Unit - 1

Number System

→ Convert Binary to Decimal

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

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

$= (21)_{10}$

→ Convert Decimal to Binary

1) $(21)_{10}$

$21 \div 2$	1 LSB → least significant bit
$10 \div 2$	0
$5 \div 2$	1
$2 \div 2$	0
	1 MSB → Most significant bit

★ Binary = 0-1
Octal = 0-7
Decimal = 0-9
Hexadecimal = 0-F

	2^2	2^1	2^0	
1 =	0	0	1	10 = A
2 =	0	1	0	11 = B
3 =	0	1	1	12 = C
4 =	1	0	0	13 = D
5 =	1	0	1	14 = E
6 =	1	1	0	15 = F
7 =	1	1	1	

→ Convert Binary into decimal

1] $(101110)_2$

$= 1\times2^5 + 0\times2^4 + 1\times2^3 + 1\times2^2 + 1\times2^1 + 0\times2^0$

$= 32 + 0 + 8 + 4 + 2 + 0$

$= (46)_{10}$

2] $(00011)_2$

$= 0 + 0 + 0 + 2 + 1$

$= (3)_{10}$

3] $(100011)_2$

$= 1\times2^5 + 0\times2^4 + 0\times2^3 + 0\times2^2 + 1\times2^1 + 1\times2^0$

$= 32 + 0 + 0 + 0 + 2 + 1$

$= (35)_{10}$

→ Convert decimal to binary

1] $(21)_{10}$

$21 \div 2$	1
$10 \div 2$	0
$5 \div 2$	1
$2 \div 2$	0
	1

$(10101)_2$

2] $(29)_{10}$

$29 \div 2$	1
$14 \div 2$	0
$7 \div 2$	1
$3 \div 2$	1
$1 \div 2$	1

$(11101)_2$

→ Convert ~~to~~ Octal to decimal

1] $(215)_8$

$= 2\times8^2 + 1\times8^1 + 5\times8^0$

$= 128 + 8 + 5$

$= (141)_{10}$

2] $(12570)_8$

$= 1\times8^4 + 2\times8^3 + 5\times8^2 + 7\times8^1 + 0\times8^0$

$= 4096 + 1024 + 320 + 56 + 0$

$= (5496)_{10}$

3] $(5496)_8$

$= 5\times8^3 + 4\times8^2 + 9\times8^1 + 6\times8^0$

$= 2560 + 256 + 72 + 6$

$= (4894)_{10}$

→ Convert binary to Octal

1] $(10\,101)_2$

$(25)_8$

2] $(1\,100\,111)_2$

$(147)_8$

3] $(101\,011)_2$

$(53)_8$

→ Octal to Binary

1] $(25)_8$

2 5

010 101

$= (10101)_2$

2] $(29)_8$

2 9 × Not possible

3] $(346)_8$

3 4 6

011 100 110

$(011100110)_2$

→ Convert binary to Hexadecimal

1] $(10101)_2$

$= (15)_H$

$= (F)_H$

→ Convert Hexadecimal to binary

1] $(12EA)_{16}$

$(\underset{1}{0001}\ \underset{2}{0010}\ \underset{E}{1110}\ \underset{A}{1010})$

$(0001001011101010)_2$

→ Convert binary to Decimal, Octal and Hexadecimal

1] $(1011011)_2 = (?)_{10} \quad (?)_8 \quad (?)_{16}$

$(?)_{10}$

$= 1\times2^6 + 0\times2^5 + 1\times2^4 + 1\times2^3 + 0\times2^2 + 1\times2^1 + 1\times2^0$

$= 64 + 0 + 16 + 8 + 0 + \cancel{0\times1}\, 2 + 1$

$= (91)_{10}$

$(?)_8$

(1011011)

$= (133)_8$

$(?)_{16}$

(1011011)

$= (5B)_{16}$

2] $(1001001)_2 = (?)_{10} \quad (?)_8 \quad (?)_{16}$

$(?)_{10}$

$= 1\times2^6 + 0\times2^5 + 0\times2^4 + 1\times2^3 + 0\times2^2 + 0\times2^1 + 1\times2^0$

$= 64 + 0 + 0 + 8 + 0 + 0 + 1$

$= (75)_{10}$

$(?)_8$

(1001001)

$= (111)_8$

$(?)_{16}$

(1001001)

$(49)_{16}$

3] $(100001)_2 = (?)_{10}\ (?)_8\ (?)_{16}$
$= 1\times2^5 + 0\times2^4 + 0\times2^3 + 0\times2^2 + 0\times2^1 + 1\times2^0$
$= 32+0+0+0+0+1$
$= (33)_{10}$

$= (41)_8$
$= (21)_{16}$

4] $(10011101)_2 = (?)_{10}\ (?)_8\ (?)_{16}$
$= 1\times2^7 + 0\times2^6 + 0\times2^5 + 1\times2^4 + 1\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0$
$= 128+0+0+16+8+4+0+1$
$= (157)_{10}$

$= (235)_8$
$= (9D)_{16}$

5] $(1011010)_2 = (?)_{10}$
$= 1\times2^6 + 0\times2^5 + 1\times2^4 + 1\times2^3 + 0\times2^2 + 1\times2^1 + 0\times2^0$
$= 64+0+16+8+0+2+0$
$= (90)_{10}$

6] $(011001.1011)_2 = (?)_8\ (?)_{16}$
$= (31.54)_8$
$= (19.B)_{16}$

→ Conversion

1] $(101011)_2 = (?)_{10}$
$= 1\times2^5 + 0\times2^4 + 1\times2^3 + 0\times2^2 + 1\times2^1 + 1\times2^0$
$= 32 + 0 + 8 + 0 + 2 + 1$
$= (43)_{10}$

2] $(1101)_2 = (?)_{10}$
$= 1\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0$
$= 8 + 4 + 0 + 1$
$= (13)_{10}$

3] $(111001)_2 = (?)_8$
$= \underline{111}\ \underline{001}$
$= 7\quad 1$
$= (71)_8$

4] $(1100011)_2 = (?)_8$
$= \underline{1}\,\underline{100}\,\underline{011}$
$= 1\ 4\ 3$
$= (143)_8$

5] $(111001.1011)_2 = (?)_8$
$= (71.54)_8$

6] $(1110011)_2 = \cancel{(163)}\ (?)_{16}$
$= (73)_{16}$

7] $(11000101)_2 = (?)_{16} = (180)_{16}$

→ Convert decimal to binary

1] $(13)_{10} = (?)_2$

	Quotient	Remainder	
			LSB
$13 \div 2$	6	1	
$6 \div 2$	3	0	
$3 \div 2$	1	1	↑
$1 \div 2$	0	1	MSB

$(13)_{10} = (1101)_2$

2] $(174)_{10} = (?)_2$

$174 \div 2$	87	0
$87 \div 2$	43	1
$43 \div 2$	21	1
$21 \div 2$	10	1
$10 \div 2$	5	0
$5 \div 2$	2	1
$2 \div 2$	1	0
		1

$= (10101110)_2$

→ Convert Decimal to ~~Hexadecimal~~ Octal

3] $(501)_{10} = (?)_8$

	Quotient	Remainder
$501 \div 8$	62.625	$0.625 \times 8 = 5$
$62 \div 8$	7.75	$0.75 \times 8 = 6$
$7 \div 8$	0.875	$0.875 \times 8 = 7$

$$(501)_{10} = (765)_8$$

4] $(1465)_{10} = (?)_8$

$1465 \div 8$	183.125	$0.125 \times 8 = 1$
$183 \div 8$	22.875	$0.875 \times 8 = 7$
$22 \div 8$	2.75	$0.75 \times 8 = 6$
$2 \div 8$	0.25	$0.25 \times 8 = 2$

$$(1465)_{10} = (2671)_8$$

→ Convert Decimal to Hexadecimal

$(501)_{10} = (?)_{16}$

	Quotient	Remainder
$501 \div 16$	31.3125	$0.3125 \times 16 = 5$
$31 \div 16$	1.9375	$0.9375 \times 16 = 15 = F$
$1 \div 16$	0.0625	$0.0625 \times 16 = 1$

$$(1F5)_{16}$$

→ Decimal to Binary

$(501)_{10} = (?)_2$

	Quotient	Remainder
$501 \div 2$	250	1
$250 \div 2$	125	0
$125 \div 2$	62	1
$62 \div 2$	31	0
$31 \div 2$	15	1
$15 \div 2$	7	1
$7 \div 2$	3	1
$3 \div 2$	1	1
$1 \div 2$	0	1

$(111110101)_2$

→ Octal to Binary

- $(205)_8 = (?)_2$

$= 2 \quad 0 \quad 10+5$

$= 010 \; 000 \; 101$

$= (010000101)_2$

→ $(205)_8 = (?)_{10} \longrightarrow (?)_2$

$= 2 \times 8^2 + 0 \times 8^1 + 5 \times 8^0$

$= 128 + 0 + 5$

$= (133)_{10} \longrightarrow (?)_2$

$= (10001101)_2$

→ $\cancel{(133)_{10}} = \cancel{(00101101 1)}_2$

$133 \div 2$	1
$66 \div 2$	0
$33 \div 2$	1
$16 \div 2$	1
$8 \div 2$	0
$4 \div 2$	0
$2 \div 2$	0
	1

→ Decimal to Hexadecimal

1] $(4253)_{10} = (?)_H$

4253 ÷ 16	265.8125	.8125×16 = D
265 ÷ 16	16.5625	.5625×16 = 9
16 ÷ 16	1	.0×16 = 0
16 ÷ 16	0.0625	0625×16 = 1

$(4253)_{10} = (109D)_{16}$

2] $(252)_{10} = (?)_H$

252 ÷ 16	15.75	C
15 ÷ 16	0.9375	F

$(252)_{10} = \cancel{(CF)_{16}}\ (FC)_{16}$.

3] $(289)_{10} = (?)_H$

289 ÷ 16	18.0625	1
18 ÷ 16	1.125	2
1 ÷ 16	0.0625	1

$(289)_{10} = (121)_{16}$

4] $(3333)_{10} = (?)_H$

3333 ÷ 16	208.3125	5
208 ÷ 16	13	0
13 ÷ 16	0.8125	D

$(3333)_{10} = (D05)_{16}$

5] $(5749)_{10} = (?)_H = (1675)_H$

5749 ÷ 16	359.3125	5
359 ÷ 16	22.4375	7
22 ÷ 16	1.375	6
1 ÷ 16	0.0625	1

→ Convert Hexadecimal to decimal

1] $(A210)_H = (?)_{10}$
$= 10\times16^3 + 2\times16^2 + 1\times16^1 + 0\times16^0$
$= 40960 + 512 + 16 + 0$
$= (41488)_{10}$

2] $(459)_H = (?)_{10}$
$= 4\times16^2 + 5\times16 + 9\times16^0$
$= 1024 + 80 + 9$
$= 1113$

3] $(92F)_H = (?)_{10}$
$= 9\times16^2 + 2\times16^1 + 15\times16^0$
$= 2304 + 32 + 15$
$= 2351$

→ Convert Hexadecimal to octal

1] $(981)_H \rightarrow (?)_8$
1st convernt $(981)_H \longrightarrow (?)_2$ and then into octal
$(981)_H = (100110000001)_2$
$(100110000001)_2 = (?)_8$
$= (4601)_8$

2] $(FF)_H = (?)_8$
$(FF)_H = (?)_2 = (11111111)_2$
$(011111111)_2 = (?)_8$
$= (377)_8$

→ Octal to Decimal

1] $(756)_8 = (?)_{10}$
$= 7 \times 8^2 + 5 \times 8^1 + 6 \times 8^0$
$= 448 + 40 + 6$
$= (494)_{10}$

2] $(1034)_8 = (?)_{10}$
$= 1 \times 8^3 + 0 \times 8^2 + 3 \times 8^1 + 4 \times 8^0$
$= 512 + 0 + 24 + 4$
$= (540)_{10}$

3] $(5602)_8 = (?)_{10}$
$= 5 \times 8^3 + 6 \times 8^2 + 0 \times 8^1 + 2 \times 8^0$
$= 2560 + 384 + 0 + 2$
$= (2946)_{10}$

→ Hexadecimal to binary

1] $(A2B)_{16} = (?)_2$
$(A2B)_{16} = (?)_{10}$
$= A \times 16^2 + 2 \times 16^1 + B \times 16^0$
$= 2560 + 32 + 11$
$= (2603)_{10}$

$(2603)_{10} =$

$2603 \div 2$	1
$1301 \div 2$	1
$650 \div 2$	0
$325 \div 2$	1
$162 \div 2$	0

81 ÷ 2   1
40 ÷ 2   0
20 ÷ 2   0
10 ÷ 2   0
5 ÷ 2   1
2 ÷ 2   0
   1

$(2603)_{10} = (101000101011)_2$

→ Convert Octal into decimal and then into binary

1] $(540)_8 = (?)_{10} \longrightarrow (?)_2$
$= 5 \times 8^2 + 4 \times 8^1 + 0 \times 8^0$
$= 320 + 32 + 0$
$= (352)_{10}$

352 ÷ 2   0
176 ÷ 2   0
88 ÷ 2   0
44 ÷ 2   0
22 ÷ 2   0
11 ÷ 2   1
5 ÷ 2   1
2 ÷ 2   0
   1

$(352)_{10} = (101100000)_2$

2] $(667)_8 = (?)_{10} \longrightarrow (?)_2$

$= 6\times8^2 + 6\times8^1 + 7\times8^0$

$= 384 + 48 + 7$

$= (439)_{10}$

$439 \div 2$	1
$219 \div 2$	1
$109 \div 2$	1
$54 \div 2$	0
$27 \div 2$	1
$13 \div 2$	1
$6 \div 2$	0
$3 \div 2$	1
$1 \div 2$	1

$(439)_{10} = (110110111)_2$

3] $(352)_8 = (?)_{10} \longrightarrow (?)_8$

$= 3\times8^2 + 5\times8^1 + 2\times8^0$

$= 192 + 40 + 2$

$= (234)_{10}$

$234 \div 2$	0
$117 \div 2$	1
$58 \div 2$	0
$29 \div 2$	1
$14 \div 2$	0
$7 \div 2$	1
$3 \div 2$	1
$1 \div 2$	1

$(234)_{10} = (11101010)_2$

4] $(157)_8 = (?)_{10} \longrightarrow (?)_2$

$= 1\times8^2 + 5\times8^1 + 7\times8^0$

$= 64 + 40 + 7$

$= (111)_{10}$

$111 \div 2$	1
$55 \div 2$	1
$27 \div 2$	1
$13 \div 2$	1
$6 \div 2$	0
$3 \div 2$	1
$1 \div 2$	1

$(111)_{10} = (1101111)_2$

5) $(6273)_8 = (?)_{10} \longrightarrow (?)_2$

$= 6\times8^3 + 2\times8^2 + 7\times8^1 + 3\times8^0$

$= 3072 + 128 + 56 + 3$

$= (3259)_{10}$

$3259 \div 2$	1
$1629 \div 2$	1
$814 \div 2$	0
$402 \div 2$	0
$201 \div 2$	1
$100 \div 2$	0
$50 \div 2$	0
$25 \div 2$	1
$12 \div 2$	0
$6 \div 2$	0
$3 \div 2$	1
$1 \div 2$	1

$(3259)_{10} = (110010010011)_2$

1] $(1101.011)_2 = (?)_{10}$

$= 1\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0 + 0\times2^{-1} + 1\times2^{-2} + 1\times2^{-3}$

$= 8 + 4 + 0 + 1 + 0 + \frac{1}{4} + \frac{1}{8}$

$= (13.375)_{10}$

2] $(276.43)_8 = (?)_{10}$

$= 2\times64 + 7\times8 + 6\times8^0 + 4\times8^{-1} + 3\times8^{-2}$

$= 128 + 56 + 6 + \frac{4}{8} + \frac{3}{64}$

$= (190.546875)_{10}$

3] $(A1.23)_{16} = (?)_{10}$

$= 10\times16 + 1\times16^0 + 2\times16^{-1} + 3\times16^{-2}$

$= 160 + 1 + \frac{1}{8} + \frac{3}{256}$

$= (161.136)_{10}$

4] $(88.37)_{10} = (?)_8$

$(88)_{10} = (?)_8$

$88 \div 8$	11	0
$11 \div 8$	1.375	3
$1 \div 8$	0.125	1

$(88.\cancel{37})_{10} = (130)_8$

$(.37)_8 = (?)_{10}$

$0.37\times8 = 2.96$	2
$0.96\times8 = 7.68$	7
$0.68\times8 = 5.44$	5
$0.44\times8 = 3.52$	3
$0.52\times8 = 4.16$	4

$(0.37)_8 = (\cancel{43572}$
$\cancel{275}\ (27534)_8$

$(88.37)_{10} = (130.27534)_8$

~~$(27.47)_{10} = (?)_8$~~

$2\times 8^1 + 7\times 8^0 + 4\times 8^{-1} + 7\times 8^{-2}$

~~16~~ $+ 7 + 1/2 + 7/64$

5] $(27.47)_{10} = (?)_8$

$(27)_{10} = (?)_8$

$27 \div 8$	3.375	$0.375 \times 8 = 3$
$3 \div 8$	0.375	$0.375 \times 8 = 3$

$(27)_{10} = (33)_8$

$(0.47)_{10} = (?)_8$

$0.47\times 8 = 3.76$	3
$0.76 \times 8 = 6.08$	6
$0.08 \times 8 = 0.64$	0
$0.64 \times 8 = 5.12$	5
$0.12 \times 8 = 0.96$	0

$(0.47)_{10} = (3605)_8$

$(27.47)_{10} = (33.3605)_8$

6] $(27.47)_{10} = (?)_{16}$

$(27)_{10} = (?)_{10}$

~~$27 \div 16875$~~

$27 \div 16$	1.6875	$11 = B$
$1 \div 16$	0.0625	1

$(27)_{10} = (1B)_{16}$

$(0.47)_{10} = (?)_{16}$

$0.47 \times 16 = 7.52$	7
$0.52 \times 16 = 8.32$	8
$0.32 \times 16 = 5.12$	5
$0.12 \times 16 = 1.92$	1

$(0.47)_{10} = (7851)_{16}$

$(27.47)_{10} = (1B.7851)_{16}$

BCD (Binary coded decimal)

0	00	0000
1	01	0001
2	10	0010
3	11	0011
4	100	0100
5	101	0101
6	110	0110
7	111	0111
8	1000	1000
9	1001	1001

8421, 2421, 5211 } weighted code

excess-3, gray code } Non weighted code

1] $(15)_{10} = (?)$ excess-3

$$\begin{array}{r} 1\ \ 5 \\ +3\ +3 \\ \hline 4\ \ 8 \end{array}$$

0100 1000

$(15)_{10} = (01001000)$

2] $(237.75)_{10} = (?)$ excess-3

$$\begin{array}{ccccc} 2 & 3 & 7 & . & 7 & 5 \\ +3 & +3 & +3 & . & +3 & +3 \\ 5 & 6 & 10 & . & 10 & 8 \end{array}$$

$(237.75)_{10} = (010101101010.10101000)$ excess-3

→ Excess-3 to Decimal

1] $(010101101010.10101000)_{excess-3} = (?)_{10} = (237.75)_{10}$

$\underline{0101}\,\underline{0110}\,\underline{1010}.\underline{1010}\,\underline{1000}$
5 6 A . A 8

56A . A8
-3 -3 -3 . -3 -3
237 . 75

2] $(110010100011.01110101)_{excess-3} = (?)_{10}$

1100 1010 0011 . 0111 0101
-0011 -0011 -0011 . -0011 -0011
1001 0111 0000 . 0100 0010
9 7 0 . 4 2

