Homework #3 (Covers 11, 12 13,14)
CDA Computer Logic Design
Total Points: 100

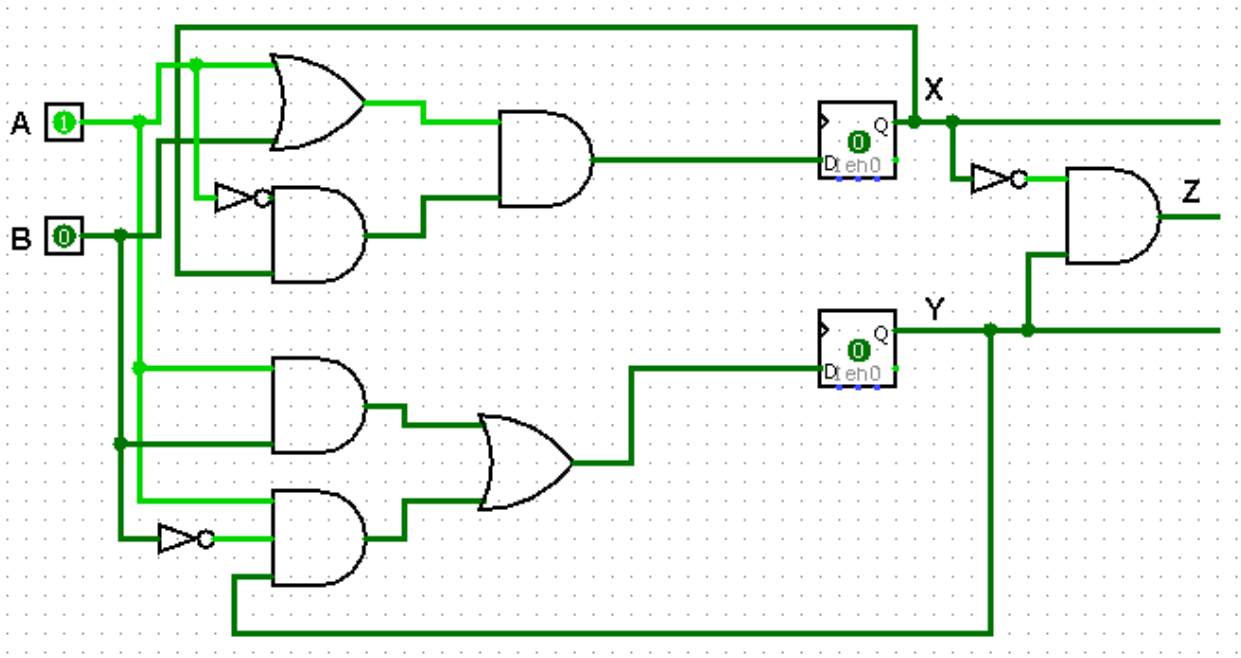
Notes:
1. All homework should be done and submitted individually
2. Show all steps for each question to get full points (Use extra pages if required)
3. Submit electronically in canvas as a single pdf file
4. Follow instructions for each question
5. A' is the complement of A

Name: SOLUTIONS **UID:**

Q1. (3x5 points) A sequential circuit with two D flip-flops, X and Y; two inputs, A and B; and one output, Z, is specified by the following next-state and output equations:

$$X(t+1) = (A + B)(A'X)$$
$$Y(t+1) = AB + AB'Y$$
$$Z = X'Y$$

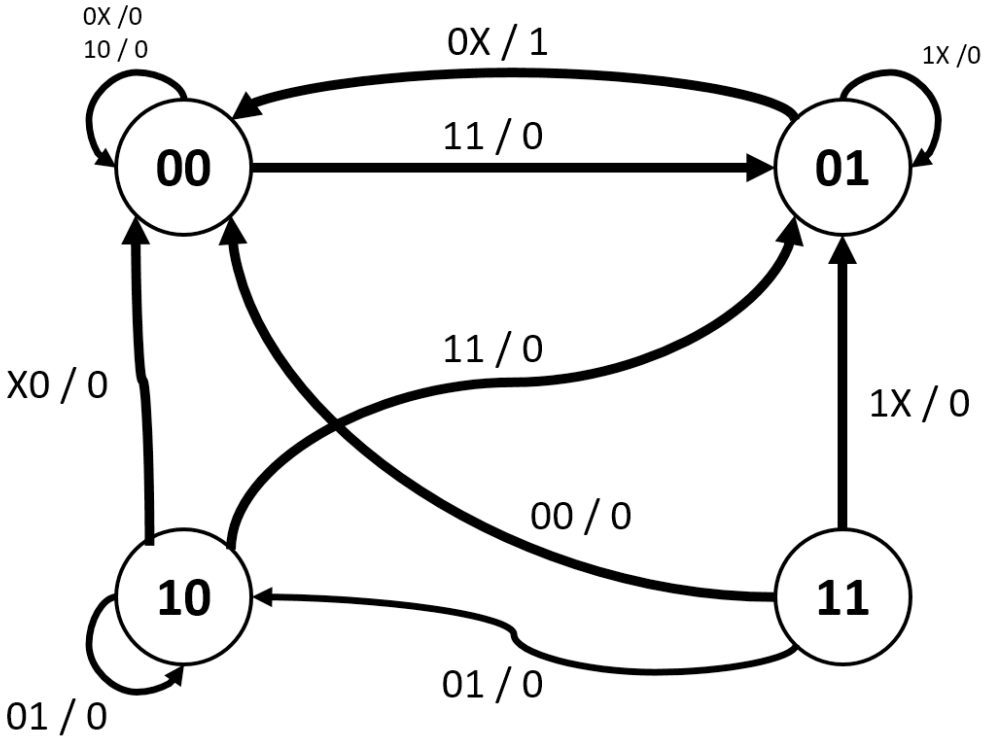
(a) Draw the logic diagram of the circuit



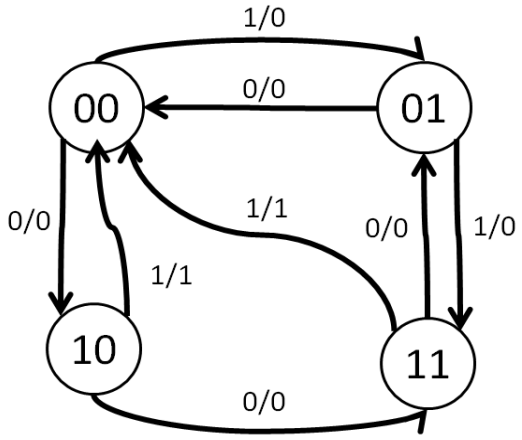
(b) Derive the state table

Present State		Inputs		Next State		Output
X	Y	A	B	X	Y	Z
0	0	0	0	0	0	0
0	0	0	1	0	0	0
0	0	1	0	0	0	0
0	0	1	1	0	1	0
0	1	0	0	0	0	1
0	1	0	1	0	0	1
0	1	1	0	0	1	1
0	1	1	1	0	1	1
1	0	0	0	0	0	0
1	0	0	1	1	0	0
1	0	1	0	0	0	0
1	0	1	1	0	1	0
1	1	0	0	0	0	0
1	1	0	1	1	0	0
1	1	1	0	0	1	0
1	1	1	1	0	1	0

(c) Draw the corresponding state diagram



Q2. (2x10 points) Given the state diagram below, (for reference: 0/0 Input / Output)



(a) create the state table

Present State		Input	Next State D Inputs		Output
Q1	**Q2**	**I**	**D1**	**D2**	**O**
0	0	0	1	0	0
0	0	1	0	1	0
0	1	0	0	0	0
0	1	1	1	1	0
1	0	0	1	1	0
1	0	1	0	0	1
1	1	0	0	1	0
1	1	1	0	0	1

