Tutorial - 4

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1) Peform the following as indicated:

1) $(9001180)_{10} = (?)_2$

Soln

2	9001180	
2	4500590	→ 0
2	2250295	→ 0
2	1125147	→ 1
2	562573	→ 1
2	281286	→ 1
2	140643	→ 0
2	70321	→ 1
2	35160	→ 1
2	17580	→ 0
2	8790	→ 0
2	4395	→ 0
2	2197	→ 1
2	1098	→ 1
2	549	→ 0
2	274	→ 1
2	137	→ 0
2	68	→ 1
2	34	→ 0
2	17	→ 0
2	8	→ 1
2	4	→ 0
2	2	→ 0
2	1	→ 0
	0	→ 1

↑

$\therefore (9001180)_{10} = (100010010101100011011100)_2$

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5) $(169.03125)_{10} = (?)_2$

Soln

Here, $(169.03125)_{10} = (?)_2$

Taking numeric part

$$
\begin{array}{r|l}
2 & 169 \\
2 & 84 \rightarrow 1 \\
2 & 42 \rightarrow 0 \\
2 & 21 \rightarrow 0 \\
2 & 10 \rightarrow 1 \\
2 & 5 \rightarrow 0 \\
2 & 2 \rightarrow 1 \\
2 & 1 \rightarrow 0 \\
 & 0 \rightarrow 1
\end{array}
$$

So, $(169)_{10} \rightarrow (10101001)_2$

For fractional part $(0.03125)_{10}$

$0.03125 \times 2 = 0.0625$
$\Rightarrow 0$

$0.0625 \times 2 = 0.125$
$\Rightarrow 0$

$0.125 \times 2 = 0.25$
$\Rightarrow 0$

$0.25 \times 2 = 0.5$
$\Rightarrow 0$

$0.5 \times 2 = 1$
$\Rightarrow 1$

$\therefore (0.03125)_{10} = (.00001)_2$

So, $(169.03125)_{10} = (10101001.00001)_2$

(c) $(11000011)_2 = (?)_{10}$

Soln

$(11000011)_2 = 1\times2^7 + 1\times2^6 + 0\times2^5 + 0\times2^4 + 0\times2^3 + 0\times2^2 + 1\times2^1 +$
1×2^0

$= 128 + 64 + 0 + 0 + 0 + 0 + 2 + 1$

$= 195$

$\therefore (11000011)_2 = (195)_{10}$

(d) $(10101.101)_2 = (?)_{10}$

Soln

Taking numeric part

$(10101)_2 = 1\times2^4 + 0\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0$

$= 16 + 0 + 4 + 0 + 1$

$= 21$

for fractional part

$(.101)_2 = 1\times2^{-1} + 0\times2^{-2} + 1\times2^{-3}$

$= 1/2 + 0 + 1/2^3$

$= 0.625$

$(10101.101)_2 = (21.625)_{10}$

$\therefore (10101.101)_2 = (21.625)_{10}$ Ans

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(e) $(9001180)_{10} = (?)_{BCD}$

Soln

9	0	0	1	1	8	0
↓	↓	↓	↓	↓	↓	↓
8421	8421	8421	8421	8421	8421	8421
↓	↓	↓	↓	↓	↓	↓
1001	0000	0000	0001	0001	1000	0000

$\therefore (9001180)_{10} = (1001000000000001000110000000)_{BCD}$

(f) $(2AB.5E)_{16} = (?)_8$

Soln

(Firstly) Converting to binary

2	A	B	5	E
↓	↓	↓	↓	↓
10	1010	1011	0101	1110

So, $(2AB.5E)_{16} = (1010101011.01011110)_2$

Now ~~octal~~ binary to octal

$\underbrace{001}_{1}\ \underbrace{010}_{2}\ \underbrace{101}_{5}\ \underbrace{011}_{3}\ .\ \underbrace{010}_{2}\ \underbrace{111}_{7}\ \underbrace{100}_{4}$

$\therefore (2AB.5E)_{16} = (1253.274)_8$ Ans

(g) $(375.37)_8 = (?)_{16}$

Soln

Converting octal to binary number

3	7	5 .	3	7
↓	↓	↓	↓	↓
011	111	101	011	111

$\therefore (375.37)_8 = (011111101.011111)_2$

Now, binary to hexadecimal

$\cancel{\underbrace{1111}_{15\,(F)}\underbrace{1101}_{13\,(D)} . \underbrace{1111}_{15\,(F)}\underbrace{1000}_{8}}$

$\cancel{\therefore (375.37)_8 = (FD.F8)_{16}}$

$\underbrace{01111}_{15(F)}\underbrace{1101}_{13(D)} . \underbrace{0111}_{7}\underbrace{1100}_{C}$

