Tutorial-3

1. Convert each of the following decimal numbers to BCD:

a. 2439 b. 4091 c. 1475

Ans:- a. $(2439)_{10}$ - $(0010\ 0100\ 0011\ 1001)_{BCD}$

b. $(4091)_{10}$ - $(0100\ 0000\ 1001\ 0001)_{BCD}$

c. $(1475)_{10}$ - $(0001\ 0100\ 0111\ 0101)_{BCD}$

2. Convert each of the following BCD codes to decimal.

a. 10000110 b. 001101010001 c. 1001010001110000

Ans: a $(1000,0110)_{BCD}$ = $(86)_{10}$

b $(0011,0101,0001)_{BCD}$ = $(351)_{10}$

c. 1001 0100 0111 0000 = $(9470)_{10}$

3. Add the following BCD numbers

a. 0011 + 0100 c. 10010110 + 10010111

b. 00100011 + 00010101 d. 01100111 + 01010011

Ans:- a) 0011 +
0100
0111

b) 0010 0011 +
0001 0101
0011 1000

c) 1001 0110 +
1001 0111
1 0010 1101
0110 0110 +
1 1001 0011

1001 0110 +
1001 0111
10010 1101

10011
0110
11001

d) 0110 0111 +
0101 0011
1 100 1010
0100 0110
10 010 10000

4. How does an exclusive-OR gate differ from an OR gate in its logical operation?

Ans:- XOR

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

OR

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

* Output is true if either of the inputs are true. The output is 'false' if both inputs are 'false' or if both inputs are true

5. Determine the sequence of ASCII codes required for writing your roll number, name in the following format and also express it in hexadecimal.

Ans:- <47>,<NITHIIN>

60556244606582671265786562

ASCII - 60556244606582671265786562

Hex - 3C373E2C3C4152 4348 414E41

6. For the Boolean functions

$$F = x\bar{y}z + \bar{x}\bar{y}z + \bar{w}xy + w\bar{x}y + wxy$$

a. Obtain the truth table of F.

b. Draw the logic diagram, using the original Boolean expressions.

c. Use Boolean algebra to simplify the functions to a minimum number of literals.

d. Obtain the truth table of the functions from the simplified expressions and show that it is the same as the one in part (a).

e. Draw the logic diagram from the simplified expressions, and compare

8. Using boolean algebra, simplify the following Expressions

a) $A\bar{B} + A\bar{B}C + A\bar{B}CD + A\bar{B}CDE$

Ans $A\bar{B} \cdot A\bar{B} \cdot 1$

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

$= A\bar{B}CD + A\bar{B}C\bar{D} + A\bar{B}\bar{C}D + A\bar{B}\bar{C}\bar{D}$

$= A\bar{B}CD(E+\bar{E}) + A\bar{B}C\bar{D}(E+\bar{E}) + A\bar{B}\bar{C}D(E+\bar{E}) + A\bar{B}\bar{C}\bar{D}(E+\bar{E})$

$= A\bar{B}CDE + A\bar{B}CD\bar{E} + A\bar{B}C\bar{D}E + A\bar{B}\bar{C}DE + A\bar{B}\bar{C}D\bar{E} +$
$A\bar{B}\bar{C}\bar{D}E + A\bar{B}C\bar{D}\bar{E}$

$\Rightarrow A\bar{B}C = A\bar{B}C \cdot 1 = A\bar{B}C \cdot (D+\bar{D}) = A\bar{B}CD + A\bar{B}C\bar{D}$

$= A\bar{B}CD(E+\bar{E}) + A\bar{B}C\bar{D}(E+\bar{E})$

$= A\bar{B}CDE + A\bar{B}CD\bar{E} + A\bar{B}C\bar{D}E + A\bar{B}C\bar{D}\bar{E}$

$\Rightarrow A\bar{B}CD = A\bar{B}CD \cdot 1 = A\bar{B}CD(E+E') = A\bar{B}CDE + A\bar{B}CDE'$

