Problem 1

A sequential circuit (Figure Q1-A) has two JK flip-flops, one input x and two outputs y1 and y2. The logic diagram of the circuit is shown. Analyze the circuit and obtain the following:

1. The flip-flop input functions
2. The external output functions
3. The next state equations
4. The state table
5. The state diagram.
6. What type of machine is this?

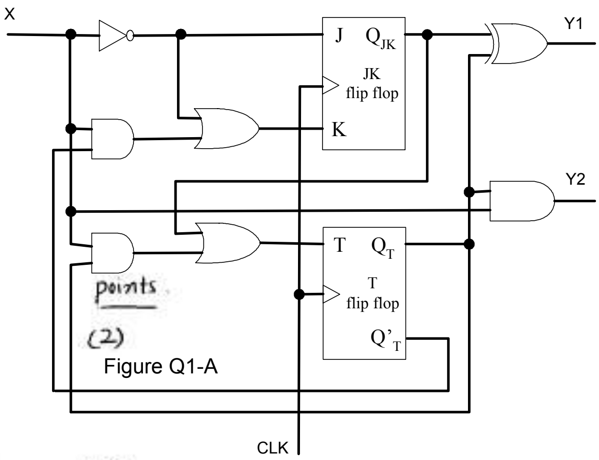


Figure Q1-A

Q1(A)

① $J = x'$ $K = x' + xQ_T'$

$T = Q_{JK} + xQ_T$

② $Y_1 = Q_{JK} \oplus Q_T$ (2)

$Y_2 = xQ_T$

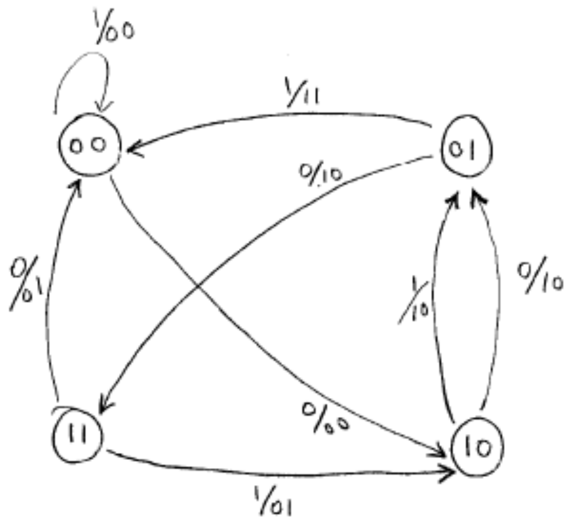
③ $Q_{JK}(t+1) = JQ_{JK}' + K'Q_{JK}$ (2)

$Q_T(t+1) = T'Q_T + TQ_T'$

④ STATE TABLE (5)

Present state		Input	Next state		FlipFlop Inputs			Outputs	
Q_{JK}	Q_T	x	Q_{JK}	Q_T	J	K	T	Y_1	Y_2
0	0	0	1	0	1	1	0	0	0
0	0	1	0	0	0	1	0	0	0
0	1	0	1	1	1	1	0	1	0
0	1	1	0	0	0	0	1	1	1
1	0	0	0	1	1	1	1	1	0
1	0	1	0	1	0	1	1	1	0
1	1	0	0	0	1	1	1	0	1
1	1	1	1	0	0	0	1	0	1

⑤ State Diagram (4)