$\therefore (375.37)_8 = (FD.7C)_{16}$

Subtract $(25)_{10}$ from $(49)_{10}$ using 2's complement

Soln

Here, $(49)_{10} - (25)_{10}$

Converting the above decimal number to binary

2	49	
2	24	→ 1
2	12	→ 0
2	6	→ 0
2	3	→ 0
2	1	→ 1
	0	→ 1

2	25	
2	12	→ 1
2	6	→ 0
2	3	→ 0
2	1	→ 1
	0	→ 1

$(49)_{10} = (110001)_2$ $(25)_{10} = (11001)_2$

let $X = (110001)_2$
$Y = (011001)_2$

2's complement of Y

$$\begin{array}{r} 100110 \\ +1 \\ \hline 100111 \end{array}$$

Now,

$$\begin{array}{r} 110001 \\ +100111 \\ \hline 1\,011000 \end{array}$$

~~Since we got end carry the answer is (-2's complement of 11000) = -~~

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Since we got end carry So, the ans will be $(11000)_2$

$\therefore (49)_{10} - (25)_{10} = (11000)_2$

(i) $(42)_{10} - (115)_{10}$ using 2's complement method

Soln

Here,

$$\begin{array}{r|l} 2 & 42 \\ 2 & 21 \rightarrow 0 \\ 2 & 10 \rightarrow 1 \\ 2 & 5 \rightarrow 0 \\ 2 & 2 \rightarrow 1 \\ 2 & 1 \rightarrow 0 \\ & 0 \rightarrow 1 \end{array}$$

$$\begin{array}{r|l} 2 & 115 \\ 2 & 57 \rightarrow 1 \\ 2 & 28 \rightarrow 1 \\ 2 & 14 \rightarrow 0 \\ 2 & 7 \rightarrow 0 \\ 2 & 3 \rightarrow 1 \\ 2 & 1 \rightarrow 1 \\ & 0 \rightarrow 1 \end{array}$$

$\therefore (42)_{10} = (101010)_2$ $(115)_{10} = (1110011)_2$

Now, let $X = (1.0101.0.)_2$
$Y = (1110011)_2$

Finding 2's complement of Y

$$\begin{array}{r} 0001100 \\ +1 \\ \hline 0001101 \end{array}$$

Now,

$$\begin{array}{r} 0101010 \\ +0001101 \\ \hline 0110111 \end{array}$$

10 , 11 , 12 , 13 , 14 | 0 0 1 0 0 0
A B C D E +1
F→15 10 10 0 1

Since we don't get end carry then the answer will be −2's complement of
$(110111)_2 \Rightarrow$ ~~$-(1001)_2$~~ $-(1001001)_2$

(3) $(423.25)_8 = (?)_2$

4	2	3	.	2	5
421	421	421		421	421
100	010	011		010	101

$\Rightarrow (100010011.010101)_2$ Ans

(b) $(AFC.00)_{16} = (?)_8$ (4-bit) (8421)

A	F	C
10	15	12
8421	8421	8421
1010	1111	1100

$\Rightarrow (101011111100)_2$

101 | 011 | 111 | 100
↓ ↓ ↓ ↓
5 3 7 4

$\Rightarrow (5374)_8$ Ans

(l) $(101101)_2 + (10111)_2$

Now,

$$
\begin{array}{r}
1\;1\;1\;1\;\;1\;\; \\
1\;0\;1\;1\;0\;1 \\
+\;0\;1\;0\;1\;1\;1 \\
\hline
1\;0\;0\;0\;1\;0\;0
\end{array}
$$

$\therefore \quad (101101)_2 + (10111)_2 \Rightarrow (1000100)_2$

(m) $(15)_{10} - (8)_{10}$ using 1's complement.

Soln

$(15)_{10} \rightarrow (1111)_2$

$(8)_{10} \rightarrow (1000)_2$

Now, let $X \rightarrow (1111)_2$
$Y \rightarrow (1000)_2$

1's complement $Y \Rightarrow (0111)_2$

Now,

$$
\begin{array}{r}
1\;1\;1\;\; \\
1\;1\;1\;1 \\
+\;0\;1\;1\;1 \\
\hline
1\;0\;1\;1\;0
\end{array}
$$

There is ~~No~~ an end carry so, the answer is [illegible]