$= A\bar{B}CDE + A\bar{B}CD\bar{E}$

$\therefore A\bar{B} + A\bar{B}C + A\bar{B}CD + A\bar{B}CDE$

$= \underline{A\bar{B}CDE} + A\bar{B}CD\bar{E} + A\bar{B}C\bar{D}E + A\bar{B}C\bar{D}\bar{E} + A\bar{B}\bar{C}DE +$
$A\bar{B}\bar{C}D\bar{E} + A\bar{B}\bar{C}D\bar{E} + A\bar{B}\bar{C}\bar{D}\bar{E} + A\bar{B}CDE + A\bar{B}CD\bar{E} + A\bar{B}C\bar{D}\bar{E} +$
$A\bar{B}C\bar{D}\bar{E} + A\bar{B}CDE + A\bar{B}CDE$

26/10/22 Tutorial

Q Simplify the following boolean functions

1) $F(x,y,z) = \Sigma m\ (2,3,6,7)$

2) $F(A,B,C,D) = \Sigma m\ (0,1,2,3,8,10,12)$

3) $F(w,x,y,z) = \Sigma m\ (3,7,11,13,14,15)$

4) $F = x'z + w'xy' + w(x'y + xy)$

5) $F = wxy + xz + wx'z + w'x$

Ans: 1) $F(x,y,z) = \Sigma m\ (2,3,6,7)$

x \ yz	y'z'	y'z	yz	yz'
x'	0	1	3: 1	2: 1
x	4	5	7: 1	6: 1

$F = y$

2) $F(A,B,C,D) = \Sigma m\ (0,1,2,3,8,10,12)$

AB \ CD	C'D'	C'D	CD	CD'
A'B'	0: 1	1: 1	3: 1	2: 1
A'B	4	5	7	6
AB	12: 1	13	15	14
AB'	8: 1	9	11	10: 1

$F = A'B' + AC'D' + AB'D'$

3) $F(w,x,y,z) = \Sigma m(3,7,11,13,14,15)$

wx \ yz	y'z'	y'z	yz	yz'
w'x'	0	1	3: 1	2
w'x	4	5	7: 1	6
wx	12	13: 1	15: 1	14: 1
wx'	8	9	11: 1	10

$F = yz + wxz + wxy$

4) $F = x'z + w'xy' + w(x'y + xy)$

wx \ yz	y'z'	y'z	yz	yz'
w'x'	0	1: 1	3: 1	2
w'x	4: 1	5: 1	7	6
wx	12: 1	13: 1	15: 1	14
wx'	8	9: 1	11: 1	10: 1

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

5) $F = wxy + xz + wx'z + w'x$

wx \ yz	y'z'	y'z	yz	yz'
w'x'	0	1	3	2
w'x	4: 1	5: 1	7: 1	6: 1
wx	12	13: 1	15: 1	14: 1
wx'	8	9: 1	11: 1	10

$F = w'x + xy + wz$

26/10/22 **Tutorial**

Q Simplify the following boolean functions

1) $F(x,y,z) = \sum m\,(2,3,6,7)$

2) $F(A,B,C,D) = \sum m\,(0,1,2,3,8,10,12)$

3) $F(w,x,y,z) = \sum m\,(3,7,11,13,14,15)$

4) $F = x'z + w'xy' + w(x'y + xy)$

5) $F = wxy + xz + wx'z + w'x$

Ans: 1) $F(x,y,z) = \sum m\,(2,3,6,7)$

x \ yz	y'z'	y'z	yz	yz'
x'	0	1	3: 1	2: 1
x	4	5	7: 1	6: 1

$F = y$

2) $F(A,B,C,D) = \sum m\,(0,1,2,3,8,10,12)$

AB \ CD	C'D'	C'D	CD	CD'
A'B'	0: 1	1: 1	3: 1	2: 1
A'B	4	5	7	6
AB	12: 1	13	15	14
AB'	8: 1	9	11	10: 1

$F = A'B' + AC'D' + AB'D'$

3) $F(w,x,y,z) = \sum m\,(3,7,11,13,14,15)$

wx \ yz	y'z'	y'z	yz	yz'
w'x'	0	1	3: 1	2
w'x	4	5	7: 1	6
wx	12	13: 1	15: 1	14: 1
wx'	8	9	11: 1	10

