ESC201 Assignment 12 Solutions

Ans 1.

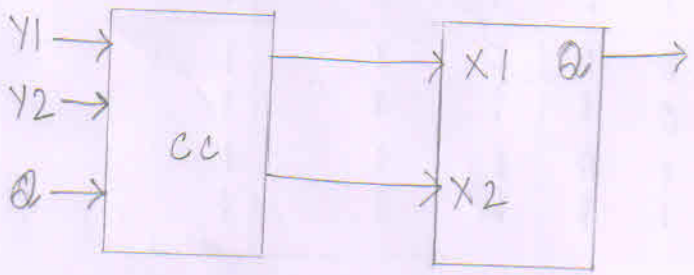
Characteristic Table:

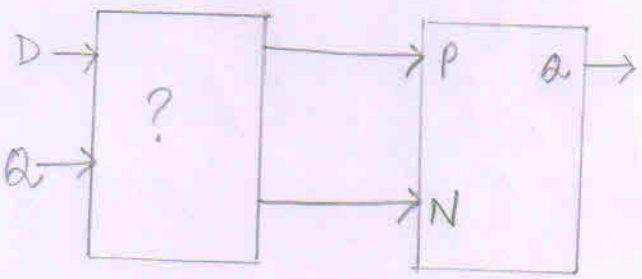
P	N	Q(t+1)	State
0	0	0	Reset
0	1	Q(t)	Hold
1	0	$\bar{Q}(t)$	Toggle
1	1	1	Set

Excitation table:

Q(t)	Q(t+1)	P	N
0	0	0	X
0	1	1	X
1	0	X	0
1	1	X	1

General circuit for converting a FF with inputs X1, X2 into a different FF with inputs Y1, Y2:

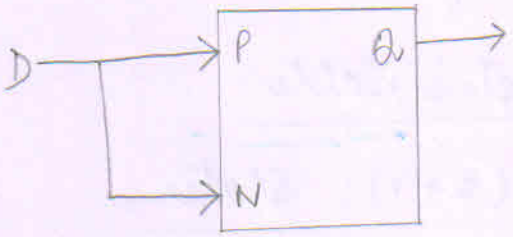




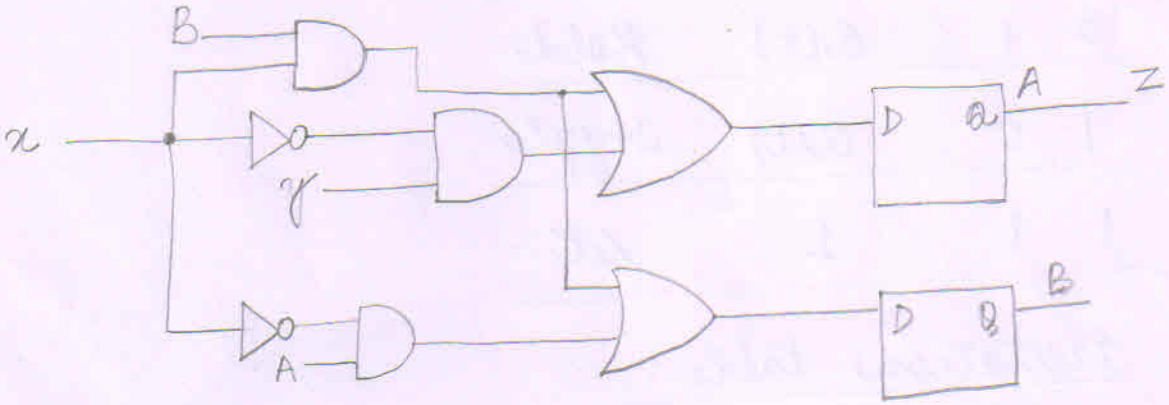
D	Q	Q(t+1)	P	N
0	0	0	0	X
0	1	0	X	0
1	0	1	1	X
1	1	1	1	1