$\Rightarrow$ [illegible]

$$\begin{array}{r} 0110 \\ +1 \\ \hline 0111 \end{array}$$

$\therefore$ $(15)_{10} - (8)_{10} \Rightarrow (0111)_2$ Ans

(n) $(100010)_2 - (1010111)_2$ using 1's complement

let $X \rightarrow (100010)_2$
$Y \rightarrow (1010111)_2$

1's complement of $Y \Rightarrow (0101000)_2$

Now,

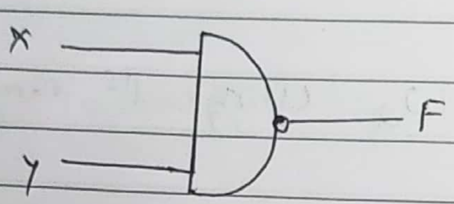
$$\begin{array}{r} 0100010 \\ +0101000 \\ \hline 1001010 \end{array}$$

Since there is no end carry so the answer is
$-$(1's complement of $1001010) \Rightarrow -(0110101)_2$

Ans

(2) Draw the basic gates with their expression and truth table.

(1) NAND



(Symbol)

Expression

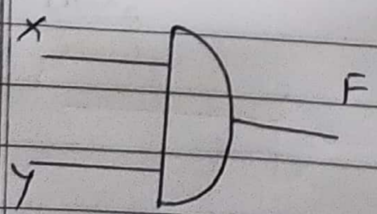
$F = (xy)'$

(Truth table)

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

(2) AND

Symbol



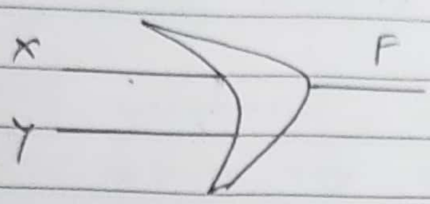
Expression

$F = XY$

Truth table

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

(3) OR

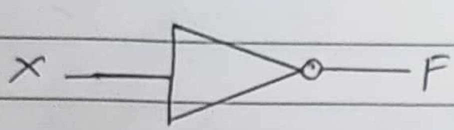


Expression

$F = X + Y$

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

(4) NOT

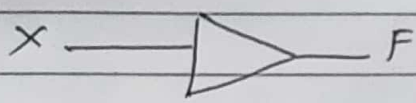


Expression

$F = \overline{X}$

x	F
0	1
1	0

(5) Buffer

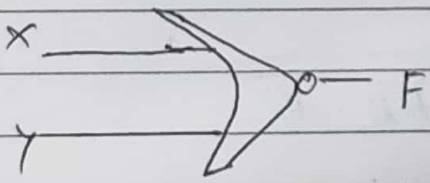


Expression

$F = X$

X	F
0	0
1	1

(6) NOR

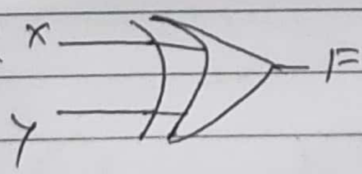


Expression

$F = (X+Y)'$

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

(7) X-OR



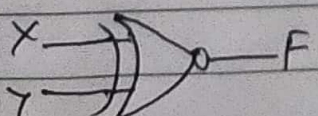
Expression

$= X \oplus Y$

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

(8) X-NOR

Expression



$F = X \odot Y$

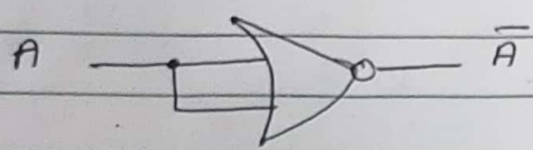
X	Y	F
0	0	1
0	1	0
1	0	0
1	1	1

(3) what do you mean by universal gates? Realize all the other gates using universal gates.

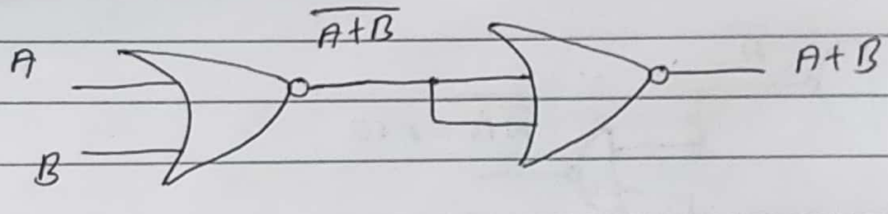
NAND gates and NOR gates are called universal gates because any types of logic gates or logic function can be constructed using these gates.