$F = yz + wxz + wxy$

4) $F = x'z + w'xy' + w(x'y + xy')$

wx \ yz	y'z'	y'z	yz	yz'
w'x'	0	1: 1	3: 1	2
w'x	4: 1	5: 1	7	6
wx	12: 1	13: 1	15	14
wx'	8	9: 1	11: 1	10: 1

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

5) $F = wxy + xz + wx'z + w'x$

wx \ yz	y'z'	y'z	yz	yz'
w'x'	0	1	3	2
w'x	4: 1	5: 1	7: 1	6: 1
wx	12	13: 1	15: 1	14: 1
wx'	8	9: 1	11: 1	10

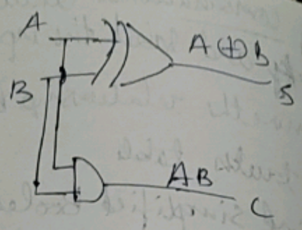
$F = w'x + xy + wz$

Logic circuit

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

$S = A \oplus B$

$C = AB$



Tutorial - 4

* Use the kmap method to implement the minimum expression for the logic function specified in given truth table

AB \ CD	C'D'	C'D	CD	CD'
A'B'	0	1	0	1
A'B	0	0	1	1
AB	1	1	1	0
AB'	1	0	0	1

$X = AC'D' + B'CD' + ABD + A'BC + A'B'C'D$

* Find all the prime complicates for the following Boolean function, and determine which are essential.

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

AB \ CD	C'D'	C'D	CD	CD'
A'B'	1	0	1	1
A'B	0	1	1	0
AB	0	0	1	1
AB'	1	0	1	1

$A'B'CD$

$A'B'CD'$

$AB'C'D'$

$AB'CD'$

Prime implicants $= B'D', A'BD + CD + AC$

essential $= B'D', A'BD + CD + AC$

$F = B'D' + A'BD + CD + AC$

b) $F(w,x,y,z) = \sum(1,3,6,7,8,9,12,13,14,15)$

wx \ yz	y'z'	y'z	yz	yz'
	0	1	1	0
	0	0	1	1
	1	1	1	1
	1	1	0	0

$F = wy' + xy + w'x'z$

$m_1\ m_3\ m_6\ m_7\ m_8\ m_9\ m_{12}\ m_{13}\ m_{14}\ m_{15}$

xy

wy'

$w'x'z$

Prime complicants $= wy' + xy, w'x'z$

essential complicants $= xy, wy', w'x'z$

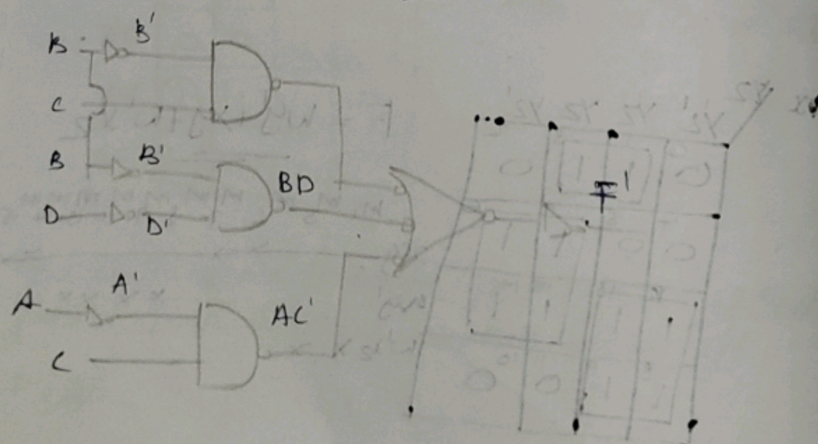
*) Draw a NAND logic diagram that complements the complement of the following functions. Also, draw the logic diagram only using NOR gates

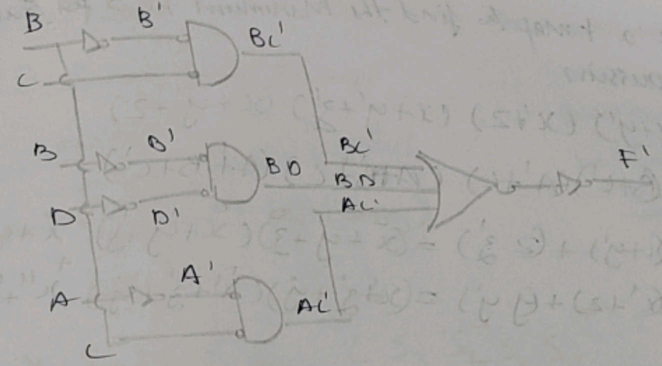
$F(A,B,C,D) = \Sigma(0,1,2,3,6,10,11,14)$

