1. [16] A sequence detector is to be designed to detect both the sequence *11* and *010* simultaneously.
   a. [8] Find a Mealy machine state graph and table for the network.
   b. [8] Find a Moore machine state graph and table for the network.

2. [26] You are to design and draw the circuit to implement the state graphs from 1a and 1b.

   For full credit you must show that you use the principles of state assignment discussed in class and explicitly show that you have eliminated all redundant states in your design. Use JK flip-flops for the implementation: $Q+ = JQ'+K'Q$.

   a. [10] Draw the circuit for 1a.
   b. [10] Draw the circuit for 1b.
   c. [6] Comment on the relative merits of the design from 1a and 1b. Compare such things as difficulty of design and implementational complexity.

   If you cannot answer 1a or 1b. SEE ME and I'll give you the state graphs to use for parts 2 a,b, and c.

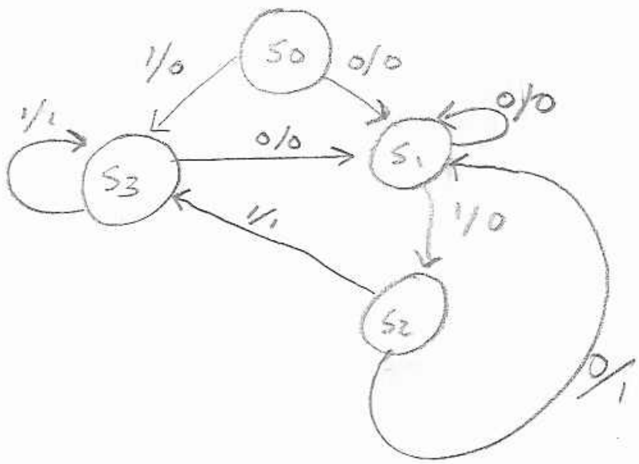
3. [18] Complete the following short problems concerning multiple-output networks using the function $f(a,b,c,d) = a'b + cd + ab'c + d'$.
   a. [5] Show how to implement the function f using an 8-to-1 multiplexer.
   b. [5] Show how to implement the function f using a 4-to-16 line decoder.
   c. [8] Show how you can create a 4-to-1 multiplexer using 2-to-1 multiplexers and no additional gates. Implement $g(a,b,c) = a'b + bc + c'$ using this design.

4. [18] Find the minimum SOP form for the following functions.
   a. [2½] $f(a,b,c,d) = (b'+c'+d)(a'+b'+c')(a+b+c)(b+c+d)$
   b. [2½] $f(a,b,c,d) = \sum m(0,1,3,5,7,8,9)$
   c. [2½] $f(a,b,c,d) = \left(\sum m(2,4,6,7,8,9)\right)\cdot\left(\sum m(0,1,3,5,7,8,9)\right)$
   d. [2½] $f(a,b,c,d) = \left(\prod M(2,4,6,7,8,9)\right)\cdot\left(\prod M(0,1,3,5,7,8,9)\right)$
   e. [2½] $f(a,b,c,d) = (a+b+c+d')(a+b+c+d)(b+d')(a'+b'+c')$
   f. [2½] $f(a,b,c,d) = \prod M(1,3,5,13) + a'b'c + \sum m(1,3,5,13)$
   g. [3] $f(w,x,y,z) = wxy'+(w'y' \equiv x) + (y \oplus wz)$. Recall $a \oplus b = a'b + ab'$, and $(a \equiv b) = (a \oplus b)'$

5. [22] Answer the following short problems.
   a. [5] Minimize the function $f(a,b,c,d) = \sum m(0,1,3,4,512,13) + \sum d(2,14,15)$ using QM.
   b. [5] Design a minimum three-level NOR-gate network to realize $f = a'b + ad'+ab'c'$
   c. [5] A combinational network has 4 inputs ($X_1, \ldots, X_4$) and 1 output (Z). The output Z is to be 1 if and only if exactly two of the X_i are 1. Write Z in both minterm and maxterm form.
   d. [4] Give two examples of where one may encounter incompletely specified functions in practice.
   e. [3] Write $(ab + ac + d)'(a+b+c)'(ad)'$ in SOP form.