NOR gate as a universal gate

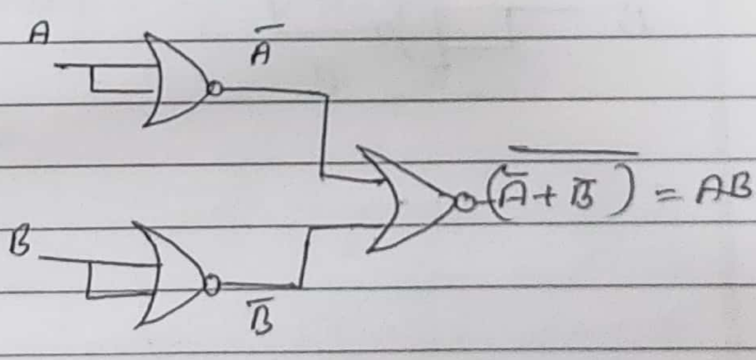
(1) NOT from NOR



(2) OR from NOR



(3) AND from NOR



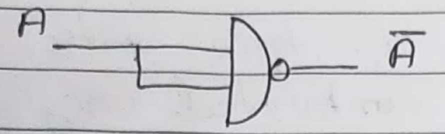
$Y = AB$

$= (AB)''$

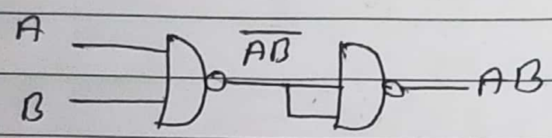
$= (\bar{A}+\bar{B})'$

NAND Gate as a Universal Gate

(i) NOT from NAND

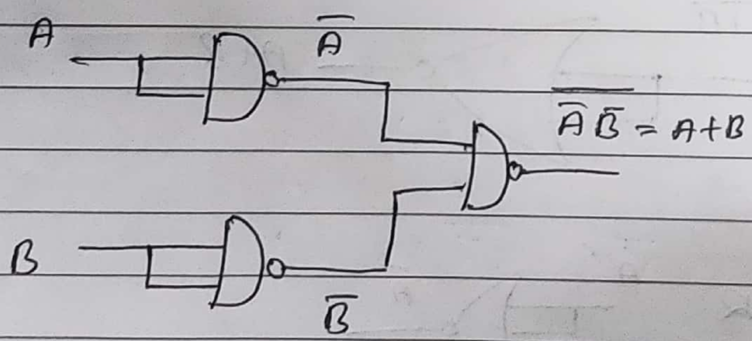


(2) AND from NAND



(3) OR from NAND

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



(4) State and prove De Morgan's Theorems,

1st law

It says that the complement of two or more variables ORed is equivalent to the AND of the complements of individual variables.

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

Inputs		outputs	
A	B	$\overline{A+B}$	$\bar{A}\,\bar{B}$
0	0	1	1
0	1	0	0
1	0	0	0
1	1	0	0

2nd law

It says that the complement of two or more variable ANDed is equivalent to the OR of the complements of individual variables.

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

~~Diagram~~

Inputs		outputs	
A	B	$\overline{AB}$	$\bar{A}+\bar{B}$
0	0	1	1
0	1	1	1
1	0	1	1
1	1	0	0

(Q.5) Simplify the following expressions using K-Map and realize it with only universal gates.

ⓐ $Y = A'BC' + ABC' + ABC$

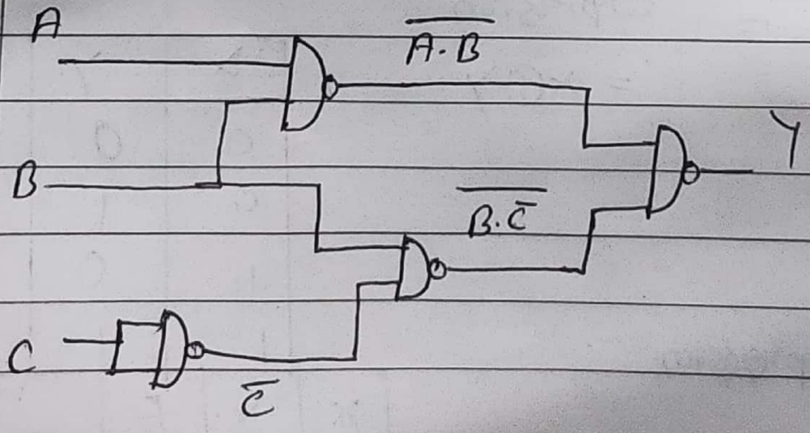
Here,

$$Y = A'BC' + ABC' + ABC$$
$$= 010 + 110 + 111$$
$$= 2 + 6 + 7$$
$$= m_2 + m_6 + m_7$$
$$= \Sigma(2, 6, 7)$$