AB \ CD	C'D'	C'D	CD	CD'
A'B'	1	1	1	1
A'B	0	0	0	1
AB	0	0	0	1
AB'	0	0	1	1

$F = A'B' + CD' + AB'C$

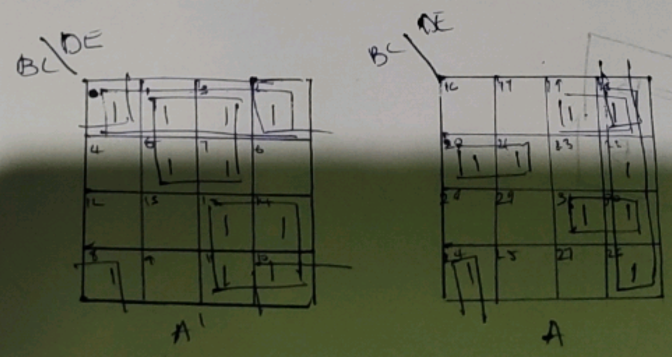
$F' = BC' + BD + AC'$





* Simplify the Boolean functions to find the minimum SOP expression

a) $F(A,B,C,D,E) = (0,1,2,3,5,7,8,10,11,14,15,18,19,20,21,22,24,26,30,31)$



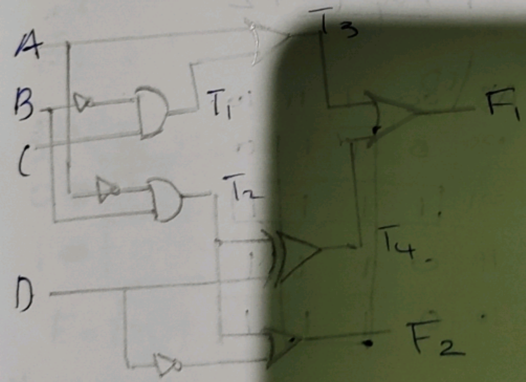
$F = A'BD + A'B'E + A'B'C'E' + BC'DE' + ADE' + AB'CD' + ABCD + AB'C'D$

14	01110	10100
15	01111	10101
16	10000	10110
17	10001	10111
18	10010	11000
19	10011	11001

Tutorial - 5

Module 3

1. Consider the combinational circuit shown in figure below



a) Derive the Boolean expressions for T_1 through T_4. Evaluate the outputs F_1 and F_2 as a function of the four inputs.

b) List the truth table with 16 binary combinations of the four input variables. Then list the binary values for T_1 through T_4 and outputs F_1 and F_2 in the table

c) Plot the output Boolean functions obtained in part(b) on maps and show that the simplified Boolean expressions are equivalent to the ones obtained in part

Ans a) $T_1 = B'C$, $T_2 = A'B$

$T_3 = A + B'C$, $T_4 = A' B \oplus D$

$= (A'B)D + A'BD'$

$= AD + A'B + A'BD'$

$F_1 = T_3 + T_4$

$= A + B'C + AD + B'D + A'BD'$

$= A(1+D) + B'C + B'D + A'BD'$

$= (\cancel{A+A}BD') + B'C + B'D$

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

$= A + BD' + B'C + B'D$

$F_2 = T_5 = A'B + D$

b)

ABCD	T_1	T_2	T_3	T_4	F_1	F_2
0000	0	0	0	0	0	0
0001	0	0	0	1	1	1
0010	1	0	1	0	1	0
0011	1	0	1	1	1	1
0100	0	1	0	0	1	1
0101	0	1	0	1	0	1
0110	0	1	0	0	1	1
0111	0	1	0	1	0	1
1000	0	0	1	0	1	0
1001	0	0	1	1	1	1
1010	1	0	1	0	1	0
011	1	0	1	1	1	1
1100	0	0	1	0	1	[illegible]
1101	0	0	1	1	1	0
1110	0	0	1	0	1	0
1111	0	0	1	1	1	1