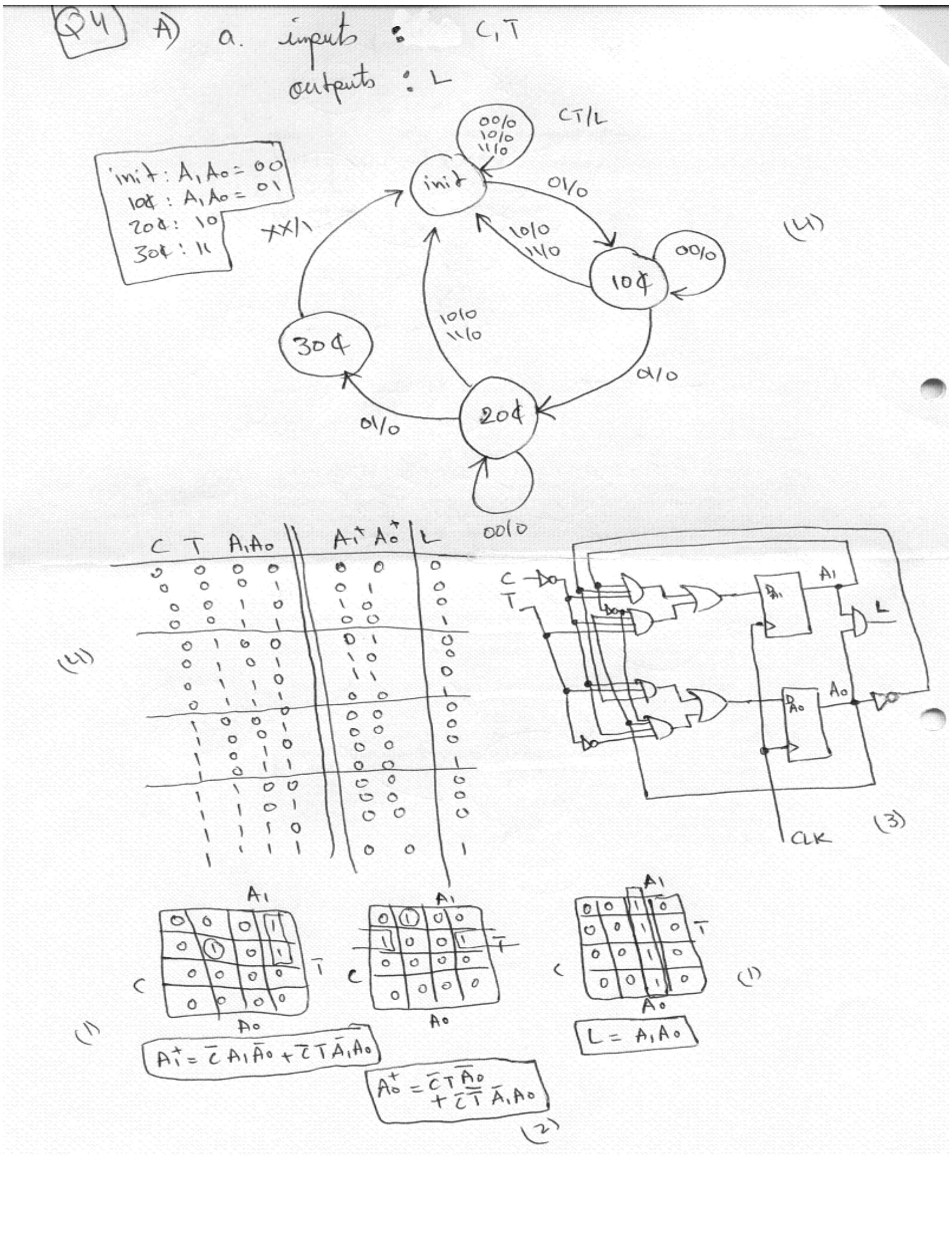
Problem 4

A vending machine that dispenses water bottles accepts one type of coins, 10 cents (T). The price of a single water bottle is 30 cents. Each time the user inserts a coin, the circuit will go to the following state at the presence of a clock pulse. The states of the circuit represent the amount of coins being inserted. When the user inserts the correct number of coins, the machine will dispense a water bottle on the next clock and will set the signal LED (L) to high, then goes to the initial state. If the user changes his mind after inserting some coins (less than 30 cents), he can get his money back by pressing the button CANCEL (C), and after that the system goes back to the initial state.

a) Come up with the state diagram of this vending machine

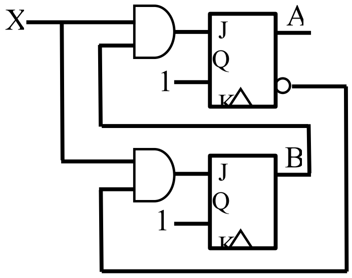
b) Construct the state table based on the state diagram

c) Design a sequential logic circuit that can be used inside this vending machine using D-FF.