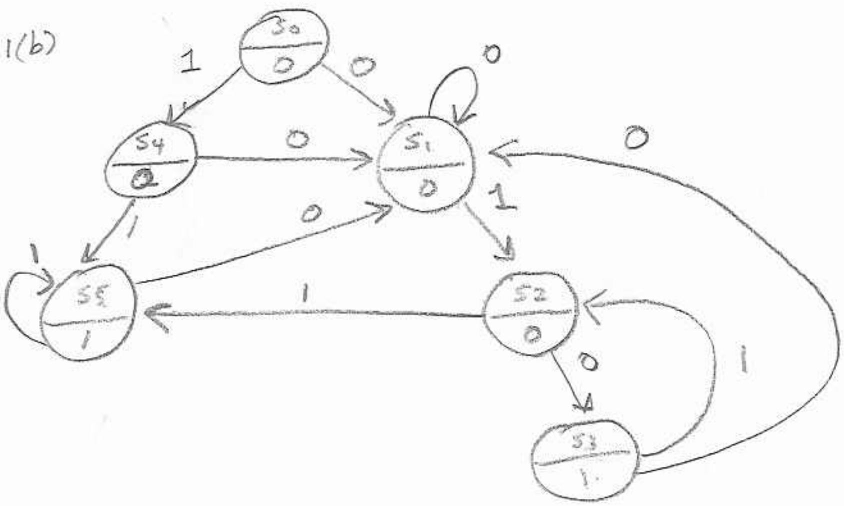
KEY

1(a)



STATE	NEXT x=0	NEXT x=1	output x=0	output x=1
S_0	S_1	S_3	0	0
S_1	S_1	S_2	0	0
S_2	S_1	S_3	1	1
S_3	S_1	S_3	0	1

1(b)



STATE	NEXT x=0	NEXT x=1	output
S_0	S_1	S_4	0
S_1	S_1	S_2	0
S_2	S_3	S_5	0
S_3	S_1	S_2	1
S_4	S_1	S_5	0
S_5	S_1	S_5	1

KEY

2(a) Show no redundancy:

S_1	~~S_2-S_3~~		
S_2	X	X	
S_3	X	X	X
	S_0	S_1	S_2

$$Q^+ = JQ' + K'Q$$

J	K	Q	Q^+
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

Q	Q^+	JK
0	0	0 X
0	1	1 X
1	0	X 1
1	1	X 0

assign states: Need 2 FF's

Guideline (1) (S_0, S_1, S_2, S_3), (S_0, S_2, S_3)

(2) $(S_1, S_3)^3$, (S_1, S_2)

b \ a	0	1
0	S_0	S_3
1	S_2	S_1

S_0 : 00
S_1 : 11
S_2 : 01
S_3 : 10

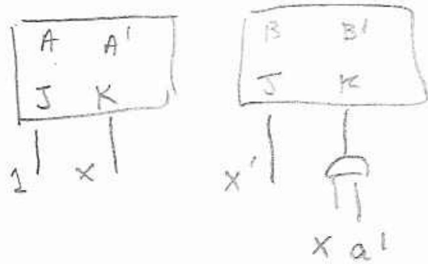
STATE	Next x=0	Next x=1	Output		x=0 $J_A K_A$	x=1 $J_A K_A$	x=0 $J_B K_B$	x=1 $J_B K_B$
00	11	10	0	0	1 X	1 X	1 X	0 X
11	11	01	0	0	X 0	X 1	X 0	X 0
01	11	10	1	1	1 X	1 X	X 0	X 1
10	11	10	0	1	X 0	1 X	1 X	0 X

