Question 1.

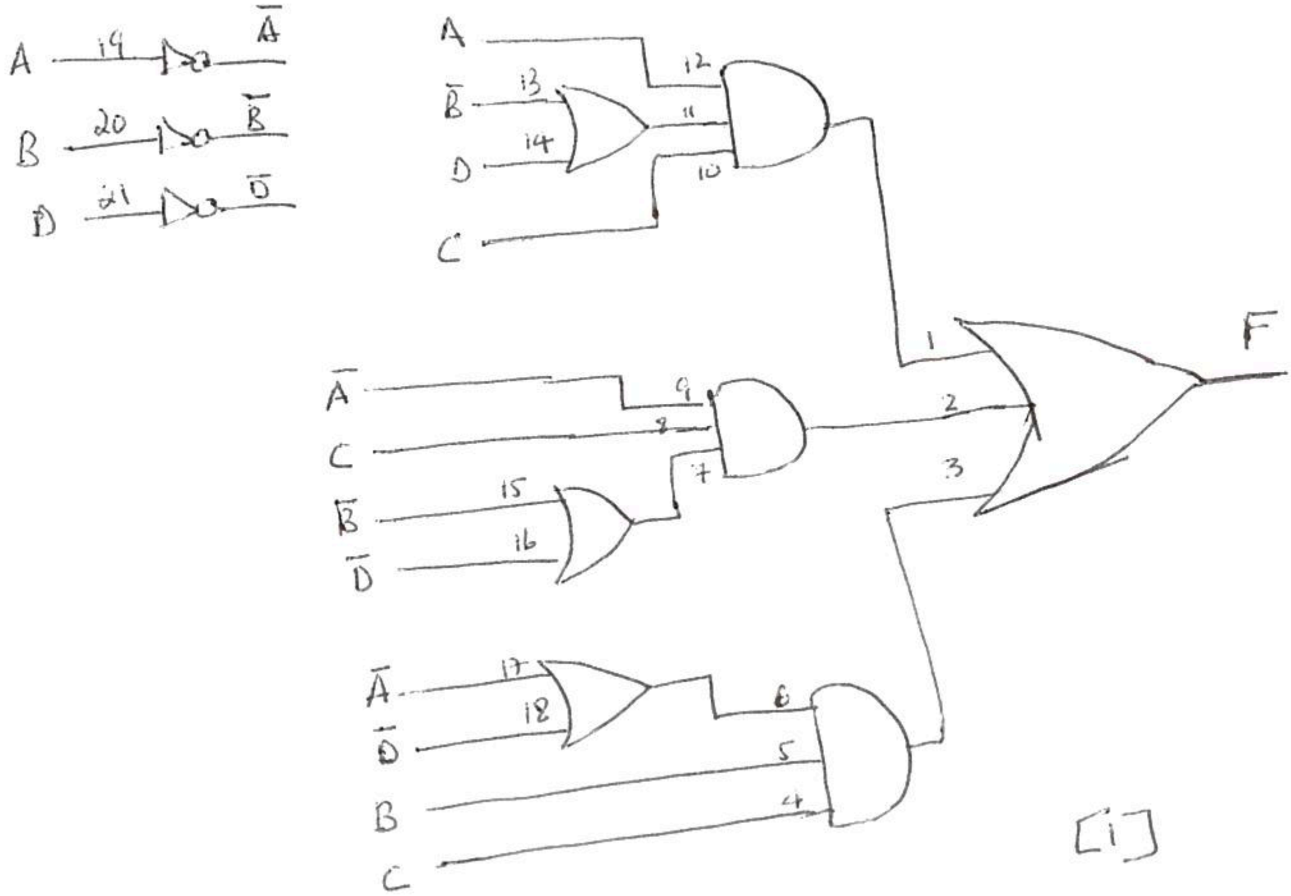
$F(A, B, C, D) = AC(\bar{B}+D) + \bar{A}C(\bar{B}+\bar{D}) + BC(\bar{A}+\bar{D})$

a) No of terms = 6

No of literals = 4 + 4 + 4 = 12

No of complimented literals = 3

Total gate input cost = 6 + 12 + 3 = 21



GIC = 21

b) $F = A\bar{B}C + ACD + \bar{A}\bar{B}C + \bar{A}C\bar{D} + \bar{A}BC + BC\bar{D}$

Truth table

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

$F = \sum m(2, 3, 6, 7, 10, 11, 14, 15)$

[2]

c) $F = \sum m(2, 3, 6, 7, 10, 11, 14, 15)$ [2]

d) $F = \prod M(0, 1, 4, 5, 8, 9, 12, 13)$ [2]

e) Four variable K-map

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

$F = C$

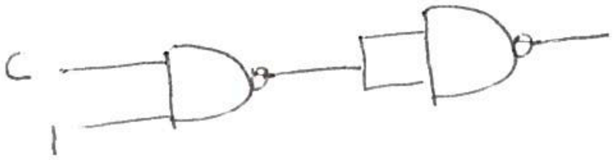
There is only one prime implicant, which is also essential. [4]

f) product of sums

Combine the zeros to find $\overline{F}$

$\overline{F} = \overline{C} \Rightarrow F = C$ is also product of sums [3]

g) $F = C \cdot 1$



possible answer

no implementation is needed as the funct is a single variable [2]

implementation in (g) is 4 →

h) GIC for implementat, total reduction in

But if no implementation

GIC = 21

otherwise, total reduction in gic is 21 - 4 = 17 [1]

ii) $(23B4.A5)_{12} = 2\times12^3 + 3\times12^2 + 11\times12^1 + 4\times12^0$
$+ 10\times12^{-1} + 5\times12^{-2}$

$= 3456 + 432 + 132 + 4 + 0.8333\ldots + 0.0347222$
$+ 0.86805222\ldots$

$= (4024.86805222\ldots)_{10}$

Integral part to base 5

$4024 \div 5 = 804 \quad 4$
$\cancel{804} \div 5 = 160 \quad 4$
$160 \div 5 = 32 \quad 0$
$32 \div 5 = 6 \quad 2$
$6 \div 5 = 1 \quad 1$
$1 \div 5 = 0 \quad 1$

$(112044)_5$

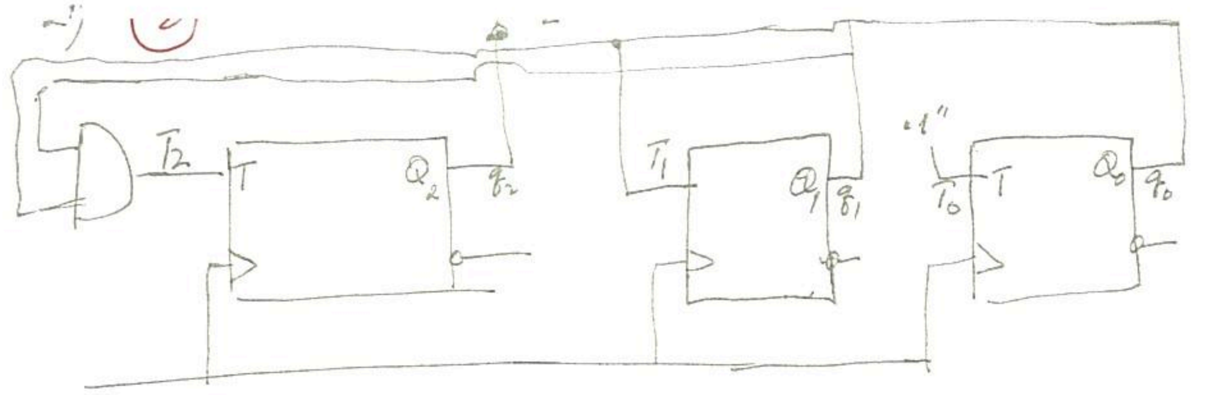
Fractional part

$0.86805222\ldots \times 5 = 4$
$0.34026111\ldots \times 5 = 1$
$0.70130555\ldots \times 5 = 3$
$0.50652777\ldots \times 5 = 2$
$0.53263888\ldots \times 5 = 2$

$(0.4132)_5$ [3]

Truncating into 4 digits after radix point
$(112044.4132)_5$

-) (c)



Excitation equations

d)

$T_0 = 1$

$T_1 = q_0$

$T_2 = q_0 \cdot q_1$

$C_0 = Q_0$

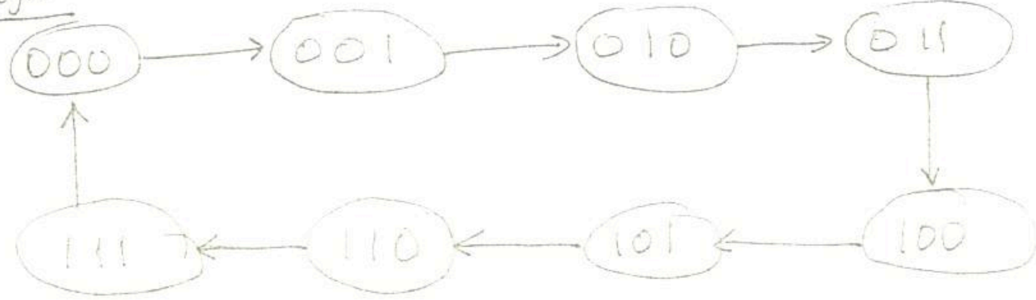
$C_1 : Q_1$

$C_2 : Q_2$

State table

Present state q_2	q_1	q_0	Next State Q_2	Q_1	Q_0	Excitation inputs T_2	T_1	T_0
0	0	0	0	0	1	0	0	1
0	0	1	0	1	0	0	1	1
0	1	0	0	1	1	0	0	1
0	1	1	1	0	0	1	1	1
1	0	0	1	0	1	0	0	1
1	0	1	1	1	0	0	1	1
1	1	0	1	1	1	0	0	1
1	1	1	0	0	0	1	1	1

State diagram



ii) Moore Type (...

iii) Three bit binary Counter

iv) Characteristic table for JK flip flop

J	K	Q(t+1)
0	0	Q(t)
0	1	0
1	0	1
1	1	$\bar{Q}(t)$

Q(t)	Q(t+1)	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

Present State			Next State			Flip-flop inputs					
q_2	q_1	q_0	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0
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	1	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

K_0:

$q_2 \backslash q_1q_0$				
$\bar{q}_2$	X	1	1	X
q_2	X	1	1	X

$K_0 = 1$

J_0:

$q_2 \backslash q_1q_0$				
$\bar{q}_2$	1	X	X	1
q_2	1	X	X	1

$J_0 = 1$

K_1:

$q_2 \backslash q_1q_0$				
$\bar{q}_2$	X	X	1	0
q_2	X	X	1	0

$K = q_0$

J_1:

$q_2 \backslash q_1q_0$				
$\bar{q}_2$	0	1	X	X
q_2	0	1	X	X

$J = q_0$

J_2:

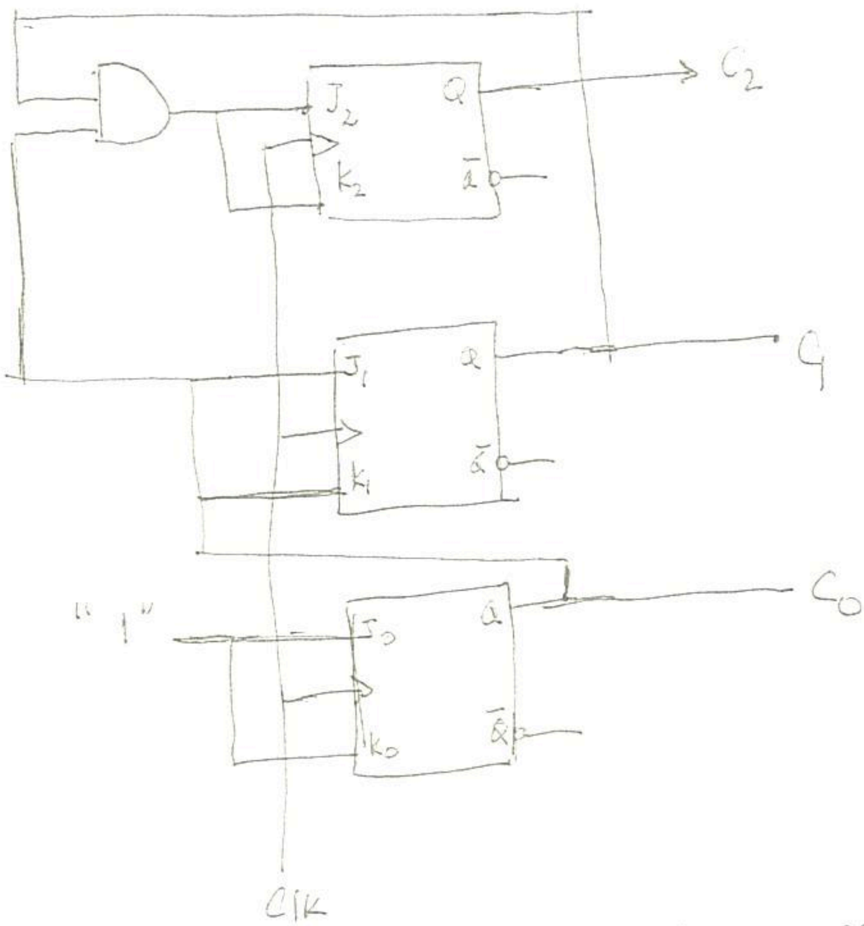
0	0	1	0
X	X	X	X

$J_2 = q_0 q_1$

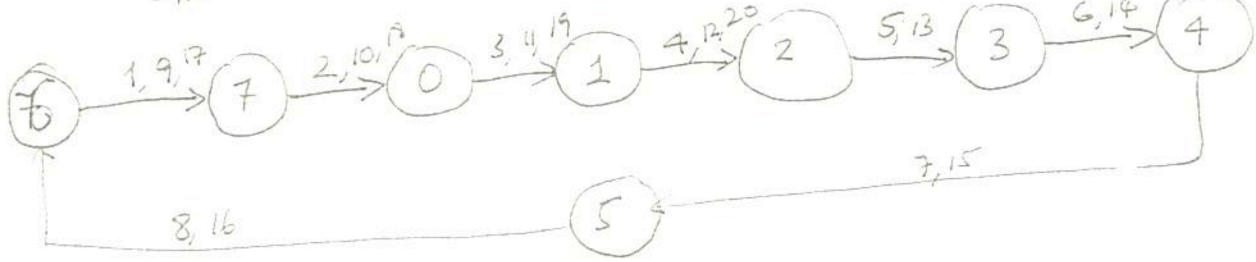
K_2:

X	X	X	X
0	0	1	0

$K_2 = q_0 q_1$



V)

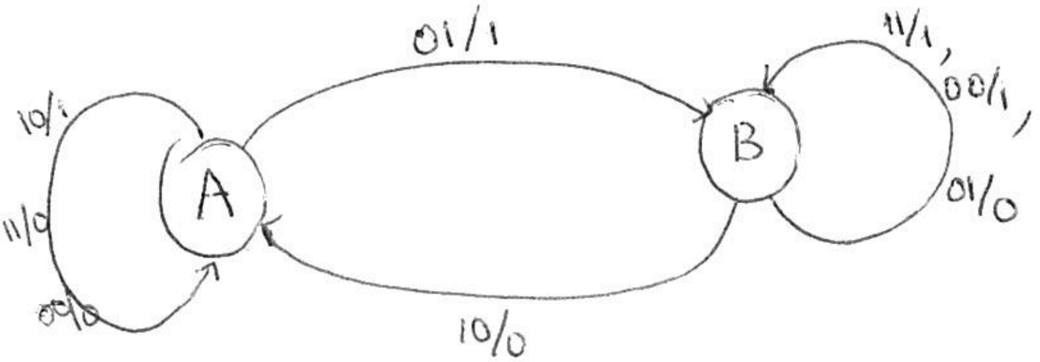


The output of the system will be 010 after 20 clock cycle.

3) a) Two possible states are available

A – with no borrow

B – with borrow



[3]

b) State assignment

A = 0 B = 1

State table

Present state	next state, output			
	xy=00	xy=01	xy=11	xy=10
A	A, 0	B, 1	A, 0	A, 1
B	B, 1	B, 0	B, 1	A, 0

with state assignment

Present state	Next state, output			
	xy=00	xy=01	xy=11	xy=10
0	0, 0	1, 1	0, 0	0, 1
1	1, 1	1, 0	1, 1	0, 0

Q_0^+

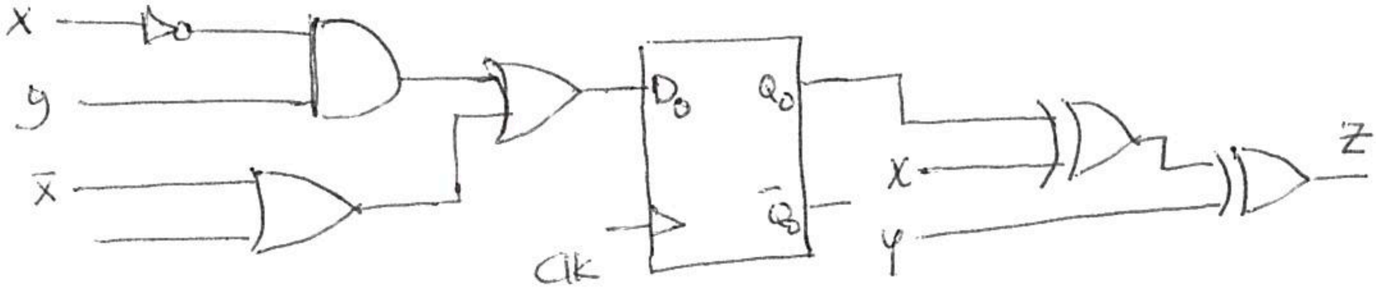
Q_0 \ xy		y	xy	x
$\bar{Q}_0$	0	1	0	0
Q_0	1	1	1	0

$$Q_0^+ = \bar{x}y + Q_0(\bar{x}+y)$$

Z

$Q_0 \backslash xy$			x	x
$\bar{Q_0}$	0	1	0	1
Q_0	1	0	1	0
		y	y	

$$Z = Q_0 \oplus X \oplus Y$$



[4]

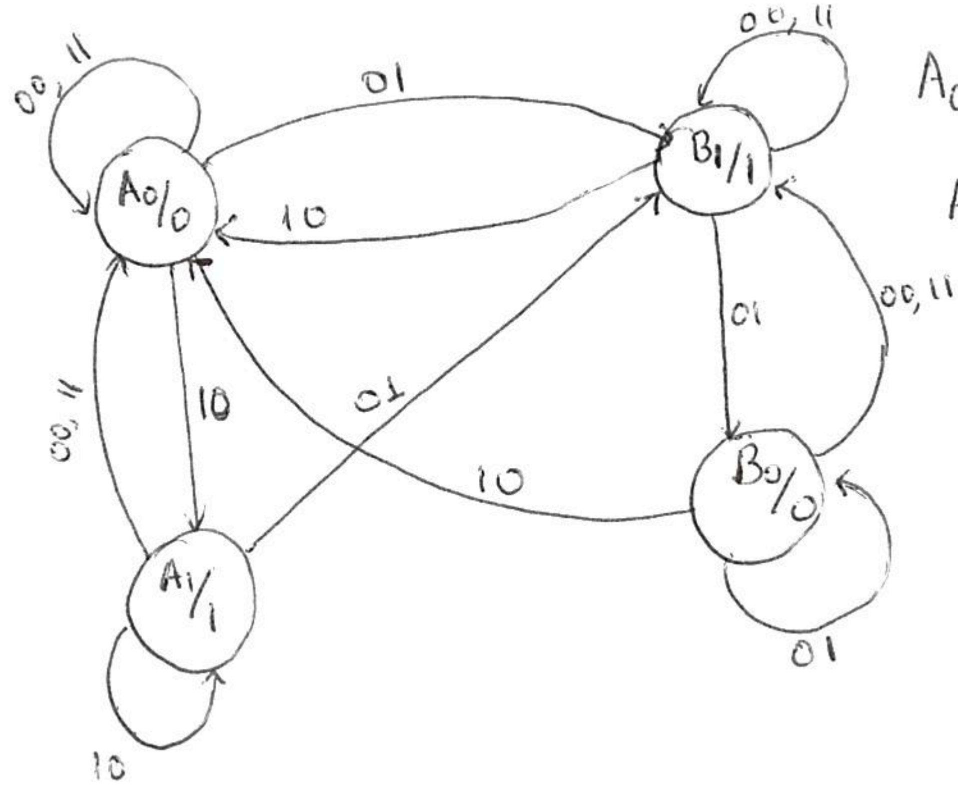
c)

```
module Seq-binary-sub(x, y, clk);
 input x, y, clk;
 output z;
 wire A;
 reg B;
  assign A = (~x & y) | (B & ((~x) | y));
  assign Z = X^y^B;
  DFF D(B, A, clk);
endmodule

module DFF(Q, D0, clk);
 input D0, clk;
 output reg Q;
 always @(posedge clk)
   Q <= A;
```

[3]

d)



A_0 = no borrow and sub is zero

A_1 = no borrow and sub one

B_0 = borrow and sub is z

B_1 = borrow but sub is o

[4]

ii) a)

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

C should be Low

$A < B$ y or c = 1

$A \geq B$ y or c = 0

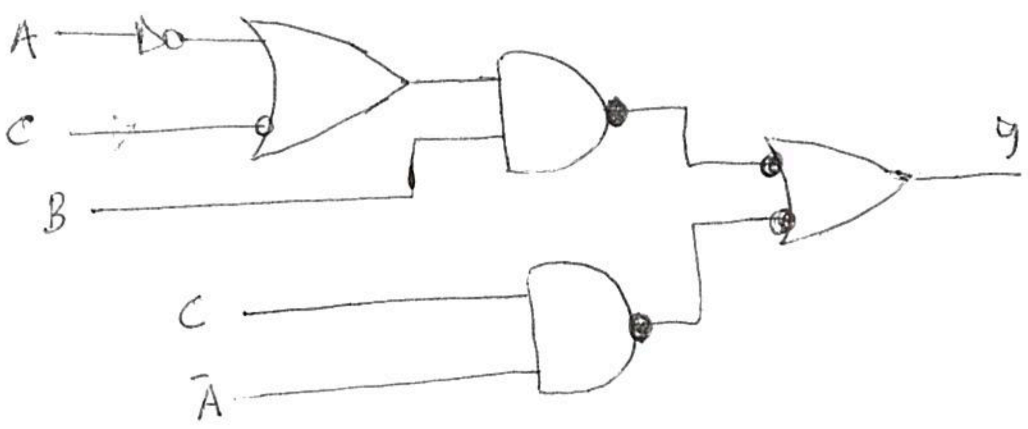
Starting value should be low to ~~assum~~ take into account the possible equality

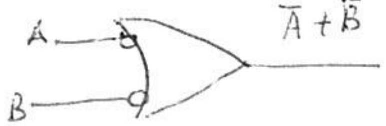
[2]

b) $y =$

C \ AB			A	A
	0	1	0	0
C	1	1	1	0
		B	B	

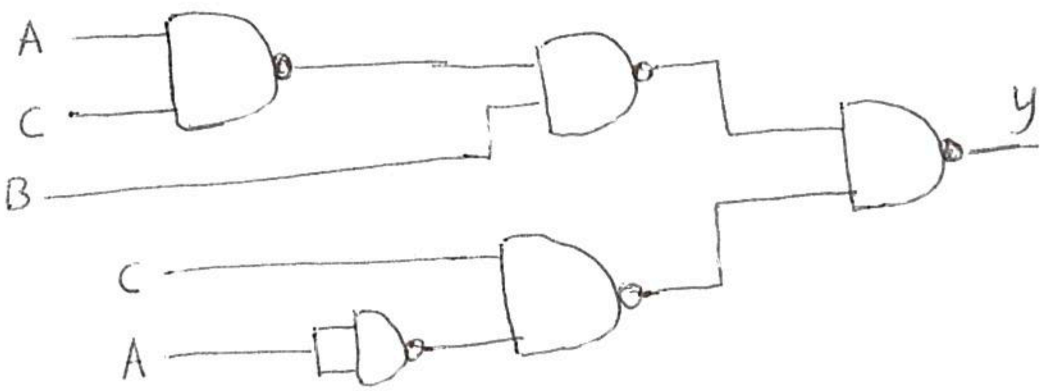
$y = B(\bar{A} + C) + C\bar{A}$





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

$\equiv$

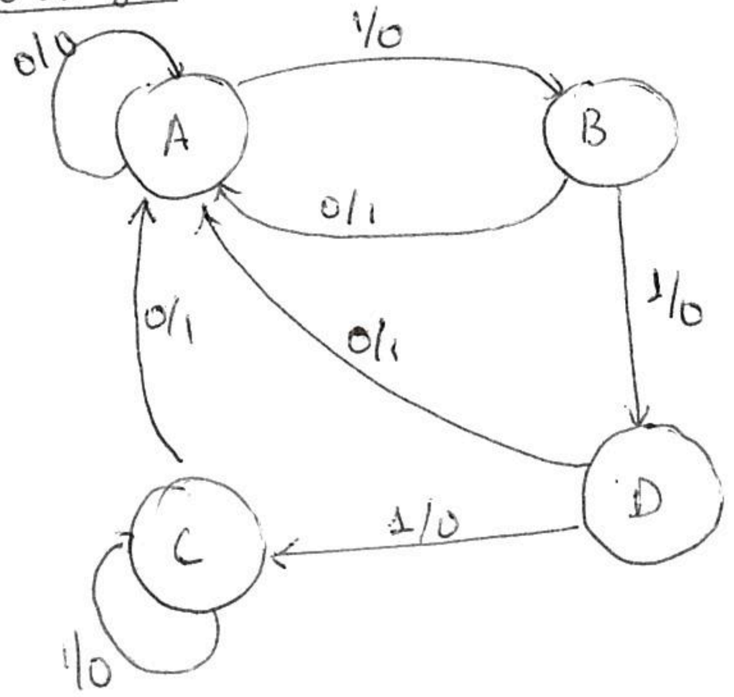


[4]

Questi 7

State diagra-

i)

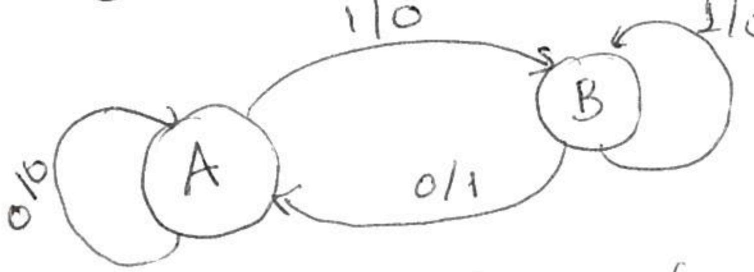


State table

Present State	Next State, output	
	X = 0	X = 1
A	A, 0	B, 0
B	A, 1	D, 0
C	A, 1	C, 0
D	A, 1	C, 0

State reduction

C = D = B , A reduces to two states



a) Mealy, output is a function of X [2]

b)

Present State	Next State, output $x=0$	$x=1$
Q_0	Q_0^+, y	Q_0^+, y
	0, 0	1, 0
0		1, 0
1	0, 1	

A : 0
B : 1

Q_0^+

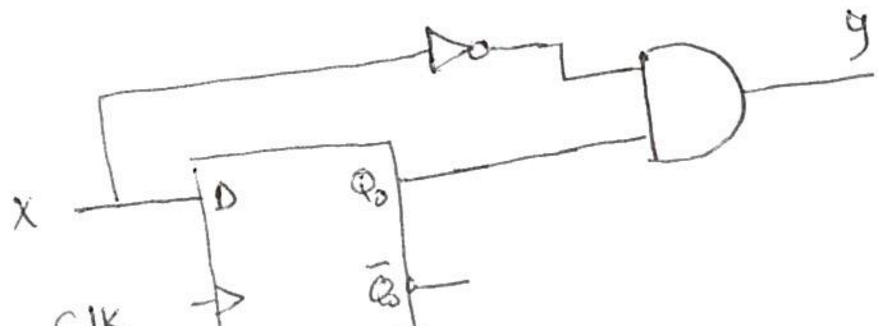
$Q_0 \backslash x$	$\bar{x}$	x
$\bar{Q_0}$	0	$\boxed{1}$
Q_0	0	$\boxed{1}$

$Q_0^+ = x$

y

$Q_0 \backslash x$	$\bar{x}$	x
$\bar{Q_0}$	0	0
Q_0	$\boxed{1}$	0

$y = Q_0\bar{x}$



[4]

c)

input	0	1	0	1	1	0	0	
State	B	A	B	A	B	B	A	A
Output	1	0	1	0	0	1	0	

[2]