A \ B	$\bar{B}\bar{C}$	$\bar{B}C$	BC	$B\bar{C}$
$\bar{A}$	0	0	0	1
A	0	0	1	1

$$Y = AB + B\bar{C}$$

$$Y = \overline{\overline{AB + B\bar{C}}} = \overline{\overline{AB} \cdot \overline{B\bar{C}}}$$



(5) $F = XY + X'Z + YZ$

Here,

$F = XY + X'Z + YZ$

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

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

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

$= 111 + 110 + 011 + 001$

$= 7 + 6 + 3 + 1$

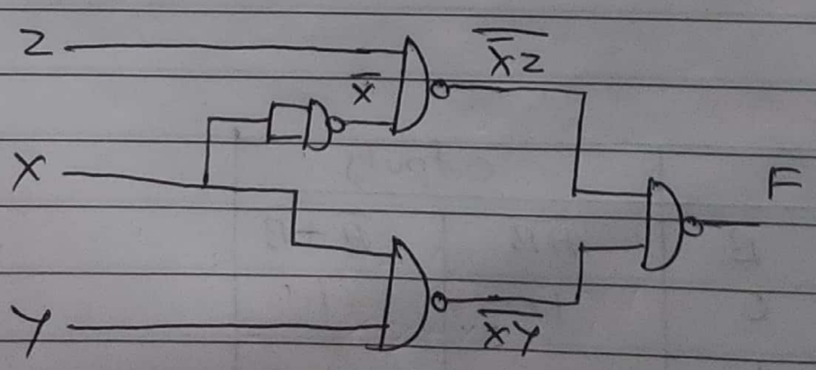
$= \Sigma(7, 6, 3, 1)$

	$\bar{Y}\cdot\bar{Z}$	$\bar{Y}Z$	YZ	$Y\bar{Z}$
$\bar{X}$	0	1	1	0
X	0	0	1	1

$F = \bar{X}Z + XY$

$F = (\bar{X}Z + XY)''$

$F = (\overline{\bar{X}Z} \cdot \overline{XY})'$



(c) $F = xyz + x'y'z + x'y'z' + xy'z' + x'yz$

Here,

$$F = xyz + x'y'z + x'y'z' + xy'z' + x'yz$$
$$= 111 + 001 + 000 + 100 + 011$$
$$= \Sigma(0, 1, 3, 4, 7)$$