$\therefore P = N = D$

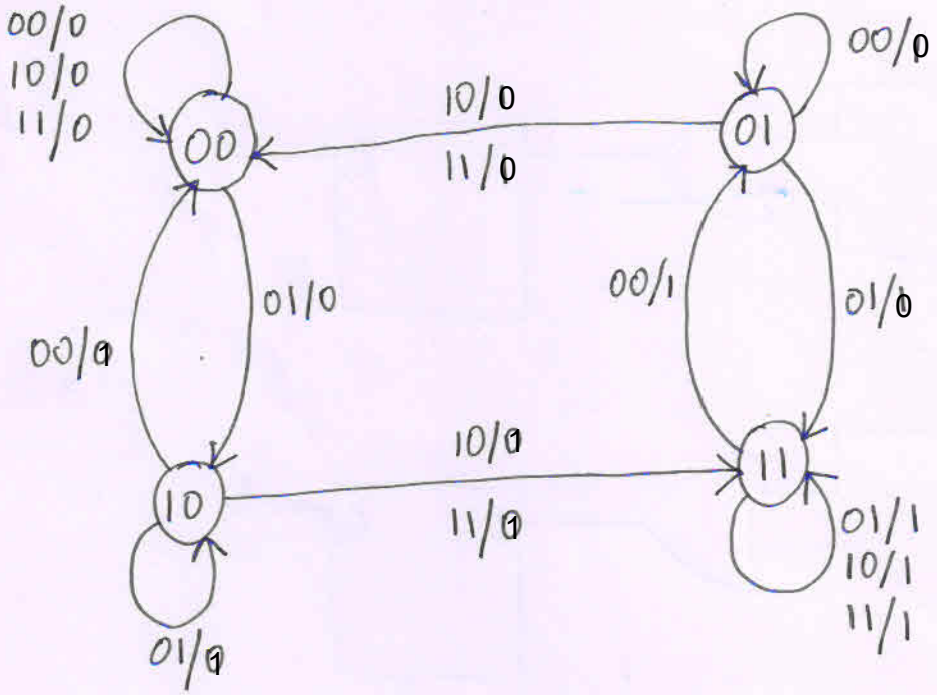
Therefore, PN FF can be converted to a D FF by:



Ans 2.

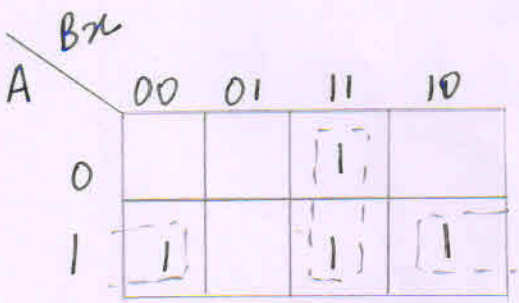


Present state A	Present state B	Input x	Input y	Next state A	Next state B	z
0	0	0	0	0	0	0
0	0	0	1	1	0	0
0	0	1	0	0	0	0
0	0	1	1	0	0	0
0	1	0	0	0	1	0
0	1	0	1	1	1	0
0	1	1	0	0	0	0
0	1	1	1	0	0	0
1	0	0	0	0	0	1
1	0	0	1	1	0	1
1	0	1	0	1	1	1
1	0	1	1	1	1	1
1	1	0	0	0	1	1
1	1	0	1	1	1	1
1	1	1	0	1	1	1
1	1	1	1	1	1	1

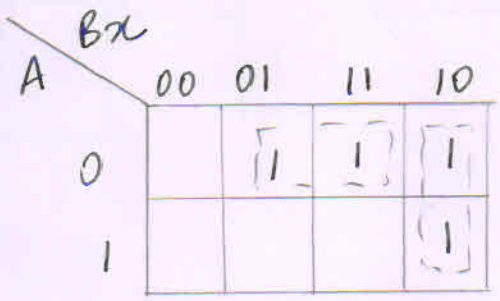


Ans 3.

