Name Solutions

ECE Box

ECE 2029 **Homework 6** **D16**

Each problem is worth the number of points shown.
Show your work in a neat, organized and easily followed sequence if you expect to get any partial credit. This assignment is due **Thuesday, April 26** by 5 pm at the ECE office AK202.

Problem 1 -20 points total

The following sequential circuit is a Pulse Distributor:

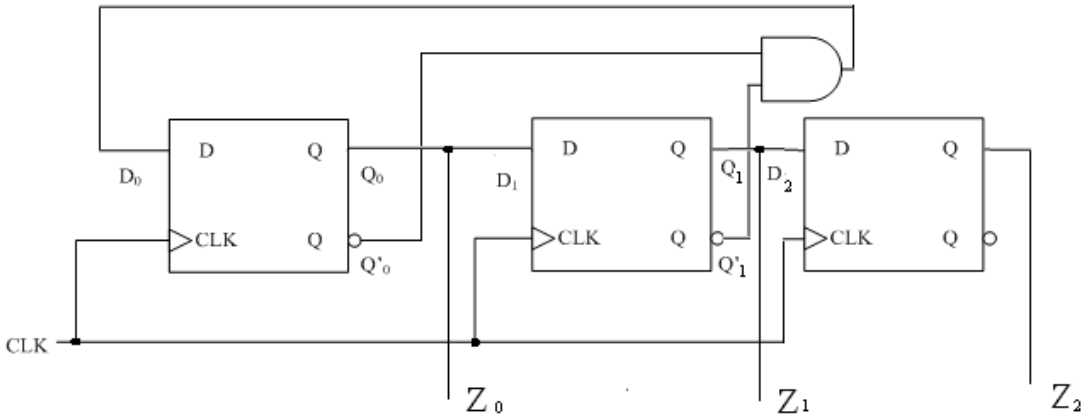


Figure 1

Notice: This sequential circuit does not have the input signal and the output Z is the present state of D flip-flop. The initial condition of output is set as 000.

a) (5 pts) Determine Boolean expressions for next state logic and output logic from the circuit. That is, express D_2, D_1, D_0 and Z_2, Z_1, Z_0 as logic expressions in terms of Q_2, Q_1 and Q0. (do **not** write D logic expression in terms of Z since Z is the output)
Output logic expression: $Z_0 = Q_0^n, Z_1 = Q_1^n, Z_2 = Q_2^n$

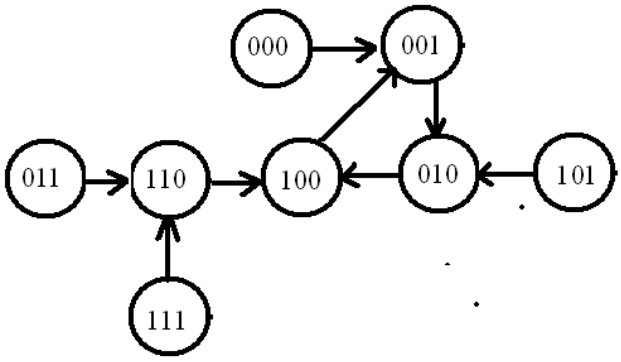
Next state logic expression: $Q_0^{n+1} = D_0 = \overline{Q_0^n}\ \overline{Q_1^n}$, $Q_1^{n+1} = D_1 = Q_0^n$,

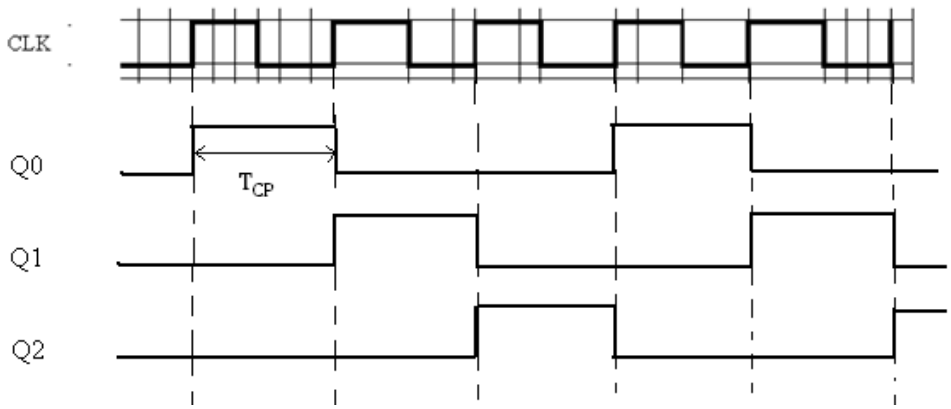
$Q_2^{n+1} = D_2 = Q_1^n$

b) (10 pts) Fill in the state table, given below.

