Computer Logic Design Fall-2016
Homework – 6 Solutions

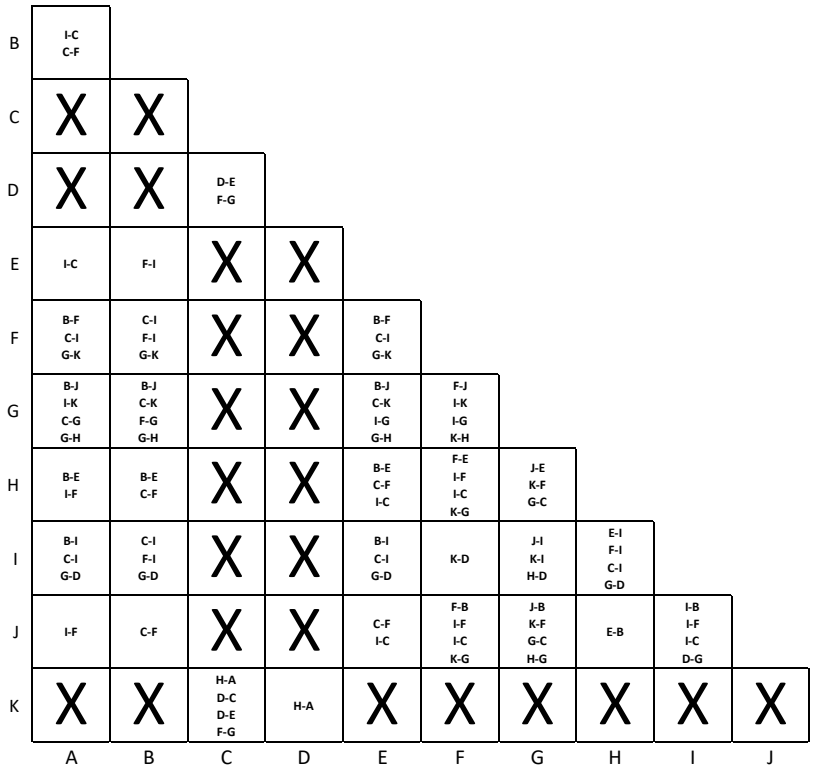
1) Reduce the following state table to minimum number of states using the Implication chart method. (20 points)

Present State	Next State				Output
	Inputs (XY)				Z
	00	01	11	10	
A	B	I	C	G	0
B	B	C	F	G	0
C	H	D	D	F	1
D	H	C	E	G	1
E	B	C	I	G	0
F	F	I	I	K	0
G	J	K	G	H	0
H	E	F	C	G	0
I	I	I	I	D	0
J	B	F	C	G	0
K	A	C	E	G	1

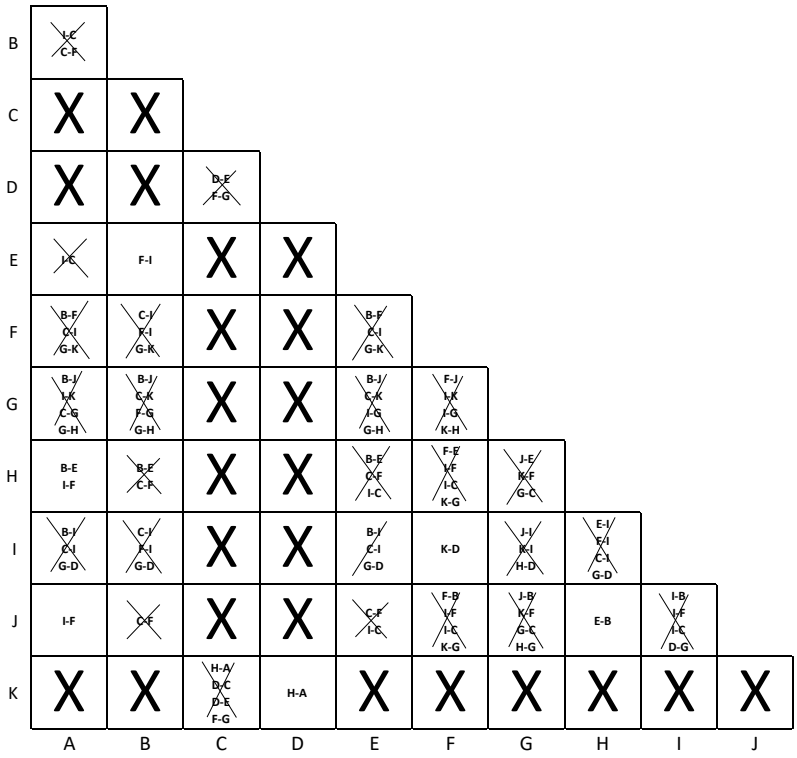
A) Implication Chart :