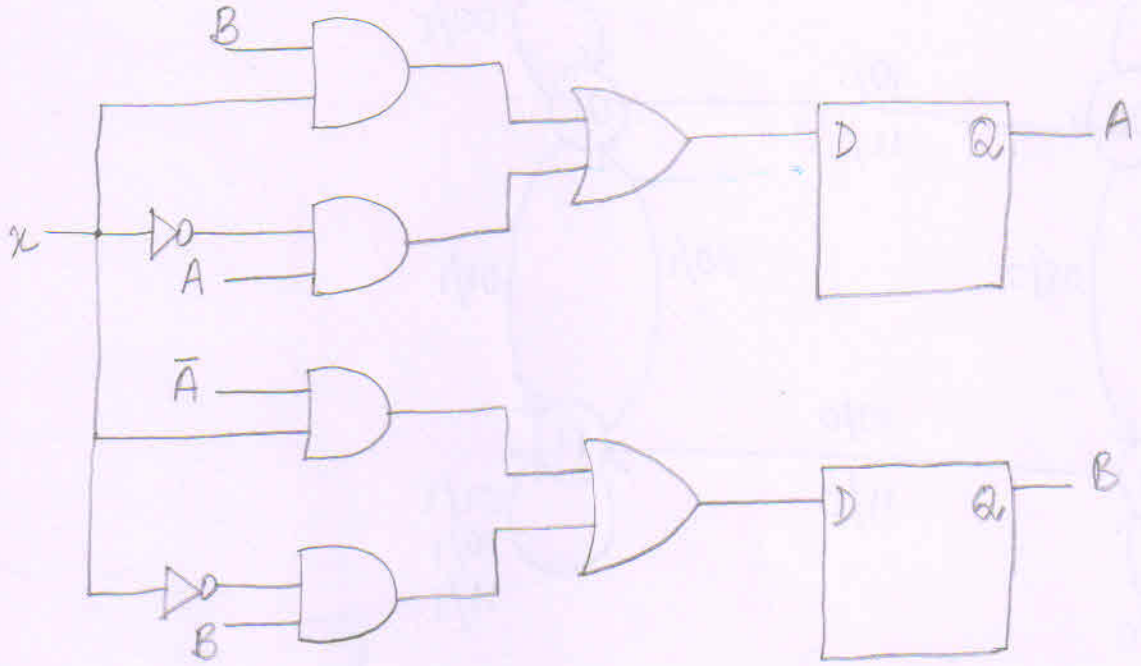
Present state A	Present state B	Input x	Next state A	Next state B	D_A	D_B
0	0	0	0	0	0	0
0	0	1	0	1	0	1
0	1	0	0	1	0	1
0	1	1	1	1	1	1
1	0	0	1	0	1	0
1	0	1	0	0	0	0
1	1	0	1	1	1	1
1	1	1	1	0	1	0