Present State(Output)			Next State		
Q_2^n	Q_1^n	Q_0^n	Q_2^{n+1}	Q_1^{n+1}	Q_0^{n+1}
0	0	0	0	0	1
0	0	1	0	1	0
0	1	0	1	0	0
0	1	1	1	1	0
1	0	0	0	0	1
1	0	1	0	1	0
1	1	0	1	0	0
1	1	1	1	1	0

c) (10 pts) Draw a state transition diagram and timing diagram for this sequential machine.



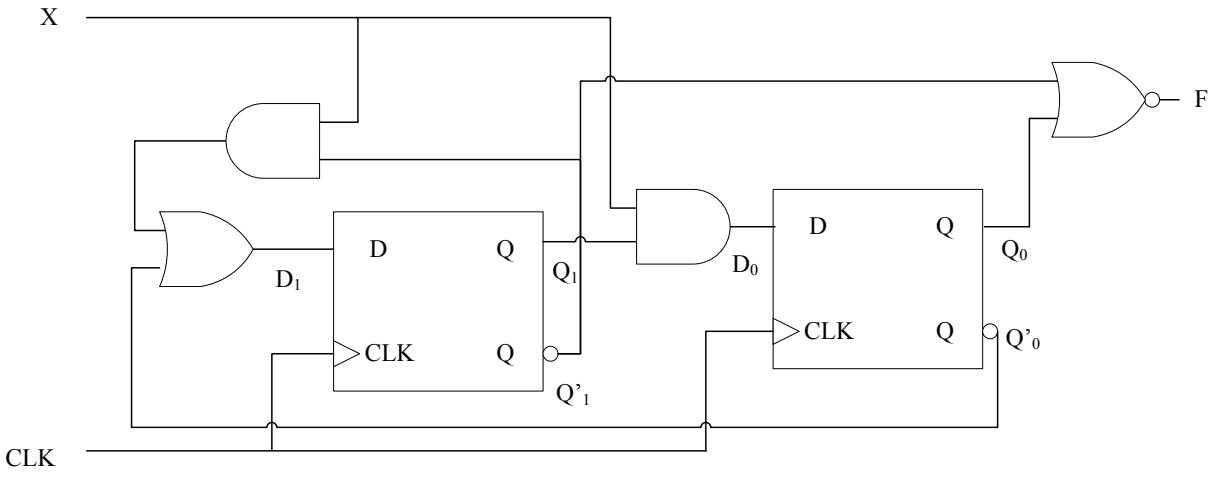


d) (5 pts) From the timing diagram, what the logic function of this sequential circuit.
Answer: We can see from timing diagram, this sequential circuit is a Pulse Distributor.

It assigns a pulse with pulse width T_{CP} (period of CLK) to three outputs sequentially.

Problem 2 -20 points total

For the sequential machine in the circuit diagram:



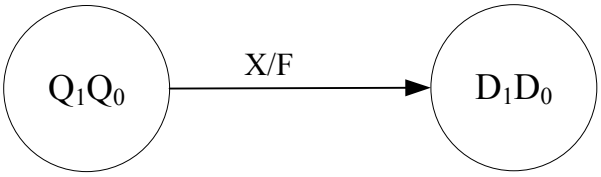
a) (15 total ,each 5 pts) Determine Boolean expressions for next state logic and output logic from the circuit. That is, express D_1, D_0 and F as logic expressions in terms of Q_1, Q_0 and X.