D1	Q1Q2			
Input I	00	01	11	10
0	1	0	0	1
1	0	1	0	0

D1 = Q2'I' + Q1'Q2I

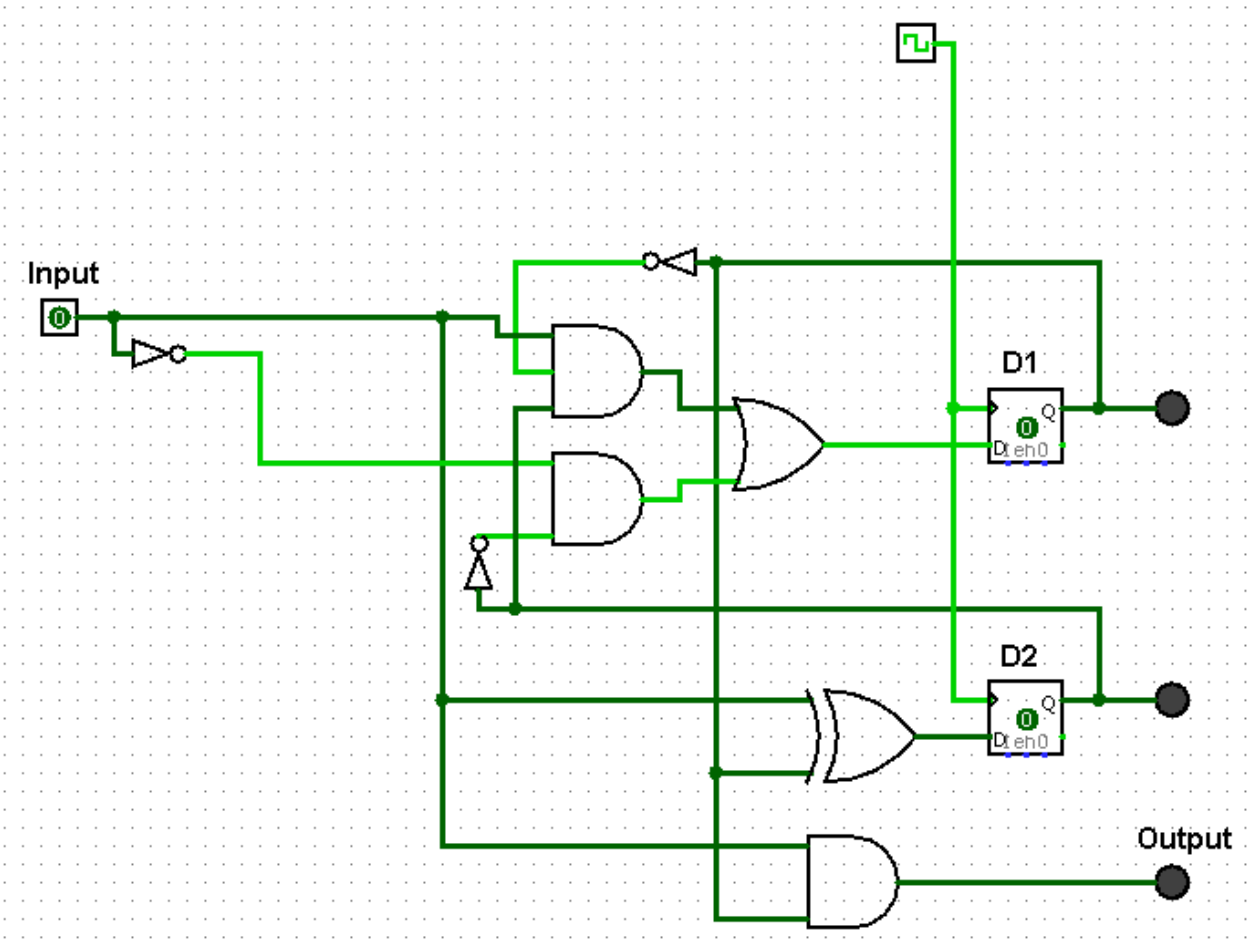
D2	Q1Q2			
Input I	00	01	11	10
0	0	0	1	1
1	1	1	0	0

D2 = Q1'I + Q1I' = I XOR Q1

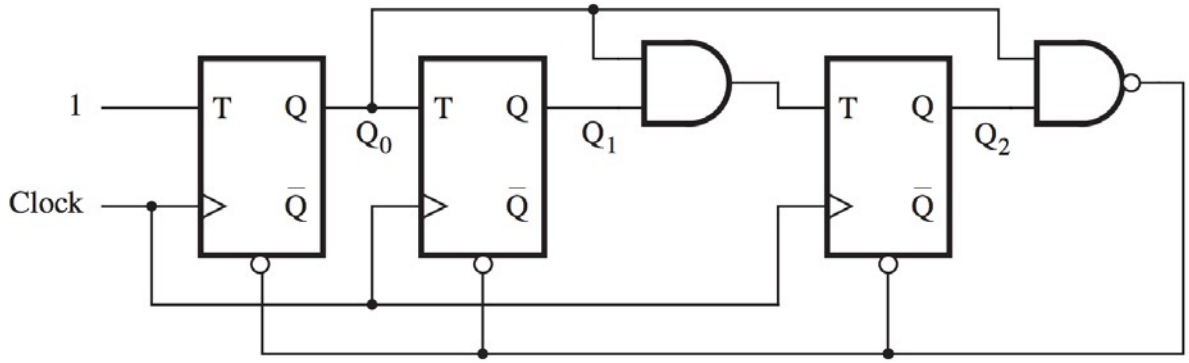
Output	Q1Q2			
Input I	00	01	11	10
0	0	0	0	0
1	0	0	1	1

