KEY

ECE 273 Final Exam

04.29.02 Version B

Name:
Honor Code:

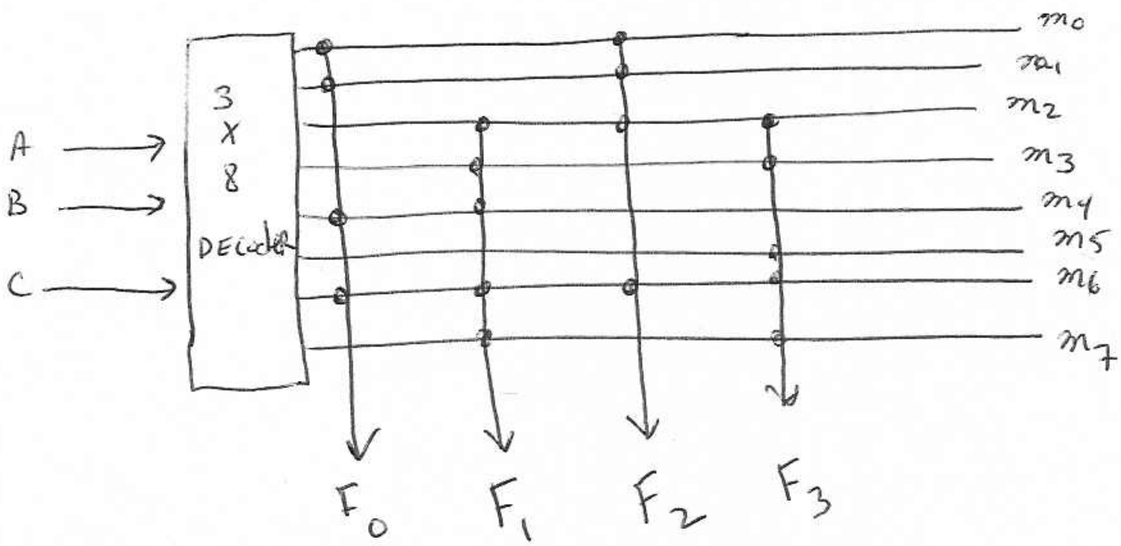
Instructions:

- As discussed in class, there are 5 problem categories resulting in 6 problems:
    - (15%) Complete state machine design (problem 5)
    - (19%) State assignment, minimization, and realization (problem 6)
    - (18%) Multiple-input / Multiple-output devices. (problem 1)
    - (25%) Various short minimization problems (problem 2)
    - (23%) Short problems for misc. topics (problem 3 and problem 4)
- Work the problems in the space provided. Do not use a bluebook. If you need additional paper, put your name on it and attach it to the exam.
- Make sure the location of your answers is clear (circle them if necessary).
- Each problem has a set number of points assigned to it, designated by a number in square brackets. Problems with subparts have the point value for each subpart similarly marked.
- If you're not sure about something, ***ask***. I will be happy to clarify, reword, or explain the intent of a question to you and the class. Someone else is probably wondering the same thing.
- Don't panic.

[18] 1. Complete the following problems dealing with multiple-input / multiple-output devices

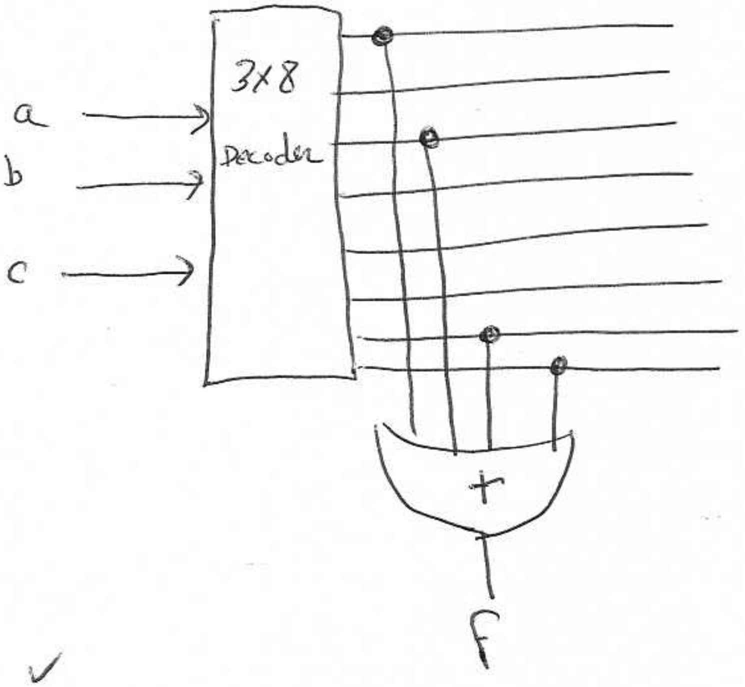
[10] (a) Show how to implement the following logic table using a ROM.

	Input				Output			
	A	B	C		F_0	F_1	F_2	F_3
0	0	0	0		1	0	1	0
1	0	0	1		1	0	1	0
2	0	1	0		0	1	1	1
3	0	1	1		0	1	0	1
4	1	0	0		1	1	0	0
5	1	0	1		0	0	0	1
6	1	1	0		1	1	1	1
7	1	1	1		0	1	0	1



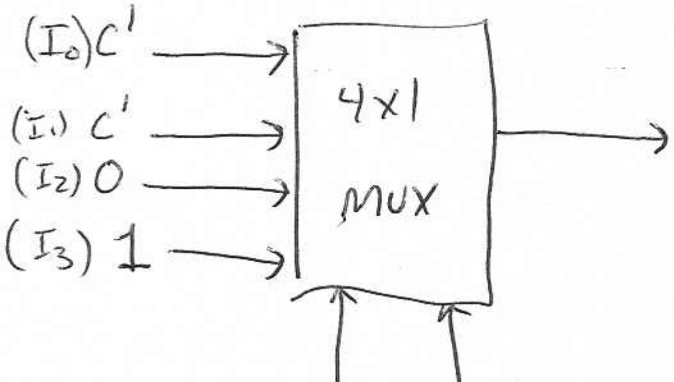
[4] (b) Show how to use a 3-8 Line Decoder to implement $f(a,b,c) = ab + a'c'$

$$= abc + abc' + a'bc' + a'b'c'$$
$$= \sum m(0, 2, 6, 7)$$



[4] (c) Show how to implement $f(a,b,c) = ab + a'c'$ using a 4x1 multiplexer.

$$= abc + abc' + a'bc' + a'b'c'$$
$$= ab(c+c') + a'b(c') + a'b'(c')$$
$$+ ab'(0) + \cdot$$



[25] 2. Simplify each of the following as directed [2.5 points each].Write your answers next to the question and use the following pages for your work.

Simplify to *minimum sum of products* form.

(a) $(A+B+C)(A'+B'+D')(A'+B'+C')(A+B+D)$

(b) $(A'+B+D)(A+C)(A+B'+D)(A'+C'+D')(A'+B)$

(c) $f(a,b,c,d)=\sum m(1,3,5,7,9,12)$

(d) $f(a,b,c,d)=\prod M(0,2,4,6,8,10,11)$

Write in *product of sums* form (doesn't need to be minimum POS form)

(e) $ab+a'c'+a'bc$

(f) $a'b'c'+abd+a'c+a'cd'+ac'd+ab'c'$

Write in *minterm* form (i.e. write as $f=\sum m(....)$)

(g) $f(a,b,c,d)=(abc'd+abcd+a'b'c'd'+abcd'+ab'c'd+ab'c'd'+a'bcd+a'b'cd)'$

(h) $f(a,b,c,d)=ab+c'd$

Write in *maxterm* form (i.e. write as $f=\prod M(...)$)

(i) $f(a,b,c,d)=[(a+b+c+d)(a'+b'+c+d')(a+b'+c'+d)(a+b+c'+d)(a'+b+c'+d)]'$

(j) $f(a,b,c,d)=(a+b)(c'+d)$

✓

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

$ab'+ac'+a'b+bc'+a'c+b'c$

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

$\{(x+y)(x+z)=x+yz\}$

$=(a+b+cd)\,(a'+b'+c'd')=ab'+ac'd'+a'b+bc'd'+a'cd+b'cd$

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

$\longrightarrow a'b+ab'+a'cd+ac'd'$

(b) $\underbrace{(a'+b+d)(a'+b)}_{(a'+b)}\ (a+c)\ \underbrace{(a+b'+d)(a'+c'+d')}_{}$

$(a'+b) \qquad (a+c) \ (ac'+ad'+a'b'+b'c'+b'd'$
$+a'd+c'd)$

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

$=(a'b'c+\cancel{a'b'cd'}+\cancel{a'b'cd'}+a'cd+$

$abc'+abd'+\cancel{abc'd}+$

$\cancel{abcd'}+a'bcd)$

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

$= \underline{abc'+a'cd+a'b'c+abd'+ab'cd}$

(c)