	A	B	C	D	E	F	G	H	I	J
B	I-C C-F									
C	X	X								
D	X	X	D-C D-E F-G							
E	I-C	F-I	X	X						
F	B-F C-I G-K	B-F C-I F-I G-K	X	X	B-F C-I G-K					
G	B-J I-K C-G G-H	B-J C-K F-G G-H	X	X	B-J C-K I-G G-H	F-J I-K I-G K-H				
H	B-E I-F	B-E C-F	X	X	B-E C-F I-C	F-E I-F I-C K-G	J-E K-F G-C H-G			
I	B-I C-I G-D	B-I C-I F-I G-D	X	X	B-I C-I G-D	F-I K-D	J-I K-I G-I H-D	E-I F-I C-I G-D		
J	I-F	C-F	X	X	C-F I-C	F-B I-F I-C K-G	J-B K-F G-C H-G	E-B	I-B I-F I-C D-G	
K	X	X	H-A D-C D-E F-G	H-A	X	X	X	X	X	X

After First Pass



After Second Pass



A ≡ H ≡ J ; B ≡ E ; D ≡ K ; F ≡ I ;

Reduced state table :

Present State	Next State				Output
	Inputs (XY)				Z
	00	01	11	10	
A	B	F	C	G	0
B	B	C	F	G	0
C	A	D	D	F	1
D	A	C	B	G	1
F	F	F	F	D	0
G	A	D	G	A	0

2) Reduce the following state table to minimum number of states using Implication chart method. (20 points)

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

A) Implication chart:

	A	B	C	D	E	F
B	B-G					
C	F-C B-G	F-C				
D	F-A	F-A G-B	C-A G-B			
E	X	X	X	X		
F	F-A B-A	F-A G-A	C-A G-A	B-A	X	
G	B-A	G-A	C-F G-A	A-F B-A	X	A-F

A ≡ B ≡ C ≡ D ≡ F ≡ G ;

Reduced state table:

Present State	Next State		Output	
	X=0	X=1	X=0	X=1
A	A	A	0	0
E	E	A	1	0

3) (a) For the following state table, apply the three guidelines to generate three possible nonequivalent state assignments. Which one of these is preferred, and why? (10 points)
(b) Using your answer to (a), derive D flip-flop input equations and the output equations. (10 points)

Present State	Next State				Outputs (PQ)			
	Inputs (XY)							
	XY = 00	01	11	10	XY = 00	01	11	10
A	A	A	C	C	01	01	01	01
B	B	D	B	D	11	11	11	11
C	A	A	B	D	11	11	00	00
D	D	D	A	C	01	01	01	01

A) Using guideline 1,
For Inputs XY (00 , 01)
A,C have same next states

For Inputs XY (10)
A,D have same next state

For Inputs XY (11 , 10)
B,C have same next states

Possible adjacencies:
(A,C) twice (A,D)(B,C) twice

Using guideline 2,
Possible adjacencies:
(A,C)(B,D)(A,B,D)(A,B,C,D)

Using guideline 3,
(A,D) have same outputs PQ

Satisfying adjacency, state map:

Q2 \ Q1	0	1
0	A	C
1	D	B

A = 00, B = 11, C = 10, D = 01

State assignment table:

Q_1Q_2	XY				PQ			
	00	**01**	**11**	**10**	**00**	**01**	**11**	**10**
00	00	00	10	10	01	01	01	01
11	11	01	11	01	11	11	11	11
10	00	00	11	01	11	11	00	00
01	01	01	00	10	01	01	01	01