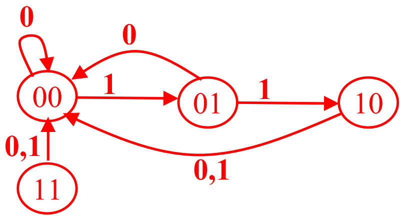
Problem (2)

i- Obtain the state diagram of the following sequential circuit and **specify if there are any unused states**.



J_A= XB, K_A=1, J_B=XA', K_B=1

A	B	X	J_A	K_A	J_B	K_B	A^+	B^+
0	0	0	0	1	0	1	0	0
0	0	1	0	1	1	1	0	1
0	1	0	0	1	0	1	0	0
0	1	1	1	1	1	1	1	0
1	0	0	0	1	0	1	0	0
1	0	1	0	1	0	1	0	0
1	1	0	0	1	0	1	0	0
1	1	1	1	1	0	1	0	0



State 11 is an unused state – No input sequence would get the circuit into that state – 1 point

i- For the following state table:

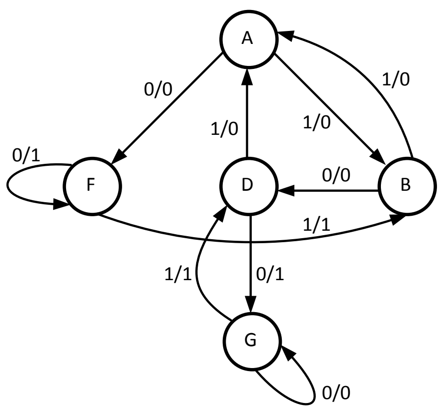
Present State	Next State		Output	
	X=0	X=1	X=0	X=1
A	F	B	0	0
B	D	C	0	0
C	F	E	0	0
D	G	A	1	0
E	D	C	0	0
F	F	B	1	1
G	G	H	0	1
H	G	A	1	0

a- Obtain the reduced state table.

b- Draw the state diagram of the reduced table

(i) States H and D are equivalent; therefore, every H is replaced by D and eliminate H.
States B and E are equivalent; therefore, every E is replaced by B and eliminate E.
After doing the above one finds, states A and C are equivalent, therefore every C is replaced by A and Eliminate C.

Present State	Next State		Output	
	X=0	X=1	X=0	X=1
A	F	B	0	0
B	D	A	0	0
D	G	A	1	0
F	F	B	1	1
G	G	D	0	1

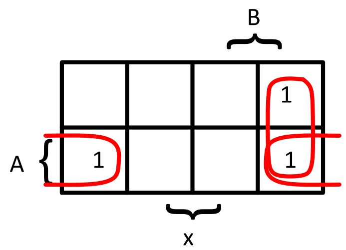


ii- For the state table shown below, design the corresponding sequential circuit using D-Flip-Flops.

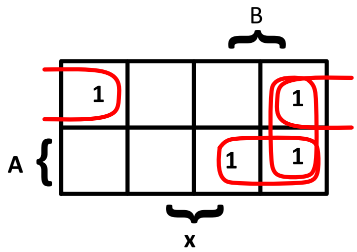
Present State		Input	Next State		Output
A	B	x	A	B	y
0	0	0	0	1	1
0	0	1	0	0	0
0	1	0	1	1	1
0	1	1	0	0	0
1	0	0	1	0	1
1	0	1	0	0	1
1	1	0	1	1	0
1	1	1	0	1	0

(i) Fins expression for inputs of Flip flops.

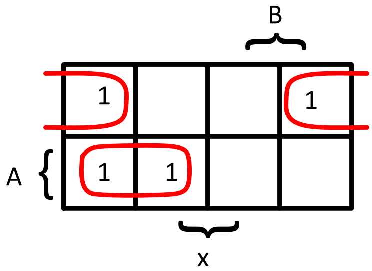
$D_B = B(t+1) = A\overline{x} + B\overline{x} = (A+B)\overline{x}$



$D_A = A(t+1) = AB + +B\overline{x} + \overline{A}\overline{x} = AB + (\overline{A}+B)\overline{x}$



$y = A\overline{B} + \overline{A}\overline{x}$



We implement the above expressions as: