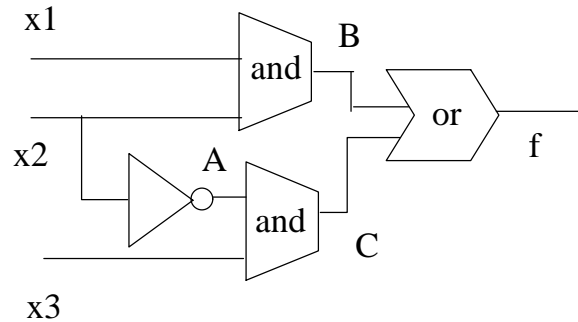


**Question 3 – [15 marks]**

a. Consider the circuit below:



Show the tests that can detect each of the faults: b/0, c/1 and f/0

ANSWER:

b/0.

$b = D \rightarrow b=1 \rightarrow x1=1 \text{ and } x2=1$

$c=0 \rightarrow x3 = X$

2 tests: 11X

d/1

$c = D/ \rightarrow c=0 \rightarrow x2=1 \text{ or } x3=0$

$b=0 \rightarrow x1=0 \text{ or } x2=0$

4 tests: 01X

X00

f/0

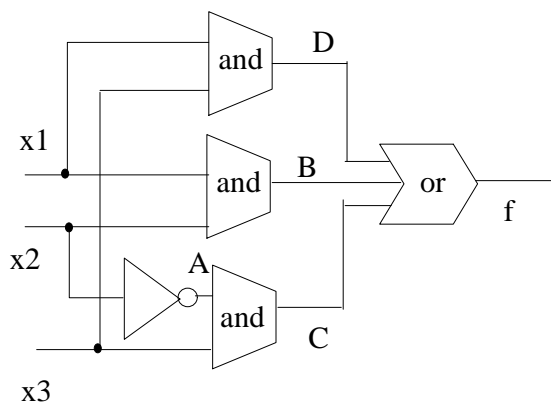
$b=1 \text{ or } c=1$

4 tests

11X

X01

b. Consider the circuit below



What is the function of the upper AND gate?

ANSWER : suppress the static hazard

Show the tests that can detect each of the faults: d/1 and d/0

ANSWER

d/1

d=0  $\rightarrow$  x1=0 or x3=0

b=0  $\rightarrow$  x1=0 or x2=0

c=0  $\rightarrow$  x2=1 or x3=0

6 tests

01X

0X0

X00

d/0

d=1  $\rightarrow$  x1=1 and x3=1

b=0  $\rightarrow$  x2=0 (as x1=1)

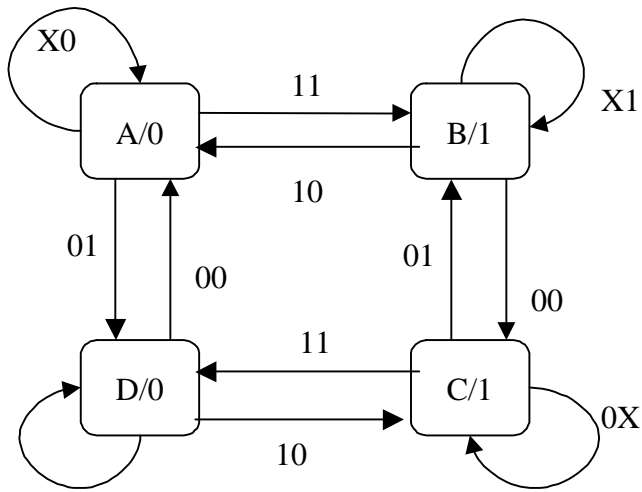
c=0  $\rightarrow$  x2=1 (as x3=1)

No solution

**Question 4 - [15 marks]**

Design an asynchronous sequential circuit with two inputs C and T and one output Q. If T = 1 then Q should change whenever C changes, and if T = 0, then Q should not change. (This is like a T flip flop which is sensitive to both positive and negative clock edges).

Give the corresponding state diagram. (You are asked to label the inputs as TC).



X1

Each **state** corresponds to one **output-clock combination**.