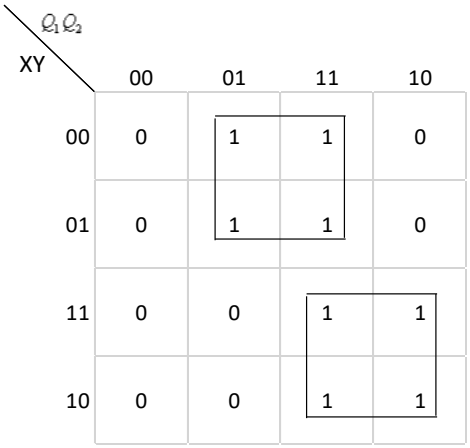
Next State Map:

XY \ Q_1Q_2	00	01	11	10
00	A	D	B	A
01	A	D	D	A
11	C	A	B	B
10	C	C	D	D

Next State Map for D_A:

XY \ Q_1Q_2	00	01	11	10
00	0	0	1	0
01	0	0	0	0
11	1	0	1	1
10	1	1	D	0

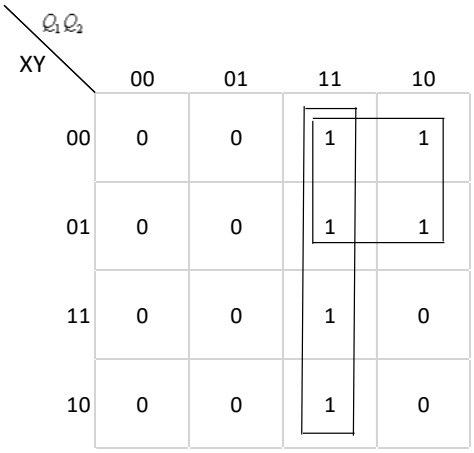
Next State Map for D_B:



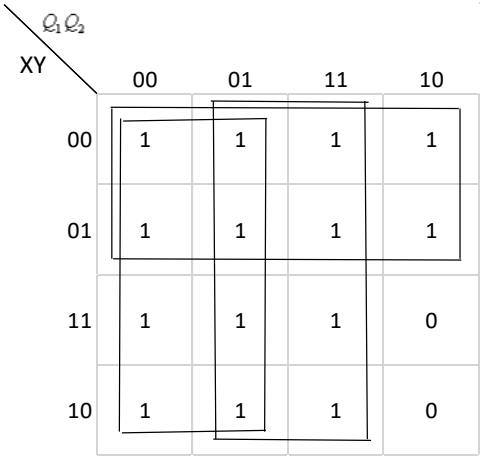
$D_A = Q_1Q_2X'Y' + Q_1XY + Q_1'XY' + Q_1'Q_2'X$

$D_B = Q_2X' + Q_1X$

Next State Map for P:



Next State Map for Q:



$P = Q_1Q_2 + Q_1X'$
$Q = Q_1' + X' + Q_2$

4) (a) Consider the following Mealy sequential circuit. Derive the equations for a one-hot state assignment. (Show your answer in the form of a Boolean expression) (10 points)
(b) Implement the circuit using D-flip flops. (10 points)

Present State	Next State		Present Output	
	X=0	X=1	X=0	X=1
A	B	A	0	0
B	C	A	0	0
C	D	A	0	1
D	D	A	0	0

A) a) Number of D flip flops in (b) is chosen such that it is equal to the number of states = 4
For each state, one of the bits is set to high and three bits are set low in this particular case.

State	Assignment
A	1000
B	0100
C	0010
D	0001

State Table

Present State	Next State		Present Output	
	X=0	X=1	X=0	X=1
1000	0100	1000	0	0
0100	0010	1000	0	0
0010	0001	1000	0	1
0001	0001	1000	0	0