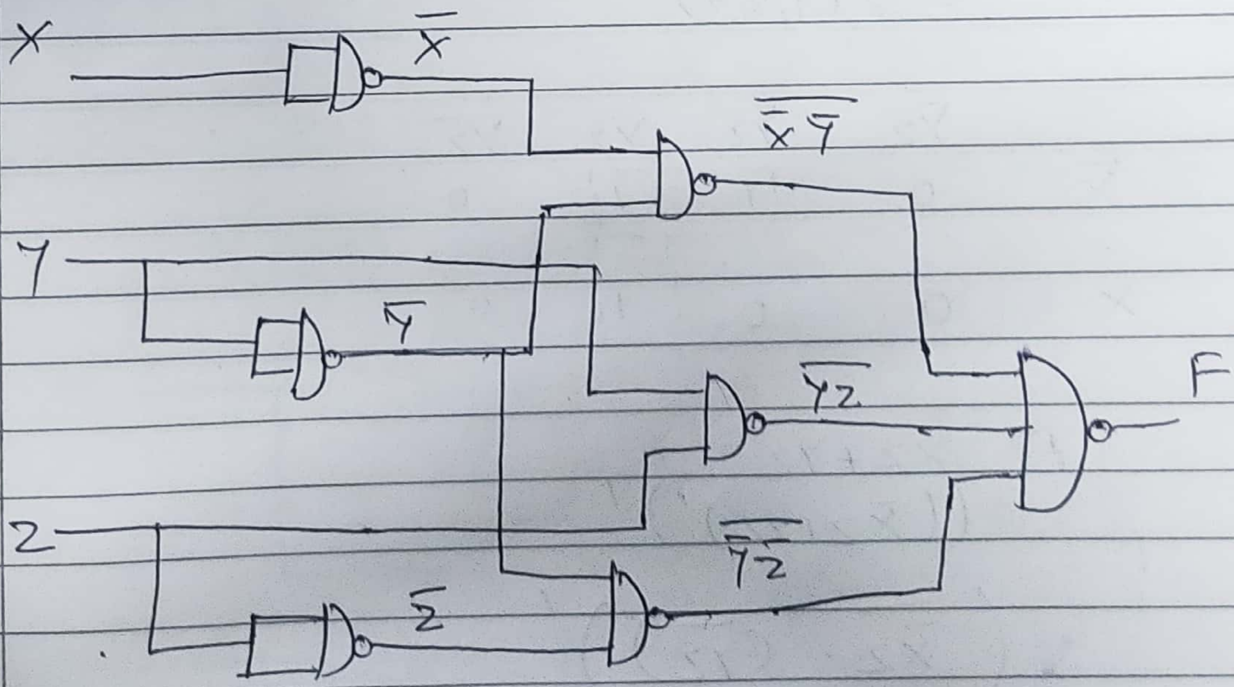
Now,

	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{x}$	1	1	1	0
x	1	0	1	0

$$F = \bar{y}\bar{z} + yz + \bar{x}\bar{y}$$

$$F = (\bar{y}\bar{z} + yz + \bar{x}\bar{y})''$$

$$F = \left(\overline{\bar{y}\bar{z}} \cdot \overline{yz} \cdot \overline{(\bar{x}\bar{y})}\right)'$$

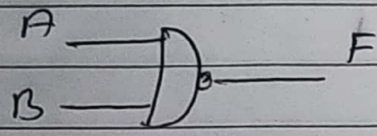


(d) $F(A,B,C) = \Sigma(0,1,2,5) + D(3,4,6)$

Presenting K-map

	$\bar{B}\bar{C}$	$\bar{B}C$	BC	$B\bar{C}$
$\bar{A}$	1	1	x	1
A	x	1		x

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



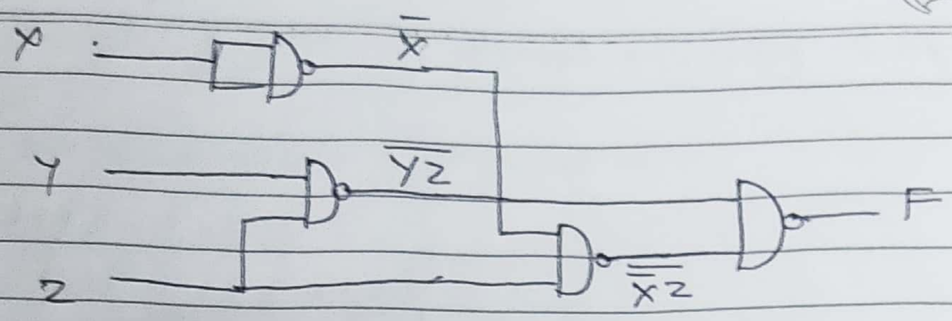
(e) $F = X'YZ + X'Y'Z + XYZ$

Here,

$$F = X'YZ + X'Y'Z + XYZ$$
$$= 011 + 001 + 111$$
$$= \Sigma(1,3,7)$$

	$\bar{Y}\bar{Z}$	$\bar{Y}Z$	YZ	$Y\bar{Z}$
$\bar{X}$	0	1	1	0
X	0	0	1	0

$$F = \bar{X}Z + YZ$$
$$= ((\bar{X}Z + YZ)')'$$
$$= \left(\overline{\bar{X}Z} \cdot (\overline{YZ})\right)'$$



(f) $Y = A'B' + BC' + AC'$

Now,

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

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

$= 011 + 010 + 110 + 100$

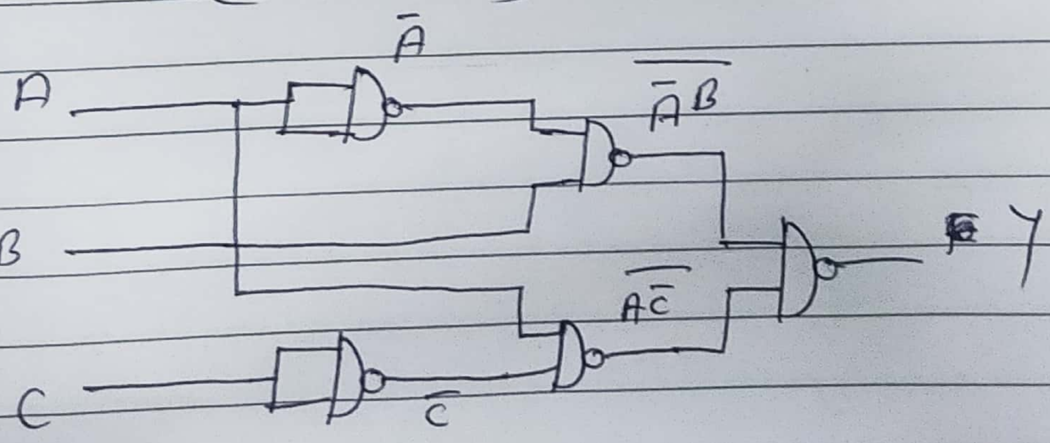
$= \Sigma(2, 3, 4, 6)$

	$\overline{B}\overline{C}$	$\overline{B}C$	BC	$B\overline{C}$
$\overline{A}$	0	0	1	1
A	1	0	0	1