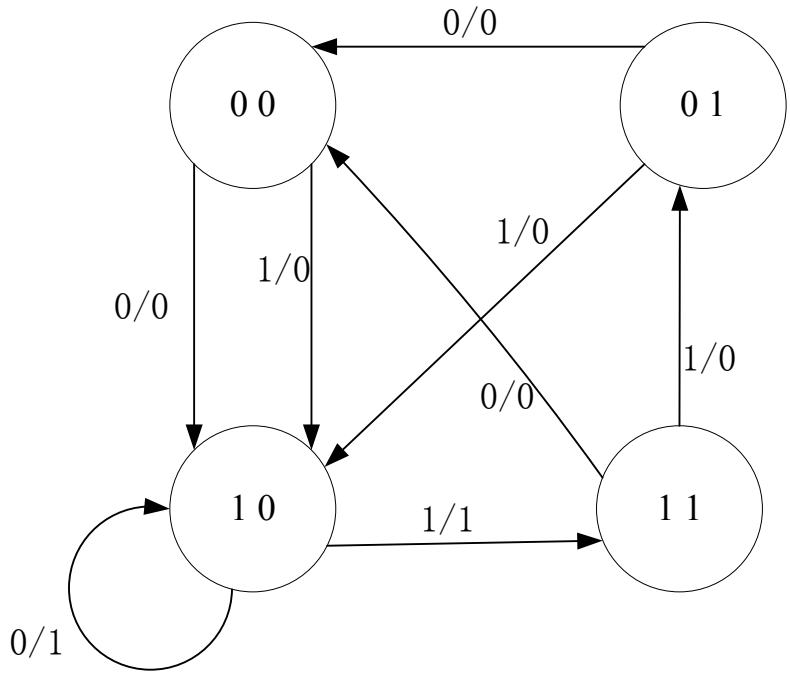
$D_1=Q_1'X+Q_0'$
$D_0=Q_1X$
$F = (Q_1'+Q_0)'$ or Q_1Q_0'

b) (10 pts total, each wrong 1 pt) Fill in the state table, given below.

Present State		**Input**	**Next State**		**Output**
Q_1	**Q_0**	**X**	**D_1**	**D_0**	**F**
0	0	0	1	0	0
0	0	1	1	0	0
0	1	0	0	0	0
0	1	1	1	0	0
1	0	0	1	0	1
1	0	1	1	1	1
1	1	0	0	0	0
1	1	1	0	1	0

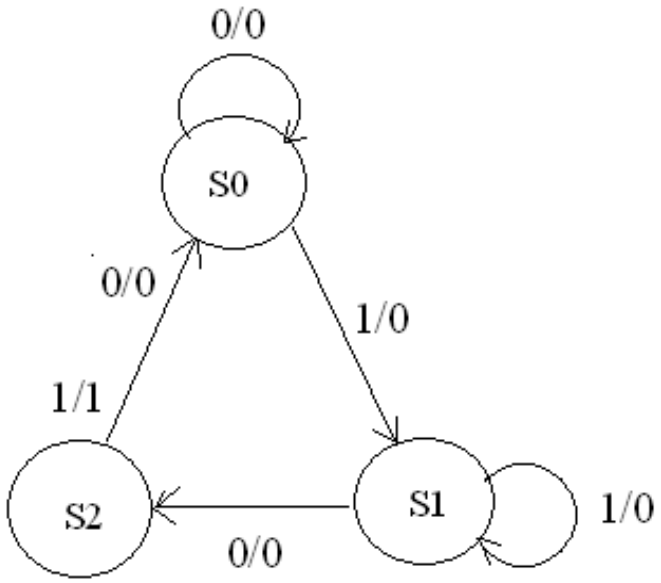
c) (5 pts) Draw a state transition diagram for this sequential machine.





Problem 3 - 30 points total

Applying the same procedure as in Problem 2, use positive-edge triggered D flip-flop to design a sequential circuit following the transition diagram shown in figure below.