$(110010100011.01110101)_{excess-3} = (970.42)_{10}$

3] $(101111100101.10001011)_{excess-3} = (?)_{10}$

1011 1111 00101 . 1000 1011
-0011 -0011 -0011 . -0011 -0011
1000 1100 0000 . 0101 1000
8 C 0 . 5 8

$(1011111011.10001011)_{excess-3} = (8C0.58)_{10}$

→ Decimal to Excess-3

i] $(742.48)_{10} = (?)_{excess-3}$

7	4	2	.	4	8
+3	+3	+3		+3	+3
A	7	5	.	7	B

A75.7B = 101001110101.01111011

$(742.48)_{10} = (101001110101.01111011)_{excess-3}$

→

Decimal	BCD	XS-3	gray code
0	0000	0011	0000
1	0001	0100	0001
2	0010	0101	0011
3	0011	0110	0010
4	0100	0111	0110
5	0101	1000	0111
6	0110	1001	0101
7	0111	1010	0100
8	1000	1011	1100
9	1001	1100.	1101

	Sum	Carry
0+0 =	0	0
0+1 =	1	0
1+0 =	1	0
1+1 =	0	1

$(24)_{10} \longrightarrow (?)_{xs-3}$

$$\begin{array}{r} 0010\ 0100 \\ 0011\ 0011 \\ \hline 0101\ 0111 \end{array}$$

$(24)_{10} = (01010111)_{xs-3}$

→ Gray code

1] $(110111)_2 = (?)_{graycode}$

111011

↓

(1001010) gray code

2] (100110) gray code $= (?)_2$

1 0 0 1 1 0

$(1\ 1\ 1\ 0\ 1\ 1)_2$

3] $(11011101)_2 = (?)$ gray code

11011101

↓

(10110011) gray code

4] (10001001) gray code $= (?)_2$

$$10001001$$
$$\downarrow$$
$$(11110001)_2$$

Conversion

1] $(110101)_2 = (?)_{10}$

$= 2^5 \times 1 + 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$

$= 32 + 16 + 0 + 4 + 0 + 1$

$= (53)_{10}$

2] $(101101.10101)_2 = (?)_{10}$

$= 1 \times 2^5 + 0 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 + 1 \times 2^{-1} + 0 \times 2^{-2} + 1 \times 2^{-3} + 0 \times 2^{-4} + 1 \times 2^{-5}$

$= 32 + 0 + 8 + 4 + 0 + 1 + 0.5 + 0.25 + 0.125 + 0 + 0.03125$

$= (45.9375)_{10}$

3] $(11111111)_2 = (?)_{10}$

$= 1 \times 2^7 + 1 \times 2^6 + 1 \times 2^5 + 1 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 1 \times 2^0$

$= 128 + 64 + 32 + 16 + 8 + 4 + 2 + 1$

$= (255)_{10}$

4] $(00000000)_2 = (?)_{10}$

$= 0 \times 2^7 + 0 \times 2^6 + 0 \times 2^5 + 0 \times 2^4 + 0 \times 2^3 + 0 \times 2^2 + 0 \times 2^1 + 0 \times 2^0$

$= 0$

5]

5] $(25.5)_{10} = (?)_2$

25 ÷ 2	1
12 ÷ 2	0
6 ÷ 2	0
3 ÷ 2	1
1 ÷ 2	1

$(25)_{10} = (11101)_2$

6] $(10.625)_{10} = (?)_2$

10 ÷ 2	0	0.625×2 = 1.250	1
5 ÷ 2	1	0.250×2 = 0.50	0
2 ÷ 2	0	60×2 =	
1 ÷ 2	1	0.50×2 = 1.0	1

$(10)_{10} = (1010)_2$

$(10.625)_{10} = (1010.101)_2$

7] $(0.65625)_{10} = (?)_2$

0.65625×2 = 1.3125	1
0.3125×2 = 0.625	0
0.625×2 = 1.25	1
0.25×2 = 0.5	0
0.5×2 = 1	1

$(0.65625)_{10} = (0.10101)_2$

8] $(6327.4051)_8 = (?)_{10}$

$= 6\times8^3+3\times8^2+2\times8^1+7\times8^0+4\times8^{-1}+0\times8^{-2}+5\times8^{-3}+1\times8^{-4}$

$= 3072+192+16+7+0.5+0+0.00976+0.00024$

$= (3287.510004)_{10}$

9] $(247)_{10} = (?)_8$

$247 \div 8$	30.875	0.875×8	7
$30 \div 8$	3.75	0.75×8	6
$3 \div 8$	0.375	0.375×8	3

$(247)_{10} = (367)_8$

10] $(0.6075)_{10} = (?)_8$

0.6075×8	$= 4.86$	4
0.86×8	$= 6.88$	6
0.88×8	$= 7.04$	7
0.04×8	$= 0.32$	0
0.32×8	$= 2.56$	2

~~0.20164~~ $(0.6075)_{10} = (0.46702)_8$

11] $(95.5)_{10} = (?)_{16}$

$95 \div 16$	5.9375	$15 = F$	$0.5 \times 16 = 8$
$5 \div 16$	0.3125	5	

$(95)_{10} = (5F)_{16}$ $(0.5)_{10} = (8)_{16}$

$(95.5)_{10} = (5F.8)_{16}$

12] $(675.625)_{10} = (?)_{16}$ $\quad 0.625 \times 16 = 10$

$675 \div 16 \quad 42.1875 \quad 3$

$42 \div 16 \quad 2.625 \quad 10 = A$

$2 \div 16 \quad 0.125 \quad 2$

$(0.625)_{10} = (10)_{16}$

$= (A)_{16}$

$(675)_{10} = (2A3)_{16}$

$(675.625)_{10} = (2A3 \cdot A)_{16}$

13] $(2F9A)_{16} = (?)_2$

2	F	9	A
0010	1111	1001	1010

$(2F9A)_{16} = (0010111110011010)_2$

14] Represent the decimal no. a] 27 b] 396 c] 4096 in binary form using.

1] Binary code
2] BCD code
3] XS-3 code
4] Gray code
5] Octal code
6] Hexadecimal code

→ **Signed numbers**

$\boxed{\begin{array}{l} 0\ +ve \\ 1\ -ve \end{array}}$

$\underbrace{101100}_{-12} = 0\times2^4 + 1\times2^3 + 1\times2^2 + 0\times2^1 + 0\times2^0$
$= 0 + 8 + 4 + 0 + 0 = 12$

$\underbrace{01110001}_{(+113)} = \cancel{0\times2^7} + 1\times2^6 + 1\times2^5 + 1\times2^4 + 0\times2^3 + 0\times2^2 + 0\times2^1 + 1\times2^0$
$= \cancel{0} + 64 + 32 + 16 + 0 + 0 + 0 + 1$
$= (+113)$

→ **Complement's code**

1's
2's } complement
9's

1] $+7 \rightarrow 0111 \rightarrow (1000)_2$
$-7 \rightarrow 1111 \rightarrow (0000)_2$

$+15 \rightarrow 01111 \rightarrow (10000)_2$
$-15 \rightarrow 11111 \rightarrow (00000)_2$

→ **2's compliment**

1] $(01001110)_2$

1st convert it into 1's compliment, then add 1 from LSB.

$$\begin{array}{r} \cancel{10110001} \\ +\ \ \ \ \ \ \ \ \ 1 \\ \hline \cancel{10110000} \end{array} \qquad \begin{array}{r} 10110001 \\ +\ \ \ \ \ \ \ \ \ 1 \\ \hline 10110010 \end{array}$$

→ Arithmetic operation 2 beats

	Sum	Carry
0 + 0 =	0	0
0 + 1 =	1	0
1 + 0 =	1	0
1 + 1 =	0	1

→ Arithmetic operation 3 beats

	Sum	Carry
0+0+1 =	1	
0 1 0 =	1	
0 1 1 =	0	1
1 0 0 =	1	
1 0 1 =	0	1
1 1 0 =	0	1
1 1 1 =	1	1

→ 9's compliment

i) $(29)_{10} = (?)_{9's}$

$$\begin{array}{r} 99 \\ -\ 29 \end{array}$$

$(29)_{10} = (70)_{9's}$

Date ___ / /

H.W

1) $(+259)_{10} = (?)_{1's} = (?)_{2's} = (?)_{9's}$

259 ÷ 2	1
129 ÷ 2	1
64 ÷ 2	0
32 ÷ 2	0
16 ÷ 2	0
8 ÷ 2	0
4 ÷ 2	0
2 ÷ 2	0
	1

$\therefore (+259)_{10} = (0100000011) = (1011111100)_2$

Now, convert it into 2's compliment

To convert it into in 2's compliment add 1 from LSB

$$\begin{array}{r} 1011111100 \\ + \quad\quad\quad\quad 1 \\ \hline 1011111101 \end{array}$$

$\therefore (259)_{10} = (1011111101)_{2's}$

→ $(259)_{10} = (?)_{9's}$

$$\begin{array}{r} 999 \\ -\ 259 \\ \hline 740 \end{array}$$

$\therefore (259)_{10} = (740)_{9's}$

Date / /

3] $(74)_{10} = (?)_{1's} = (?)_{2's} = (?)_{9's}$

$74 \div 2$	0
$37 \div 2$	1
$18 \div 2$	0
$9 \div 2$	1
$4 \div 2$	0
$2 \div 2$	0
	1

$\therefore (+74)_{10} = (00101001) = (11010110)_{1's}$

Now, convert it into 2's compliment
To convert $(11010110)_{1's}$ in 2's compliment add 1 from LSB

$$\begin{array}{r} 11010110 \\ +\quad\quad\quad 1 \\ \hline 11010111 \end{array}$$

$\therefore (74)_{10} = (11010111)_{2's}$

→ $(74)_{10} = (?)_{9's}$

$$\begin{array}{r} 99 \\ -74 \\ \hline 25 \end{array}$$

$\therefore (74)_{10} = (25)_{9's}$

Rule :-

		Sum	Carry	Result
0	0	0	0	0
0	1	1	0	1
1	0	1	0	1
1	1	0	1	10

1]
```
   10101
+  01101
  100010
```

2]
```
   101110
   101101
+  101010
  10000101
```

3]
```
     101011
     111001
    1101011
+   1100010
   10110001
```

→ Even no 1's in column the result is 0.
→ Odd no 1's in column the result is 1.

Binary Arithmetic

1] Addition
2] Subtraction
3] Multiplication
4] Division

→ Subtraction

A	B	Diff	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

1]
```
  1 1 0 1
- 0 1 1 1
---------
  0 1 1 0
```

2]
```
  1 0 0 1
- 0 1 1 1
---------
  0 0 1 0
```

3]
```
  1010101
- 1001110
---------
  0000111
```

4]
```
  10111 0.1 1 0
- 10001 0.0 1 1
---------------
  00011 0.0 1 1
```

5]
```
  10000
- 00001
-------
  01111
```

Multiplication

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

i)

```
      1 0 1 0
x       1 0 1
-------------
      1 0 1 0
    0 0 0 0 x
+ 1 0 1 0 x x
-------------
  1 1 0 0 1 0
```

Division

1]

```
      01   ⟶ quotient
 11 | 101
     -0
     ---
     101
      11
     ---
      10   ⟶ Remainder
```

2]

```
        0
 111 | 110
        0
      ----
       110
```

3]

```
      1
 10 | 11
     -10
     ---
      01
```

4]

```
         1
 101 | 1011
      -1011 ↓
      -----
         01
```

Page No. ______
Date __ / __ / __

→ Boolean Algebra

Boolean Algebra is a system of mathematical logic any & complex statement can be expressed by boolean function

The boolean algebra is govered by certain well developed rules and laws.

The binary digit 0 and 1 are used to represent the 2 voltage levels

Binary 1 represent the higher of 2 voltage levels i.e. +5 V and binary 0 reprent the lower of 2 voltage level i.e. 0V

In boolean algebra the multiplication and adddition of the variables and function are also only logical

logical multiplication is the same as a AND operation and logical addition is same as OR operation

Defination of Boolean algebra:

It is the set of rule used to simplify the given logic expression without changing its functionality. It is used when number of variables are less.

Date / /

logic operations:

1] AND, OR, and NOT are the 3 basic operations or functions that are performed in boolean algebra. ~~in addition~~

2] In addition their are some derived operations such as NAND, NOR, X-OR and X-Nor that are are also performed in boolean algebra

AND operation: The AND operation in boolean algebra is similar to multiplication in ordinary algebra infact it is logical multiplication as performed by the AND gate.

~~Boolean laws~~

~~1 Complementation law~~

UNIT - 2

Boolean laws

1] Complementation law

1. $\bar{0} = 1$
2. $\bar{1} = 0$
3. If $A = 0$ then $\bar{A} = 1$
4. If $A = 1$ then $\bar{A} = 0$
5. $\bar{\bar{A}} = A$

2] AND law

1. $A \cdot 0 = 0$
2. $A \cdot 1 = A$
3. $A \cdot A = A$
4. $A \cdot \bar{A} = 0$

3] OR law

1. $A + 0 = A$
2. $A + 1 = 1$
3. $A + A = A$
4. $A + \bar{A} = 1$

Page No.
Date / /

4] Commulative law

$A+B = B+A$
$A \cdot B = B \cdot A$

5] Idempotence law
$A \cdot A = A$
$A+A = A$

6] Transposition law
$AB + \bar{A}C = (A+C)(\bar{A}+B)$

7] The Associative law

The Associative law allow grouping of variable. There are 2 assotication law

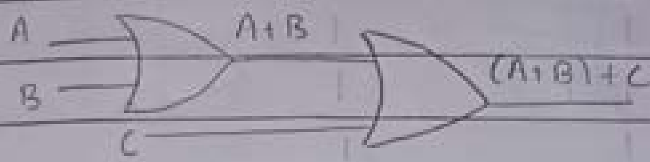
law1 $(A+B)+C = A+(B+C)$
law2 $(A \cdot B) \cdot C = A \cdot (B \cdot C)$

o In law 1 A OR B ored with C is same that in A ordered with B OR C.

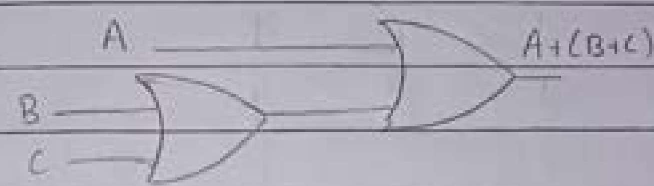
This law states that the way the variable are grouped and ORed is immaterial

Shrikrupa

logic diagram:



=



Truth table

A	B	C	A+B	(A+B)+C
0	0	0	0	0
0	0	1	0	1
0	1	0	1	1
0	1	1	1	1
1	0	0	1	1
1	0	1	1	1
1	1	0	1	1
1	1	1	1	1

=

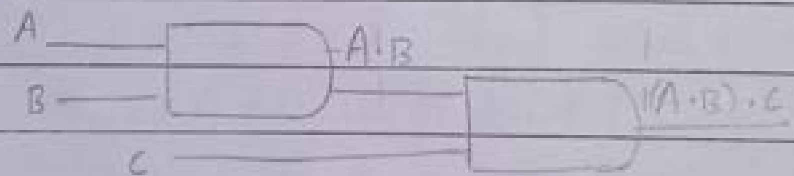
A	B	C	(B+C)	A+(B+C)
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	1	1
1	0	0	0	1
1	0	1	1	1
1	1	0	1	1
1	1	1	1	1

o Law 2: $(A \cdot B) \cdot C = A \cdot (B \cdot C)$

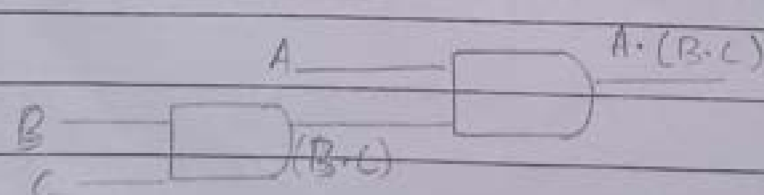
A and B anded with C same as A ANDed with B and C

This law states that the way the variable are grouped and ANDed is immaterial.

logic diagram



=



Page No. ______

Date __/__/__

Truth table

ABC	A·B	(A·B)·C
000	0	0
001	0	0
010	0	0
011	0	0
100	0	0
101	0	0
110	1	0
111	1	1

=

A B C	B·C	A·(B·C)
0 0 0	0	0
0 0 1	0	0
0 1 0	0	0
0 1 1	1	0
1 0 0	0	0
1 0 1	0	0
1 1 0	0	0
1 1 1	1	1

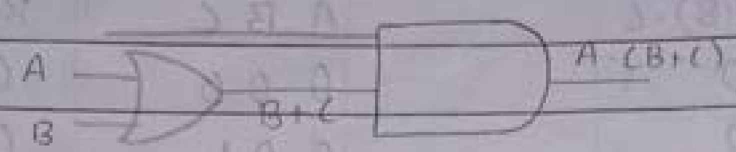
$$(A\cdot B)\cdot C\cdot D = (A\cdot B\cdot C)\cdot D = (A\cdot B)\cdot(C\cdot D)$$

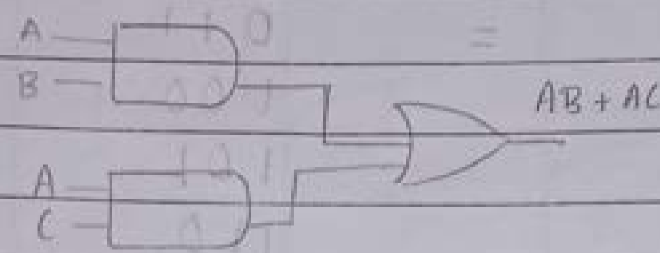
8] Distributive law

This distributive law allow factoring or multipling out of expressions. So their are 3 distributive laws:

law 1: $A(B+C) = AB+BC$

This law states that ORing of several variables and ANDing the result with a singal variable is equivivalent to ANDing that singal variable with of the several variables and than ORing the products logic diagram:





ABC	B+C	A·(B+C)	AB	AC	AB+AC
000	0	0	0	0	0
001	1	0	0	0	0
010	1	0	0	0	0
011	1	0	0	0	0
100	0	0	0	0	0
101	1	1	0	1	1
110	1	1	1	0	1
111	1	1	1	1	1

This law applies to singal variable as well as combination of variable

Ex: $ABC(D+E) = ABCD + ABCE$

$AB(CD+EF) = ABCD + ABEF$

The distributive property is often use in the reverse that is $AB + BC$ replace by $A(B+C)$ and $ABC + ABD$ replaced by $AB(C+D)$

This law states that ANDing of several variables and ORing the result with a singal variable is equivalent to ORing that singal variable ~~with~~ with each of the several variables and then ANDing the sums. This can be proved algebrically or by truth table.

law 2: $A + BC = (A+B)(A+C)$

law 3: $A + \bar{A}B = A + B$

$(A+B) \quad (A+C)$

$= A \cdot A + AC + AB + BC$

$= A(1 + C + B) + BC$

$= A \cdot 1 + BC$

$= A + BC$

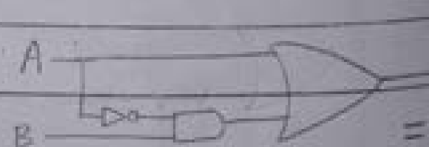
A B C	BC	A+B+C
0 0 0	0	0
0 0 1	0	0
0 1 0	0	0
0 1 1	1	1
1 0 0	0	1
1 0 1	0	1
1 1 0	0	1
1 1 1	1	1

A B C	A+B	A+C	(A+B) . (A+C)
0 0 0	0	0	0
0 0 1	0	1	0
0 1 0	1	0	0
0 1 1	1	1	1
1 0 0	1	1	1
1 0 1	1	1	1
1 1 0	1	1	1
1 1 1	1	1	1

Law 3: $A + \bar{A}B = A + B$

This law states that ORing of variable with AND of the ~~variable~~ complement of that variable with another variable is equal to ORing of 2 variables

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



=

Date / /

A	B	$\bar{A}$	$\bar{A}B$	$A+\bar{A}B$
0	0	1	0	0
0	1	1	1	1
1	0	0	0	1
1	1	0	0	1

=

A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	1

Demorgan's theorem : Demorgan's theorem represents 2 most powerful laws in Boolean Algebra

law 1 : $\overline{A+B} = \bar{A} . \bar{B}$

This law states that compliment of sum of variab is equals to the product of their individual compliment.