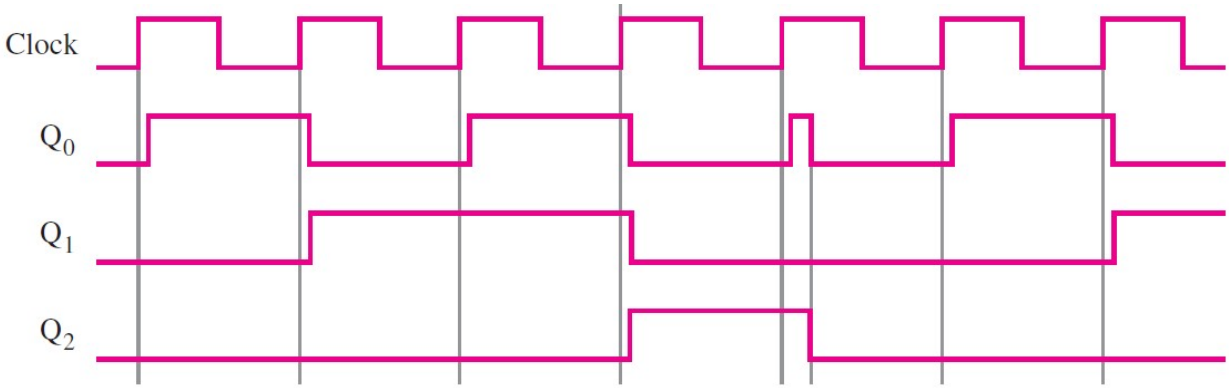
Output = Q1I

(b) Create a sequential circuit design using only two D flip flops, and any additional simple logic gates (AND, OR, NOT, XOR, NAND, NOR)



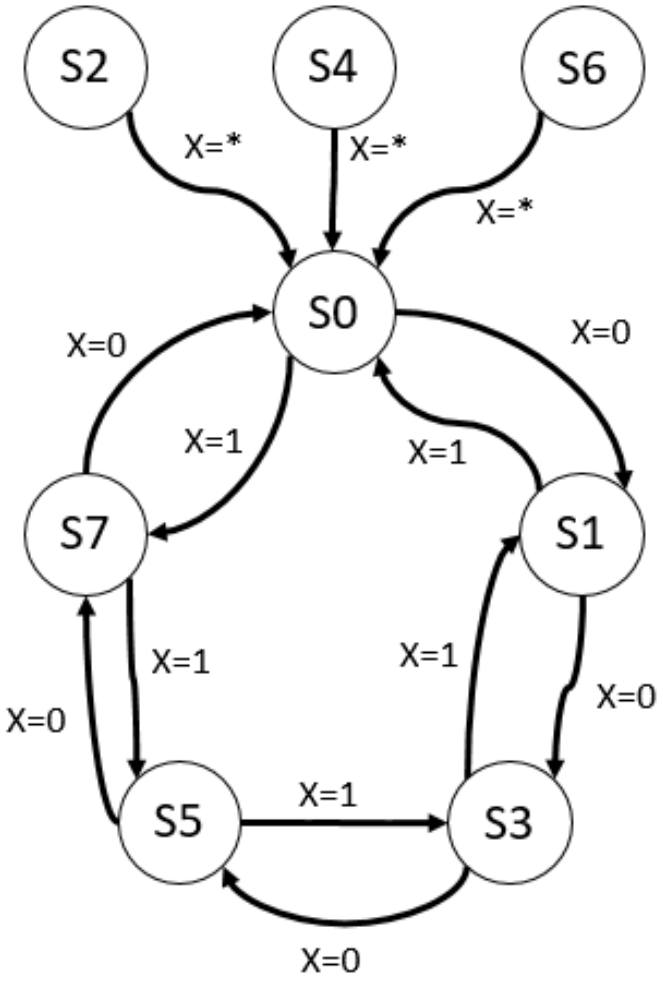
Q3. (15 points) For the following circuit complete the timing diagram.