S_0 $J_A = 1$ $K_A = X$

$J_B = X'$ $K_B = X a'$

x \ ab	00	01	11	10
0	X	0	0	X
1	X	1	0	X

K_B



KEY

2b)

S_1	~~S_2-S_4~~				
S_2	~~S_1-S_3, S_4-S_5~~	~~S_1, S_3, S_2-S_5~~			
S_3	X	X	X		
S_4	~~S_4-S_5~~	~~S_2-S_5~~	~~S_1-S_3~~	X	
S_5	X	X	X	~~S_2, S_5~~	X
	S_0	S_1	S_2	S_3	S_4

State Assignment guidelines:

(1) $(S_0, S_1, S_3, S_4, S_5)$, (S_1, S_3), (S_2, S_4, S_5)

(2) (S_1, S_4), $(S_1, S_2)^2$, (S_3, S_5), $(S_1, S_5)^2$

c \ ab	00	01	11	10
0	S_0	S_5	S_4	
1	S_3	S_1	S_2	

$S_0 = 000$
$S_1 = 011$
$S_2 = 111$
$S_3 = 001$
$S_4 = 110$
$S_5 = 010$

State	Next State $x=0$	Next State $x=1$
000	011	110
011	011	111
111	000	010
001	011	111
110	001	010
010	011	010

cx \ ab	00	01	11	10
00	0	0	0	X
01	1	0	0	X
11	1	1	0	X
10	0	0	0	X

A^+

$J_A = cx + b'x$

$K_A' = 0$

cx \ ab	00	01	11	10
00	1	1	1	X
01	1	1	1	X
11	1	1	1	X
10	1	1	0	X

B^+

$J_B = 1$

$K_b' = a' + c' + x$

$K_b = acx'$

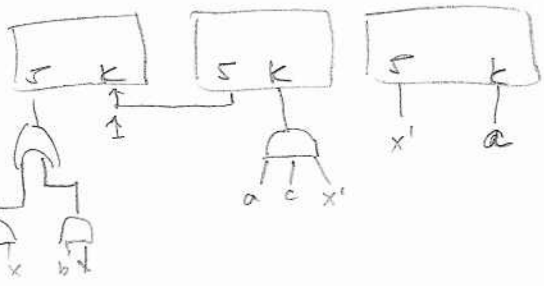
cx \ ab	00	01	11	10
00	1	1	1	X
01	0	0	0	X
11	1	1	0	X
10	1	1	0	X