That is the compliment of 2 or more variables or together is same as the AND of compliments of each of the individual variables.
It shows that NOR gate equivalent to Bubbled AND gates.

This law can be extended to any number of variab or combinations of variables, for example :

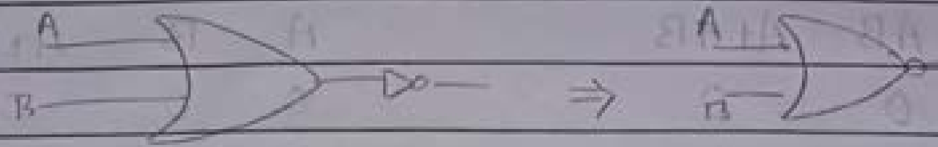
$$\overline{A+B+C+D\ldots} = \bar{A} + . \bar{B} . \bar{C} . \bar{D} \text{ - - - -}$$

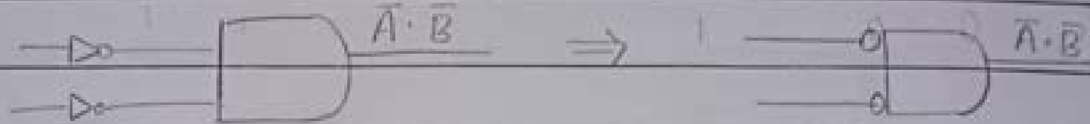
$$\overline{AB+CD+EF+AE\ldots} = \overline{AB} . \overline{CD} . \overline{EF} . \overline{AE} \text{ - - - -}$$

This law permits ~~individual~~ removal of individual ~~fr~~ variable from a 'NOR' sign and transformati from a sum of product from (SOP) to a product of sums formed

Shrikrupa

Page No. ____
Date __ / __ / __





A	B	A+B	$\overline{A+B}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

=

A	B	$\bar{A}$	$\bar{B}$	$\bar{A}\cdot\bar{B}$
0	0	1	1	1
0	1	1	0	0
1	0	0	1	0
1	1	0	0	0

Q. Reduce $\overline{\overline{AB} + \bar{A} + AB}$

$= \overline{\overline{AB}} \cdot \bar{\bar{A}} \cdot \overline{AB}$

$= AB \cdot A \cdot \overline{AB}$

$= AB \cdot \overline{AB}$

$= 0$

2] $A\left[B+\bar{C}\left(\overline{AB+A\bar{C}}\right)\right]$

$= A\left[B+\bar{C}\left(\overline{AB}\cdot\overline{A\bar{C}}\right)\right]$

$= A\left[B+\bar{C}\left((\bar{A}+\bar{B})(\bar{A}+C)\right)\right]$

$= A\left[B+\bar{C}\left(\bar{A}\bar{A}+\bar{A}C+\bar{B}\bar{A}+\bar{B}C\right)\right]$

$= A\left[B+\bar{C}\left(\bar{A}+\bar{A}C+\bar{B}\bar{A}+\bar{B}C\right)\right]$

$= A\left[B+\bar{A}\bar{C}+\bar{A}C\cdot\bar{C}+\bar{B}\bar{A}\bar{C}+\bar{B}C\cdot\bar{C}\right]$

$= A\left[B+\bar{A}\bar{C}+0+\bar{A}\bar{B}\bar{C}+0\right]$

$= A\left[B+\bar{A}\bar{C}(1+\bar{B})\right]$ $\qquad 1+A=1$

$= A\left[B+\bar{A}\bar{C}\right]$

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

$= AB+0$

$= AB$

3] $\left(\overline{A+\overline{BC}}\right)\left(A\bar{B}+ABC\right)$

$\left(\bar{A}\cdot\overline{\overline{BC}}\right)\left(A\bar{B}+ABC\right)$

$\left(\bar{A}\cdot BC\right)\left(A\bar{B}+ABC\right)$

$\left(\bar{A}\cdot BC\right)A\left(\bar{B}+BC\right)$

0

4] $(B+BC)(B+\bar{B}C)(B+D)$

$= \cancel{BB+B\bar{B}C+BBC+BC\bar{B}C}\,(B+D)$

$= \cancel{B+0+BC+0\,(B}+D)$

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

$= (B+0)(B+D)$

$= B$

* Sum of product and product of Sum

→ $AB + AC$

$AB(C+\bar{C}) + AC(B+\bar{B})$

$ABC + AB\bar{C} + ABC + A\bar{B}C$

$ABC + AB\bar{C} + A\bar{B}C$

$\;\;7 \qquad 6 \qquad 5$

$\Sigma M(5,6,7)$

→ $AB\bar{C} + A\bar{C}D + CD$

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

$AB\bar{C}D + AB\bar{C}\bar{D} + AB\bar{C}D + A\bar{B}\bar{C}D + ACD(B+\bar{B}) + \bar{A}CD(B+\bar{B})$

$AB\bar{C}D + AB\bar{C}\bar{D} + A\cancel{B}\bar{C}D + A\bar{B}\bar{C}D + \cancel{A\bar{B}CD}^{A\bar{B}CD} + ABCD + \bar{A}BCD + \bar{A}\bar{B}CD$

$D \qquad C \qquad \cancel{9}\,A\,9 \qquad B \qquad F \qquad 7 \qquad 3$

$\Sigma M(3,7,9,B,C,D,F)$

* Boolean function & their representation

Function of 'n' boolean variable denoted by $F(x_1, x_2 - - - x_n)$ is another variable of algebra and takes one of the 2 possible values 0 & 1 the variable ways of representing given function are:

1] Sum of product (SOP) form
2] Product of Sum (POS) form
3] Standard SOP form / Canonical SOP form
4] Standard POS form / Canonical POS form

Date / /

1] SOP :

This form is also called disjuctive normal form.

$$Ex : f(A, B, C) = \bar{A}B + \bar{B}C$$

2] POS :

This form is also called conjuctive normal form.

$$Ex : f(A, B, C) = (\bar{A} + \bar{B})(B + C)$$

3] Standard SOP form:

This form is also called as disjuctive canonical form also it is called expanded SOP form or canonical SOP form. In this form function is sum of a number of product terms where each product term contains all the variable of the function either in complimented form. A product term which contains all the variable of the function. either in complimented or uncomplimented form is called minterm. A minterm assume the value 1 only for 1 combination of the variable. An 'n' variable function can have at the most 2^n minterms. The sum of minterm whose value is equal to 1 is the standard sum of the product form of the function. The minterm denoted as $m_0, m_1 - - - - - m_n$ where suffixes are the decimal code of the combinations

$$\bar{A}B + \bar{B}C$$
$$= \bar{A}BC + \bar{A}B\bar{C} + A\bar{B}C + \bar{A}\bar{B}C$$
$$= m_3 + m_2 + m_5 + m_1$$
$$= \Sigma m(1, 2, 3, 5)$$

Where Σm represents all the minterms whose element denoted decimal term is given in paranthesis.

Page No. ______

Date ___ / ___ / ___

4] Standard POS form :

This is called conjuctive canonical form. It is also called conjuctive expanded POS form or canonical POS form. This derived by considering the combination form which $f=0$. Each term is the sum of all the variable. A variable appears in uncomplimented form if it has a value of 0 in the combination and appear in complimented form if it has a value of 1 in the combination.

$$
\begin{aligned}
f(A,B,C) &= (\bar{A}+\bar{B})(B+C) \\
&= (\bar{A}+\bar{B}+C\bar{C})(A\bar{A}+B+C) \\
&= (\bar{A}+\bar{B}+C)(\bar{A}+\bar{B}+\bar{C})(A+B+C)(\bar{A}+B+C) \\
&= 6 \cdot 7 \cdot 0 \cdot 4 \\
&= \prod M(0,4,6,7)
\end{aligned}
$$

A sum terms which contains each of the 1 variable in either complimented or uncomplimented form.

A maxterm assume the value 0 only for the 1 combination it will be 1. Their will be at the most 2^n maxterms.

Page No.

Date / /

Q. $A(\bar{B}+A)B$

$= \cancel{AAB}\ (A+B\bar{B})(A+\bar{B})\cdot(B+A\bar{A})$

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

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

$= M_0 \cdot M_2 \cdot M_1$

$= \Pi M(0,1,2)$

Q. $F(A,B,C) = (AB+C)(AC+B)$ $\longrightarrow$ in POS

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

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

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

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

$= M_0 \cdot M_2 \cdot M_1 \cdot M_4$

$= \Pi M(0,1,2,4)$

Q. $F(A,B,C) = (AB+C)(AC+B)$ $\longrightarrow$ in SOP

$= AB\cdot AC + AB\cdot B + CAC + C\cdot B$

$= ABC + AB + AC + CB$

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

$= M_7 + M_6 + M_5 + M_3$

$= \Sigma m(3,5,6,7)$

Q. $F = \bar{B}D + \bar{A}D + BC$

$= \bar{B}DA + \bar{B}D\bar{A} + \bar{A}DB + \bar{A}D\bar{B} + BCA + BC\bar{A}$

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

$\bar{A}B\bar{C}D + \cancel{\bar{A}\bar{B}C\bar{D}} + \cancel{\bar{A}\bar{B}\bar{C}D} + ABCD + ABC\bar{D} + \cancel{\bar{A}BCD} + \bar{A}BC\bar{D}$

2] $F = AB + A\bar{C}$

$= ABC + AB\bar{C} + \cancel{AB\bar{C}} + A\bar{B}\bar{C}$

$= M_7 + M_6 + M_4$

$= \Sigma M(4,6,7)$

$= \Pi m(0,1,2,3,5)$

3] $F = A(\bar{A}+B)(\bar{A}+B+\bar{C})$

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

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

$= \Pi M(0, M_0 \cdot M_1 \cdot M_2 \cdot M_4 \cdot M_5 \cdot M_3$

$= \Pi M(0,1,2,4,5)$

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

1] $F = \bar{B}D + \bar{A}D + BD$

$= A\bar{B}D + \bar{A}\bar{B}D + \bar{A}BD + \cancel{\bar{A}\bar{B}D} + ABD + \cancel{\bar{A}BD}$

$= M_5 + M_1 + M_3 + M_7$

$= \Sigma m(1,3,5,7)$

→ K map is use upto only 6 variabl

→ No. of cells = 2^n

→ Only adjust element can form group

→ diagonal element can not form group

Page No. ____

Date __/__/__

Unit 3:

Combination Logic and Comination Circuit

* Karnaugh map

→ SOP: $A = 1$, $\bar{A} = 0$

→ POS: $A = 0$, $\bar{A} = 1$

2- variable

→ SOP

A \ B	$\bar{B}$	B
$\bar{A}$	1 (0)	1 (1)
A	(2)	(3)

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

$F = \bar{A}$

→ POS

A \ B	B	$\bar{B}$
A	0 (0)	0 (1)
$\bar{A}$	(2)	(3)

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

3- Variable

SOP

A \ BC	00 $\bar{B}\bar{C}$	01 $\bar{B}C$	11 BC	10 $B\bar{C}$
A 0	0	1	3	2
A 1	4	5	7	6

$x_1c_1 + x_2c_2$

POS

A \ BC	$B+C$ 00	$B+\bar{C}$ 01	$\bar{B}+\bar{C}$ 11	$B+C$ 10
A 0	0	1	3	2
$\bar{A}$ 1	4	5	7	6

$(x_1+c_1)(x_2+c_2)$

i] $\Sigma m(0,2,3,4,5,6)$

ii] $\Pi M(0,1,2,3,4,7)$

i]

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

$\{ r_1c_1 + r_2c_2$

$\bar{A}\bar{B}\bar{C} + A\bar{B}\bar{C} + \bar{A}B\bar{C} + AB\bar{C}$

$\bar{B}\bar{C}(\bar{A}+A) + B\bar{C}(A+\bar{A})$

$\bar{B}\bar{C} + B\bar{C}$

$(\bar{B}+B)\bar{C}$

$\bar{C}$

$F = \bar{C} + A\bar{B} + \bar{A}B$

ii]

$A \backslash BC$	$B+C$	$B+\bar{C}$	$\bar{B}+\bar{C}$	$\bar{B}+C$	
A 0	0^{0}	0^{1}	0^{2}	0^{3}	$\rightarrow A$
$\bar{A}$ 1	0^{4}	^{5}	0^{7}	^{6}	
	$B+C$		$\bar{B}+\bar{C}$		

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

$F(P,Q,R) = \Sigma m(0,1,3,5,7)$

$P \backslash QR$	$\bar{Q}\bar{R}$	$\bar{Q}R$	QR	$Q\bar{R}$
$\bar{P}$ 0	1^{0}	1^{1}	^{2}	1^{3}
P 1	^{4}	1^{5}	1^{7}	^{6}

$\{ r_1c_1 + r_2c_2$

$F(A,B,C) = \prod M(1,2,4,6)$

$F(A,B,C) = \sum m(1,2,4,5,7)$

$F(A,B,C) = \sum m(1,2,4,5,7)$

Reduce the following expression by, using K-map

1] $AB + A\bar{B}C + \bar{A}B\bar{C} + B\bar{C}$

$= ABC + AB\bar{C} + A\bar{B}C + \bar{A}B\bar{C} + \cancel{AB\bar{C}} + \cancel{\bar{A}B\bar{C}}$

$= \cancel{0 + 7 + 6 + 5 + 0 + 2}\ m_7 + m_6 + m_5 + m_2$

$= \Sigma m(\cancel{0}, 2, 5, 6, 7)\ (m_2, m_5, m_6, m_7)$

A \ BC	$\bar{B}\bar{C}$ 00	$\bar{B}C$ 01	BC 11	$B\bar{C}$ 10
$\bar{A}$ 0	0	1	3	1 (2)
A 1	4	1 (5)	1 (7)	1 (6)

$A\bar{B}C + \bar{A}B\bar{C} + ABC + AB\bar{C}$

$= AC + B\bar{C}$

2] $(A+B)(A+\bar{B}+C)(A+\bar{C})$

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

$= \cancel{0 \cdot 1 \cdot 2 \cdot 3}\ M_0 \cdot M_1 \cdot M_2 \cdot M_3$

$= \Pi M(M_1 \cdot M_2 \cdot M_3 \cdot M_0)$

A \ BC	$B+C$ 00	$B+\bar{C}$ 01	$\bar{B}+\bar{C}$ 11	$\bar{B}+C$ 10
A 0	0 (0)	0 (1)	0 (3)	0 (2)
$\bar{A}$ 1	4	5	7	6

$(A+B+C)(A+B+\bar{C})(A+\bar{B}+\bar{C})(A+\bar{B}+C)$

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

$= A$

* 4 variable K-map

SOP

$AB \backslash CD$	$\bar{C}\bar{D}$ 00	$\bar{C}D$ 01	CD 11	$C\bar{D}$ 10
$\bar{A}\bar{B}$ 00	0	1	3	2
$\bar{A}B$ 01	4	5	7	6
AB 11	12	13	15	14
$A\bar{B}$ 10	8	9	11	10

POS

$AB \backslash CD$	$C+D$ 00	$C+\bar{D}$ 01	$\bar{C}+\bar{D}$ 11	$C+\bar{D}$ 01
$A+B$ 00	0	1	3	2
$A+\bar{B}$ 01	4	5	7	6
$\bar{A}+\bar{B}$ 11	12	13	15	14
$\bar{A}+B$ 10	8	9	11	10

possible combinations of octet = 8

Q. $\Sigma m(0,1,2,6,13,15)$

$AB \backslash CD$	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	1 (0)	1 (1)	(3)	1 (2)
$\bar{A}B$	(4)	(5)	(7)	1 (6)
AB	(12)	1 (13)	1 (15)	(14)
$A\bar{B}$	(8)	(9)	(11)	(10)

→ $\bar{A}C\bar{D}$

→ ABD

$\bar{A}\bar{B}\bar{C}\bar{D} + \bar{A}\bar{B}\bar{C}D + \bar{A}\bar{B}C\bar{D} + \bar{A}BC\bar{D} + AB\bar{C}D + ABCD$

$\bar{A}\bar{B}\bar{C} + \bar{A}C\bar{D} + ABD$

$$F = \bar{A}\bar{B}\bar{C} + \bar{A}C\bar{D} + ABD$$

Page No. ______
Date __/__/__

Q. $\Sigma m(3,7,11,12,14)$

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

$\bar{A}\bar{B}CD + \bar{A}BCD + AB\bar{C}\bar{D} + ABC\bar{D} + A\bar{B}CD$

$\bar{A}\cancel{B}CD + AB\bar{D} + A\bar{B}CD$

Q. $\Pi M(5,7,6,9,11,14)$

AB \ CD	$C+D$	$C+\bar{D}$	$\bar{C}+\bar{D}$	$\bar{C}+D$
$A+B$	0	1	2	2
$A+\bar{B}$	4	1 (5)	1 (7)	1 (6)
$\bar{A}+\bar{B}$	12	13	15	1 (14)
$\bar{A}+B$	8	1 (9)	1 (11)	10

$(\bar{B}+\bar{C}+D)$

$(A+\bar{B}+\bar{D})$ $(\bar{A}+B+\bar{D})$

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

M.IMP Reduce by using K-map

i] $AB + A\bar{C} + C + AD + A\bar{B}C + ABC$

ii] $A\bar{B}C + B + B\bar{D} + AB\bar{D} + \bar{A}C$

iii] $A(B+\bar{C})(A+\bar{B})(B+C+\bar{D})$

iv] $\bar{A} + B(A+B+\bar{D})(B+\bar{C})$
$(B+C+D)$

i] $AB + A\bar{C} + C + AD + A\bar{B}C + ABC$

$\cancel{ABC} + \cancel{AB\bar{C}} + \cancel{AB\bar{C}} + \cancel{A\bar{B}\bar{C}} + \cancel{A}$ $\qquad AC + \bar{A}C + ABC\bar{D}$

$= ABC + AB\bar{C} + AB\bar{C} + A\bar{B}\bar{C} + ABD + A\bar{B}D + A\bar{B}CD + A\bar{B}C\bar{D} + ABCD +$

$= ABCD + ABC\bar{D} + AB\bar{C}\bar{D} + AB\bar{C}D + A\bar{B}\bar{C}D + A\bar{B}\bar{C}\bar{D} + \cancel{ABCD} + \cancel{AB\bar{C}D} +$

$\cancel{A\bar{B}\bar{C}D} + A\bar{B}CD + \cancel{A\bar{B}CD} + A\bar{B}C\bar{D} + \cancel{ABCD} + \cancel{ABC\bar{D}} + ABC + A\bar{B}C + \bar{A}BC + \bar{A}$