Q4. (2x10 points) Design a synchronous sequential circuit that will count through the sequence 0,1,3,5,7 when the control input, x=0; and through the sequence 7,5,3,1,0 when x=1. The circuit should return to state 0 if it falls into states 2, 4, or 6. Note: the sequence cycles – 0,1,3,5,7,0,1,3,…

(a) Draw a state diagram for the circuit



(b) Draw a state transition table for the circuit

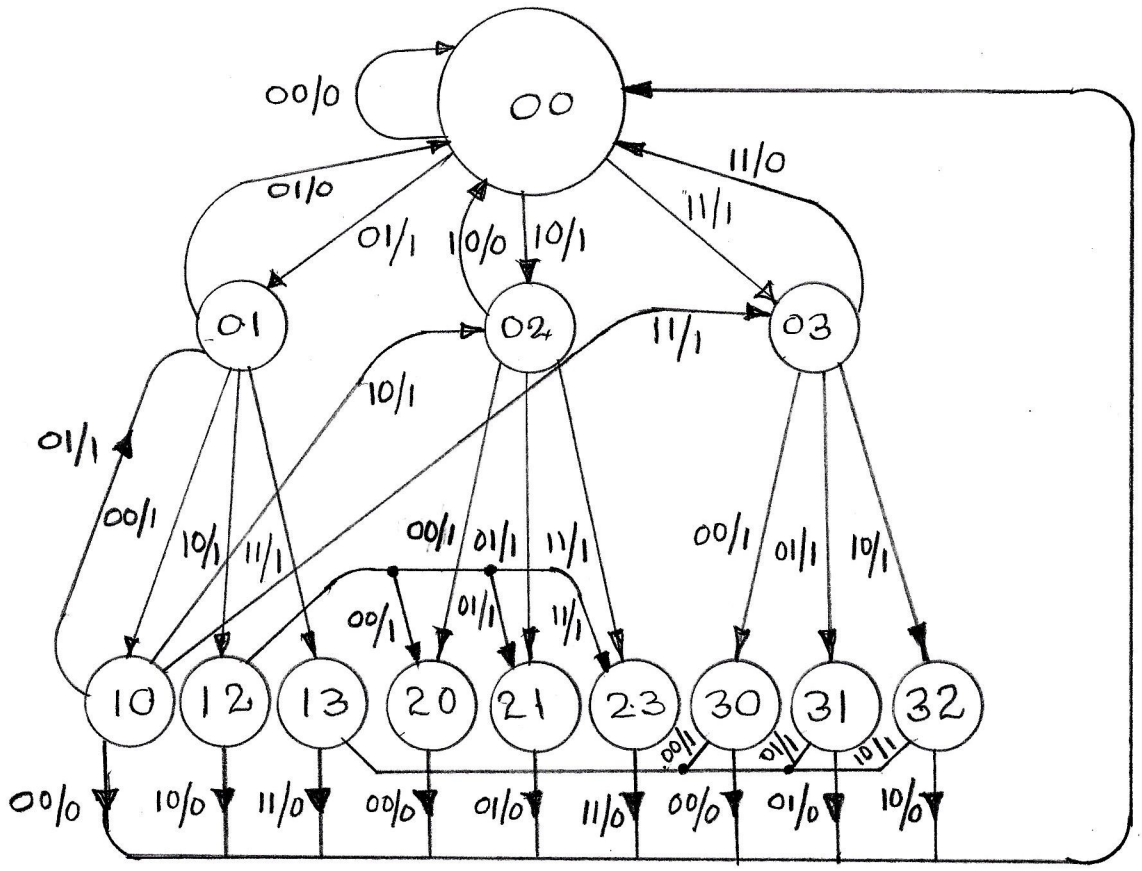
X = 0							
Present State				Next State			
State	Flip-flop			State	Flip-flop		
	Q2	Q1	Q0		Q2	Q1	Q0
S0	0	0	0	S1	0	0	1
S1	0	0	1	S3	0	1	1
S2	0	1	0	S0	0	0	0
S3	0	1	1	S5	1	0	1
S4	1	0	0	S0	0	0	0
S5	1	0	1	S7	1	1	1
S6	1	1	0	S0	0	0	0
S7	1	1	1	S0	0	0	0

X = 1							
Present State				Next State			
State	Flip-flop			State	Flip-flop		
	Q2	Q1	Q0		Q2	Q1	Q0
S0	0	0	0	S7	1	1	1
S1	0	0	1	S0	0	0	0
S2	0	1	0	S0	0	0	0
S3	0	1	1	S1	0	0	1
S4	1	0	0	S0	0	0	0
S5	1	0	1	S3	0	1	1
S6	1	1	0	S0	0	0	0
S7	1	1	1	S5	1	0	1