C^+

$J_c = x'$

$K_c' = a'$

$K_c = a$



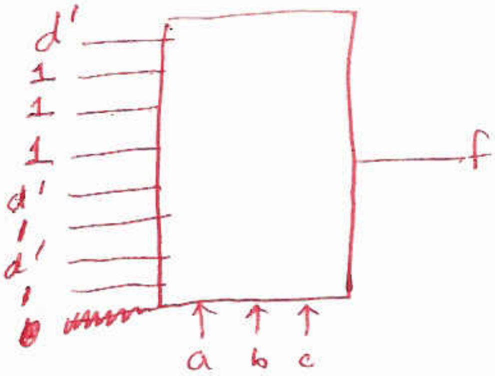
KEY

3. (a) $f(a,b,c,d) = a'b + cd + ab'c + d'$

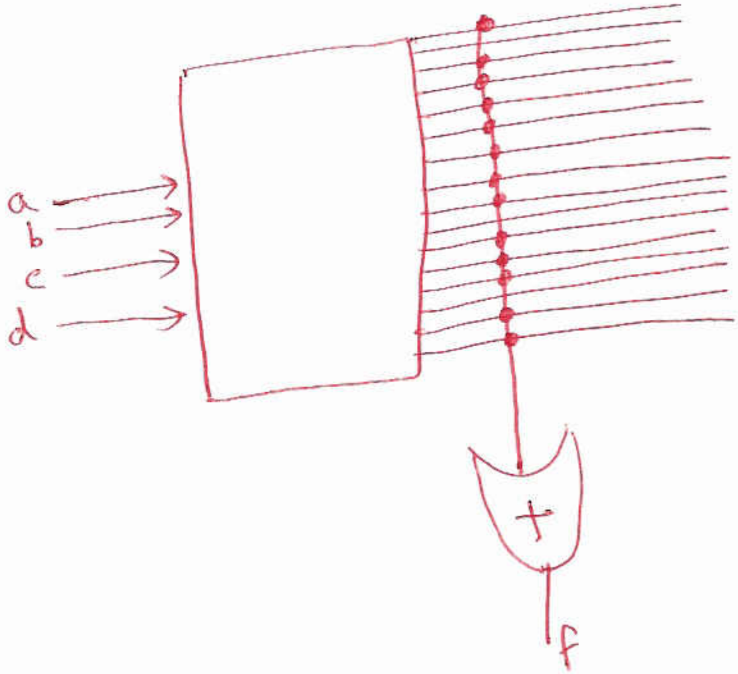
cd \ ab	00	01	11	10
00	1	1	1	1
01		1		
11	1	1	1	1
10	1	1	1	1

$= m(0,2,3,4,5,6,7,8,10,11,12,14,15)$

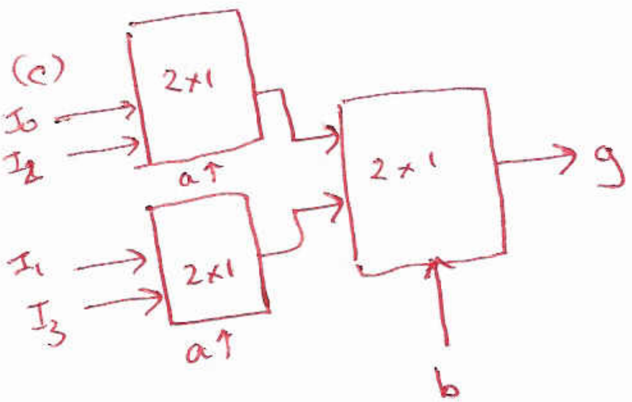
$= a'b'c'(d') + a'bc'(1) +$
$a'b'c(1) + a'bc(1) +$
$abc'(d') + ab'c'(d') +$
$abc(1) + ab'c(1)$



(b)



(c)



$g = a'b + bc + c'$

$= \cancel{a'b(1} \; a'b + abc + a'bc$
$+ abc' + ab'c + a'bc + a'b'c$

$= a'b'(c) + a'b(c+1+c)$
$+ ab'(c) + ab(c+c')$

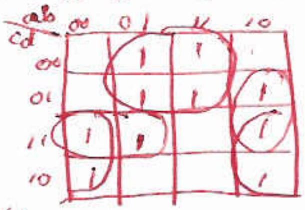
use $I_0 = c$, $I_1 = 1$
$I_2 = c$, $I_3 = 1$

4)

a) $(b'+c'+d)(a'+b'+c')(a+b+c)(b+c+d)$

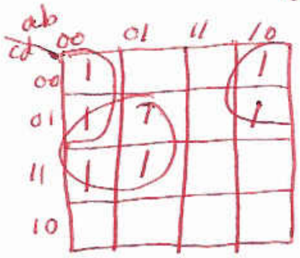
$(b'+c'+da')(b+c+ad)$

$b'c+b'ad+c'b+c'ad+da'b+da'c$



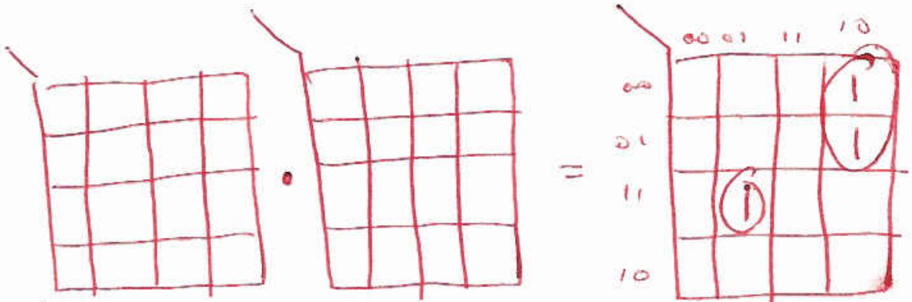
$= bc'+b'c+a'cd+ab'd$

b)