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

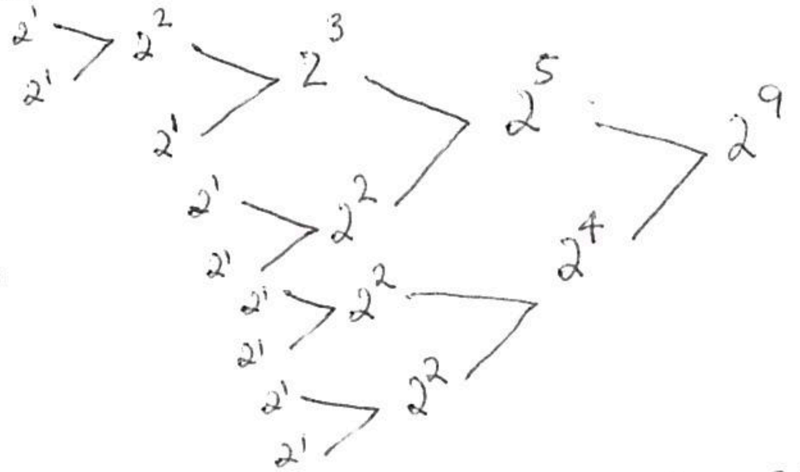
~~$B(A+C)B = BA+BC$~~

$A+B = 1$ and $A = B = 0 \Rightarrow A = \bar{B}$

$B(A+C)(B+B) = B(A+C) = BA+BC$ [4]

$= AB + BC = 0 + BC = BC$

iii) 9 to 2^9 line decoder



2^1  GIC=1

2^2 4 AND (two input)

$GIC = 2.(2^9 + 2^4 + 2^5 + 2^2 + 2^2 + 2^2 + 2^3 + 2^2) + 9$

$= 2(512 + 32 + 16 + 4 + 4 + 4 + 8 + 4) + 9$ [4]

$= \underline{\underline{1177}}$

iv) a) Bidirectional shift register [2]

b) Moore type system [2]

Question 5

1)

A A_3	B A_2	C A_1	D A_0	B_3	B_2	B_1	B_0
0	0	0	0	0	0	0	0
0	0	0	1	1	1	1	1
0	0	1	0	1	1	1	0
0	0	1	1	1	1	0	1
0	1	0	0	1	1	0	0
0	1	0	1	1	0	1	1
0	1	1	0	1	0	1	0
0	1	1	1	1	0	0	1
1	0	0	0	1	0	0	0
1	0	0	1	0	1	1	1
1	0	1	0	0	1	1	0
1	0	1	1	0	1	0	1
1	1	0	0	0	1	0	0
1	1	0	1	0	0	1	1
1	1	1	0	0	0	1	0
1	1	1	1	0	0	0	1

B_0 (K-map; A_1 above, A_2 right, A_3 left, A_0 below)

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

$B_0 = A_0$

B_1

$A_3A_2 \backslash A_1A_0$				
	0	1	0	1
	0	1	0	1
	0	1	0	1
	0	1	0	1

A_1, A_2, A_3, A_0

$$B_1 = A_1\bar{A}_0 + A_0\bar{A}_1 = A_0 \oplus A_1$$

B_2

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

A_1, A_2, A_3, A_0

$$B_2 = \bar{A}_3\bar{A}_1(A_0 \oplus A_2) + A_3\bar{A}_1(A_0 \oplus A_2) + \bar{A}$$

$$= (A_0 \oplus A_2)(A_3\bar{A}_1 + \bar{A}_3\bar{A}_1) + A_1\bar{A}_2$$

$$= \bar{A}_1(A_0 \oplus A_2) + A_1\bar{A}_2$$

$$= \bar{A}_1(A_0 \oplus A_2) \oplus A_1\bar{A}_2$$

B_3

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

A_1, A_2, A_3, A_0

$$B_3 = (A_3 \oplus A_0)\bar{A}_1\bar{A}_2 + A_1\bar{A}_3 + A_2\bar{A}_3$$

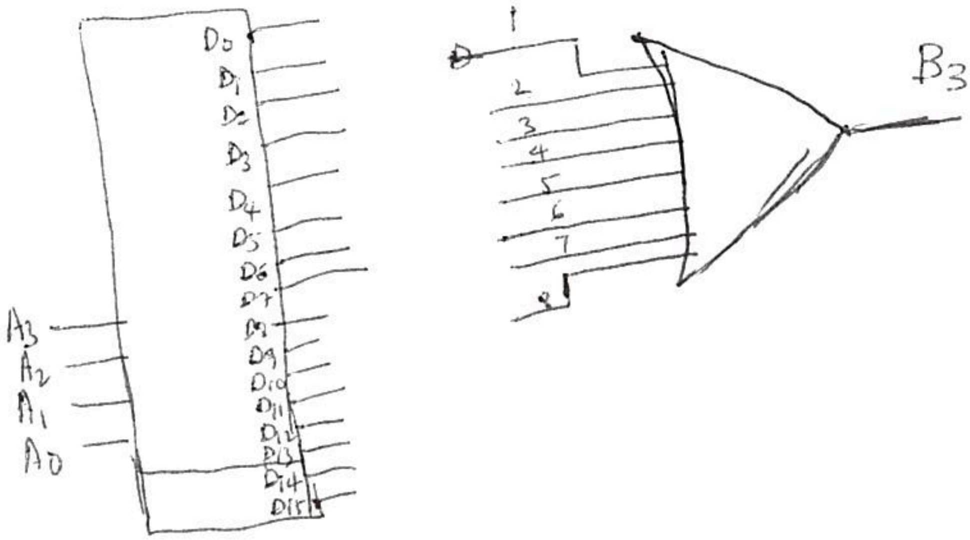
$$= \left(\bar{A}_1\bar{A}_2(A_0 \oplus A_3) \oplus A_1\bar{A}_3\right) + A_2\bar{A}_3$$

$$= \left(\bar{A}_1\bar{A}_2(A_0 \oplus A_3) \oplus A_1\bar{A}_3\right) \oplus A_2\bar{A}_3$$

