Homework Set 4
- Solutions -

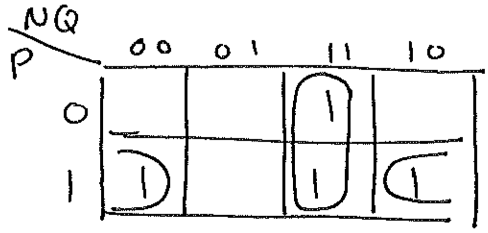
Problem 1 The PN Flip-Flop

(a) characteristic Table

P	N	Q(t+1)
0	0	0
0	1	Q(t)
1	0	Q'(t)
1	1	1

(b) characteristic equation

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



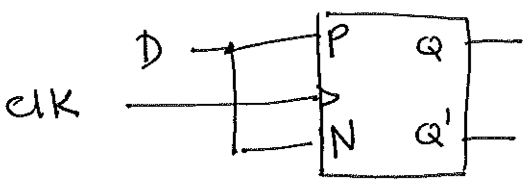
$$Q(t+1) = PQ'(t) + NQ(t)$$

(c) 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

(d) convert the PN FF to a D FF.

By connecting P to N. D = P = N



Problem 2:

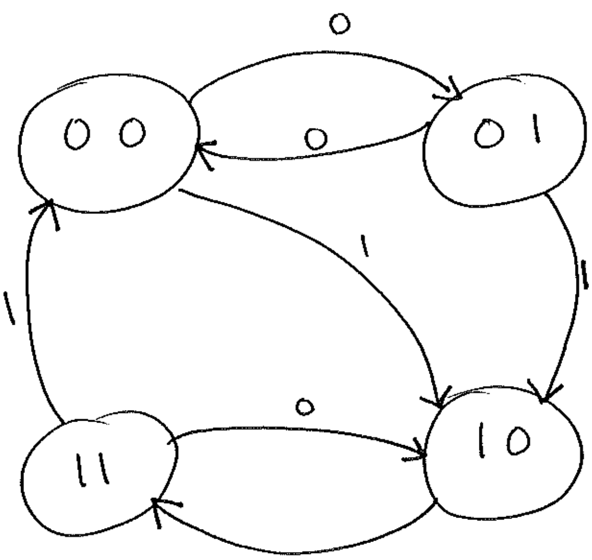
(a) $Q(t+1) = J Q'(t) + K' Q(t)$

$$A(t+1) = J_A A'(t) + K_A' A(t)$$
$$= x A'(t) + (x B(t))' A(t)$$

$$B(t+1) = J_B B'(t) + K_B' B(t)$$
$$= (x' + A(t)) B'(t) + (A'(t) + B(t))' B(t)$$
$$= x' B'(t) + A(t) B(t) + \cancel{A(t) B'(t) B(t)} \to 0$$
$$= x' B'(t) + A(t) B(t)$$