(i) K-map for F_1

AB \ CD	00	01	11	10
00	0	1	1	1
01	1	0	0	1
11	1	1	1	1
10	1	1	1	1

$F_1 = A + BD' + B'D + B'C$

K-map for F_2

AB \ CD	00	01	11	10
00	0	1	1	0
01	1	1	1	1
11	0	1	1	1
10	0	1	1	1

$F_2 = D + A'B$

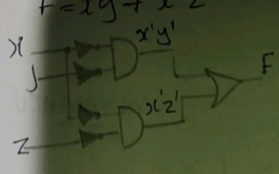
2) Design a combinational circuit with 3 inputs and one output. The output is 1 when the binary value of the input is less than 3. The output is 0 otherwise

ans:

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

x \ yz	00	01	11	10
0	1	1	0	1
1	0	0	0	0

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



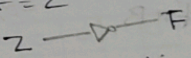
3) Design a combinational circuit with 3 inputs and one output. The output is 1 when the binary value of the input is an even number

Ans:

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	0

x \ yz	00	01	11	10
0	1	0	0	1
1	1	0	0	1

$F = z'$



4) Design a combinational circuit with three inputs x, y and z and three outputs A, B and C. When the binary input is 0, 1, 2 or 3 the binary output is one greater than the input. When the binary input is 4, 5, 6 or 7 the binary output is two less than the input.

Ans

x	y	z	A	B	C
0	0	0	0	1	0
0	0	1	0	1	1
0	1	0	1	0	0
0	1	1	1	0	1
1	0	0	0	1	0
1	0	1	0	1	1
1	1	0	1	0	0
1	1	1	1	0	1

Kmap for C

x \ yz	00	01	11	10
0	0	1	1	0
1	0	1	1	0

$C = Z$

Z —— C

Kmap for A

x \ yz	00	01	11	10
0	0	0	1	1
1	0	0	1	1

$A = y$

y —— A

Kmap for B

x \ yz	00	01	11	10
0	1	1	0	0
1	1	1	0	0

$B = y'$

y —▷o— B

5. Design a code converter that converts a decimal digit from the 8, 4, -2, -1 code to BCD

Ans:

Decimal digit	8 A	4 B	-2 C	-1 D	BCD (8421) W	x	y	z
0	0	0	0	0	0	0	0	0
1	0	1	1	1	0	0	0	1
2	0	1	1	0	0	0	1	0
3	0	1	0	1	0	0	1	1
4	0	1	0	0	0	1	0	0
5	1	0	1	1	0	1	0	1
6	1	0	1	0	0	1	1	0
7	1	0	0	1	0	1	1	1
8	1	0	0	0	1	0	0	0
9	1	1	1	1	1	0	0	1

Map for W

AB \ CD	00	01	11	10
00	0	X	X	X
01	0	0	0	0
11	X	X	1	X
10	1	0	0	0

$W = AB + AC'D'$

Map for x

AB \ CD				
	0	X	X	X
	1	0	0	0
	X	X	0	X
	0	1	1	1

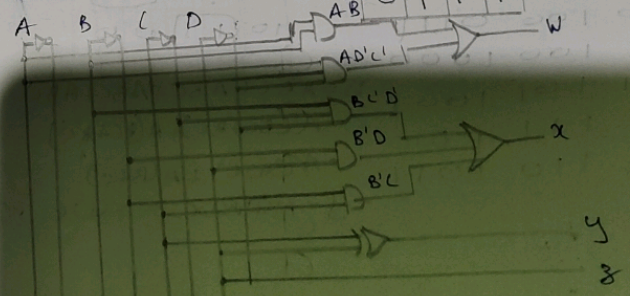
$x = BC'D' + B'D + B'C$

Map for y

AB \ CD	00	01	11	10
00	0	X	X	X
01	0	1	0	1
11	X	X	0	X
10	0	1	0	1

$\boxed{y = CD' + C'D = C \oplus D}$

$\boxed{z = D}$



6) A Majority circuit is a combinational circuit whose output is equal to 1 if the input variables have more 1's than 0's the output is 0 Otherwise. Design a 3 input majority circuit of finding the circuits truthtable. Boolean equation and a logical diagram.