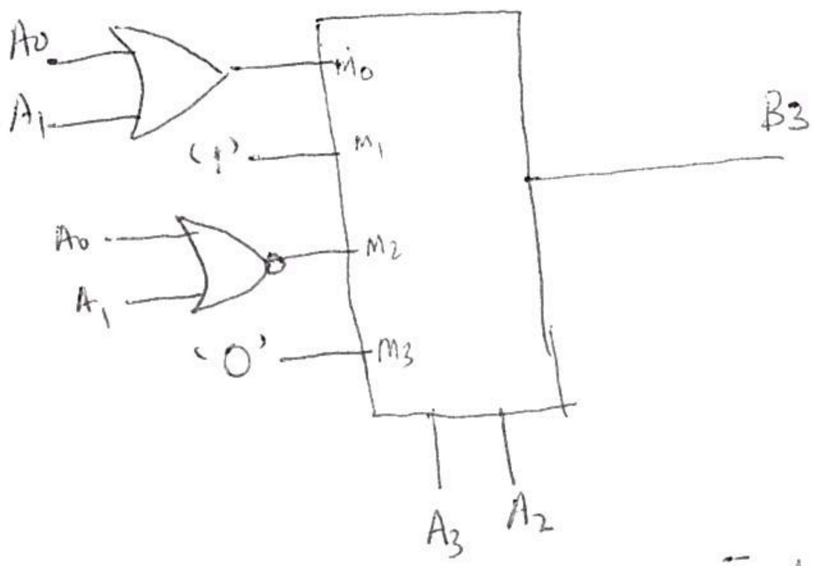
[4]

b) $B_3 = \sum m(1,2,3,4,5,6,7,8)$

using decoder



Multiplexer



[2]

c) $B_3 = A_1\bar{A}_3 + A_2\bar{A}_3 + \bar{A}_3A_0 + \bar{A}_0\bar{A}_1\bar{A}_2A_3$

$= \bar{A}_3(A_1+A_2+A_0) + A_3(\bar{A}_0\bar{A}_1\bar{A}_2)$

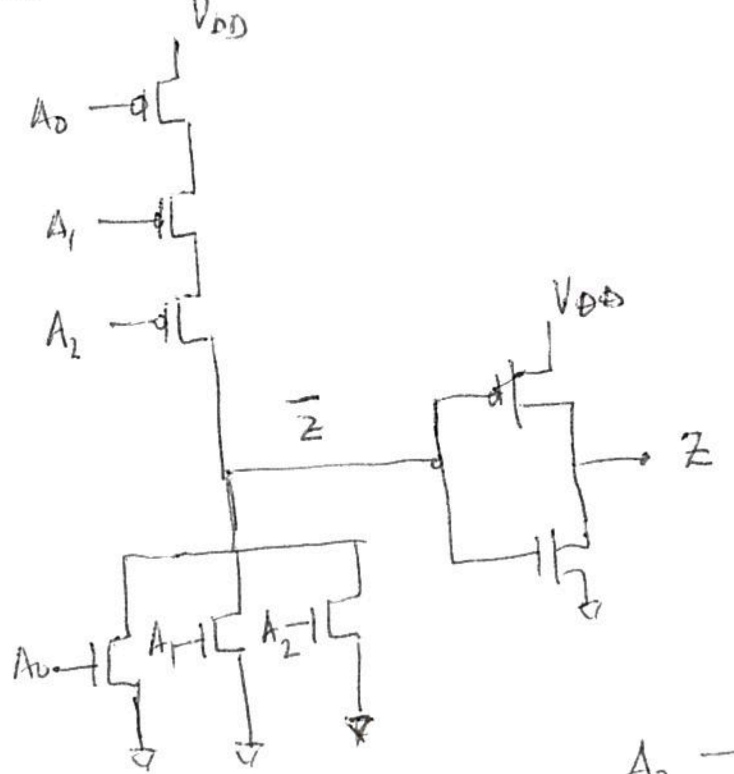
$= \bar{A}_3(A_1+A_2+A_0) + A_3(\overline{A_0+A_1+A_2})$