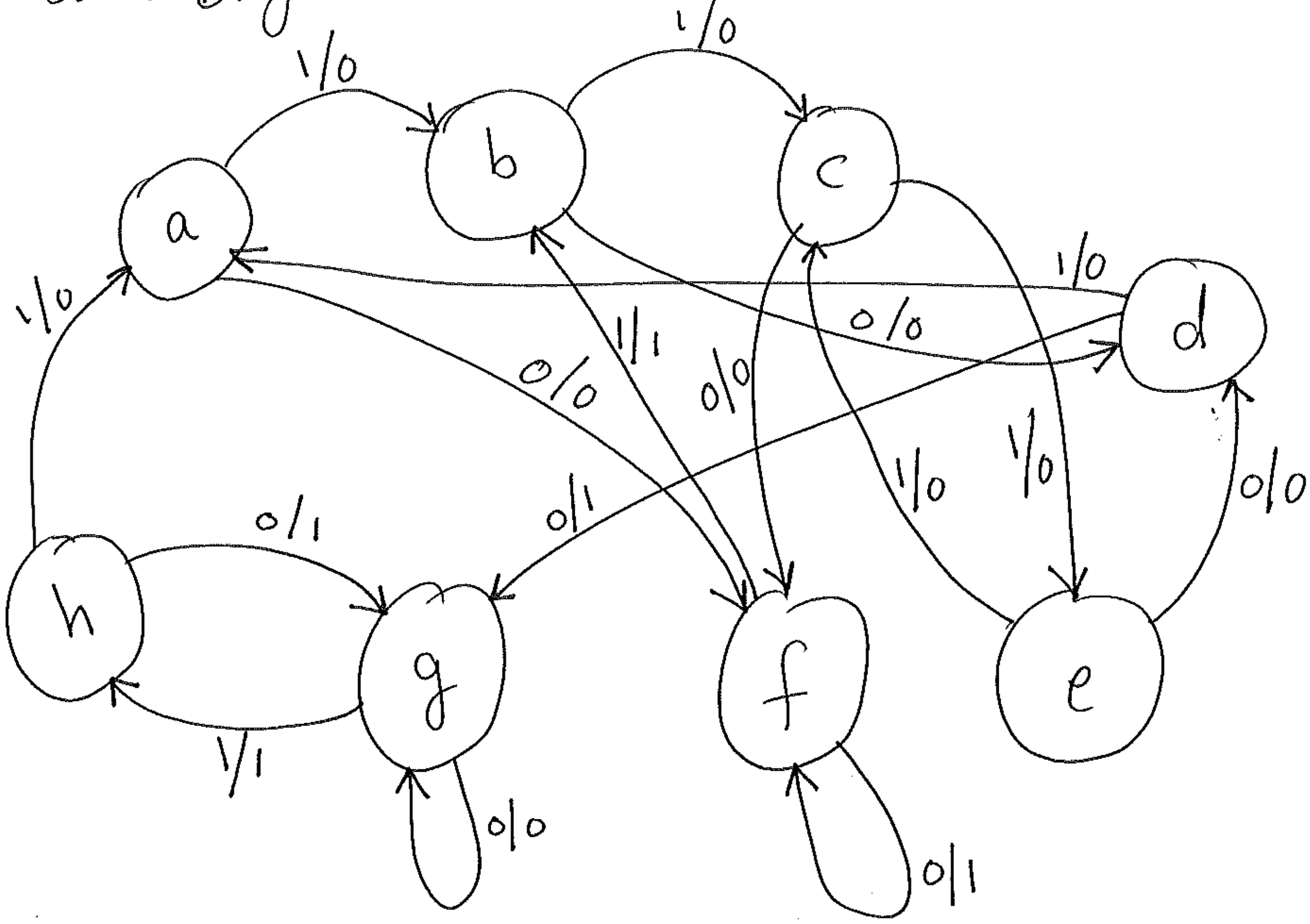
(b) State Table

Present State		Next State x = 0		Next State x = 1	
A	B	A	B	A	B
0	0	0	1	1	0
0	1	0	0	1	0
1	0	1	1	1	1
1	1	1	0	0	0



Problem 3

(a) State Diagram.



(b) Starting with state a:

State:	a	f	b	c	e	d	g	h	g	g	h	a
input:	0	1	1	1	0	0	1	0	0	1	1	
output:	0	1	0	0	0	1	1	1	0	1	0	

(c)

	a	b	c	d	e	f	g
b	~~f,d c,e~~						
c	b,e ✓	~~f,d c,e~~					
d	×	×	×				
e	~~f,d c,e~~	✓	~~f,d c,e~~	×			
f	×	×	×	×	×		
g	×	×	×	×	×	×	
h	×	×	×	✓	×	×	×

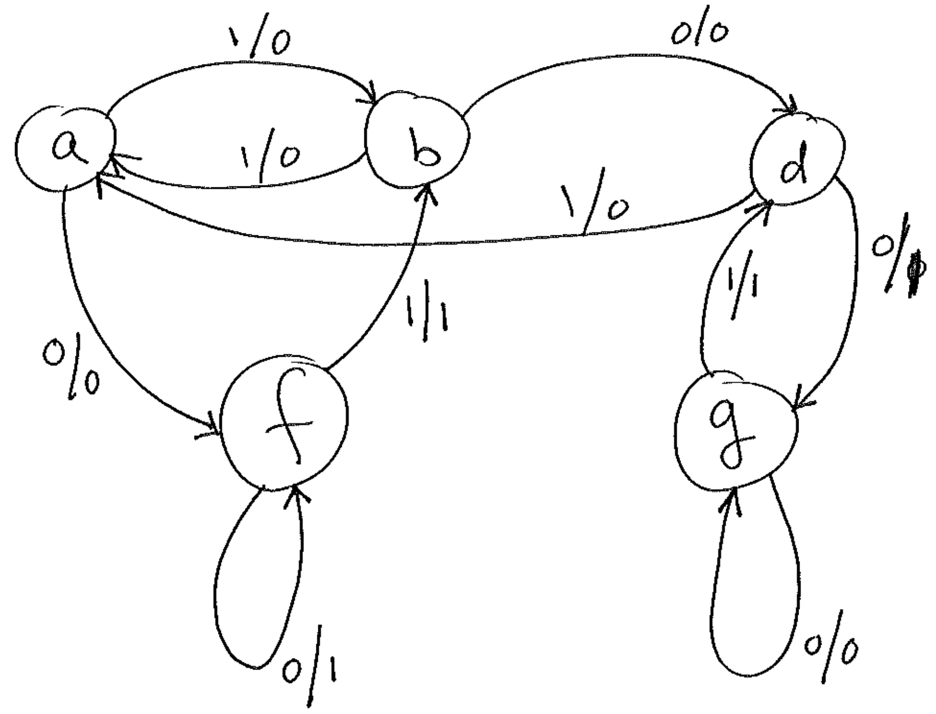
$h \equiv d$, $e \equiv b$, $c \equiv a$

Thus we remove c, e, and h.

The reduced state table:

Present State	Next State x=0	Next State x=1	Output x=0	Output 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

(d) The reduced State diagram:



(e) Starting with state a

state :	a	f	b	a	b	d	g	d	g	g	d	a
input :	0	1	1	1	0	0	1	0	0	1	1	
output :	0	1	0	0	0	1	1	1	0	1	0	

(f) Assign a = 000, b = 001, d = 010, f = 011, g = 100

Three JK FFs are needed, call them A, B, C.

<u>Excitation Table</u>

Q(t)	Q(t+1)	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

Present State			input	Next State			output	Flip-Flop inputs					
A	B	C	x	A	B	C	y	J_A	K_A	J_B	K_B	J_C	K_C
0	0	0	0	0	1	1	0	0	x	1	x	1	x
0	0	0	1	0	0	1	0	0	x	0	x	1	x
0	0	1	0	0	1	0	0	0	x	1	x	x	1
0	0	1	1	0	0	0	0	0	x	0	x	x	1
0	1	0	0	1	0	0	1	1	x	x	1	0	x
0	1	0	1	0	0	0	0	0	x	x	1	0	x
0	1	1	0	0	1	1	1	0	x	x	0	x	0
0	1	1	1	0	0	1	1	0	x	x	1	x	0
1	0	0	0	1	0	0	0	x	0	0	x	0	x
1	0	0	1	0	1	0	1	x	1	1	x	0	x
1	0	1	0	x	x	x	x	x	x	x	x	x	x
⋮			⋮	⋮			⋮	⋮					⋮
1	1	1	1	x	x	x	x	x	x	x	x	x	x

<u>Note</u>: unused states are being treated as Don't care states.

$y = Bx' + BC + AC'x$

AB \ Cx	00	01	11	10
00				
01	1		1	1
11	x	x	x	x
10		1	x	x

$J_A = BC'x'$

AB \ Cx	00	01	11	10
00				
01	1			
11	x	x	x	x
10	x	x	x	x

$K_A = B'x$

AB \ Cx	00	01	11	10
00	x	x	x	x
01	x	x	x	x
11	x	x	x	x
10		1	x	x

$J_B = A'x' + Ax$

AB \ Cx	00	01	11	10
00	1			1
01	x	x	x	x
11	x	x	x	x
10		1	x	x

$K_B = A'C' + A'x$

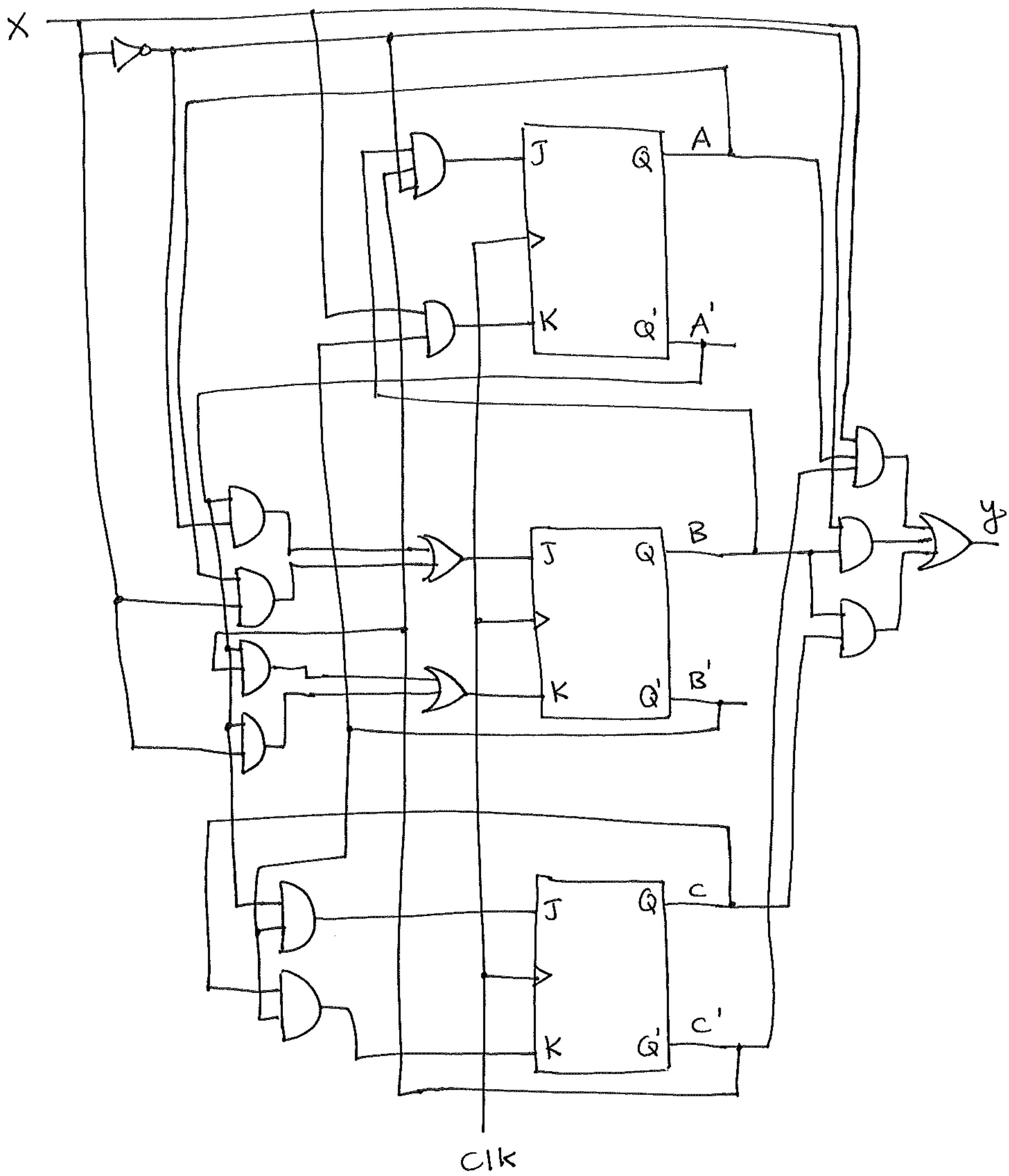
AB \ Cx	00	01	11	10
00	x	x	x	x
01	1	1	1	
11	x	x	x	x
10	x	x	x	x