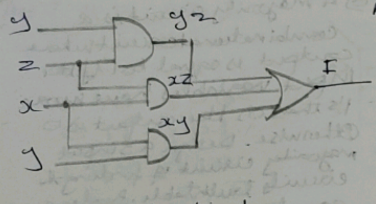
Ans

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

Kmap of F

x \ yz				
0	0	0	1	0
1	0	1	1	1

$F = yz + xz + xy$



AB\CD

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

$W = A$

AB\CD

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

$x = A'B + AB' = A \oplus B$

7) Design a combinational circuit that converts a four bit Gray code to a bit 4 binary no. Implement the circuit with ex-or gate

Ans

Input A B C D	Output W x y z
0 0 0 0	0 0 0 0
0 0 0 1	0 0 0 1
0 0 1 1	0 0 1 0
0 0 1 0	0 0 1 1
0 1 1 0	0 1 0 0
0 1 1 1	0 1 0 1
~~1 1 0 0~~ 0 1 0 1	0 1 1 0
0 1 0 0	0 1 1 1
1 1 0 0	1 0 0 0
1 1 0 1	1 0 0 1
1 1 1 1	1 0 1 0
1 1 1 0	1 0 1 1

AB\CD	00	01	11	10
00	0	0	1	1
01	1	1	0	0
11	0	0	1	1
10	1	1	0	0

$y = A'B'C + A'BC' + ABC + AB'C'$

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

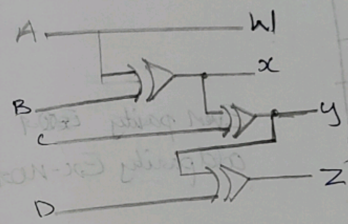
$= A'(B \oplus C) + A(B \oplus C)'$

$y = A \oplus B \oplus C = x \oplus C$

AB\CD	00	01	11	10
00	0	1	0	1
01	1	0	1	0
11	0	1	0	1
10	1	0	1	0

$x = A \oplus B \oplus C \oplus D$

$= y \oplus D$



Magnitude comparator

A_1A_2 \ B_1B_2	00	01	11	10
00		1	1	1
01			1	1
11				
10			1	

$L = A_1'B_1 + A_1'A_2'B_2 + A_2'B_1B_2$

29/11/22

Tutorial

1.A

A	B	C	D	a	b	c	d	e	f	g
0	0	0	0	1	1	1	1	1	1	0
0	0	0	1	0	1	1	0	0	0	0
0	0	1	0	1	1	0	1	1	0	1
0	0	1	1	1	1	1	1	0	0	1
0	~~0~~	0	0	0	1	1	0	0	1	1
0	1	0	1	1	0	1	1	0	1	1
0	1	1	0	1	0	1	1	1	1	1
0	1	1	1	1	1	1	0	0	0	0
1	0	0	0	1	1	1	1	1	1	1
1	0	0	1	1	1	1	1	0	1	1

K-map for 'a'

AB\CD	00	01	11	10
00	1	0	1	1
01	0	1	1	1
11	0	0	0	0
10	1	1	0	0

$a = A'C + A'BD + AB'C' + B'C'D'$

K-map for 'b'

AB\CD	00	01	11	10
00	1	1	1	1
01	1	0	1	0
11	0	0	0	0
10	1	1	0	0

$b = A'B' + A'C'D' + A'CD + AB'C'$

K-map for 'c'

AB\CD	00	01	11	10
00	1	1	1	0
01	1	1	1	1
11	0	0	0	0
10	1	1	0	0

$c = A'B + A'D + AB'C' + B'C'D'$

K-map for 'd'

AB\CD	00	01	11	10
00	1	0	1	1
01	0	1	0	1
11	0	0	0	0
10	1	1	0	0

$d = A'B'C + A'CD' + AB'C' + B'C'D'$
$+ A'BC'D$

K-map for 'e'

~~AB\CD~~

AB\CD	00	01	11	10
00	1	0	0	1
01	0	0	0	1
11	0	0	0	0
10	1	0	0	0

$e = A'CD' + B'C'D'$

K-map for 'f'

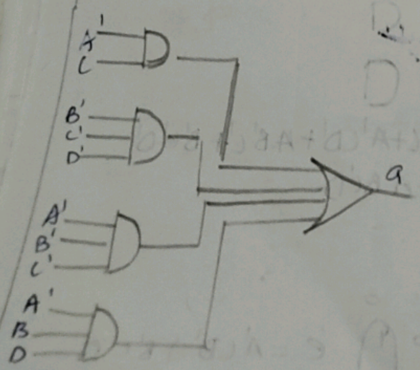
AB\CD	00	01	11	10
00	1	0	0	0
01	1	1	0	1
11	0	0	0	0
10	1	1	0	0

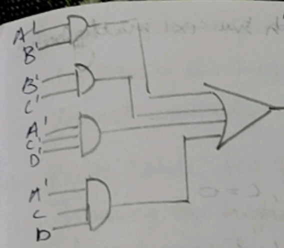
$f = A'C'D' + AB'C' + A'BC' + A'BD'$

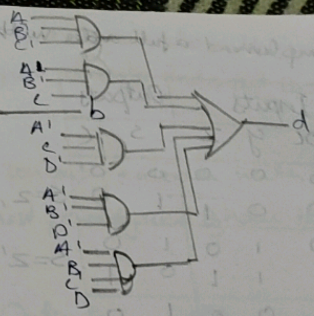
Kmap for 'g'

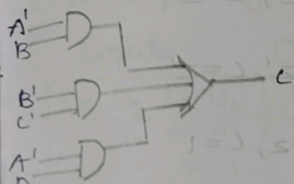
AB\CD	00	01	11	10
00	0	0	1	1
01	1	1	0	1
11	0	0	0	0
10	1	1	0	0

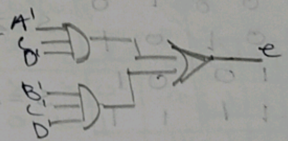
$g = AB'C' + A'BC' + A'B'C + A'CD'$

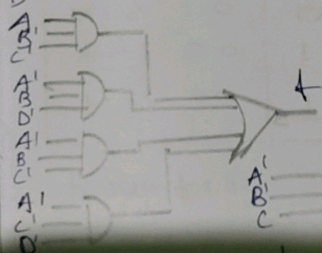


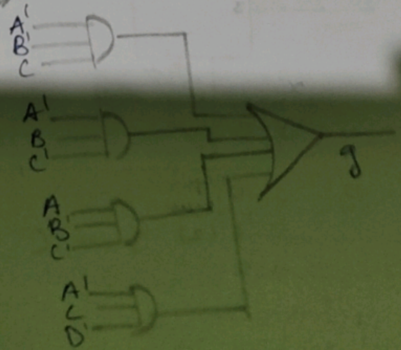












2. Implement a full adder with two 4x1 multiplexer

A.

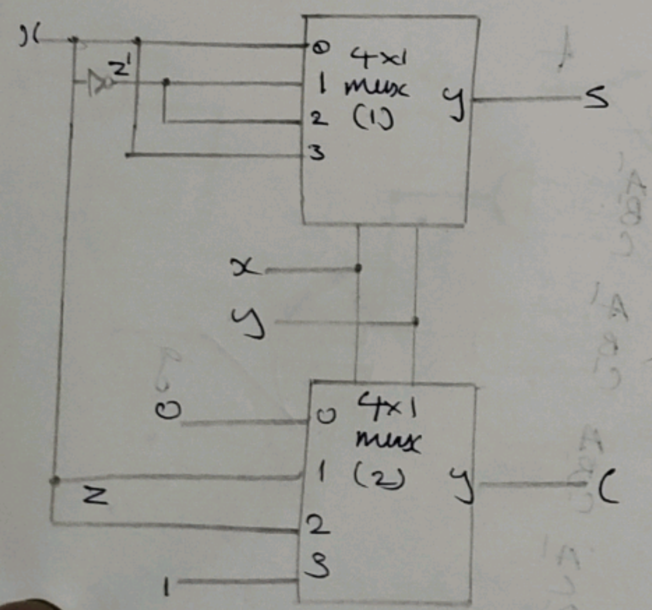
Inputs			Outputs	
x	y	z	S	C
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

$S = z, C = 0$

$S = z', C = z$

$S = z', C = z'$

$S = z, C = 1$



3. Design a four-input priority encoder with input D_0 having the highest priority and input D_3 the lowest priority

A. Truth table for priority encoder with D_0 having the highest priority and D_3 have the lowest priority.

Inputs				Outputs		
D_3	D_2	D_1	D_0	x	y	V
0	0	0	0	x	x	0
x	x	x	1	0	0	1
x	x	1	0	0	1	1
x	1	0	0	1	0	1
1	0	0	0	1	1	1

D_3D_2 \ D_1D_0	00	01	11	10
00	0	1	1	1
01	1	1	1	1
11	1	1	1	1
10	1	1	1	1

$V = (D_3' D_2' D_1' D_0')'$

$V = D_3 + D_2 + D_1 + D_0$

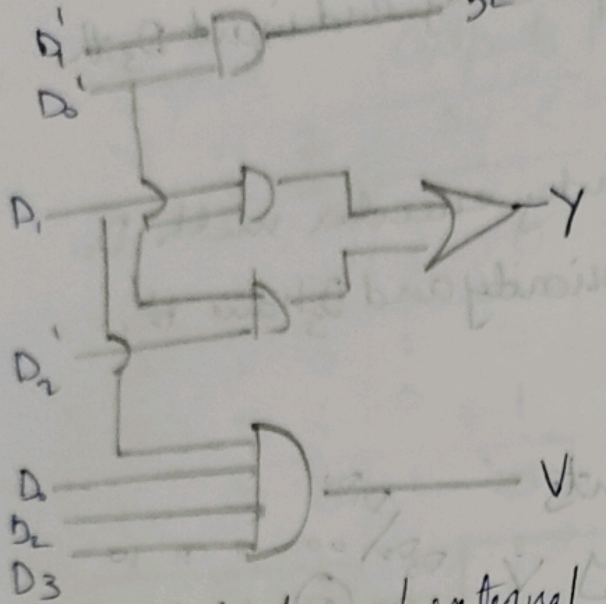
K map for x

D_3D_2 \ D_1D_0	00	01	11	10
00	X	0	0	0
01	1	0	0	0
11	1	X	X	X
10	1	0	0	0

$x = D_1' D_0'$

D_3D_2 \ D_1D_0	00	01	11	10
00	X	0	0	1
01	0	0	0	1
11	0	0	0	1
10	1	0	0	1

$y = D_1 D_0' + D_2' D_0'$



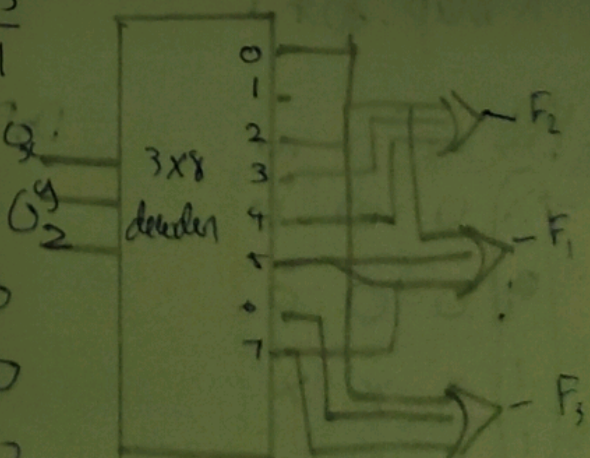
4. Using a decoder and external gate design the combinational circuit defined by the following 3 boolean functions

$$F_1 = x'yz' + xz = x'yz' + xyz + xy'z = \Sigma_m(2,5,7)$$

$$F_2 = xy'z' + x'y = xy'z' + x'yz + x'yz' = \Sigma_m(2,3,4)$$

$$F_3 = x'y'z' + xy = x'y'z' + xyz + xyz' = \Sigma_m(0,6,7)$$

x	y	z	F_1	F_2	F_3
0	0	0	0	0	1
0	0	1	0	0	0
0	1	0	1	1	0
0	1	1	0	1	0
1	0	0	0	1	0
1	0	1	1	0	0
1	1	0	0	0	1
1	1	1	1	0	1



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