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

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

$= \left(\overline{(\overline{A}B)} \cdot \overline{(A\overline{C})}\right)'$

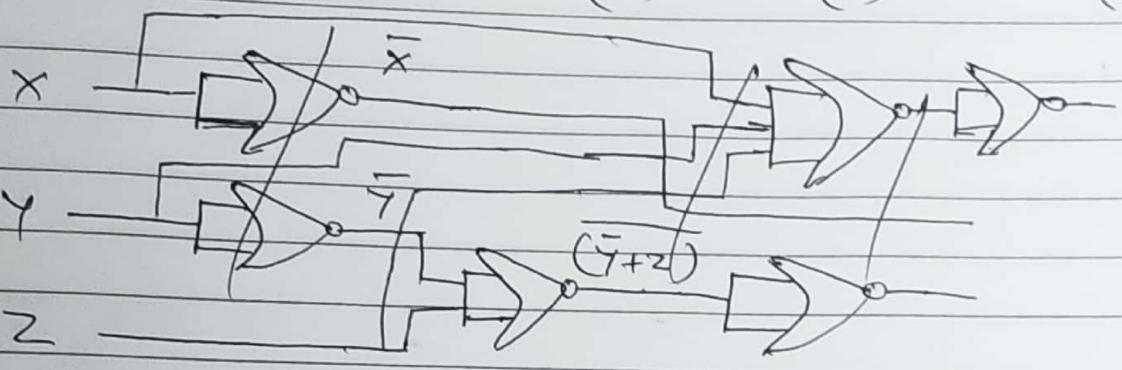


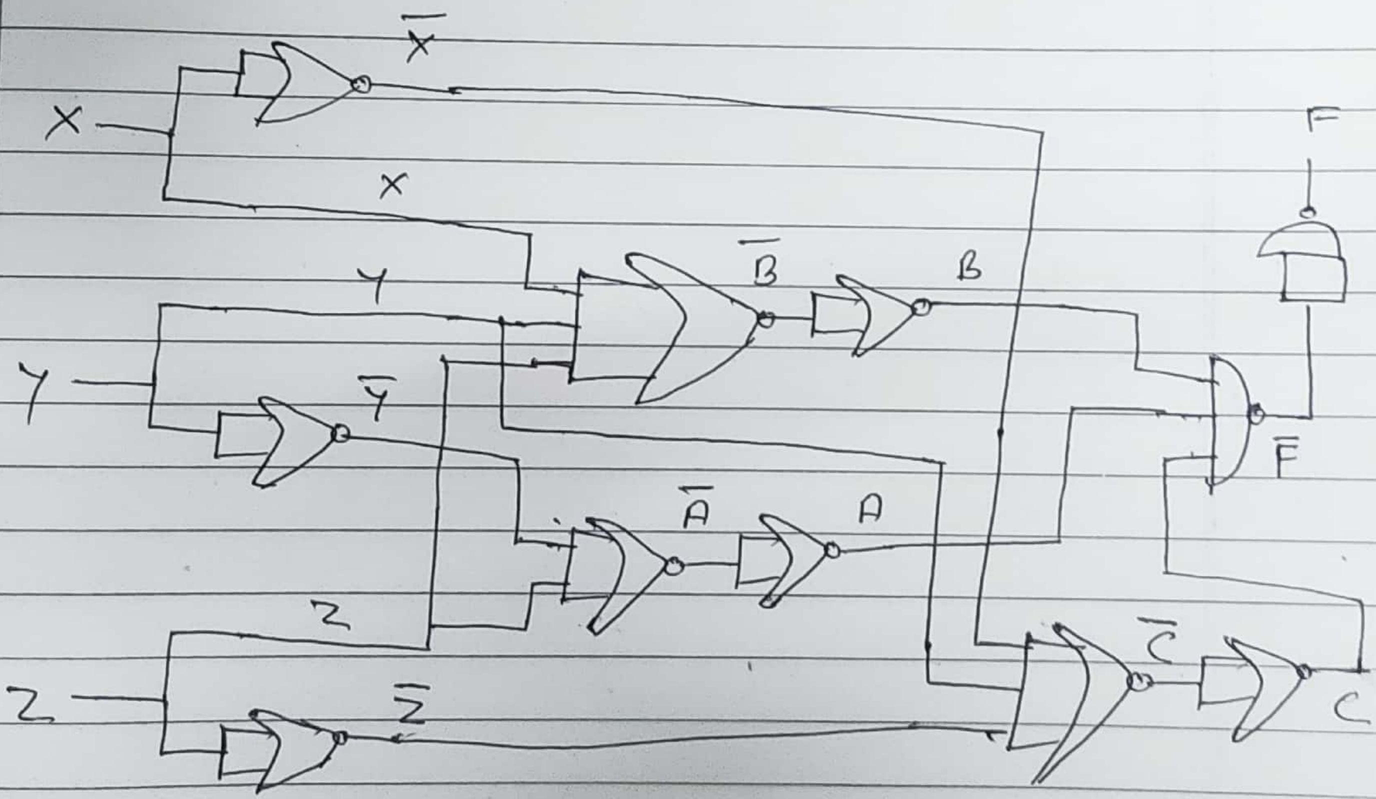
(9) $F(x,y,z) = \pi(0,2,5,6)$

Now,

	$Y+Z$	$Y+\bar{Z}$	$\bar{Y}+\bar{Z}$	$\bar{Y}+Z$
X	0	1	1	0
$\bar{X}$	1	0	1	0

$$F(x,y,z) = \underbrace{(\bar{Y}+Z)}_{(A)} \cdot \underbrace{(X+Y+Z)}_{(B)} \cdot \underbrace{(\bar{X}+Y+\bar{Z})}_{(C)}$$





(6) Simplify the expression using Boolean algebra

(a) $A'B'C' + A'B'C + AB'C' + AB'C$

Here,

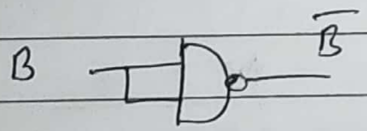
$$F = A'B'C' + A'B'C + AB'C' + AB'C$$
$$= 000 + 001 + 100 + 101$$
$$= m_0 + m_1 + m_4 + m_5$$

$\therefore F = \Sigma(0, 1, 4, 5)$

Now,

A \ BC	$\bar{B}\bar{C}$	$\bar{B}C$	BC	$B\bar{C}$
$\bar{A}$	1	1	0	0
A	1	1	0	0

$\therefore F = \bar{B}$



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5) $AC' + ABC + A(C + AC')$

Here,

$$F = AC' + ABC + AC + AC'$$
$$= AC'(B+B') + ABC + AC(B+B') + AC'(B+B')$$
$$= ABC' + AB'C' + ABC + ABC + AB'C + ABC' + AB'C'$$

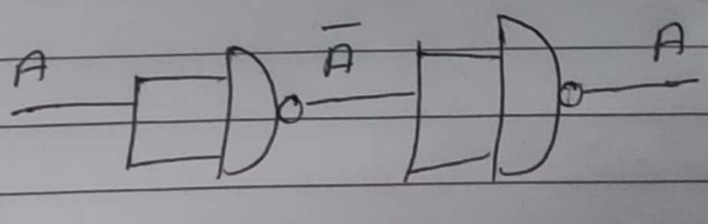