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

$\cancel{ABCD} + \cancel{ABC\bar{D}} + \cancel{A\bar{B}CD} + \cancel{A\bar{B}C\bar{D}} + \bar{A}BCD + \bar{A}BC\bar{D} + \bar{A}\bar{B}CD + \bar{A}\bar{B}C\bar{D}$

$= \Sigma m_{15} + m_{14} + m_{12} + m_{13} + m_9 + m_8 + m_{11} + m_{10} + m_7 + m_6 + m_3 + m_2$

Page No. ______

Date ___ / ___ / ___

Q. Reduce the expression
$\Sigma m(0, 2, 3, 4, 5, 6)$ ~~wa~~ using K-map and implement it in AOI logic as well as in NAND logic

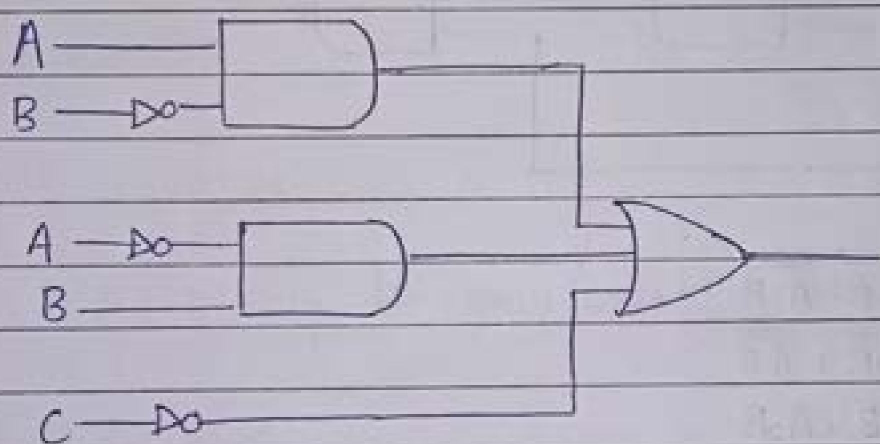
A \ BC	$\bar B \bar C$ 00	$\bar B C$	BC	$B\bar C$
$\bar A$ 0	1 [0]	[1]	1 [3]	1 [3]
A 1	1 [4]	1 [5]	[7]	1 [6]

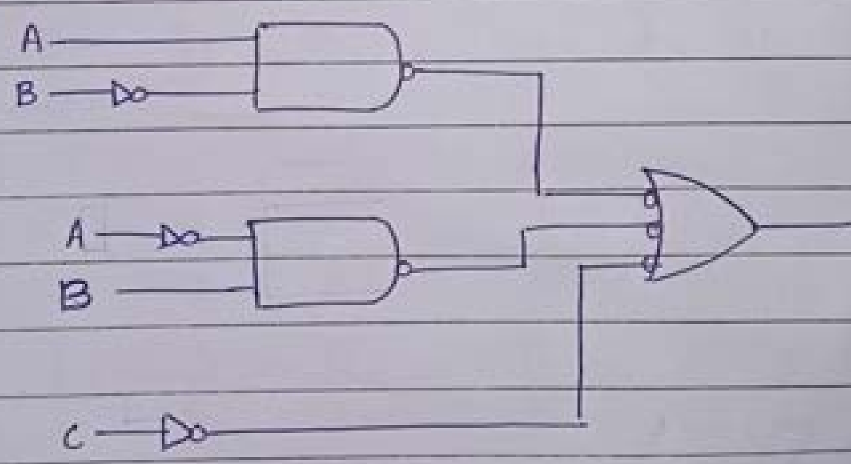
$\bar A \bar B \bar C + A \bar B \bar C + A \bar B C + \bar A B C + \bar A B \bar C + A B \bar C$

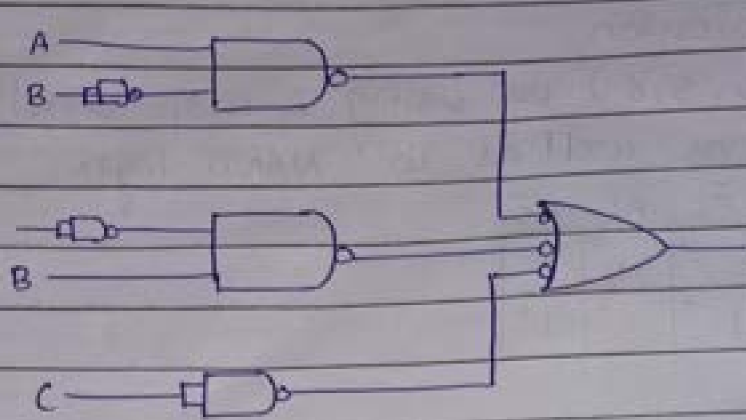
$\bar B \bar C + B \bar C$

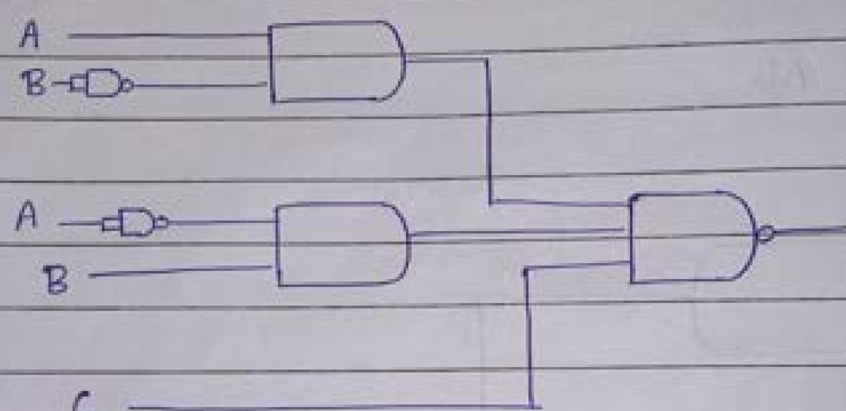
$F = \bar C + A\bar B + \bar A B$

Not → Nand









$$\overline{C\cdot\overline{A\cdot\overline{B}}\cdot\overline{\overline{A}\cdot B}}$$

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

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

Page No.
Date

Q. $\Sigma m(0,3,4,6) + d(1,5)$

A \ BC	$\bar{B}\bar{C}$	$\bar{B}C$	BC	$B\bar{C}$
$\bar{A}$	1 (0)	X (1)	1 (3)	(2)
A	1 (4)	X (5)	(7)	1 (6)

$F = \bar{B} + A\bar{C} + \bar{A}C$

Q. $\Sigma m(0,1,4,5) + d(3,7)$

	$\bar{B}\bar{C}$	$\bar{B}C$	BC	$B\bar{C}$
$\bar{A}$	1 (0)	1 (1)	X (3)	(2)
A	1 (4)	1 (5)	X (7)	(6)

$F = \bar{B}$

Code Converters

4 bit binary to gray code converter

Conversion table

	I/P 4 bit binary				O/P Gray code			
	B_4	B_3	B_2	B_1	G_4	G_3	G_2	G_1
0	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	0	1
2	0	0	1	0	0	0	1	1
3	0	0	1	1	0	0	1	0
4	0	1	0	0	0	1	1	0
5	0	1	0	1	0	1	1	1
6	0	1	1	0	0	1	0	1
7	0	1	1	1	0	1	0	0

	B_4	B_3	B_2	B_1	G_4	G_3	G_2	G_1
8	1	0	0	0	1	1	0	0
9	1	0	0	1	1	1	0	1
10	1	0	1	0	1	1	1	1
11	1	0	1	1	1	1	1	0
12	1	1	0	0	1	0	1	0
13	1	1	0	1	1	0	1	1
14	1	1	1	0	1	0	0	1
15	1	1	1	1	1	0	0	0

$G_4 = \Sigma m\,(8, 9, 10, 11, 12, 13, 14, 15)$
$G_3 = \Sigma m\,(4, 5, 6, 7, 8, 9, 10, 11)$
$G_2 = \Sigma m\,(2, 3, 4, 5, 10, 11, 12, 13)$
$G_1 = \Sigma m\,(1, 2, 5, 6, 9, 10, 13, 14)$

→ For G_4

LSB, MSB

$B_4B_3 \backslash B_2B_1$	$\bar{B}_2\bar{B}_1$	$\bar{B}_2B_1$	B_2B_1	$B_2\bar{B}_1$
$\bar{B}_4\bar{B}_3$	0	1	3	2
$\bar{B}_4B_3$	4	5	7	6
B_4B_3	1 (12)	1 (13)	1 (15)	1 (14)
$B_4\bar{B}_3$	1 (8)	1 (9)	1 (11)	1 (10)

$G_4 = B_4B_3\bar{B}_2\bar{B}_1 + B_4B_3\bar{B}_2B_1 + B_4B_3B_2B_1 + B_4B_3B_2\bar{B}_1 + B_4\bar{B}_3\bar{B}_2\bar{B}_1 + B_4\bar{B}_3\bar{B}_2B_1 + B_4\bar{B}_3B_2B_1 + B_4B_3B_2\bar{B}_1$

$G_4 = B_4B_3\bar{B}_2 + B_4B_3B_2 + B_4\bar{B}_3\bar{B}_2 + B_4\bar{B}_3B_2$
$= B_4B_3 + B_4\bar{B}_3 = B_4$

→ For G_3

$B_4B_3 \backslash B_2B_1$	$\bar{B}_2\bar{B}_1$	$\bar{B}_2B_1$	B_2B_1	$B_2\bar{B}_1$
$\bar{B}_4\bar{B}_3$	0	1	3	2
$\bar{B}_4B_3$	1 (4)	1 (5)	1 (7)	1 (6)
B_4B_3	12	13	15	14
$B_4\bar{B}_3$	1 (8)	1 (9)	1 (11)	1 (10)

$G_3 = \bar{B}_4B_3\bar{B}_2\bar{B}_1 + \bar{B}_4B_3\bar{B}_2B_1 + \bar{B}_4B_3B_2B_1 + \bar{B}_4B_3B_2\bar{B}_1 + B_4\bar{B}_3\bar{B}_2\bar{B}_1 + B_4\bar{B}_3\bar{B}_2B_1 + B_4\bar{B}_3B_2B_1 + B_4\bar{B}_3B_2\bar{B}_1$
$= \bar{B}_4B_3\bar{B}_2 + \bar{B}_4B_3B_2 + B_4\bar{B}_3\bar{B}_2 + B_4\bar{B}_3B_2$
$= \bar{B}_4B_3 + B_4\bar{B}_3 = B_4 \oplus B_3$

$B_2B_1 \rightarrow$ For G_2

B_4B_3 \ B_2B_1	$\bar B_2\bar B_1$	$\bar B_2 B_1$	$B_2 B_1$	$B_2\bar B_1$
$\bar B_4\bar B_3$	0	1	1 (3)	1 (2)
$\bar B_4 B_3$	1 (4)	1 (5)	7	6
$B_4 B_3$	1 (12)	1 (13)	15	14
$B_4\bar B_3$	8	9	1 (11)	1 (10)

$$G_2 = \bar B_4 B_3 \bar B_2 \bar B_1 + \bar B_4 B_3 \bar B_2 B_1 + B_4 B_3 \bar B_2 \bar B_1 + B_4 B_3 \bar B_2 B_1 + \bar B_4 \bar B_3 B_2 B_1 + \bar B_4 \bar B_3 B_2 \bar B_1 + B_4 \bar B_3 B_2 B_1 + B_4 \bar B_3 B_2 \bar B_1$$

$$= \bar B_4 B_3 \bar B_2 + B_4 B_3 \bar B_2 + \bar B_4 \bar B_3 B_2 + B_4 \bar B_3 B_2$$

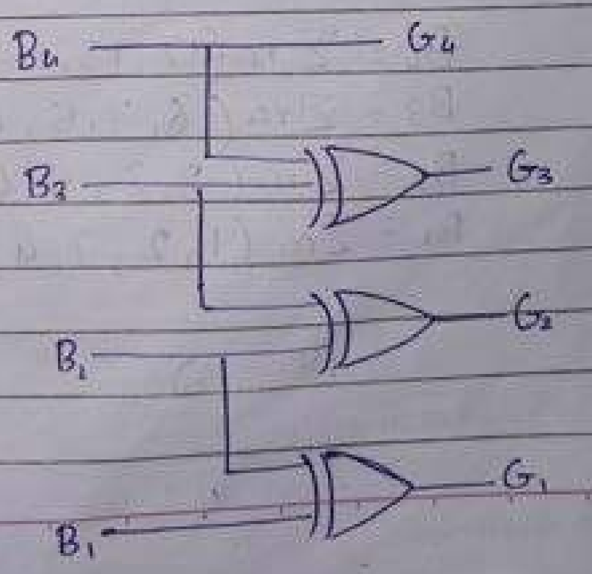
$$= B_3 \bar B_2 + \bar B_3 B_2 = B_3 \oplus B_2$$

B_4B_3 \ B_2B_1	$\bar B_2\bar B_1$	$\bar B_2 B_1$	$B_2 B_1$	$B_2\bar B_1$
$\bar B_4\bar B_3$	0	1 (1)	3	1 (2)
$\bar B_4 B_3$	4	1 (5)	7	1 (6)
$B_4 B_3$	12	1 (13)	15	1 (14)
$B_4\bar B_3$	8	1 (9)	11	1 (10)

$$G_1 = \bar B_4 \bar B_3 \bar B_2 B_1 + \bar B_4 B_3 \bar B_2 B_1 + B_4 B_3 \bar B_2 B_1 + B_4 \bar B_3 \bar B_2 B_1 + \bar B_4 \bar B_3 B_2 \bar B_1 + \bar B_4 B_3 B_2 \bar B_1 + B_4 B_3 B_2 \bar B_1 + B_4 \bar B_3 B_2 \bar B_1$$

$$= \bar B_4 \bar B_2 B_1 + B_4 \bar B_2 B_1 + \bar B_4 B_2 \bar B_1 + B_4 B_2 \bar B_1 = \bar B_2 B_1 + B_2 \bar B_1$$

$$G_1 = B_2 \oplus B_1$$



Design of a 4 bit gray to binary code converter

G to B

	I/P				O/P			
	G_4	G_3	G_2	G_1	B_4	B_3	B_2	B_1
0	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	0	1
3	0	0	1	1	0	0	1	0
2	0	0	1	0	0	0	1	1
6	0	1	1	0	0	1	0	0
7	0	1	1	1	0	1	0	1
5	0	1	0	1	0	1	1	0
4	0	1	0	0	0	1	1	1
12	1	1	0	0	1	0	0	0
13	1	1	0	1	1	0	0	1
15	1	1	1	1	1	0	1	0
14	1	1	1	0	1	0	1	1
10	1	0	1	0	1	1	0	0
11	1	0	1	1	1	1	0	1
9	1	0	0	1	1	1	1	0
8	1	0	0	0	1	1	1	1

$B_4 = \sum m(12, 13, 15, 14, 10, 11, 9, 8)$

$B_3 = \sum m(6, 7, 5, 4, 10, 11, 9, 8)$

$B_2 = \sum m(3, 2, 5, 4, 15, 14, 9, 8)$

$B_1 = \sum m(1, 2, 7, 4, 13, 14, 11, 8)$

→ For B_4

$B_4B_3 \backslash B_2B_1$	$\bar{B}_2\bar{B}_1$	$\bar{B}_2B_1$	B_2B_1	$B_2\bar{B}_1$
$\bar{B}_4\bar{B}_3$	^{0}	^{1}	^{3}	^{2}
$\bar{B}_4B_3$	^{4}	^{5}	^{7}	^{6}
B_4B_3	1^{12}	1^{13}	1^{15}	1^{14}
$B_4\bar{B}_3$	1^{8}	1^{9}	1^{11}	1^{10}

$$B_4 = B_4B_3\bar{B}_2\bar{B}_1 + B_4B_3\bar{B}_2B_1 + B_4B_3B_2B_1 + B_4B_3B_2\bar{B}_1 + B_4\bar{B}_3\bar{B}_2\bar{B}_1 + B_4\bar{B}_3\bar{B}_2B_1 + B_4\bar{B}_3B_2B_1 + B_4\bar{B}_3B_2\bar{B}_1$$

$$= B_4B_3\bar{B}_2 + B_4B_3B_2 + B_4\bar{B}_3\bar{B}_2 + B_4\bar{B}_3B_2 = B_4B_3 + B_4\bar{B}_3$$

$=$

→ For B_4

$G_4G_3 \backslash G_2G_1$	$\bar{G}_2\bar{G}_1$	$\bar{G}_2G_1$	G_2G_1	$G_2\bar{G}_1$
$\bar{B}_4\bar{G}_3$	^{0}	^{1}	^{3}	^{2}
$\bar{G}_4G_3$	^{4}	^{5}	^{7}	^{6}
G_4G_3	1^{12}	1^{13}	1^{15}	1^{14}
$G_4\bar{G}_3$	1^{8}	1^{9}	1^{11}	1^{10}

$$B_4 = G_4G_3\bar{G}_2\bar{G}_1 + G_4G_3\bar{G}_2G_1 + G_4G_3G_2G_1 + G_4G_3G_2\bar{G}_1 + G_4\bar{G}_3\bar{G}_2\bar{G}_1 + G_4\bar{G}_3\bar{G}_2G_1 + G_4\bar{G}_3G_2G_1 + G_4\bar{G}_3G_2\bar{G}_1$$

$$= G_4G_3\bar{G}_2 + G_4G_3G_2 + G_4\bar{G}_3\bar{G}_2 + G_4\bar{G}_3G_2 = G_4G_3 + G_4\bar{G}_3$$

$$B_4 = G_4$$

→ For B_3

$G_4G_3 \backslash G_2G_1$	$\bar{G}_2\bar{G}_1$	$\bar{G}_2G_1$	G_2G_1	$G_2\bar{G}_1$
$\bar{G}_4\bar{G}_3$	^{0}	^{1}	^{3}	^{2}
$\bar{G}_4G_3$	1^{4}	1^{5}	1^{7}	1^{6}
G_4G_3	^{12}	^{13}	^{15}	^{14}
$G_4\bar{G}_3$	1^{8}	1^{9}	1^{11}	1^{10}

$$B_3 = \bar{G}_4G_3\bar{G}_2\bar{G}_1 + \bar{G}_4G_3\bar{G}_2G_1 + \bar{G}_4G_3G_2G_1 + \bar{G}_4G_3G_2\bar{G}_1 + G_4\bar{G}_3\bar{G}_2\bar{G}_1 + G_4\bar{G}_3\bar{G}_2G_1 + G_4\bar{G}_3G_2G_1 + G_4\bar{G}_3G_2\bar{G}_1$$

$$= \bar{G}_4G_3\bar{G}_2 + \bar{G}_4G_3G_2 + G_4\bar{G}_3\bar{G}_2 + G_4\bar{G}_3G_2$$

$$= \bar{G}_4G_3 + G_4\bar{G}_3 = G_4 \oplus G_3$$

Date ___/___/___

→ For B_3

$G_4G_3 \backslash G_2G_1$	$\overline{G_2}\,\overline{G_1}$	$\overline{G_2}G_1$	G_2G_1	$G_2\overline{G_1}$
$\overline{G_4}\,\overline{G_3}$	0	1	1 (3)	1 (2)
$\overline{G_4}G_3$	1 (4)	1 (5)	7	6
G_4G_3	12	13	1 (15)	1 (14)
$G_4\overline{G_3}$	1 (8)	1 (9)	11	10