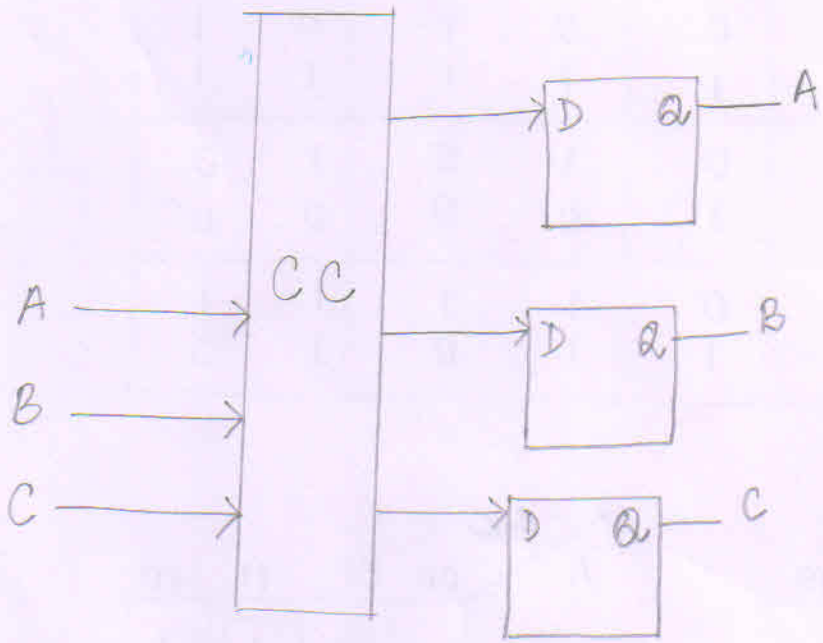
$$D_A = A.\bar{x} + B.x$$



$$D_B = \bar{A}.x + B.\bar{x}$$



Ans4. There are 8 states. So, 3 FFs are required. Let the FFs be D type.

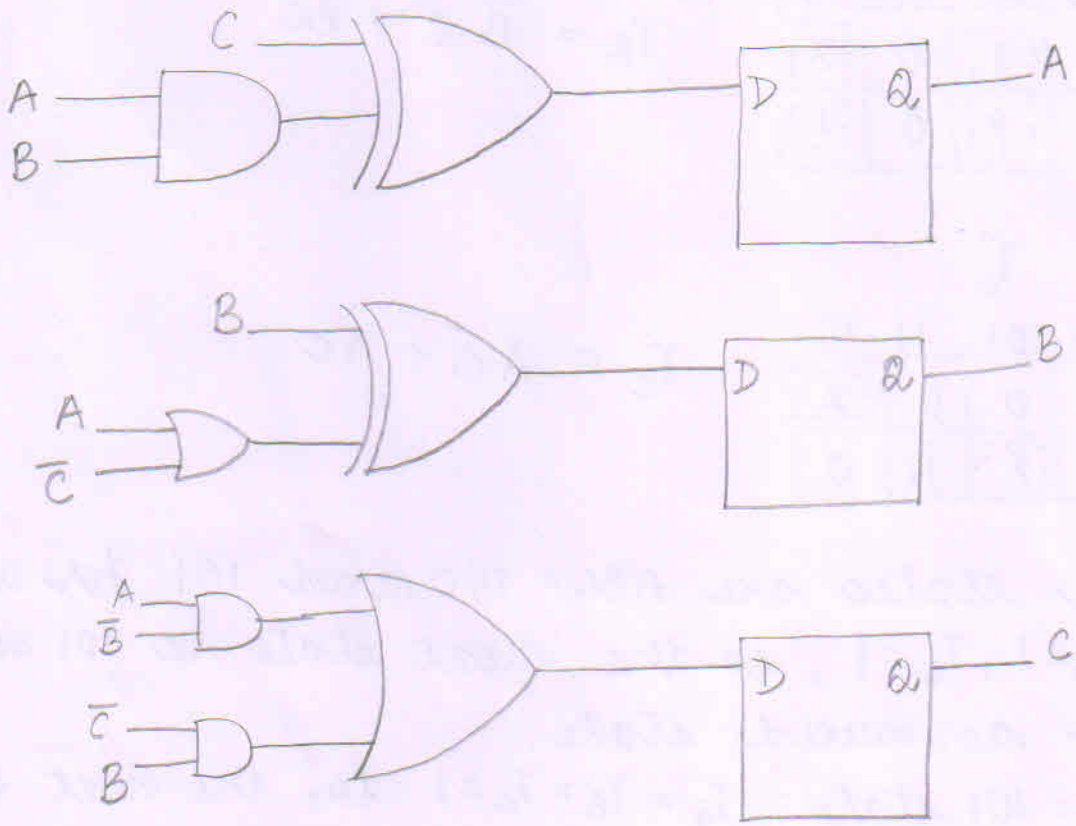


State transition table:

Present state			Next state					
A	B	C	A	B	C	D_A	D_B	D_C
0	0	0	0	1	0	0	1	0
0	1	0	0	0	1	0	0	1
0	0	1	1	0	0	1	0	0
1	0	0	0	1	1	0	1	1
0	1	1	1	1	0	1	1	0
1	1	0	1	0	1	1	0	1
1	0	1	1	1	1	1	1	1
1	1	1	0	0	0	0	0	0

