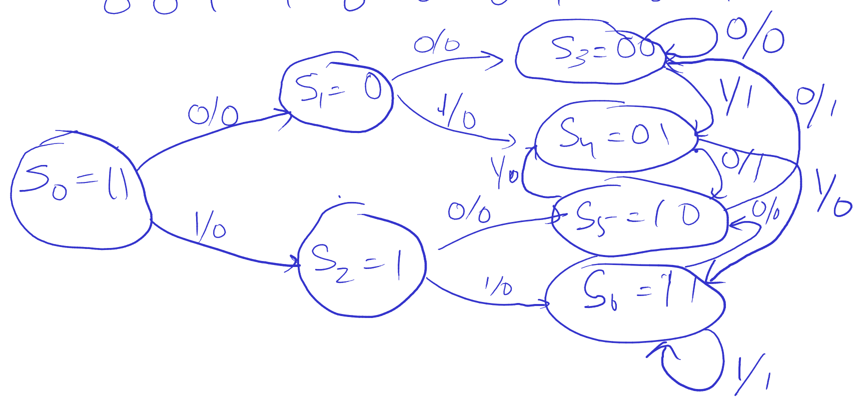
HW 8

Problem 1

Example sequence (Mealy)

t	0	1	2	3	4	5	6	7	8	9
w	0	0	1	0	1	1	0	0	0	1
p	0	0	1	1	0	0	0	1	0	1



State table

Seq	Present state	Next State $w=0$	Next State $w=1$	Output (p) $w=0$	Output (p) $w=1$
""	S_0	S_1	S_2	0	0
"0"	S_1	S_3	S_4	0	0
"1"	S_2	S_5	S_6	0	0
"00"	S_3	S_3	S_4	0	1
"01"	S_4	S_5	S_6	1	0
"10"	S_5	S_3	S_4	1	0
"11"	S_6	S_5	S_6	0	1

Problem 2

Moore modulo 6 counter

State assigned table (Not optimal)

Present State	Next State		Output
	$w=0$	$w=1$	
$y_2\ y_1\ y_0$	$Y_2\ Y_1\ Y_0$	$Y_2\ Y_1\ Y_0$	$Z_2=y_2,\ Z_1=y_1,\ Z_0=y_0$
0 0 0	0 0 0	0 0 1	
0 0 1	0 0 1	0 1 0	
0 1 0	0 1 0	0 1 1	
0 1 1	0 1 1	1 0 0	
1 0 0	1 0 0	1 0 1	
1 0 1	1 0 1	0 0 0	
1 1 0	d d d	d d d	
1 1 1	d d d	d d d	

Y_2

^{0} 0	^{4} 1	^{12} 1	^{8} 0
^{1} 0	^{5} 1	^{13} 0	^{9} 0
^{3} 0	^{7} d	^{15} d	^{11} 1
^{2} 0	^{6} d	^{14} d	^{10} 0

Y_1

^{0} 0	^{4} 0	^{12} 0	^{8} 0
^{1} 0	^{5} 0	^{13} 0	^{9} 1
^{3} 1	^{7} d	^{15} d	^{11} 0
^{2} 1	^{6} d	^{14} d	^{10} 1

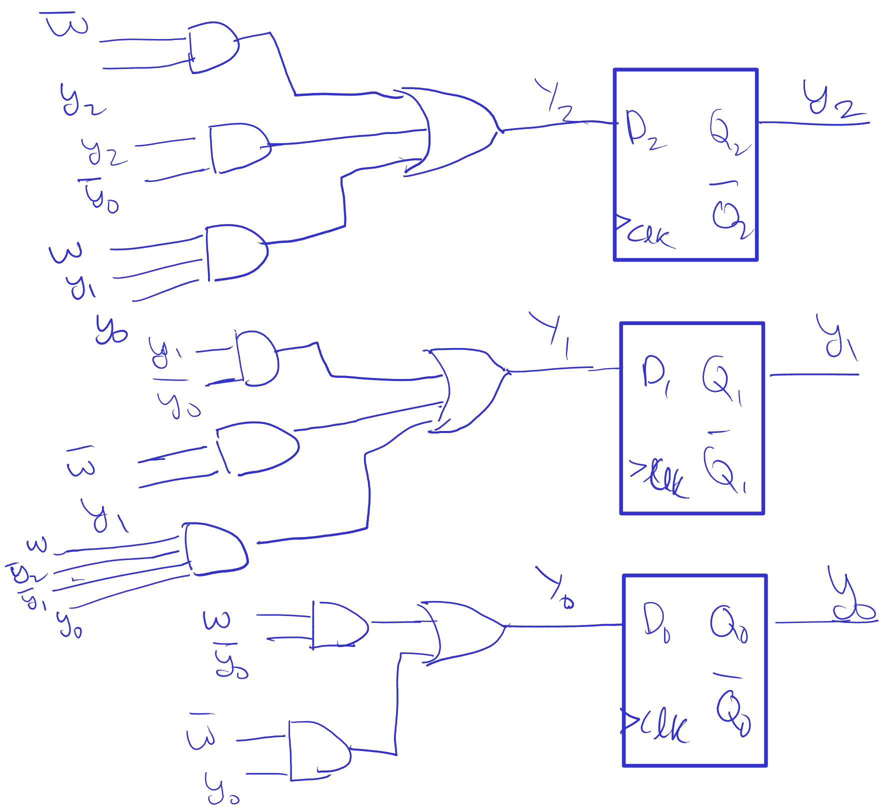
Y_0

^{0} 0	^{4} 0	^{12} 1	^{8} 1
^{1} 1	^{5} 1	^{13} 0	^{9} 0
^{3} 1	^{7} d	^{15} d	^{11} 0
^{2} 0	^{6} d	^{14} d	^{10} 1

$Y_2 = \bar{w} y_2 + y_2 \bar{y}_0 + w y_1 y_0$

$Y_1 = y_1 \bar{y}_0 + \bar{w} y_1 + w \bar{y}_2 \bar{y}_1 y_0$

$Y_0 = w \bar{y}_0 + \bar{w} y_0$



$\overline{w}$
y_2
y_2
$\overline{y_0}$
w
y_1
y_0
Y_2
D_2
Q_2
$\overline{Q_2}$
clk
y_2
y_1
$\overline{y_0}$
$\overline{w}$
y_1
w
$\overline{y_2}$
$\overline{y_1}$
y_0
Y_1
D_1
Q_1
$\overline{Q_1}$
clk
y_1
w
$\overline{y_0}$
$\overline{w}$
y_0
Y_0
D_0
Q_0
$\overline{Q_0}$
clk
y_0

Problem 3

3-bit counter like circuit (Moore)

State assigned table

Present State			Next State						Output
			$w=0$			$w=1$			
y_2	y_1	y_0	Y_2	Y_1	Y_0	Y_2	Y_1	Y_0	$Z_2=y_2$ $Z_1=y_1$ $Z_0=y_0$
0	0	0	1	1	1	0	1	0	
0	0	1	0	0	0	0	1	1	
0	1	0	0	0	1	1	0	0	
0	1	1	0	1	0	1	0	1	
1	0	0	0	1	1	1	1	0	
1	0	1	1	0	0	1	1	1	
1	1	0	1	0	1	0	0	0	
1	1	1	1	1	0	0	0	1	

Y_2

		w		
1^{0}	0^{4}	1^{12}	0^{8}	
0^{1}	1^{5}	1^{13}	0^{9}	y_0
0^{3}	1^{7}	0^{15}	1^{11}	y_1
0^{2}	1^{6}	0^{14}	1^{10}	
	y_2			

J_2

		w		
1^{0}	d^{4}	d^{12}	0^{8}	
0^{1}	d^{5}	d^{13}	0^{9}	y_0
0^{3}	d^{7}	d^{15}	1^{11}	y_1
0^{2}	d^{6}	d^{14}	1^{10}	
	y_2			

K_2

		w		
d^{0}	1^{4}	0^{12}	d^{8}	
d^{1}	0^{5}	0^{13}	d^{9}	y_0
d^{3}	0^{7}	1^{15}	d^{11}	y_1
d^{2}	0^{6}	1^{14}	d^{10}	
	y_2			

y_2 Y_2	J_2 K_2
0 0	0 d
0 1	1 d
1 0	d 1
1 1	d 0

$$J_2 = \bar{w}\bar{y}_1\bar{y}_0 + w y_1$$

$$K_2 = \bar{w}\bar{y}_1\bar{y}_0 + w y_1$$

Y_1

w, y_0, y_1, y_2

1 (0)	1 (4)	1 (12)	1 (8)
0 (1)	0 (5)	1 (13)	1 (9)
1 (3)	1 (7)	0 (15)	0 (11)
0 (2)	0 (6)	0 (14)	0 (10)

J_1

w, y_0, y_1, y_2

1 (0)	1 (4)	1 (12)	1 (8)
0 (1)	0 (5)	1 (13)	1 (9)
d (3)	d (7)	d (15)	d (11)
d (2)	d (6)	d (14)	d (10)

$\overline{J_1} = \overline{w}\, y_0$

$\Rightarrow J_1 = w + \overline{y}_0$

K_1

w, y_0, y_1, y_2

d (0)	d (4)	d (12)	d (8)
d (1)	d (5)	d (13)	d (9)
0 (3)	0 (7)	1 (15)	1 (11)
1 (2)	1 (6)	1 (14)	1 (10)

$\overline{K_1} = \overline{w}\, y_0$

$\Rightarrow K_1 = w + \overline{y}_0$

Y_0

w, y_0, y_1, y_2

1 (0)	1 (4)	0 (12)	0 (8)
0 (1)	0 (5)	1 (13)	1 (9)
0 (3)	0 (7)	1 (15)	1 (11)
1 (2)	1 (6)	0 (14)	0 (10)

J_0

w, y_0, y_1, y_2

1 (0)	1 (4)	0 (12)	0 (8)
d (1)	d (5)	d (13)	d (9)
d (3)	d (7)	d (15)	d (11)
1 (2)	1 (6)	0 (14)	0 (10)

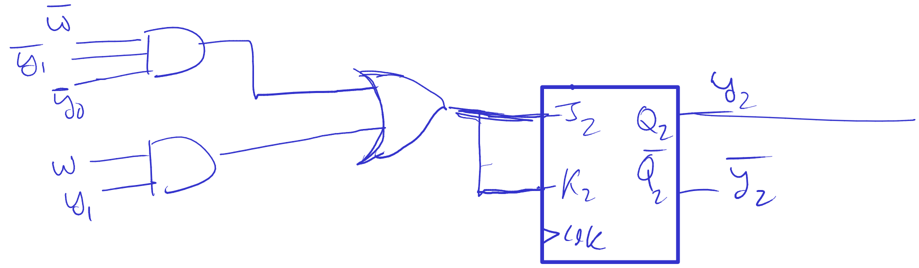
$J_0 = \overline{w}$

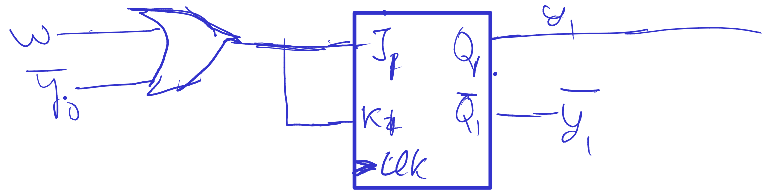
K_0

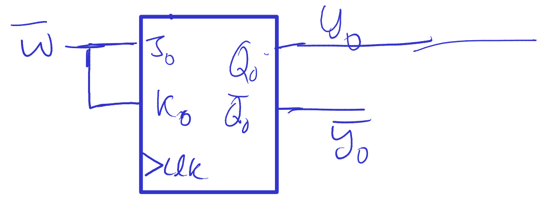
w, y_0, y_1, y_2

d (0)	d (4)	d (12)	d (8)
1 (1)	1 (5)	0 (13)	0 (9)
1 (3)	1 (7)	0 (15)	0 (11)
d (2)	d (6)	d (14)	d (10)

$K_0 = \overline{w}$


$\overline{w}$
$\overline{y_1}$
$\overline{y_0}$
w
y_1
J_2
K_2
clk
Q_2
$\overline{Q_2}$
y_2
$\overline{y_2}$


w
$\overline{y_0}$
J_1
K_1
clk
Q_1
$\overline{Q_1}$
y_1
$\overline{y_1}$

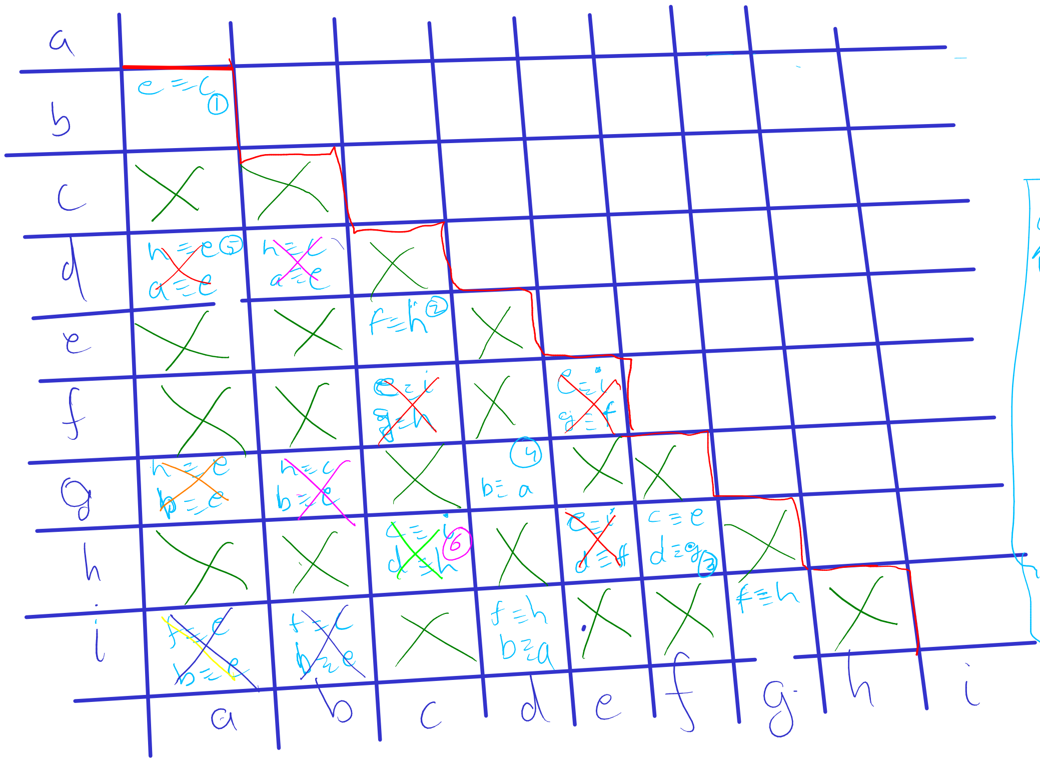

$\overline{w}$
J_0
K_0
clk
Q_0
$\overline{Q_0}$
y_0
$\overline{y_0}$

Problem 4

X = Due to mismatching output

X = Due to $e \neq i$

X = Due to $c \neq i$



Possible

$a=b$

if $e=c$ ①

if $f=h$ ②

if $c=e$ ③

$d=g$

if $a=b$ ④

also $d=e$

$a=d$

if $h \neq e$ ⑤ — if $e \neq i$ X

$a=h$

$d=f$

Not possible

$b=d$

if $h=c$ X because of ⑥

$a=e$

Not possible

Replace b with a, e with c, h with f, g and i with d,

PS	NS $x=0$	NS $x=1$	Z
a	c	c	1
c	d	f	0
d	f	a	1
f	c	d	0

Problem 5.1

X = Due to mismatching output

X = Due to $S_3 \not\equiv$ *

X = Due to $S_6 \not\equiv$ *

S_0						
S_1	~~$S_1 \equiv S_6$~~					
S_2	~~$S_2 \equiv S_4$~~	~~$S_2 \equiv S_5$~~				
S_3	X	X	X			
S_4	~~$S_4 \equiv S_5$ $S_3 \equiv S_1$~~	~~$S_4 \equiv S_5$ $S_3 \equiv S_6$~~	$S_3 \equiv S_6$	X		
S_5	✓	~~$S_0 \equiv S_5$ $S_1 \equiv S_6$~~	~~$S_0 \equiv S_2$ $S_1 \equiv S_6$~~	X	~~$S_0 \equiv S_4$ $S_1 \equiv S_3$~~	
S_6	X	X	X	$S_0 \equiv S_5$	X	X
	S_0	S_1	S_2	S_3	S_4	S_5	S_6

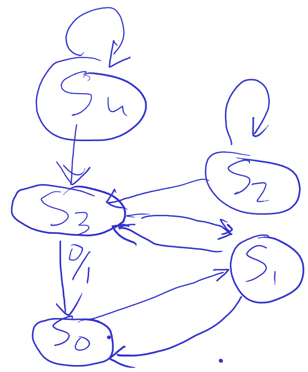
Replace S_5 with S_0, S_6 with S_3. State reduction of BINary state table still leaves us with 5 states instead of 7.

FL Ipflop's state table has only 3 states.

Mr Ipflop is not correct.

PS	NS x=0	NS 1	Output x=0	Output x=1
S_0	S_0	S_1	0	0
S_1	S_0	S_3	0	0
S_2	S_2	S_3	0	0
S_3	S_0	S_1	1	0
S_4	S_4	S_3	0	0

Problem 5.2



If S_0 is the start state S_2, S_4 are unreachable.

Remove S_2, S_4 from the state table

Combining with $S_5 \equiv S_0$, $S_3 \equiv S_6$ we get:

PS	NS $X=0$	NS 1	Output $X=0$	Output 1
S_0	S_0	S_1	0	0
S_1	S_0	S_3	0	0
S_3	S_0	S_1	1	0

Comparing with Ipflop's table

$S_3 \equiv c$ because output (1,0) is unique

$S_1 \equiv b$

$S_0 \equiv a$

Problem 6

X = Due to mismatch in output

	A	B	C	D	E	F	G	H
B	X							
C	~~A≡F B≡G~~	X						
D	X	~~E≡A~~	X					
E	~~A≡I B≡G~~	X	~~F≡I~~	X				
F	A≡H B≡I ✓	X	~~F≡H G≡I~~	X	~~I≡H G≡I~~			
G	X	~~E≡H~~	X	A≡F ✓	X	X		
H	A≡F ✓	X	~~G≡B~~	X	~~I≡F G≡B~~	I≡B ✓	X	
I	X	✓	X	~~A≡E~~	X	X	~~E≡F~~	X

A≡H≡F B≡I D≡G

Replace H and F with A
I with B
G with D

PS	NS X=0	NS X=1	Z
A	A	B	1
B	C	E	0
C	A	D	1
D	C	A	0
E	B	D	1

Problem 6.2

A C D

Guideline 1 (A, C), (B, D), (C, E),

Guideline 2 (A, B), (C, E), (A, D), (C, A), (B, D)

			y_2	
	A 0	2	6	C 4
y_0	B 1	D 3	7	E 5
		y_1		

y_2	y_1	y_0	
0	0	0	A
0	0	1	B
~~0~~	~~1~~	~~0~~	
0	1	1	D
1	0	0	C
1	0	1	E
~~1~~	~~1~~	~~0~~	
~~1~~	~~1~~	~~1~~	

	PS			NS						Output(z)
				x = 0			x = 1			
	y_2	y_1	y_0	Y_2	Y_1	Y_0	Y_2	Y_1	Y_0	
A≡H≡F	0	0	0	0	0	0	0	0	1	1
B≡I	0	0	1	1	0	0	1	0	1	0
	0	1	0	d	d	d	d	d	d	d
D≡G	0	1	1	1	0	0	0	0	0	0
C	1	0	0	0	0	0	0	1	1	1
E	1	0	1	0	0	1	0	1	1	1
	1	1	0	d	d	d	d	d	d	d
	1	1	1	d	d	d	d	d	d	d

D_2

0 (0)	0 (4)	0 (12)	0 (8)
1 (1)	0 (5)	0 (13)	1 (9)
1 (3)	d (7)	d (15)	0 (11)
d (2)	d (6)	d (14)	d (10)

x, y_0, y_1, y_2

$D_2 = \bar{y}_2 \bar{y}_1 y_0 + \bar{x} \bar{y}_2 y_1$

D_1

0 (0)	0 (4)	1 (12)	0 (8)
0 (1)	0 (5)	1 (13)	0 (9)
0 (3)	d (7)	d (15)	0 (11)
d (2)	d (6)	d (14)	d (10)

x, y_0, y_1, y_2

$D_1 = x y_2$

D_0

0 (0)	0 (4)	1 (12)	1 (8)
0 (1)	1 (5)	1 (13)	1 (9)
0 (3)	d (7)	d (15)	0 (11)
d (2)	d (6)	d (14)	d (10)

x, y_0, y_1, y_2

$D_0 = x \bar{y}_1 + y_2 y_0$

$J_2 = \bar{y}_1 y_0 + \bar{x} y_0$

0 (0)	d (4)	d (12)	0 (8)
1 (1)	d (5)	d (13)	1 (9)
1 (3)	d (7)	d (15)	0 (11)
d (2)	d (6)	d (14)	d (10)

x, y_0, y_1, y_2

$J_1 = x y_2$

0 (0)	0 (4)	1 (12)	0 (8)
0 (1)	0 (5)	1 (13)	0 (9)
d (3)	d (7)	d (15)	d (11)
d (2)	d (6)	d (14)	d (10)

x, y_0, y_1, y_2

$J_0 = x$

0 (0)	0 (4)	1 (12)	1 (8)
d (1)	d (5)	d (13)	d (9)
d (3)	d (7)	d (15)	d (11)
d (2)	d (6)	d (14)	d (10)

x, y_0, y_1, y_2

$K_2 = 1$

d (0)	1 (4)	1 (12)	d (8)
d (1)	1 (5)	1 (13)	d (9)
d (3)	d (7)	d (15)	d (11)
d (2)	d (6)	d (14)	d (10)

x, y_0, y_1, y_2

$K_1 = 1$

d (0)	d (4)	d (12)	d (8)
d (1)	d (5)	d (13)	d (9)
1 (3)	d (7)	d (15)	1 (11)
d (2)	d (6)	d (14)	d (10)

x, y_0, y_1, y_2

$K_0 = y_1 + \bar{x} y_2$

d (0)	d (4)	d (12)	d (8)
1 (1)	0 (5)	0 (13)	0 (9)
1 (3)	d (7)	d (15)	1 (11)
d (2)	d (6)	d (14)	d (10)

x, y_0, y_1, y_2

$Z = y_2 + \bar{y}_0$

1 (0)	d (2)	d (6)	1 (4)
0 (1)	0 (3)	d (7)	1 (5)

y_2, y_0, y_1