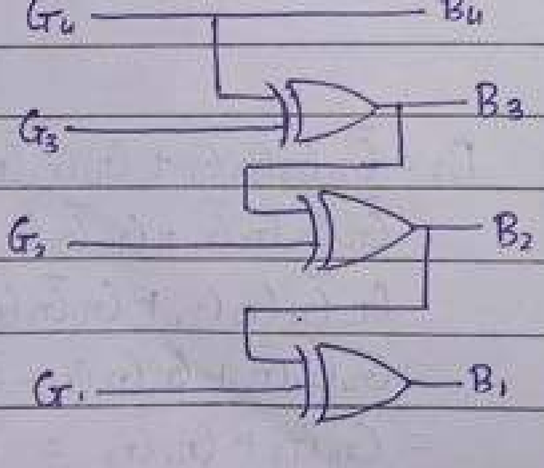
$$B_3 = \overline{G_4}\,\overline{G_3}G_2G_1 + \overline{G_4}\,\overline{G_3}G_2\overline{G_1} + \overline{G_4}G_3\overline{G_2}\,\overline{G_1} + \overline{G_4}G_3\overline{G_2}G_1 + G_4G_3G_2G_1 +$$
$$G_4G_3G_2\overline{G_1} + G_4\overline{G_3}\,\overline{G_2}\,\overline{G_1} + G_4\overline{G_3}\,\overline{G_2}G_1 =$$
$$= \overline{G_4}\,\overline{G_3}G_2 + \overline{G_4}G_3\overline{G_2} + G_4G_3G_2 + G_4\overline{G_3}\,\overline{G_2} = \overline{G_4}(G_4 \oplus G_3) +$$

$$B_3 = G_4 \oplus G_3 \oplus G_2$$

→ For B_4

	$\overline{G_2}\,\overline{G_1}$	$\overline{G_2}G_1$	G_2G_1	$G_2\overline{G_1}$
$\overline{G_4}\,\overline{G_3}$	0	1 (1)	3	1 (2)
$\overline{G_4}G_3$	1 (4)	5	1 (7)	6
G_4G_3	12	1 (13)	1 (14)	[illegible] (15)
$G_4\overline{G_3}$	1 (8)	9	1 (11)	10

$$B_4 = \overline{G_4}\,\overline{G_3}\,\overline{G_2}G_1 + \overline{G_4}\,\overline{G_3}G_2\overline{G_1} + \overline{G_4}G_3\overline{G_2}\,\overline{G_1} + \overline{G_4}G_3G_2G_1 + G_4G_3\overline{G_2}G_1 +$$
$$G_4G_3G_2\overline{G_1} + G_4\overline{G_3}\,\overline{G_2}\,\overline{G_1} + G_4\overline{G_3}G_2G_1 = G_4 \oplus G_3 \oplus G_2 \oplus G_1$$



$X_4 = B_4 + B_3 B_2 + B_3 B_1$
$X_3 = B_3 \bar{B_2} \bar{B_1} + \bar{B_2} B_1 + \bar{B_3} B_2$
$X_2 = \bar{B_2} \bar{B_1} + B_2 B_1$
$X_1 = \bar{B_1}$

Page No. ______
Date __/__/__

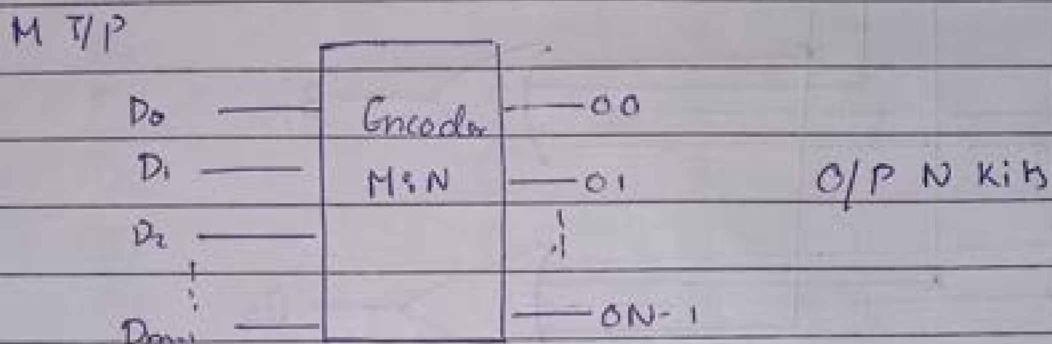
Hw # BCD to gray code converter.

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

Design of, 4-bit BCD to Ex-3 code converter

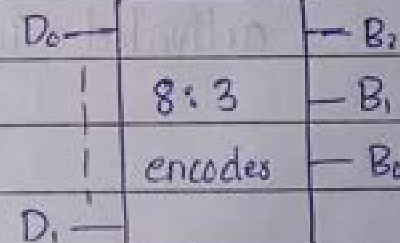
Encoder

Encoder is a device whose input are decimal digits or alphabatical characters whose output are the coded representation are the coded representation of those inputs i.e. an encoder is device which converts familier no. or symbols into coded format.



→ Octal to binary

Output I/P	Binary O/P		
	B_2	B_1	B_0
D_0	0	0	0
D_1	0	0	1
D_2	0	1	0
D_3	0	1	1
D_4	1	0	0
D_5	1	0	1
D_6	1	1	0
D_7	1	1	1

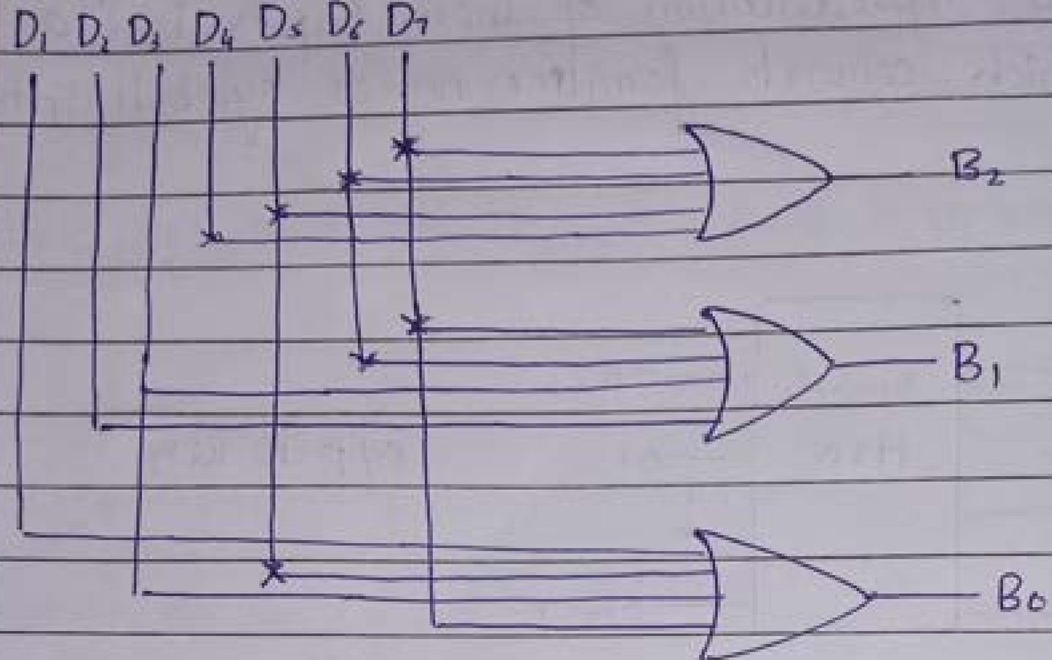


Date / /

$B_2 = D_4 + D_5 + D_6 + D_7$

$B_1 = D_2 + D_3 + D_6 + D_7$

$B_0 = D_1 + D_3 + D_5 + D_7$



An octal to binary encoder or 8 line to 3 line encoder accepts 8 input lines and produces to a three bit output code corresponding to the activated inputs.

→ Decimal to BCD encoder

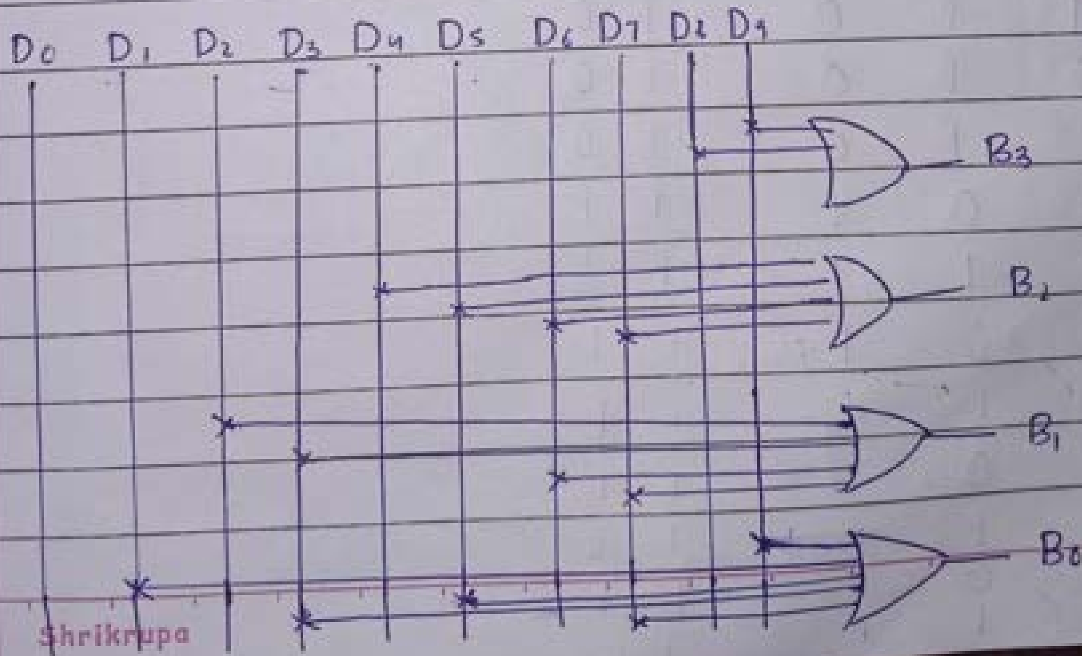
Decimal I/P	BCD O/P B_3	B_2	B_1	B_0
D_0	0	0	0	0
D_1	0	0	0	1
D_2	0	0	1	0
D_3	0	0	1	1
D_4	0	1	0	0
D_5	0	1	0	1
D_6	0	1	1	0
D_7	0	1	1	1
D_8	1	0	0	0
D_9	1	0	0	1

$B_3 = D_8 + D_9$

$B_2 = D_4 + D_5 + D_6 + D_7$

$B_1 = D_2 + D_3 + D_6 + D_7$

$B_0 = D_1 + D_3 + D_5 + D_7 + D_9$



4 input Priority Encoder

A priority encoder is a logic circuit that responds to just one input in accordance with some priority system. Among all those inputs may be simultaneously high.

4 I/P				O/P	
D_0	D_1	D_2	D_3	A	B
1	0	0	0	0	0
x	1	0	0	0	1
x	x	1	0	1	0
x	x	x	1	1	1

$A = D_3 + \cancel{B}\bar{D}_3 D_2$

$B = D_3 + D_1\bar{D}_2\bar{D}_3$

$= D_3 + D_1\bar{D}_2$

→ Octal to Binary

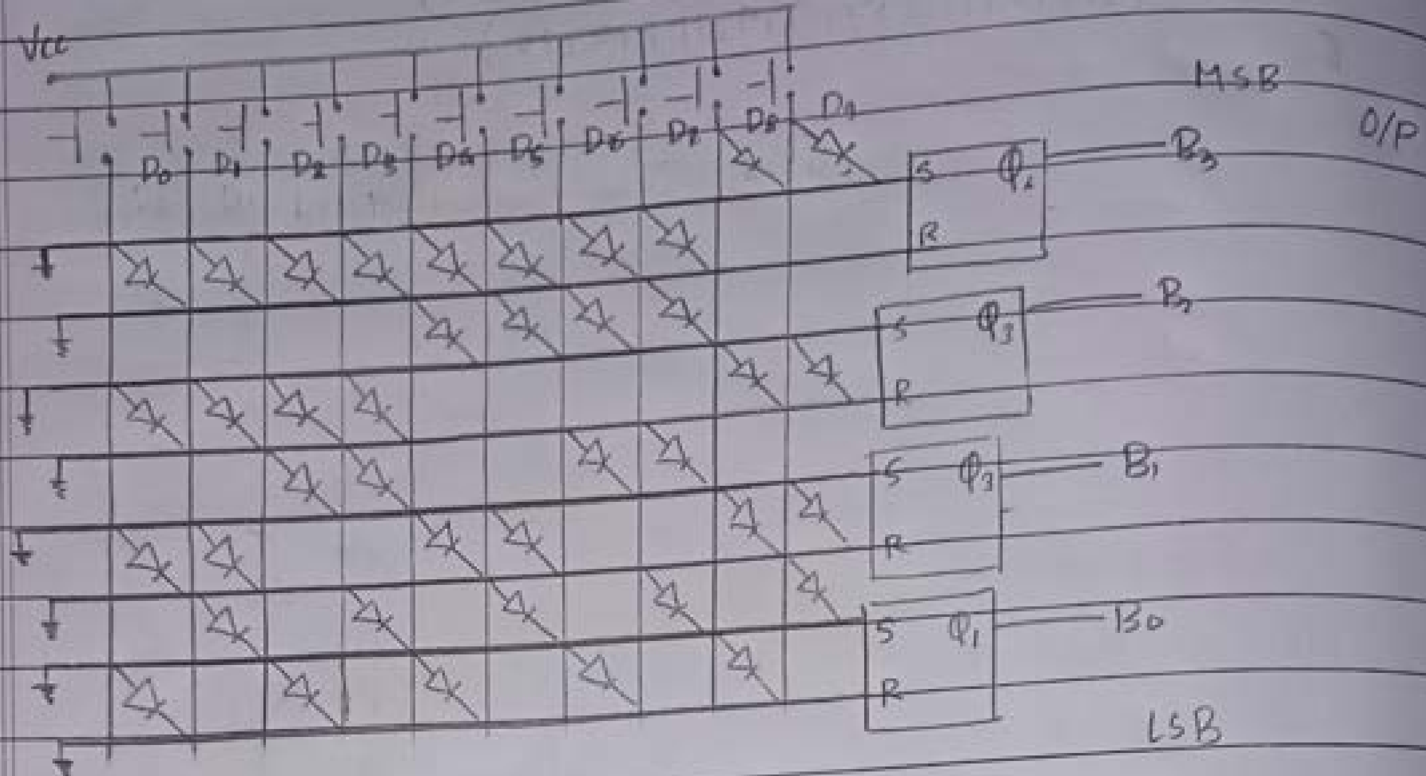
	D_0	D_1	D_2	D_3	A	B
8	~~0~~1	0	0	0	0	0
4	0	1	0	0	0	1
12	1	1	0	0	0	1
2	0	0	1	0	1	0
6	0	1	1	0	1	0
10	1	0	1	0	1	0
14	1	1	1	0	1	0
1	0	0	0	1	1	1
3	0	0	1	1	1	1
5	0	1	0	1	1	1
7	0	1	1	1	1	1
9	1	0	0	1	1	1
11	1	0	1	1	1	1
13	1	1	0	1	1	1
15	1	1	1	1	1	1

$A = \sum m(2, 6, 10, 14, 1, 3, 5, 7, 9, 11, 13, 15)$

$B = \sum m(4, 12, 1, 3, 5, 7, 9, 11, 13, 15)$

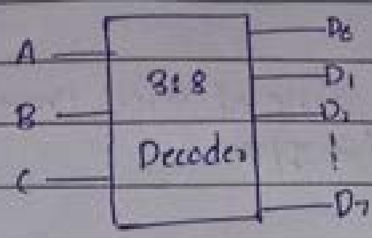
C

Encoder



B_3	B_2	B_1	B_0
0	0	0	0
0	0	0	1
0	0	1	0
0	0	1	1
0	1	0	0
0	1	0	1
0	1	1	0
0	1	1	1
1	0	0	0
1	0	0	1

Decoder



3 line to 8 line

I/P			O/P							
A	B	C	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7
0	0	0	1	0	0	0	0	0	0	0
0	0	1	0	1	0	0	0	0	0	0
0	1	0	0	0	1	0	0	0	0	0
0	1	1	0	0	0	1	0	0	0	0
1	0	0	0	0	0	0	1	0	0	0
1	0	1	0	0	0	0	0	1	0	0
1	1	0	0	0	0	0	0	0	1	0
1	1	1	0	0	0	0	0	0	0	1

$D_0 = \bar{A}\bar{B}\bar{C}$

$D_1 = \bar{A}\bar{B}C$

$D_2 = \bar{A}B\bar{C}$

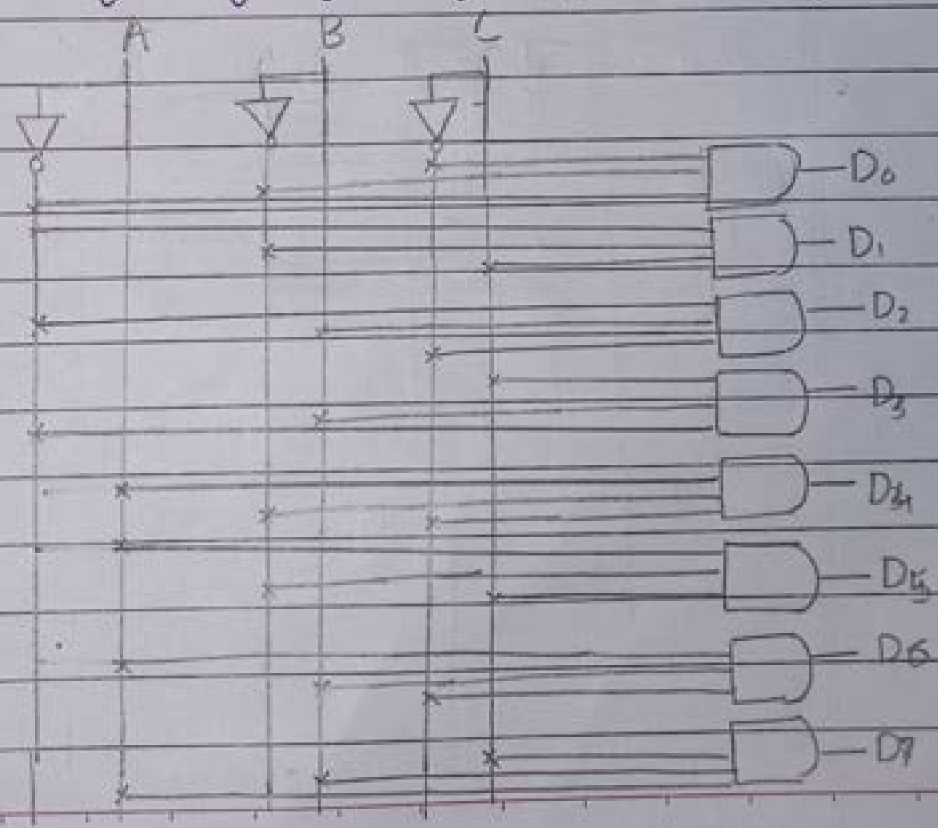
$D_3 = \bar{A}BC$

$D_4 = A\bar{B}\bar{C}$

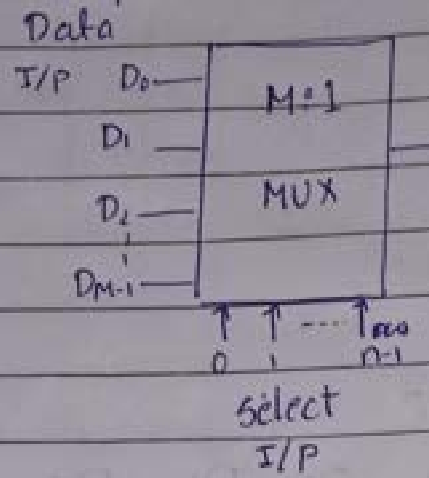
$D_5 = A\bar{B}C$

$D_6 = AB\bar{C}$

$D_7 = ABC$



Multiplexer

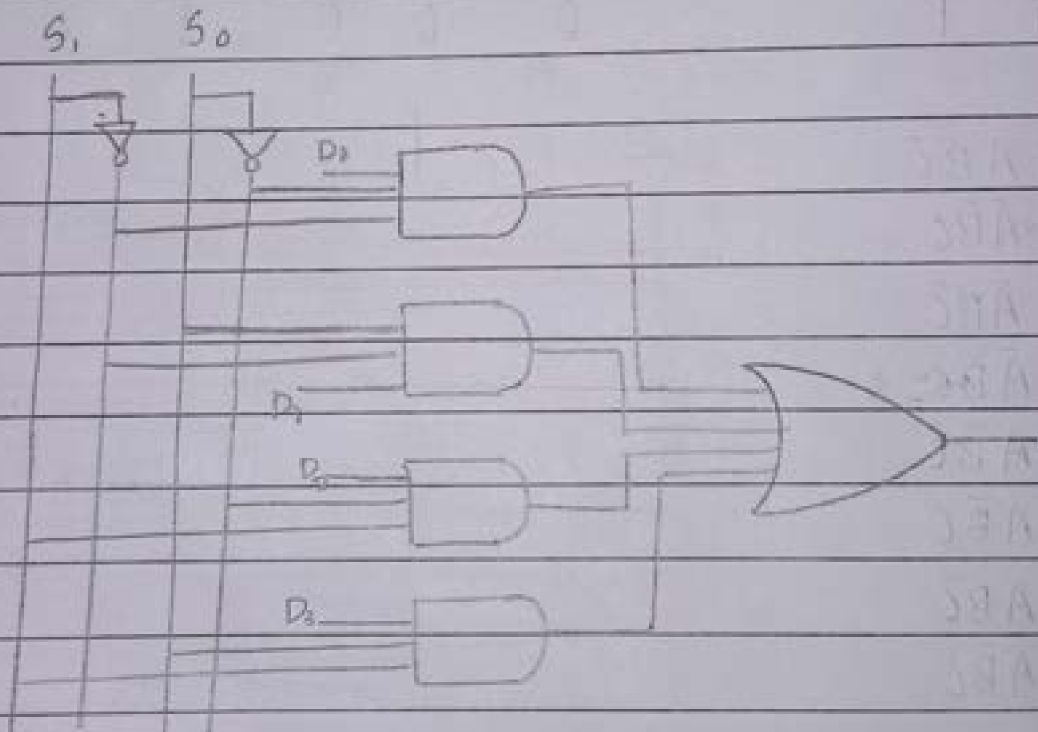


no. of select time

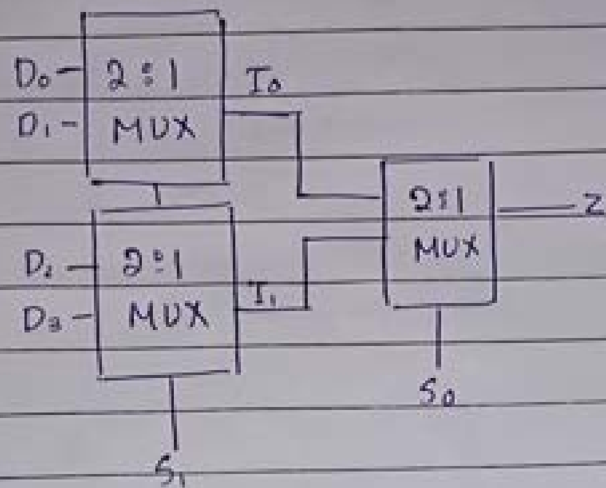
$2^n = I/P$

I/P	I/P S_1	S_0	O/P
D_0	0	0	D_0
D_1	0	1	D_1
D_2	1	0	D_2
D_3	1	1	D_3

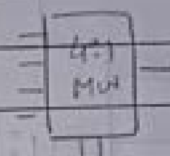
$$Z = D_0\bar{S}_1\bar{S}_0 + D_1\bar{S}_1S_0 + D_2S_1\bar{S}_0 + D_3S_1S_0$$



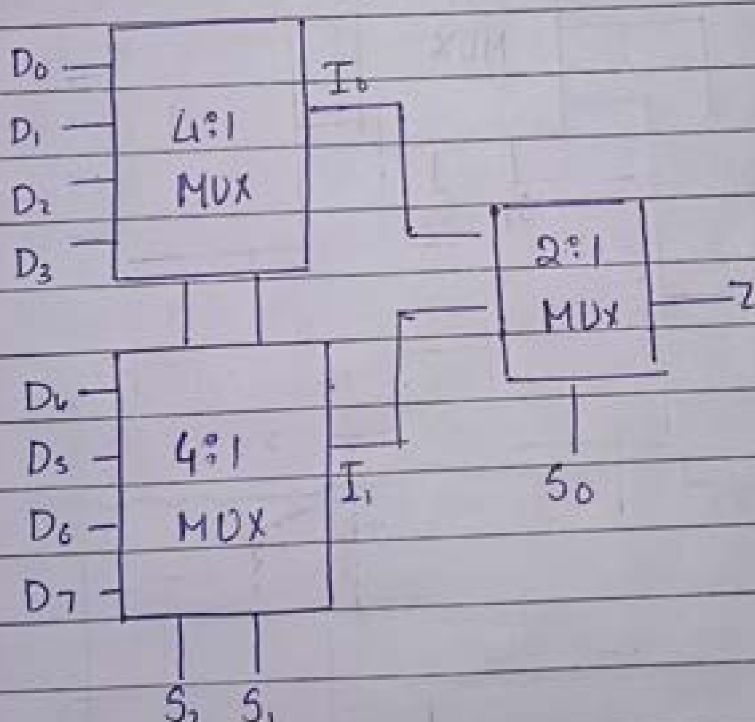
Q Design 4:1 MUX by using 2:1 MUX



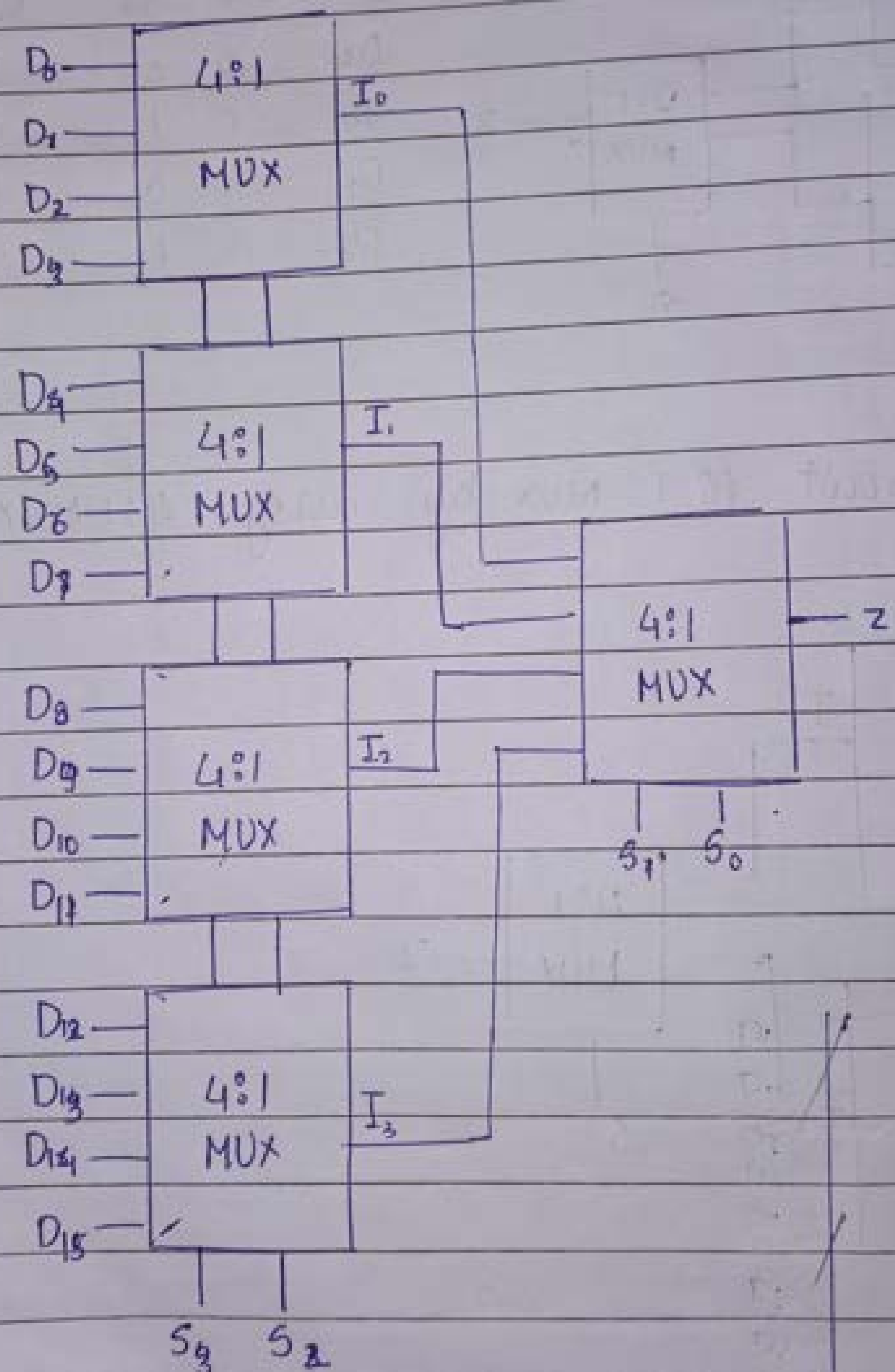
I/P	S_1	S_0	O/P
D_0	0	0	D_0
D_1	0	1	D_1
D_2	1	0	D_2
D_3	1	1	D_3



Q Draw a circuit 8:1 MUX by using 4:1 MUX

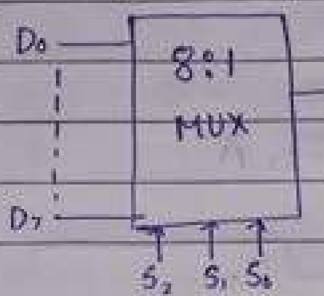


→ Draw a circuit 16:1 MUX using 4:1 MUX

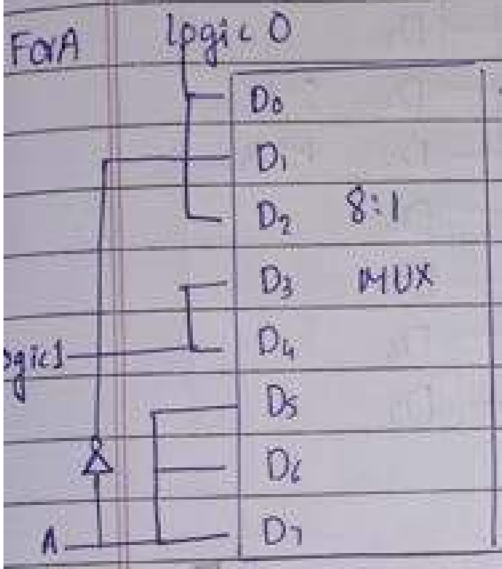


→ Implement the function using an 8×1 MUX $F(A,B,C,D) = \Sigma m(1,3,4,11,12,13,14,15)$

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



For A



	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7
$\bar{A}$	0	1	2	3	4	5	6	7
A	8	9	10	11	12	13	14	15
	0	$\bar{A}$	0	1	1	A	A	A

For D

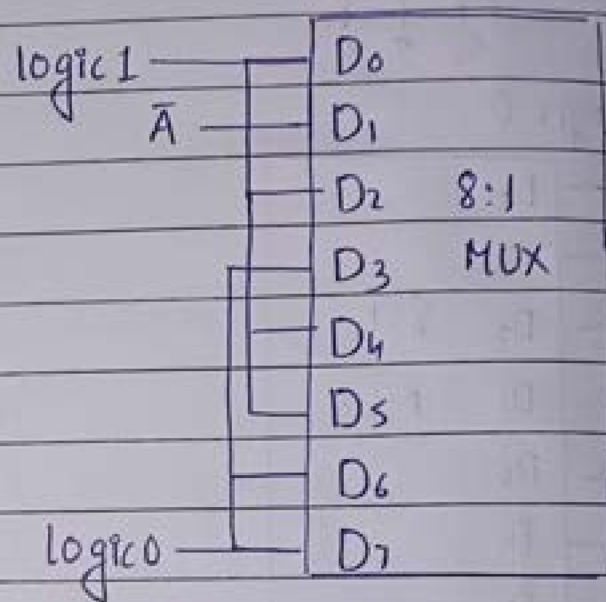
	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7
$\bar{D}$	0	2	4	6	8	10	12	14
D	1	3	5	7	9	11	13	15
	D	D	$\bar{D}$	0	0	D	1	1

Date

Q Implement the function using an 8x1 MUX
$F(A,B,C,D) = \Sigma m(0,1,2,4,5,8,10,12,13)$

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

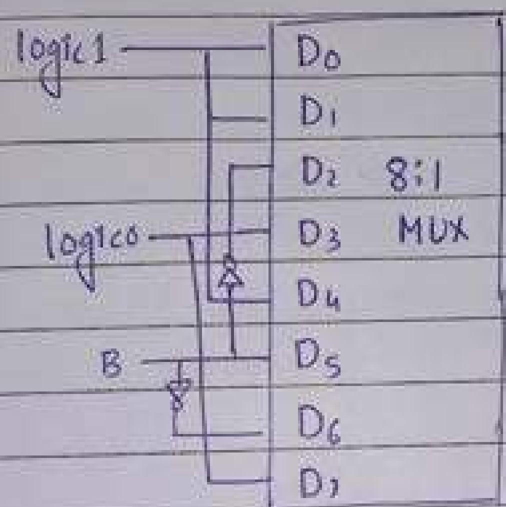
For A



	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7
$\bar{A}$	0	1	2	3	4	5	6	7
A	8	9	10	11	12	13	14	15
	1	$\bar{A}$	1	0	1	1	0	0

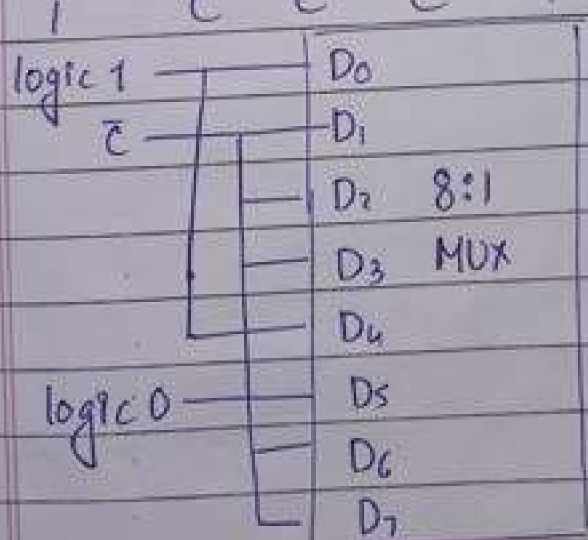
For B

	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7
$\bar{B}$	0	1	2	3	8	9	10	11
B	4	5	6	7	12	13	14	15
	1	1	$\bar{B}$	0	1	B	$\bar{B}$	0



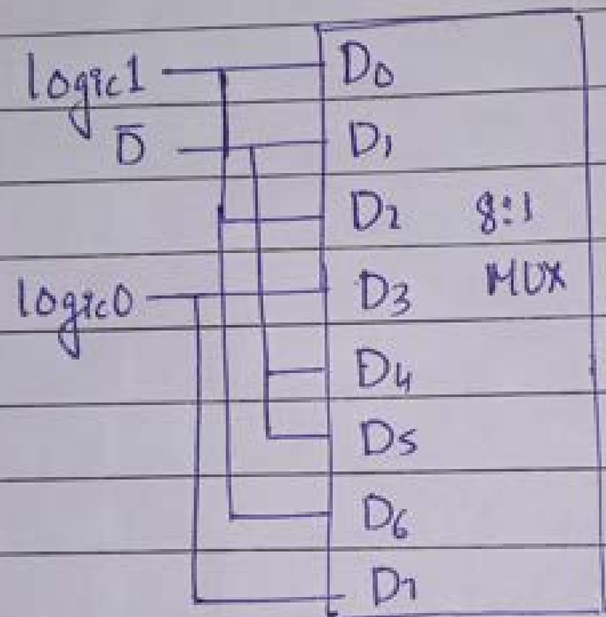
For C

	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7
$\bar{C}$	0	1	4	5	8	9	12	13
C	2	3	6	7	10	11	14	15
	1	$\bar{C}$	$\bar{C}$	$\bar{C}$	1	0	$\bar{C}$	$\bar{C}$



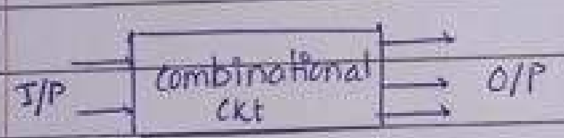
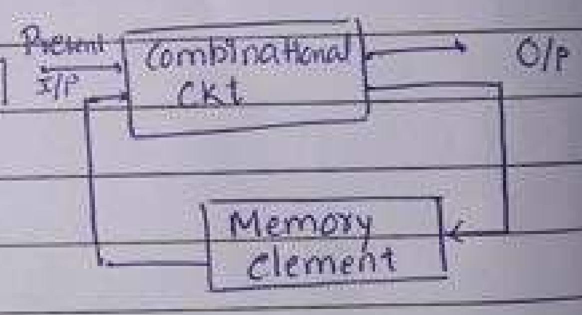
For D

	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7
$\bar{D}$	0	2	4	6	8	10	12	14
D	1	3	5	7	9	11	13	15
	1	$\bar{D}$	1	0	$\bar{D}$	$\bar{D}$	1	0

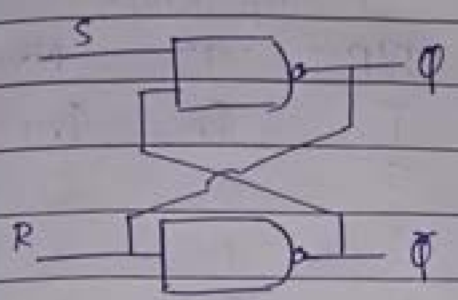


Unit : 4

Sequential logic & Sequential Circuit

Combinational ckt	Sequential ckt
1] Output is depend on present I/P	1] Output is depend on present I/P and past output.
2] Memory element is absent absent	2] Memory element is present
3] Basic building blocks are all basic logic gates.	3] Basic building blocks are Flip Flop.
4] Easy to design	4] Complex to design
5] No clock signal is applied.	5] clock signal is required.
6] Ex: Half & Full adder, encoder decoder, MUX, DeMUX	6] Ex: Flip Flop, counter, register.
7] 	7] 

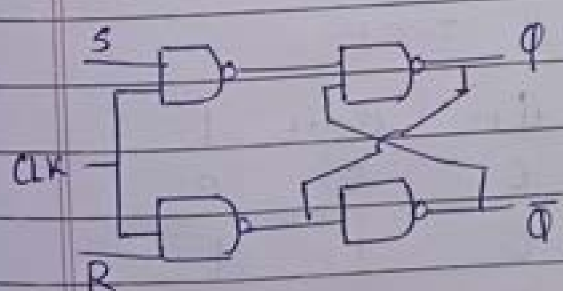
Latch



S	R	Q_n	Q_{n+1}	
0	0	0	x	} invalid state
0	0	1	x	
0	1	0	1	} set
0	1	1	1	
1	0	0	0	} reset
1	0	1	0	
1	1	0	0	} NC
1	1	1	1	

Truth Table SRFF

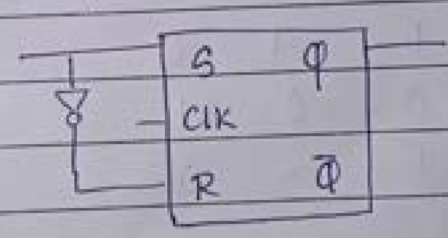
I/P		PS	NS	
S	R	Q_n	Q_{n+1}	
0	0	0	0	} NC
0	0	1	1	
0	1	0	0	} Reset
0	1	1	0	
1	0	0	1	} set
1	0	1	1	
1	1	0	x	} invalid
1	1	1	x	

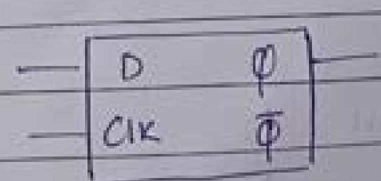


D - Flip Flop

I/P	PS	NS
D	Q_n	Q_{n+1}
0	0	0
0	1	0
1	0	1
1	1	1

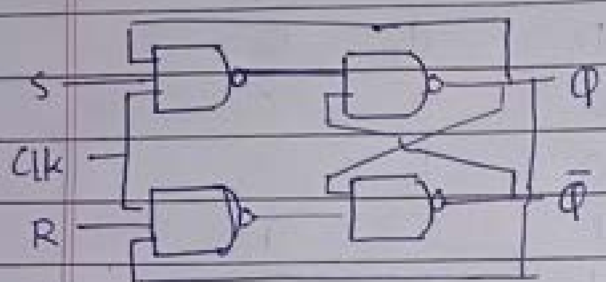
D	Q_{n+1}
0	0
1	1





J-K Flip Flop

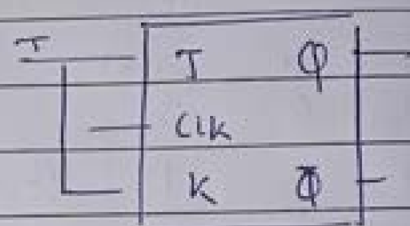
J/P		PS	NS	
J	K	Q_n	Q_{n+1}	
0	0	0	0	NC
0	0	1	1	
0	1	0	0	Reset
0	1	1	0	
1	0	0	1	Set
1	0	1	1	
1	1	0	1	~~invalid~~
1	1	1	0	



T- Flip Flop

I/P	PS	NS	
T	Q_n	Q_{n+1}	
0	0	0	NC
0	1	1	
1	0	1	$\bar{Q}_n$
1	1	0	

T	Q_{n+1}
0	Q_n
1	$\bar{Q}_n$



Excitation

1] S-R FF

Q_n	Q_{n+1}	S	R
0	0	0	x
0	1	1	0
1	0	0	1
1	1	x	0

2] J-K FF

Q_n	Q_{n+1}	J	K
0	0	0	x
0	1	1	x
1	0	x	1
1	1	x	0

3] D FF

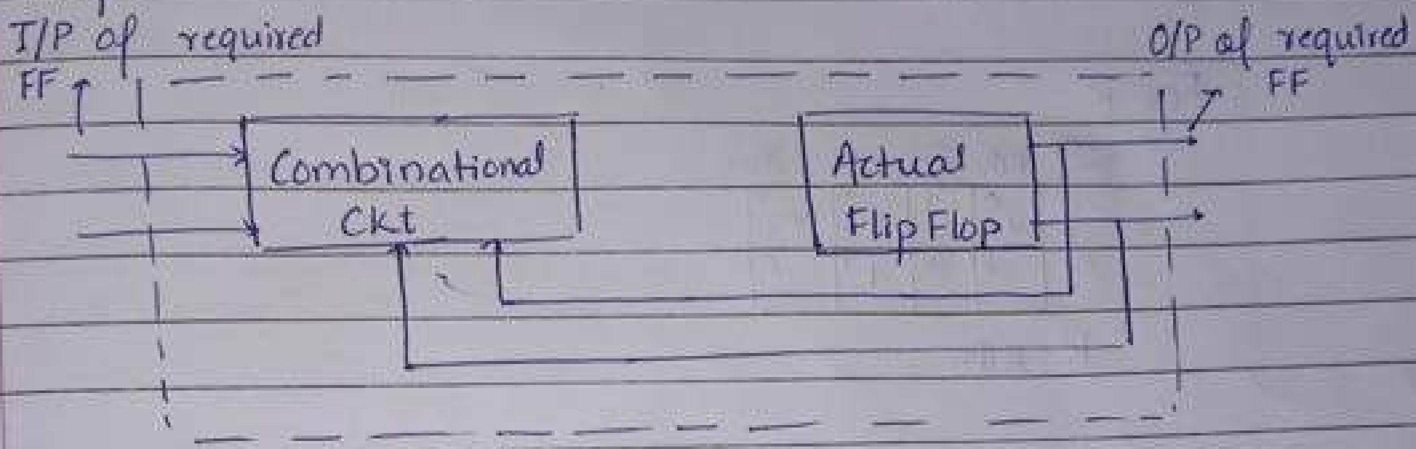
Q_n	Q_{n+1}	D
0	0	0
0	1	1
1	0	0
		1

4] T FF

Q_n	Q_{n+1}	T
0	0	0
0	1	1
1	0	1
1	1	0

Conversion of Flip Flop

To convert one type of flip flop into another type we have to obtain the expression for inputs of the existing flip flop in terms of the input of the required flip flop and the present state variables of the existing and implement them.



→ Convert S-R FF to J-K FF

1. Conversion Table

External I/P		Present state	Next state	Flip Flop I/P	
J	K	Q_n	Q_{n+1}	S	R
0	0	0	0	0	X
0	0	1	1	X	0
0	1	0	0	0	X
0	1	1	0	0	1
1	0	0	1	1	0
1	0	1	1	X	0
1	1	0	1	1	X
1	1	1	0	X	1

2. Kmap For S-R

For S

$J \backslash KQ_n$	$\bar{K}\bar{Q}_n$	$\bar{K}Q_n$	KQ_n	$K\bar{Q}_n$
$\bar{J}$		X		
J	1	X		1

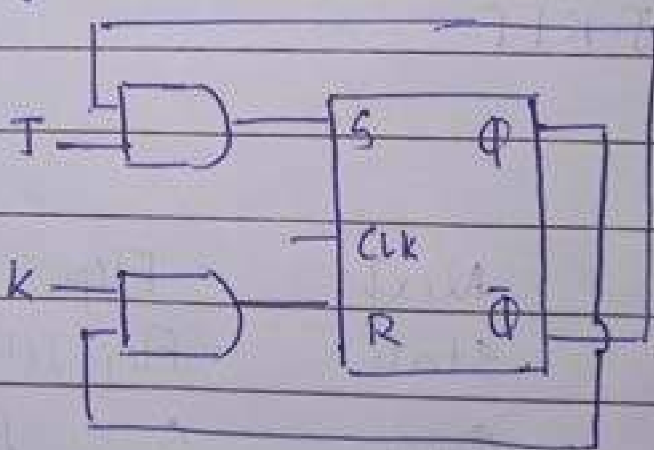
$S = J\bar{Q}_n$

For R

$J \backslash KQ_n$	$\bar{K}\bar{Q}_n$	$\bar{K}Q_n$	KQ_n	$K\bar{Q}_n$
$\bar{J}$	x		1	X
J			1	

$R = KQ_n$

3] logic diagram



→ Convert DFF to SRFF

External I/P	Present state	Next state
D S R	Q_n	Q

H.W

Convert JK to SR

Convert SR to D

Convert JK to D

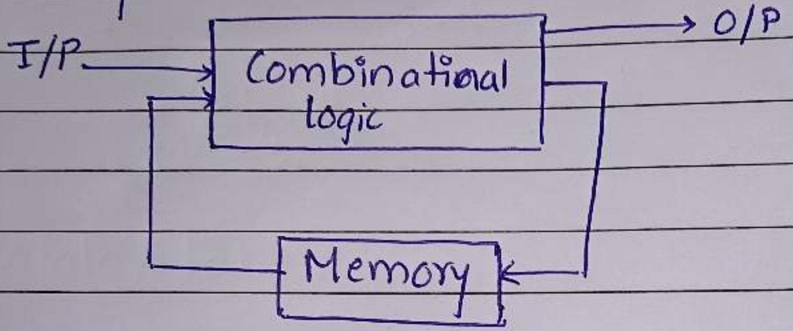
Convert D to JK

Unit 5:

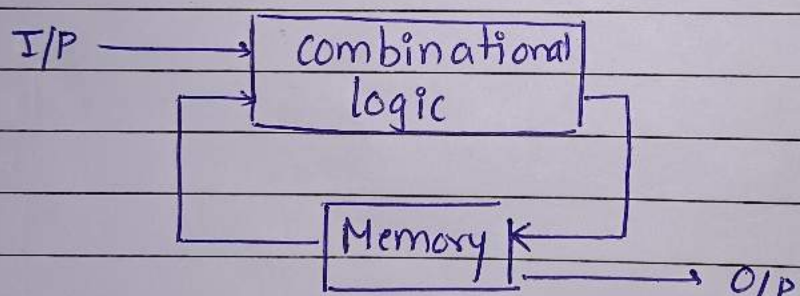
Finite State Machine

1] Mealy state Machine
2] Moore state Machine

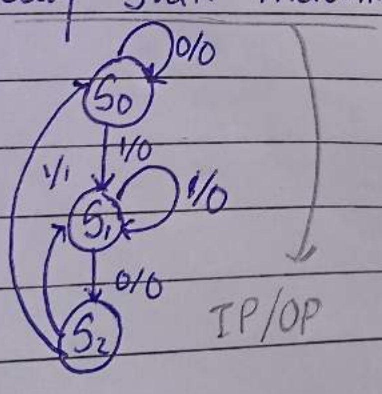
Mealy state Machine



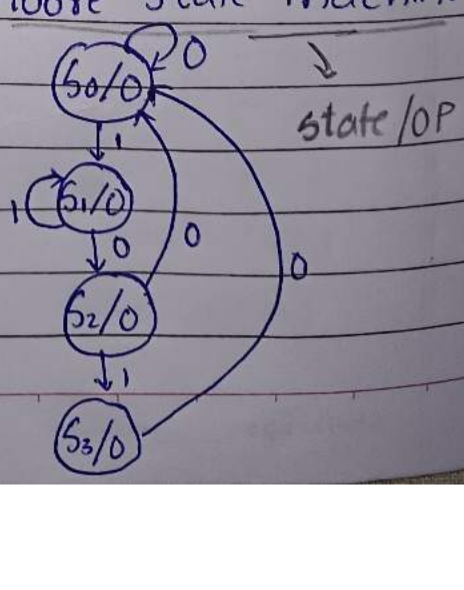
Moore state Machine



① Mealy state machine

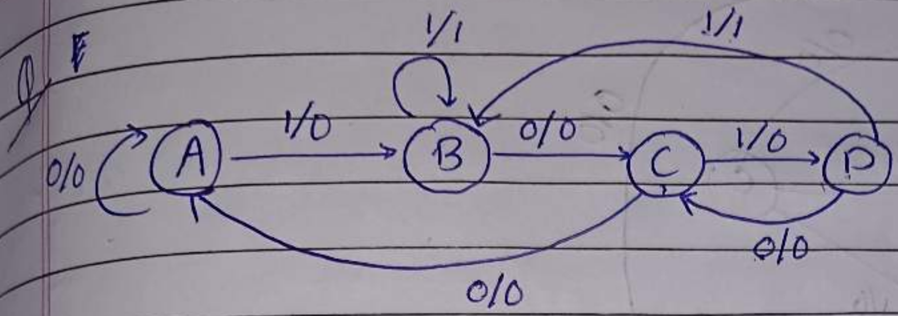


② Moore state machine



Page No. ______
Date __/__/__

Q. F



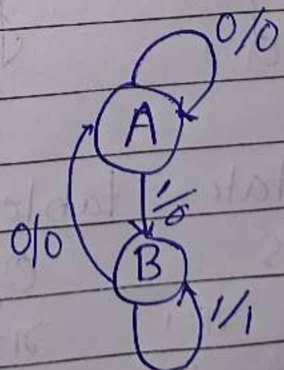
1010

State Table

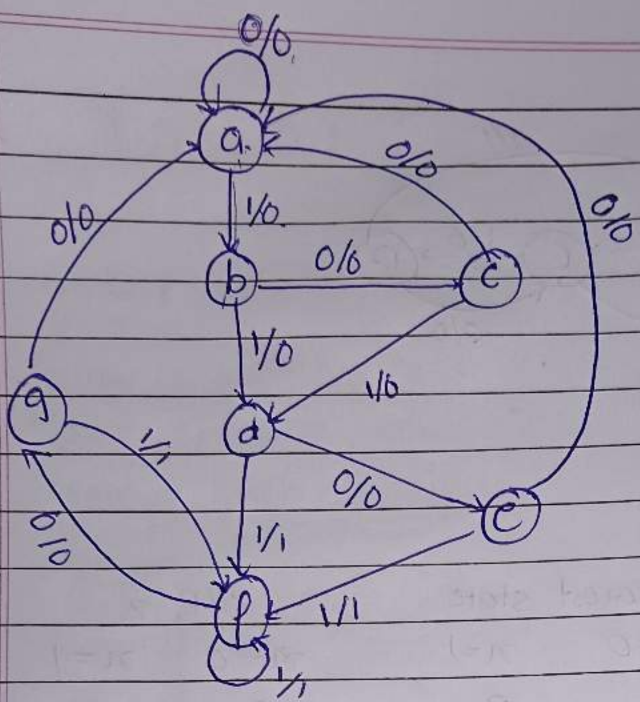
Present state	Nearest state		O/P Z	
	$x=0$	$x=1$	$x=0$	$x=1$
A	A	B	0	0
B	C = A	B	0	1
C	A	D = B	0	0
D	C	B	0	1

Reduced state table

PS	NS		O/P	
	$x=0$	$x=1$	$x=0$	$x=1$
A	A	B	0	0
B	A	B	0	1



Q/



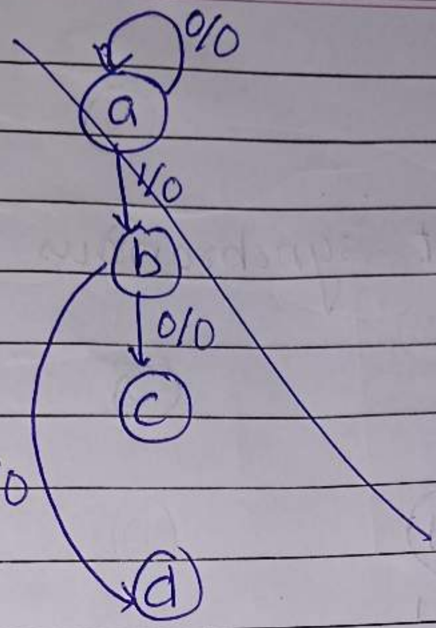
State table

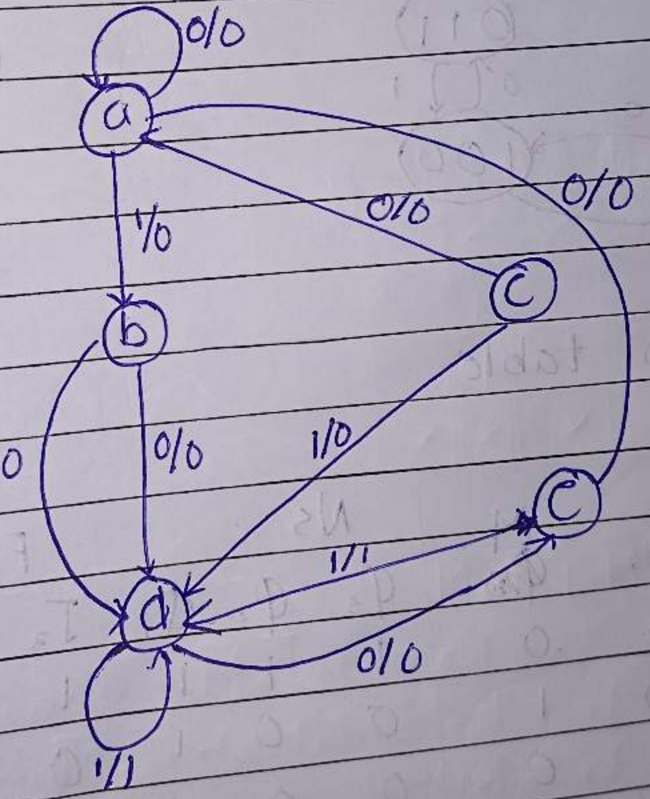
	$x=0$	$x=1$	$x=0$	$x=1$
a	a	b	0	0
b	c	d	0	0
c	a	d	0	0
✓ d	e	f = d	0	1
✓ e	a	f = d	0	1
✗ f	g = e	f	0	1
g=e ✗ g	a	f	0	1

Reduced state table

PS	NS		O/P	
	$x=0$	$x=1$	$x=0$	$x=1$
a	a	b	0	0
b	c	d	0	0
c	a	d	0	0
d	e	d	0	1
e	a	d	0	1

Date ___ / ___ / ___

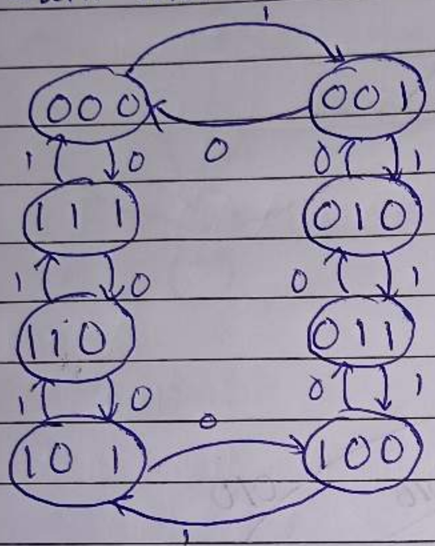




Counter

Q. Design a 3-bit synchronous up-down counter.

1] State dia



Q_n	Q_{n+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

2] Excitation table

PS				NS			FF required excitation I/P					
Q_3	Q_2	Q_1	M	Q_3	Q_2	Q_1	J_3	K_3	J_2	K_2	J_1	K_1
0	0	0	0	1	1	1	1	X	1	X	1	X
0	0	0	1	0	0	1	0	X	0	X	1	X
0	0	1	0	0	0	0	0	X	0	X	X	1
0	0	1	1	0	1	0	0	X	1	X	X	1
0	1	0	0	0	0	1	0	X	X	1	1	X
0	1	0	1	0	1	1	0	X	X	0	1	X
0	1	1	0	0	1	0	0	X	X	0	X	1
0	1	1	1	1	0	0	1	X	X	1	X	1
1	0	0	0	0	1	1	X	1	1	X	1	X
1	0	0	1	1	0	1	X	0	0	X	1	X

Date ___/___/___

Q_3	Q_2	Q_1	M	Q_3	Q_2	Q_1	J_3	K_3	J_2	K_2	J_1	K_1
1	0	1	0	1	0	0	X	0	0	X	X	1
1	0	1	1	1	1	0	X	0	1	X	X	1
1	1	0	0	1	0	1	X	0	X	1	1	X
1	1	0	1	1	1	1	X	0	X	0	1	X
1	1	1	0	1	1	0	X	0	X	0	X	1
1	1	1	~~0~~ 1	0	0	0	X	1	X	1	X	1

→ For J_3

$Q_3Q_2 \backslash Q_1M$	$\bar{Q}_1\bar{M}$	$\bar{Q}_1M$	Q_1M	$Q_1\bar{M}$
$\bar{Q}_3\bar{Q}_2$	1 (0)	(1)	(3)	(2)
$\bar{Q}_3Q_2$	(4)	(5)	1 (7)	(6)
Q_3Q_2	X (12)	X (13)	X (15)	X (14)
$Q_3\bar{Q}_2$	X (8)	X (9)	X (11)	X (10)

$$J_3 = \bar{Q}_2\bar{Q}_1\bar{M} + Q_2Q_1M$$

→ For K_3

$Q_3Q_2 \backslash Q_1M$	$\bar{Q}_1\bar{M}$	$\bar{Q}_1M$	Q_1M	$Q_1\bar{M}$
$\bar{Q}_3\bar{Q}_2$	X (0)	X (1)	X (3)	X (2)
$\bar{Q}_3Q_2$	X (4)	X (5)	X (7)	X (6)
Q_3Q_2	. (12)	(13)	1 (15)	(14)
$Q_3\bar{Q}_2$	1 (8)	X (9)	(11)	(10)

$$K_3 = \bar{Q}_2\bar{Q}_1\bar{M} + Q_2Q_1M$$

→ For J_2

Q_3Q_2 \ Q_1M	$\bar{Q}_1\bar{M}$	$\bar{Q}_1M$	Q_1M	$Q_1\bar{M}$
$\bar{Q}_3\bar{Q}_2$	1 (0)	(1)	1 (3)	(2)
$\bar{Q}_3Q_2$	X (4)	X (5)	X (7)	X (6)
Q_3Q_2	X (12)	X (13)	X (15)	X (14)
$Q_3\bar{Q}_2$	1 (8)	(9)	1 (11)	X (10)

$$J_2 = \cancel{\bar{Q}_2\bar{Q}_1\bar{M}} + \cancel{\bar{Q}_3Q_1M} + \cancel{Q_3\bar{Q}_1\bar{M}} \quad \bar{Q}_1\bar{M} + Q_1M$$

→ For K_2

Q_3Q_2 \ Q_1M	$\bar{Q}_1\bar{M}$	$\bar{Q}_1M$	Q_1M	$Q_1\bar{M}$
$\bar{Q}_3\bar{Q}_2$	X (0)	X (1)	X (3)	X (2)
$\bar{Q}_3Q_2$	1 (4)	(5)	1 (7)	(6)
Q_3Q_2	1 (12)	(13)	1 (15)	(14)
$Q_3\bar{Q}_2$	X (8)	X (9)	X (11)	X (10)

$$K_2 = \bar{Q}_1\bar{M} + Q_1M$$

→ For J_1

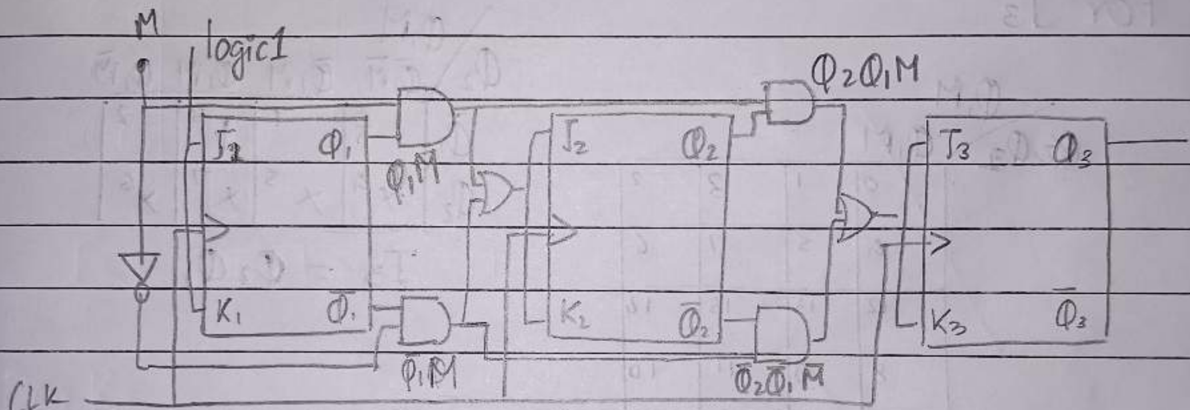
Q_3Q_2 \ Q_1M	Q_1M	Q_1M	Q_1M	Q_1M
$\bar{Q}_3\bar{Q}_2$	1 (0)	1 (1)	X (3)	X (2)
$\bar{Q}_3Q_2$	1 (4)	1 (5)	X (7)	X (6)
Q_3Q_2	1 (12)	1 (13)	X (15)	X (14)
$Q_3\bar{Q}_2$	1 (8)	1 (9)	X (10)	X (11)

$$J_1 = 1$$

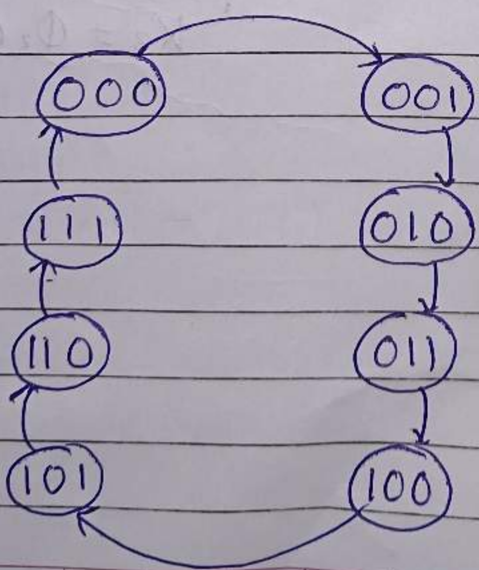
→ For K_1

$Q_3Q_2 \backslash Q_1M$	$\bar{Q}_1\bar{M}$	$\bar{Q}_1M$	Q_1M	$Q_1\bar{M}$
$\bar{Q}_3\bar{Q}_2$	X 0	X 1	1 3	1 2
$\bar{Q}_3Q_2$	X 4	X 5	1 7	1 6
Q_3Q_2	X 12	X 13	1 15	1 14
$Q_3\bar{Q}_2$	X 8	X 9	1 10	1 11

$K_1 = 1$



Q 3-bit synchronous up counter by using JK FF



$J_3 = K_3 = Q_2 Q_1$

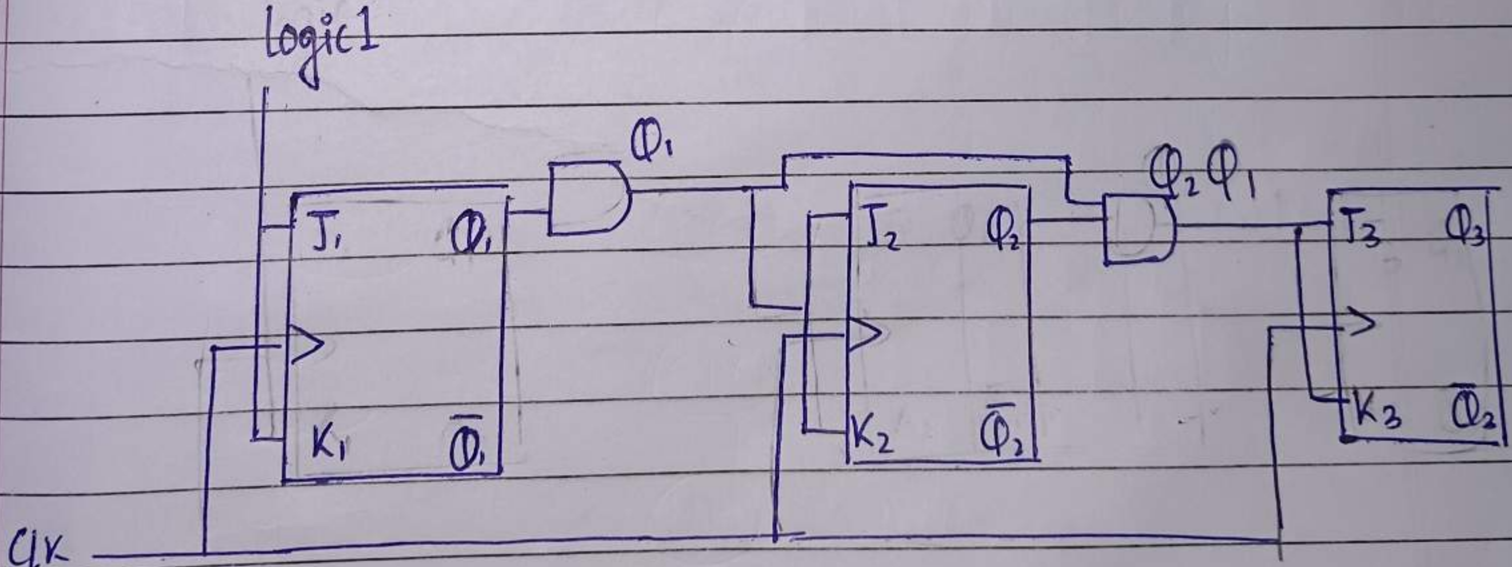
$J_2 = K_2 = Q_1$

$J_1 = K_1 = 1$

Page No. ______

Date ___/___/___

PS			NS			FF required					
Q_3	Q_2	Q_1	Q_3	Q_2	Q_1	J_3	K_3	J_2	K_2	J_1	K_1
0	0	0	0	0	1	0	X	0	X	1	X
0	0	1	0	1	0	0	X	1	X	X	1
0	1	0	0	1	1	0	X	X	0	X	X
0	1	1	1	0	0	1	X	X	1	X	1
1	0	0	1	0	1	X	0	0	X	1	X
1	0	1	1	1	0	X	0	1	X	X	1
1	1	0	1	1	1	X	0	X	0	1	X
1	1	1	0	0	0	X	1	X	1	X	1


Logic1
Q1
Q2Q1
J1
Q1
K1
Q̄1
J2
Q2
K2
Q̄2
J3
Q3
K3
Q̄3
Clk

Serial in $||^{el}$ out → SIPO
$||^{el}$ in serial out → PISO
$||^{el}$ in $||^{el}$ out → PIPO

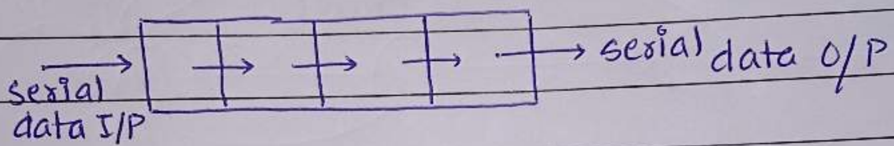
Page No.
Date / /

Register:

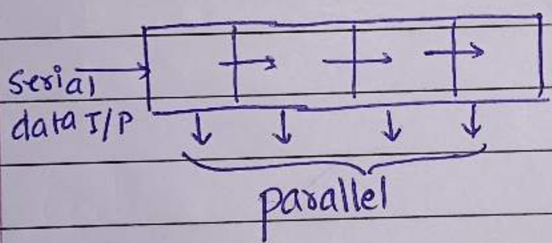
Q How many ways can be transfer data in register?

Ans:

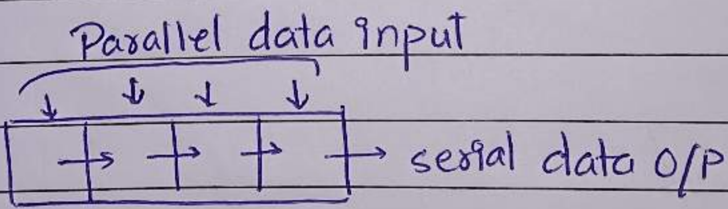
1] SISO



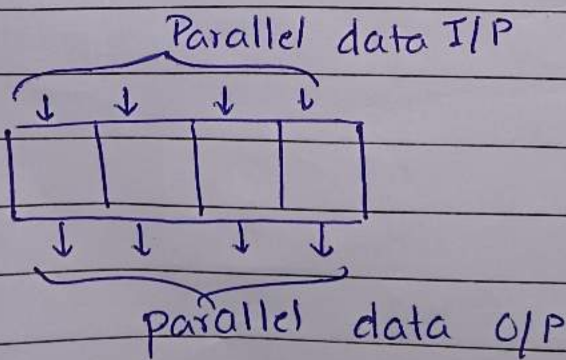
2] SIPO



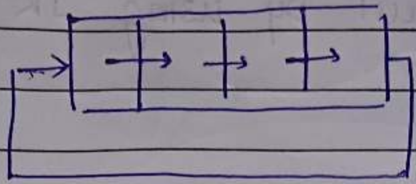
3] PISO



4] PIPO

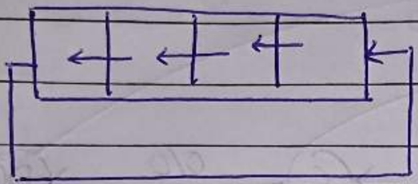


5]



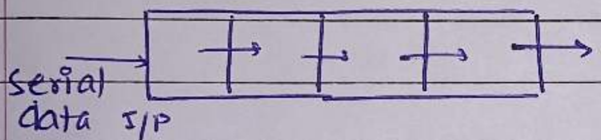
Rotate right shift

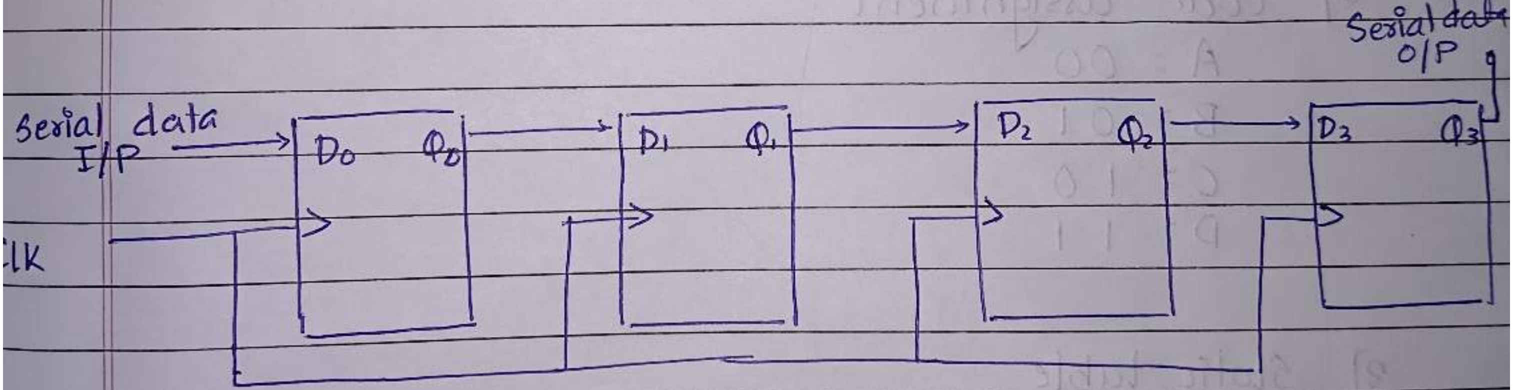
6]



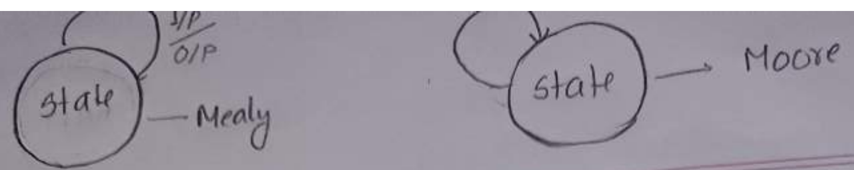
Rotate left shift

SISO





CLK	Q_3	Q_2	Q_1	Q_0
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	1	0	0
4	1	0	0	0
5	0	0	0	0



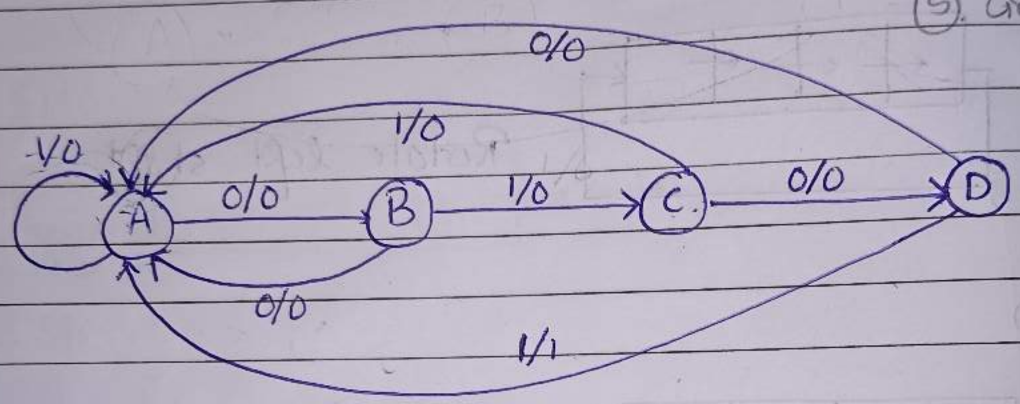
Page No.
Date / /

Q Implement mealy circuit by using JK FF for sequence 0101

① State diagram
② Code assignment
③ State Table
④ minimal expression using K-map
⑤ Circuit diagram

→

1] Non-overlaping



2] Code assignment

A = 00
B = 01
C = 10
D = 11

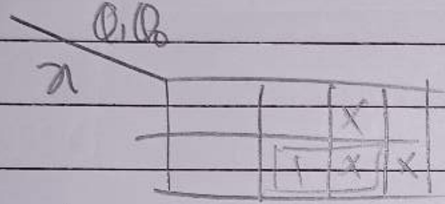
3] Static table

Present state	Next state $x=0$	Next state $x=1$	O/P $x=0$	O/P $x=1$
A	B	A	0	0
B	A	C	0	0
C	D	A	0	0
D	A	A	0	1

Page No. ______
Date ___/___/___

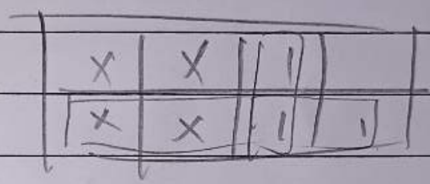
P.S.		N.S				excitation required							
P/Scr		$x=0$		$x=1$		$x=0$				$x=1$			
Q_1	Q_0	Q_1	Q_0	Q_1	Q_0	J_1	K_1	J_0	K_0	J_1	K_1	J_0	K_0
0	0	0	1	0	0	0	x	1	x	0	x	0	x
0	1	0	0	1	0	0	x	x	1	1	x	x	1
1	0	1	1	0	0	x	0	1	x	x	1	0	x
1	1	0	0	0	0	x	1	x	1	x	1	x	1

For J_1



$J_1 = x \cdot Q_0$

For K_1



$K_1 = x + Q_1 Q_0$