c + abc$
(D) $a \oplus b$