First, find the state table:

Present State		Input	Next State		Output
Q_1	Q_0	X	Q_1^+	Q_0^+	F
0	0	0	0	0	0
0	0	1	0	1	0
0	1	0	1	0	0
0	1	1	0	1	0
1	0	0	0	0	0
1	0	1	0	0	1
1	1	0	d	d	d
1	1	1	d	d	d

X \ $Q_1^nQ_0^n$	00	01	11	10
0	0	1	d	0
1	0	0	d	0

$$Q_1^{n+1} = Q_0^n\overline{X}$$

X \ $Q_1^nQ_0^n$	00	01	11	10
0	0	0	d	0
1	1	1	d	0

$$\mathbf{Q_0^{n+1} = \overline{Q_1^n}X}$$

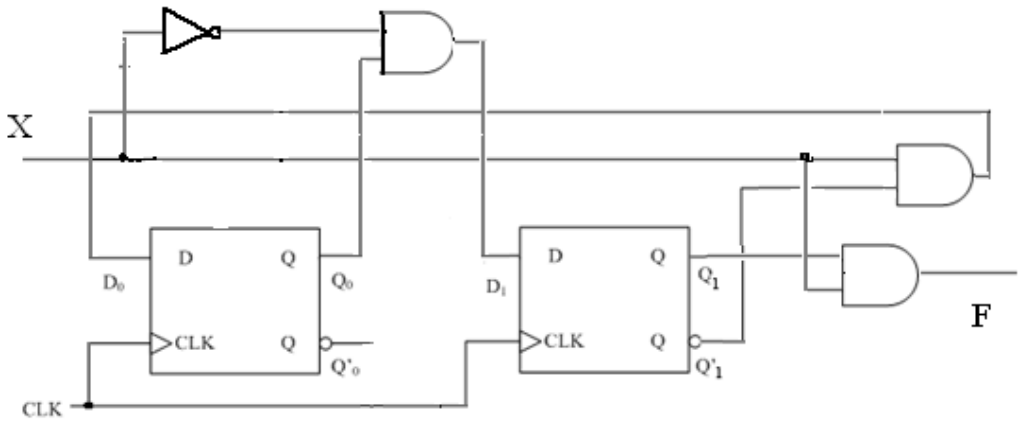
X \ $Q_1^nQ_0^n$	00	01	11	10
0	0	0	d	0
1	0	0	d	1

$$F = Q_1^nX$$

Then, we have the characteristic equation of D flip-flop as: $\mathbf{D = Q^{n+1}}$

Thus, we can get $D_1 = Q_0^n\overline{X}, D_0 = \overline{Q_1^n}X$

Now draw the sequential circuit as:



Problem 4 - 30 points total

Let us design a simple vending machine that sells drinks only. Each bottle costs 75 cents. It only accepts dollar bills and quarters. Once it receives 75 cents, a bottle is dispensed. If the current balance is more than 75 cents, it dispenses a drink and also pays the change in quarters. Design a FSM to implement the vending machine. The input signals include dollar bill and quarter insertion. The output signals are drink dispense and the number of quarters as change which could be 0 to 3. Since the circuit clock is very fast, it is safe to assume that quarter and dollar bill are not inserted at the same time.