Give the flow table

	TC				
	00	01	10	11	z
A	A	D	A	B	0
B	C	B	A	B	1
C	C	B	C	D	1
D	A	D	C	D	0

Give the state assignment table (You are asked to label the present states as  $y_2y_1$  and next states as  $Y_2Y_1$ )

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

$y_2y_1$	NS TC=00	NS TC=01	NS TC=11	NS TC=10	z
00	00	10	01	00	0
01	11	01	01	00	1
11	11	01	10	11	1
10	00	10	10	11	0

Derive the next state and output expressions:

ANSWER

$y_2y_1$	Y2 TC=00	Y2 TC=01	Y2 TC=11	Y2 TC=10
00	0	1	0	0
01	1	0	0	0
11	1	0	1	1
10	0	1	1	1

$$Y_2 = y_2T + y_1\bar{T}\bar{C} + \bar{y}_1\bar{T}C + y_2\bar{y}_1C + y_2y_1\bar{T}$$

The last two terms suppress static hazards

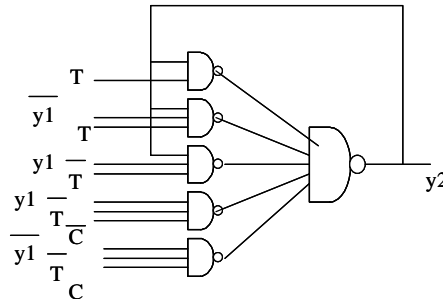
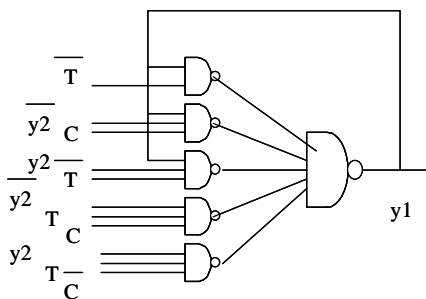
$y_2y_1$	Y1 TC=00	Y1 TC=01	Y1 TC=11	Y1 TC=10
00	0	0	1	0
01	1	1	1	0
11	1	1	0	1
10	0	0	0	1

$$Y_1 = y_1\bar{T} + y_2\bar{T}C + y_2T\bar{C} + y_2y_1C + y_2y_1\bar{T}$$

The last two terms suppress static hazards

$$z = y_1$$

Give the corresponding circuit by using NAND gates and inverters.



**Question 5 – [10 marks]**

Reduce the following primitive flow table for an asynchronous sequential circuit to a state table with a minimal number of rows. Give a Mealy output table for the circuit.

	x1x2	x1x2	x1x2	x1x2	Output
Present state	00	01	10	11	z
A	A	C	-	K	0
B	-	C	B	F	0
C	A	C	G	-	1
D	D	J	-	K	0
E	A	E	B	-	0
F	H	-	G	F	1
G	-	C	G	F	0
H	H	M	-	F	1
I	-	J	I	F	0
J	D	J	I	-	1
K	D	-	I	K	0
L	D	-	B	L	1
M	H	M	B	-	0

First step: Elimination of redundant states

States with same input and output are {A,D}, {C,J}, {E,M}, {B,G,I}, {F,L}

Eliminate {E,M} as A and H are not equivalent. Eliminate {F,L} as D and H are not equivalent.

No further elimination.

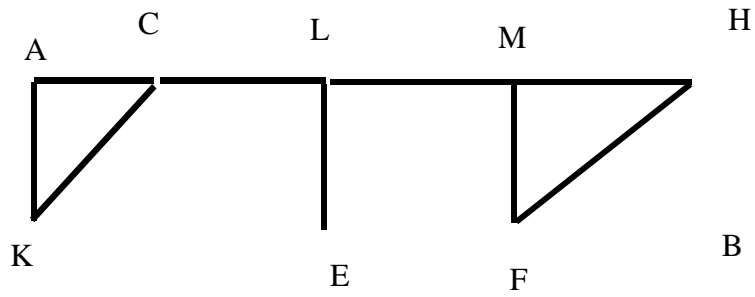
The equivalences are {A,D}, {C,J}, {B,G,I}

The reduced table is

	x1x2	x1x2	x1x2	x1x2	Z	Z	Z	z
Present state	00	01	10	11	00	01	10	11
A	A	C	-	K	0			
B	-	C	B	F			0	
C	A	C	B	-		1		
E	A	E	B	-		0		
F	H	-	B	F				1
H	H	M	-	F	1			
K	A	-	B	K				0
L	A	-	B	L				1
M	H	M	B	-		0		

Second step consists in merging states

States that can be merged : {A,C}{F,H}{A,K}{F,M}{L,M}{C,K}{C,L}{E,L}{H,M}



States to merge : {A,C,K} {F,H,M} {E,L}

		Next		State		Output		
	x1x2	x1x2	x1x2	x1x2	x1x2	x1x2	x1x2	x1x2
Present state	00	01	10	11	00	01	10	11
A	A	A	B	A	0	1	-	0
B	-	A	B	F	-	-	0	-
E	A	E	B	E	0	0	0	1
F	F	F	B	F	1	0	-	1