When X=1, Next state = 1000

$D_A = X$

When X=0 and present state is 1000, Next state = 0100

$D_B = X'Q_A$

When X=0 and present state is 0100, Next state = 0010

$D_c = X'Q_B$

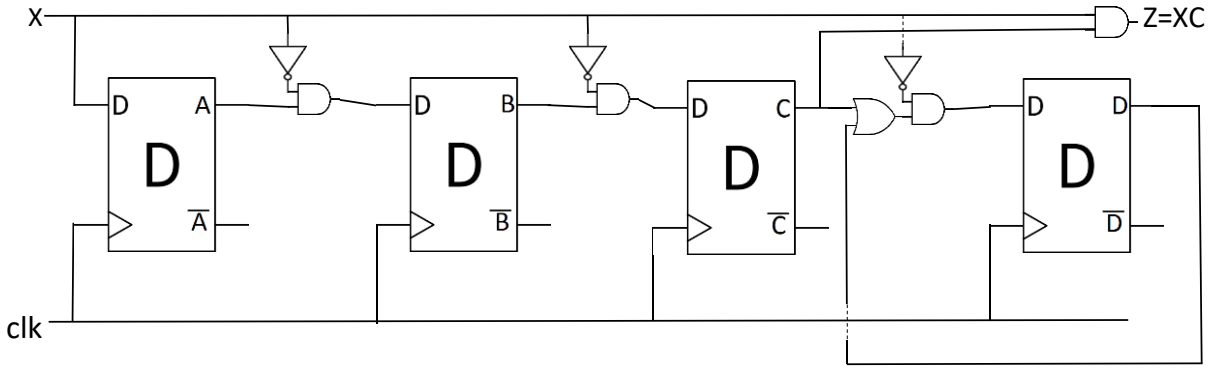
When X=0 and present state is 0010 or 0001, Next state = 0001

$D_D = X' (Q_C + Q_D)$

When X=1 and current state is C

$Z = XQ_C$

b) Output circuit



5) Circuits *M* and *N* have the state tables that follow. Show that these are equivalent. (20 points)

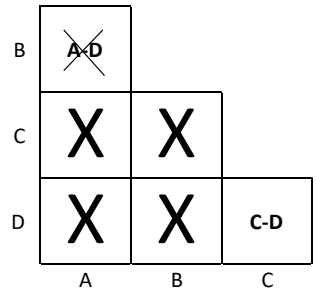
Circuit M

Present State	Input(X)		Output(Z)
	0	1	
A	D	B	0
B	A	B	0
C	A	C	1
D	A	D	1

Circuit N

Present State	Input(X)		Output(Z)
	0	1	
A	E	A	1
B	F	B	1
C	E	D	0
D	E	C	0
E	B	D	0
F	B	C	0

A) Implication chart for M

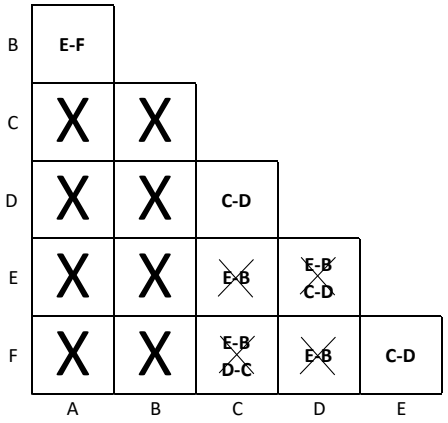


C ≡ D

Reduced state table for M

Present State	Input		Output
	X=0	X=1	X=0
A	C	B	0
B	A	B	0
C	A	C	1

Implication chart for N



E ≡ F ; C ≡ D ; A ≡ B

Reduced state table for N

Present State	Input		Output
	X=0	X=1	X=0
A	E	A	1
C	E	C	0
E	A	C	0

Represent A as C’

E as A’

C as B’

State table for N

Present State	Input		Output
	X=0	X=1	X=0
A'	C'	B'	0
B'	A'	B'	0
C'	A'	C'	1

M and N are equivalent

Another way to prove equivalence

Implication charts for M and N

	A	B	C	D	E	F
a	X	X	~~E-d~~ ~~D-b~~	~~E-B~~	**B-d** **D-b**	**B-d** **C-b**
b	X	X	**E-a** **D-b**	**E-a** **C-b**	~~**B-a**~~ ~~**C-b**~~	~~**B-a**~~ ~~**D-b**~~
c	**E-a** **A-c**	**F-a** **B-c**	X	X	X	X
d	**E-a** **A-d**	**F-a** **B-d**	X	X	X	X

a ≡ E ≡ F; b ≡ C ≡ D; c ≡ d ≡ A ≡ B

All the states in circuit M have equivalent states in circuit N
All the states in N also have equivalent states in M

M and N are equivalent