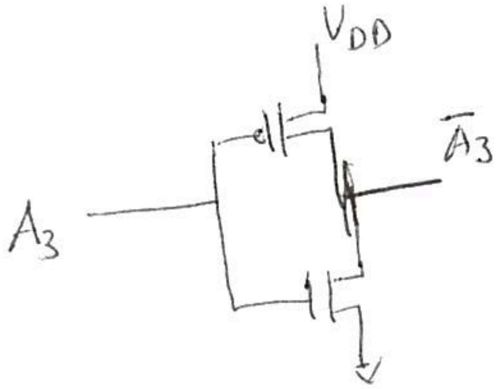
$= A_3 \oplus (A_0+A_1+A_2)$

$= A_3 \oplus Z$

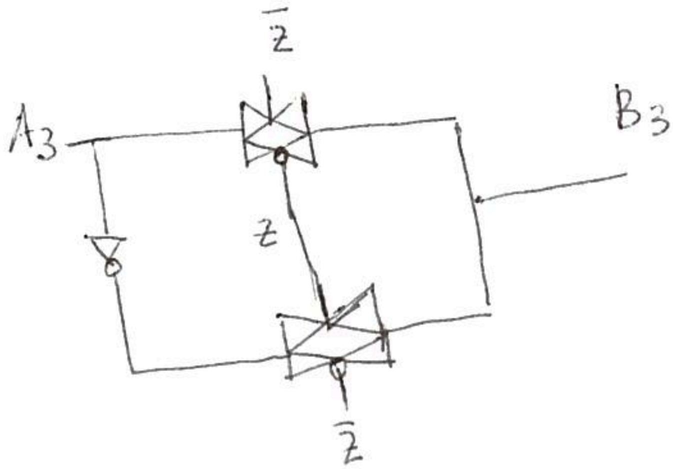
where $Z = A_0+A_1+A_2$

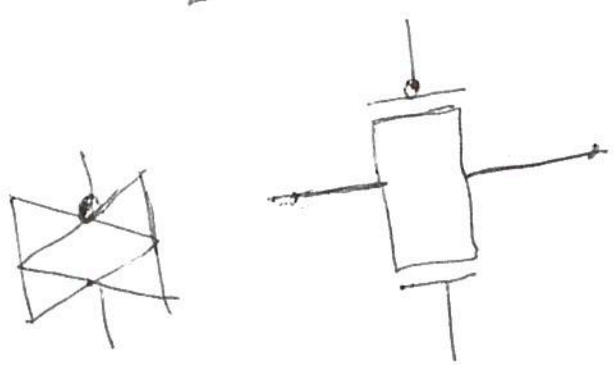
$\bar{Z} = \bar{A}_0 \cdot \bar{A}_1 \cdot \bar{A}_2$





$B_3 = A_3 \oplus Z$





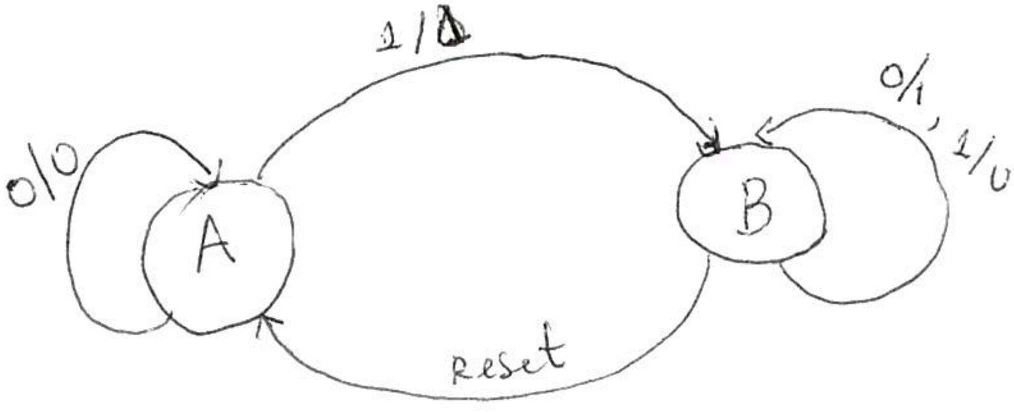
Transmissi gate

[3]

ii) There will be two states

$A \rightarrow$ State ~~to~~ in which arriving bit is unchanged

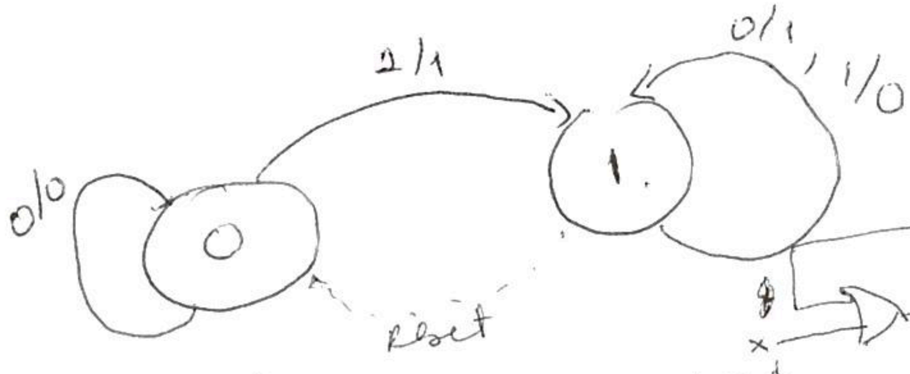
$B \rightarrow$ State in which arriving bit is Complemented

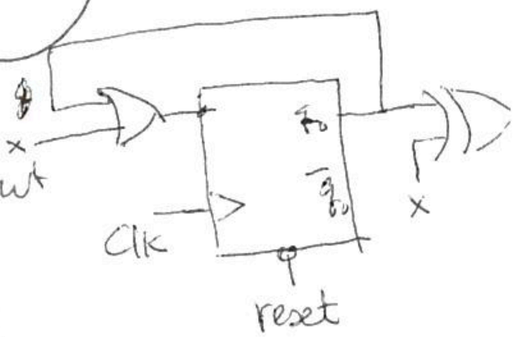


[4]

state assignment

A = 0 B = 1





state table

present State q_0	Next state, output $x = 0$ (q_0^+)	$x = 1$ (q_0^+)
0	0, 0	1, 1
1	1, 1	1, 0

q_0^+

$q_0 \backslash x$	$\bar{x}$	x
$\bar{q}_0$	0	1
q_0	1	1

$$q_0^+ = q_0 + x$$

Z

$q_0 \backslash x$	$\bar{x}$	x
$\bar{q}_0$	0	1
q_0	1	0

$$Z = q_0 \oplus x$$

iii) $R_1 = 1000\ 1111\ 0001\ 0101$
$R_2 = 1010\ 1011\ 1001\ 0111$

$0011\ 1010\ 1010\ 1100$

$V = C_{out} \oplus C_{in} = 1 \oplus 0 = 1$

$C_0 = C_{out} = 1$

[4]

$N = 0$

$Z = 0$

iv) a) When C is low and A is low

Q_6 is off, Q_7 is off, Q_8 is off

Q_1 is off, Q_2 is off, Q_3 is off

Q_5 is ON, Q_4 is ON, Y is High

b) When C is low and A is high

Q_6 is off, Q_7 is off, Q_8 is off

Q_1 is ON, Q_2 is ON, Q_3 is ON

Q_5 is off, Q_4 is off, Y is LOW

[3]

c) when C is high

Q_6 is ON, Q_7 is ON, Q_8 is ON

Q_5 is OFF, Q_4 is OFF, Q_1 is OFF

Q_2 is OFF, Q_3 is OFF, Y is high impeda

Tristate buffer