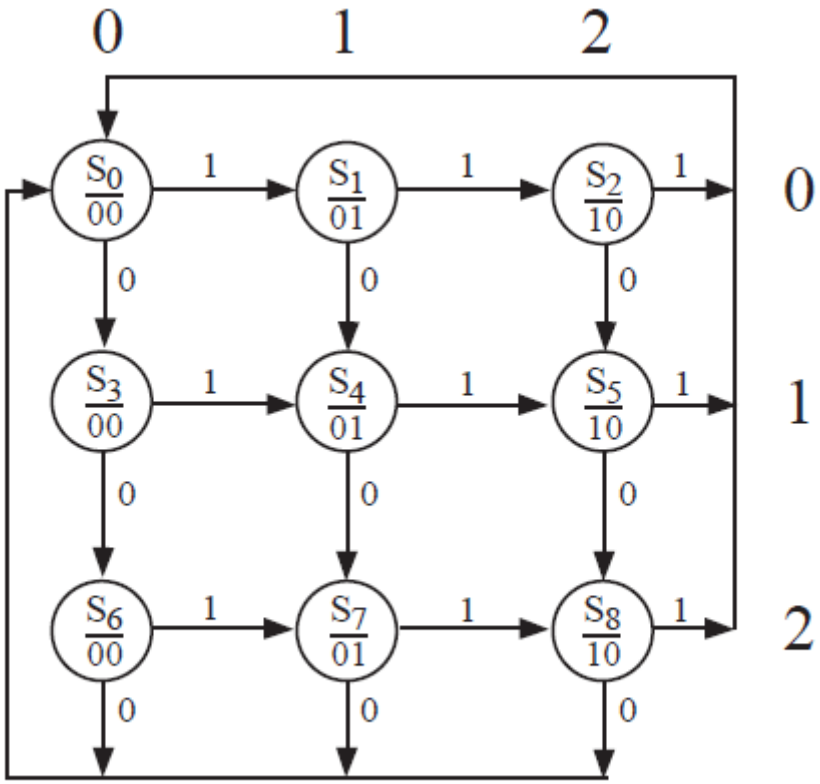
Q5. A Mealy Finite State Machine (FSM) has two binary inputs X1 and X2 and one output. The machine outputs a 0 and resets to 00 state whenever it receives two consecutive input strings that are identical (for example 01 followed by 01). In all other cases it outputs a 1. Use the following convention to label each state:

Label the state as PQ if it is reached after receiving two input strings X1X2=P and X1X2=Q where P and Q are the decimal values of X1X2. Note that P and Q range from 0 to 3; for example, if the previous two inputs to a state are 01 and 11 it is labeled as 13. For states which are children of 00 (reset) use P=0 irrespective of how the 00 state is reached.

Draw the FSM clearly labeling all inputs, outputs and state names
Hint: the FSM has more than 10 states but its structure is simple and repetitive.



Q6. A Moore machine has an input (X) and outputs (Y and Z). YZ represents a 2 bit binary number equal to the number of 1's that have been received as inputs. The circuit resets when the total number of 1's received is 3 or when the total number of 0's received is 3. Draw the state graph and state transition table for the machine.



** Horizontally: Number of 1's modulo
3** Vertically: Number of 0's modulo 3.

State	Next State		YZ
	X=0	X=1	
S0	S3	S1	00
S1	S4	S2	01
S2	S5	S0	10
S3	S6	S4	00
S4	S7	S5	01
S5	S8	S0	10
S6	S0	S7	00
S7	S0	S8	01
S8	S0	S0	10

Q7. Design the state diagram for the control unit of a coin-operated Coke machine. Coke costs 125 cents and the machine accepts quarters and dollars. Change should be returned if more than 125 cents is deposited. Assume that the machine dispenses the product and change, if any, and resets once at least 125 cents are deposited. No more than 200 cents can be deposited on a single purchase so the maximum change is three quarters.

Let Q and D represent insertion of Quarter and Dollar respectively. Let us assume that only one coin can be inserted at a time. So the three possible transitions for the FSM are Q'D' (waiting for coin), Q'D, and QD'. Possible sequence of coin insertion to get a Coke without any change returned are QD, DQ, and QQQQ. Sequences that return change and dispense Coke are DD, QQD, QQQD, and QQQQD. The Outputs are B and C representing release of Beverage and Change respectively. The state diagram is shown below (transitions Q'D and QD' are denoted as simply D and Q).