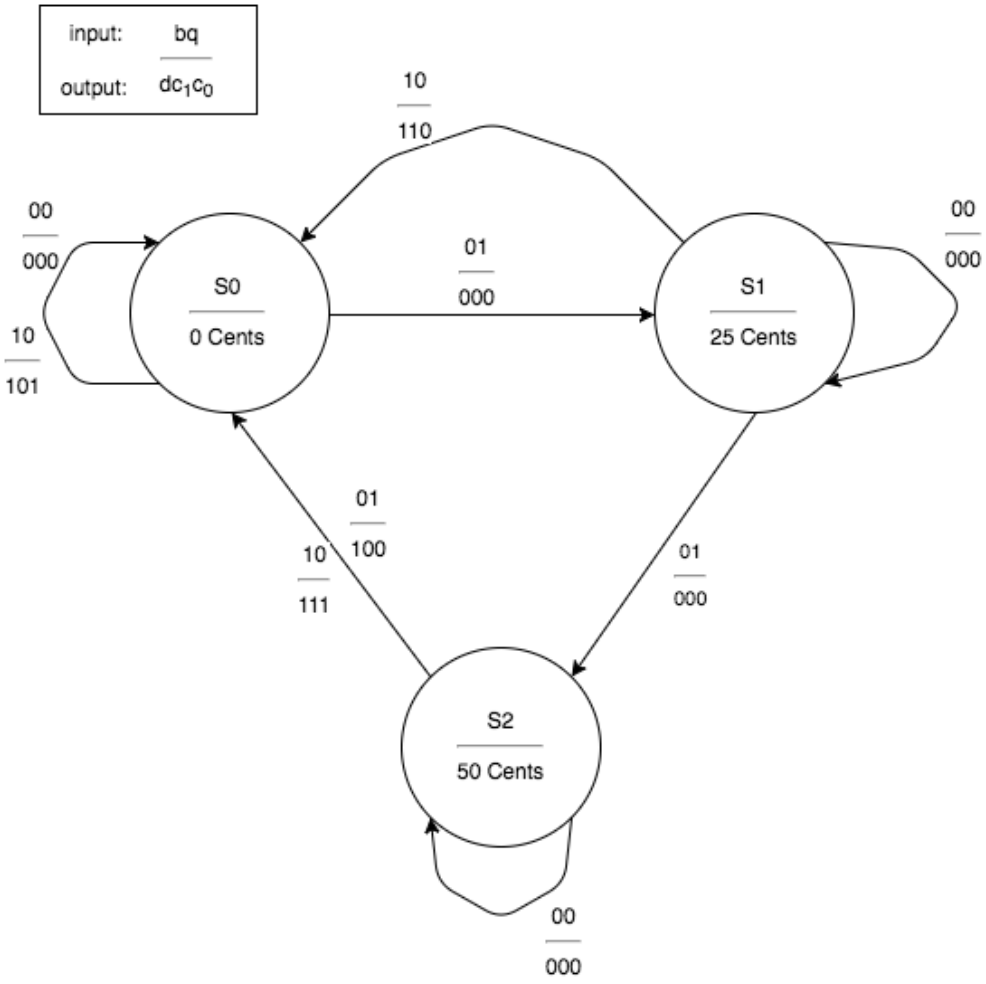
a) Draw the state transition diagram;

b) Provide a complete table with input, output, current and next states.

c) Apply K-map to obtain the logic expressions.

d) Draw the circuit diagram using D flip-flops.

a)



		current state		next state			change	
bill	**quarter**	**Q1**	**Q0**	**Q1+**	**Q0+**	**disp**	**c1**	**c0**
0	0	0	0	0	0	0	0	0
0	0	0	1	0	1	0	0	0
0	0	1	0	1	0	0	0	0
0	0	1	1	X	X	X	X	X
0	1	0	0	0	1	0	0	0
0	1	0	1	1	0	0	0	0
0	1	1	0	0	0	1	0	0
0	1	1	1	X	X	X	X	X
1	0	0	0	0	0	1	0	1
1	0	0	1	0	0	1	1	0
1	0	1	0	0	0	1	1	1
1	0	1	1	X	X	X	X	X
1	1	0	0	X	X	X	X	X
1	1	0	1	X	X	X	X	X
1	1	1	0	X	X	X	X	X
1	1	1	1	X	X	X	X	X

$Q_1^+ = \overline{\overline{bq}}Q_1 + qQ_0$

bq \ Q_1Q_0	00	01	11	10
00	0	0	X	1
01	0	1	X	0
11	X	X	X	X
10	0	0	X	0

$Q_0^+ = q\overline{\overline{Q_1}\overline{Q_0}} + \overline{\overline{bq}}Q_0$

bq \ Q_1Q_0	00	01	11	10
00	0	1	X	0
01	1	0	X	0
11	X	X	X	X
10	0	0	X	0

$\text{disp} = b + qQ_1$

bq \ Q_1Q_0	00	01	11	10
00	0	0	X	0
01	0	0	X	1
11	X	X	X	X
10	1	1	X	1

$c_1 = qQ_1 + bQ_0 + bQ_1$

bq \ Q_1Q_0	00	01	11	10
00	0	0	X	0
01	0	0	X	1
11	X	X	X	X
10	1	1	X	1

$c_0 = b\overline{Q_0}$

bq \ Q_1Q_0	00	01	11	10
00	**0**	**0**	**X**	**0**
01	**0**	**0**	**X**	**0**
11	**X**	**X**	**X**	**X**
10	**1**	**0**	**X**	**1**

d)