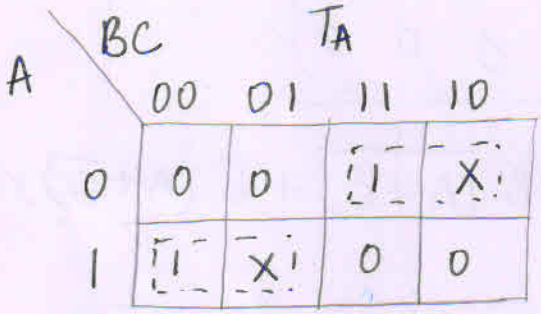
$D_A = C \cdot (\overline{A \cdot B}) + \overline{C} \cdot (AB)$; $D_B = B \cdot \overline{(A + \overline{C})} + \overline{B} \cdot (A + \overline{C})$;

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

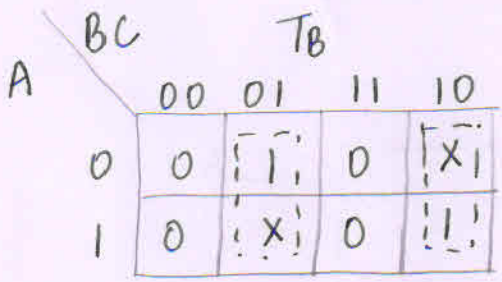


Ans 5.

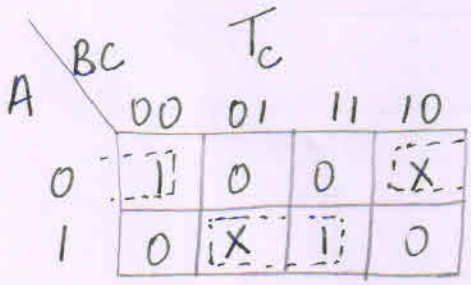
Present state			Next state					
A	B	C	A	B	C	T_A	T_B	T_C
0	0	0	0	0	1	0	0	1
0	0	1	0	1	1	0	1	0
0	1	1	1	1	1	1	0	0
1	1	1	1	1	0	0	0	1
1	1	0	1	0	0	0	1	0
1	0	0	0	0	0	1	0	0



$$T_A = \bar{A} \cdot B + A \cdot \bar{B}$$



$$T_B = \bar{B} \cdot C + B\bar{C}$$

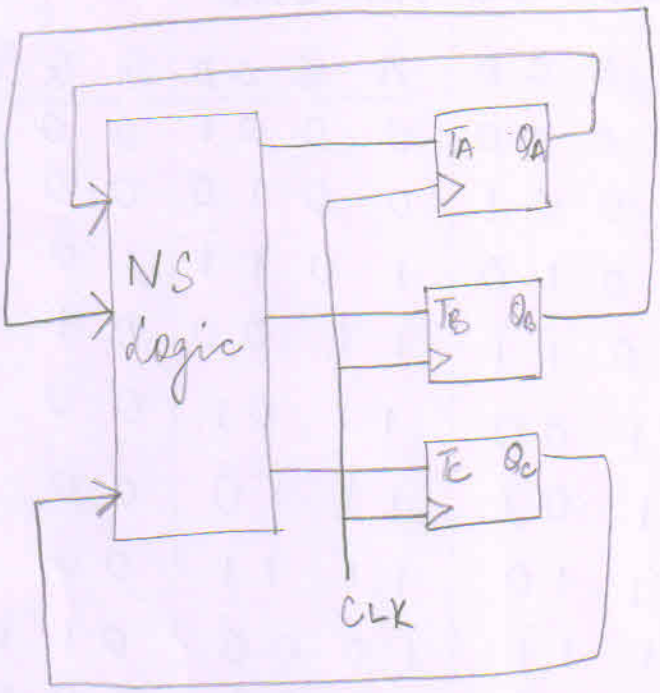


$$T_C = \bar{A}\bar{C} + AC$$

Unused states are ABC = 010 and 101. For 010, $T_A = 1$, $T_B = 1$, $T_C = 1$, so the next state is 101 which is also an unused state.