$J_C = A'B'$

AB \ Cx	00	01	11	10
00	1	1	x	x
01			x	x
11	x	x	x	x
10			x	x

$K_C = B'C$

AB \ Cx	00	01	11	10
00	x	x	1	1
01	x	x		
11	x	x	x	x
10	x	x	x	x


X
J
Q
A
K
Q'
A'
J
Q
B
K
Q'
B'
J
Q
C
K
Q'
C'
y
Clk

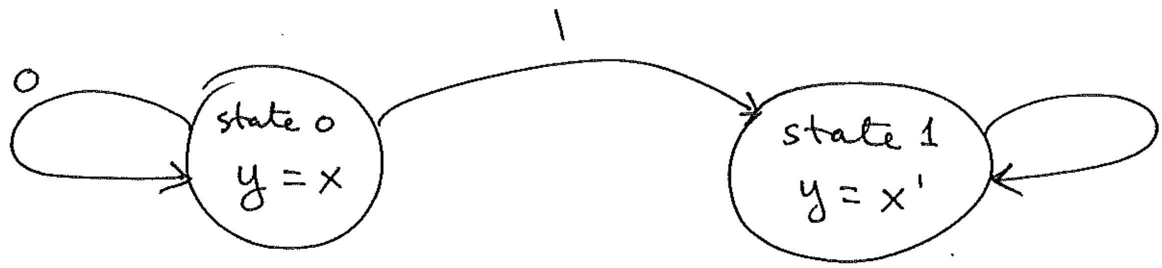
Problem 4 The serial 2's complementer begins in state 0, in which the output equals the input, and it moves to state 1 after it encounters the first 1. In state 1, the output is the complement of the input.

example: input : 1 0 1 1 0 | 1 0 0

output: 0 1 0 0 1 | 1 0 0

state 1 | state 0

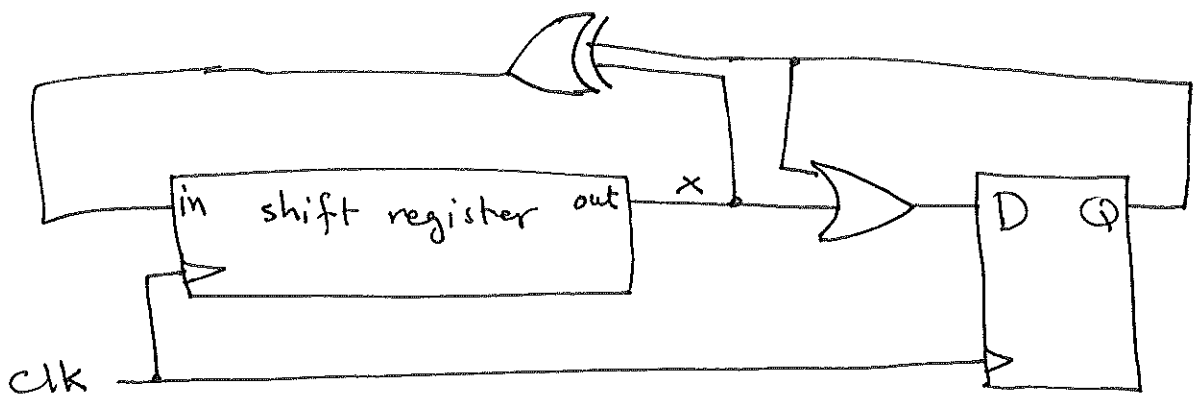
state diagram



state table using one D Flip-Flop.

Present State	input x	Next State	output y	FF input $D = Q(t+1)$
0	0	0	0	0
0	1	1	1	1
1	0	1	1	1
1	1	1	0	1

$\Rightarrow y = Q \oplus x$, $D = Q + x$



in
shift register
out
x
D
Q
clk