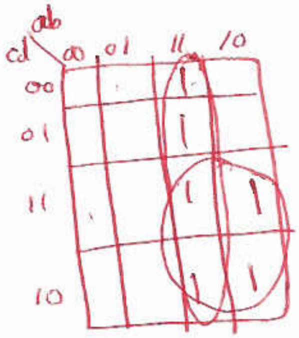
$= b'c'+a'd$

c)



$= a'bcd+ab'c'$

d)



$= \left(\sum m(0,1,3,5,10\ldots15)\right)\left(\sum m(2,4,6,10\ldots15)\right)$

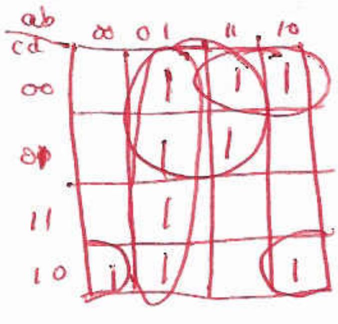
$= \sum m(10\ldots15)$

$= ab+ac$

e) $(a+b+c+d')(a+b+c+d)(b+d')(a'+b'+c')$

$(a+b+c)(a'b+bc'+d'a'+d'b'+d'c')$

$(abc'+ab'd'+ac'd'+a'b+bc'+a'bd'+bc'd'+a'bc+a'cd'+b'cd')$



$= bc'+a'b+b'cd'+ac'd'$

4)

F)

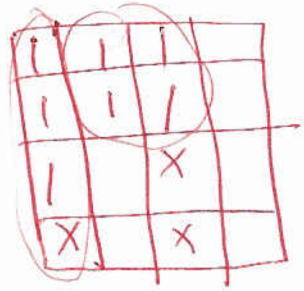
cd \ ab	00	01	11	10
00	1	1	1	1
01	1	1	1	1
11	1	1	1	1
10	1	1	1	1

$= 1$

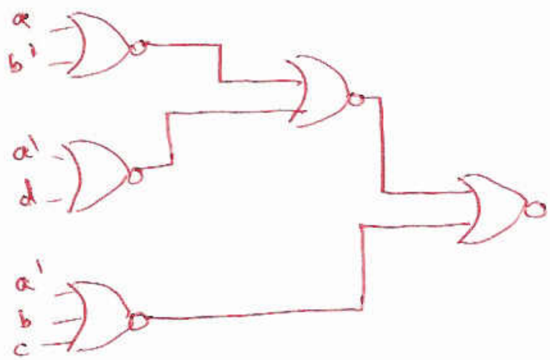
g) $wxy' + \left((w'y')'x + (w'y')x' \right)' + \left((w'y')'x + w'y'x' \right)$

$= \underline{xy' + wx' + w'y + yz'}$

5) a) Reduces to $a'b' + bc'$



b)



c) $z = \sum m(3, 5, 6, 9, 10, 12)$

$= \prod M(0, 1, 2, 4, 7, 8, 11, 13, 14, 15)$

d)

e) $(ab + ac + d)'(a + b + c)'(ad)'$

$((ab)'(ac)'d')(a'b'c')(a' + d')$

$((a'+b')(a'+c')d')(a'b'c')(a'+d')$

$(a' + b'c' \quad)(a'b'c'd' + a'b'c'd')$

$= \underline{a'b'c'd'} \cancel{+a}$