For ABC = 101 state: $T_A = T_B = T_C = 1$. So, the next state

will be 010 which is an unused state. Thus, we see that if the counter goes into one of the unused states, it will not be able to recover to a proper used state.



A way to avoid this problem is to modify the transition table so that if the counter goes to an unused state, it then transitions to a used state, like 000.

Present state			Next state					
A	B	C	A	B	C	T_A	T_B	T_C
0	0	0	0	0	1	0	0	1
0	0	1	0	1	1	0	1	0
0	1	1	1	1	1	1	0	0
1	1	1	1	1	0	0	0	1
1	1	0	1	0	0	0	1	0
1	0	0	0	0	0	1	0	0
0	1	0	0	0	0	0	1	0
1	0	1	0	0	0	1	0	1

T_A

A \ BC	00	01	11	10
0	0	0	1	0
1	1	1	0	0

$T_A = \bar{A}BC + A\bar{B}$

T_B

A \ BC	00	01	11	10
0	0	1	0	1
1	0	0	0	1

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

T_C

A \ BC	00	01	11	10
0	1	0	0	0
1	0	1	1	0

$T_C = \bar{A}\bar{B}\bar{C} + AC$

Ans 6. We need a divide by 10 counter. So, 4 ffs are required. A possible state transition of the counter:

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

Present state				Next state							
A	B	C	D	A	B	C	D	T_A	T_B	T_C	T_D
0	0	0	0	0	0	0	1	0	0	0	1
0	0	0	1	0	0	1	0	0	0	1	1
0	0	1	0	1	0	1	1	1	0	0	1
1	0	1	1	1	1	0	0	0	1	1	1
1	1	0	0	1	1	0	1	0	0	0	1
1	1	0	1	1	1	1	0	0	0	1	1
1	1	1	0	1	1	1	1	0	0	0	1
1	1	1	1	1	0	0	0	0	1	1	1
1	0	0	0	1	0	0	1	0	0	0	1
1	0	0	1	0	0	0	0	1	0	0	1

$T_D = 1$

FF A output will have the required waveform.

T_A

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

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

T_B

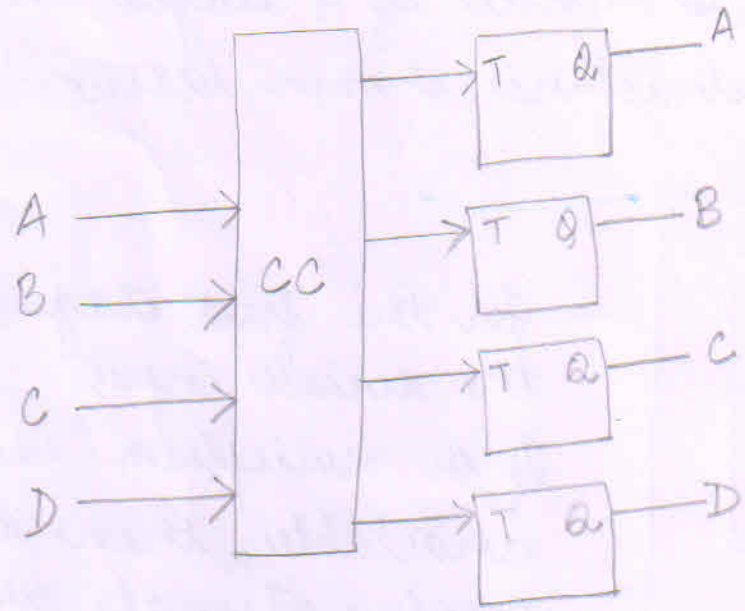
AB \ CD	00	01	11	10
00	0	0	X	0
01	X	X	X	X
11	0	0	1	0
10	0	0	1	X

$T_B = CD$

T_C

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

$T_C = CD + BD + \bar{A}D$



The combinational circuit can be synthesized using the derived expressions.