$$= ABC' + AB'C' + ABC + AB'C$$
$$= 110 + 100 + 111 + 101$$
$$= m_6 + m_4 + m_7 + m_5$$

$$\therefore F = \Sigma(4,5,6,7)$$

(K-Mapping)

	$\bar{B}\bar{C}$	$\bar{B}C$	BC	$B\bar{C}$
$\bar{A}$	0	0	0	0
A	1	1	1	1

$$\therefore F = A$$



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1) Prove that

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

Taking R.H.S $= (A+C)(A'+B)$

$= A\bar{A} + AB + \bar{A}C + BC$

$= 0 + AB + \bar{A}C + BC$

$= AB + \bar{A}C + BC(A+\bar{A})$

$= AB + \bar{A}C + BCA + \bar{A}BC$

$= AB + ABC + \bar{A}C + \bar{A}BC$

$= AB(1+C) + \bar{A}C(1+B)$

$= AB + \bar{A}C$

$=$ L.H.S proved

(b) $XY + X'Z = XY + X'Z + YZ$

Now,

R.H.S $= XY + X'Z + YZ$

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

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

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

$= XY + X'Z$

$=$ L.H.S proved

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(c) $((AB)' + A' + AB)' = 0$

Soln

$L.H.S = ((AB)' + A' + AB)'$

$= (\bar{A} + \bar{B} + \bar{A} + AB)'$

$= (\bar{A} + \bar{B} + AB)'$

$= (\overline{AB} + AB)' \Rightarrow (\bar{x} + x)$

$= \bar{1}$

$= 0 = R.H.S$ proved.