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

$= \underline{a'd+ab'c'd+abc'd'}$

(d) $f(a,b,c,d)=\sum m(1,3,5,7,9,12,13,14,15)$

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

$= \underline{ab+c'd+a'd}$

✓(e)

bc \ a	0	1
00	1	0
01	0	0
11	1	1
10	1	1

$f' = ab' + b'c$

$f = (a'+b)(b+c')$

(f)

cd \ ab	00	01	11	10
00	1	0	0	ϕ
01	1	1	1	1
11	1	1	1	0
10	1	1	0	0

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

✓

(g) $f = \left[\sum m(13, 15, 0, 14, 6, 8, 7, 3)\right]' = \sum m(1,2,4,5,9,10,11,12)$

✓

(h) $f = ab + c'd$

11XX XX01

$= \sum m(12,13,14,15,1,5,9,13) = \sum m(1,5,9,12,13,14,15)$

✓

(i) $f = \left(\prod M(0,13,6,2,10)\right)' = \prod M(1,3,4,5,7,8,9,11,12,14,15)$

✓

(j) $f = (a+b)(c'+d) = ac' + ad + bc' + bd$

cd \ ab	00	01	11	10
00	0	1	1	1
01	0	1	1	1
11	0	1	1	1
10	0	0	0	0

$f' = a'b' + cd'$

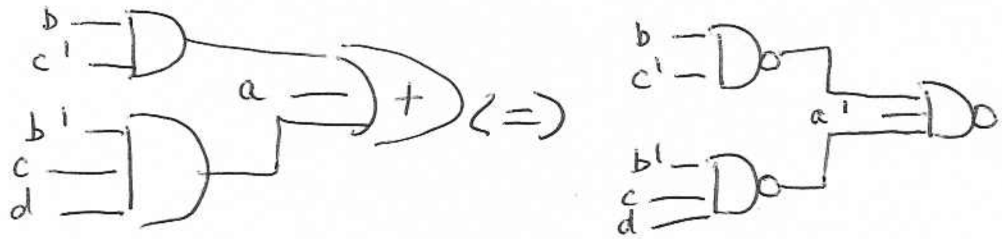
$f = (a+b)(c'+d)$

$= \prod M(0,1,2,3,4,6,10,14)$

$\cancel{= \prod M(5,7,8,9,11,12,13,15)}$

[15] 3. Work the following short problems

[3] (a) Draw a circuit diagram for $f = a + bc' + b'cd$ using only NAND gates.

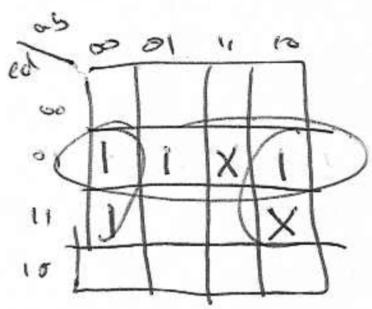


[3] (c) Given $f(a,b,c) = \sum m(0,1,2,3,6,7)$, find the minimum SOP form using the QM method.

Level I		Level II		Level III	
✓ 0	000	✓ (0,1)	00–	(0,1,2,3)	0––
✓ 1	001	✓ (0,2)	0–0	~~(0,2,1,3)~~	~~0––~~
✓ 2	010	✓ (1,3)	0–1	(2,6,3,7)	–1–
✓ 6	110	✓ (2,6)	–10	~~(2,3,6,7)~~	~~–1–~~
✓ 3	011	✓ (2,3)	01–		
✓ 7	111	✓ (6,7)	11–		
		(3,7)	–11		

$> a' + b$

[3] (d) Find a minimum SOP for $f(a,b,c,d) = \sum m(1,3,5,9) + \sum d(11,13)$



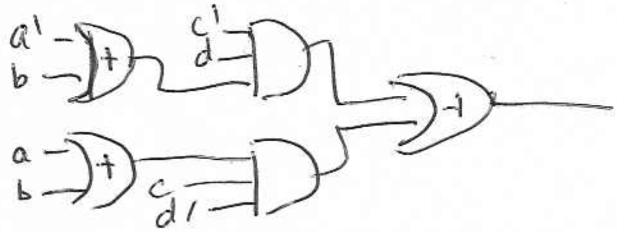
$= c'd + b'd$

[3] (e) Draw $f(a,b,c,d) = \sum m(1,5,6,10,13,14)$ using 3 OR gates and 2 AND gates by factoring.

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

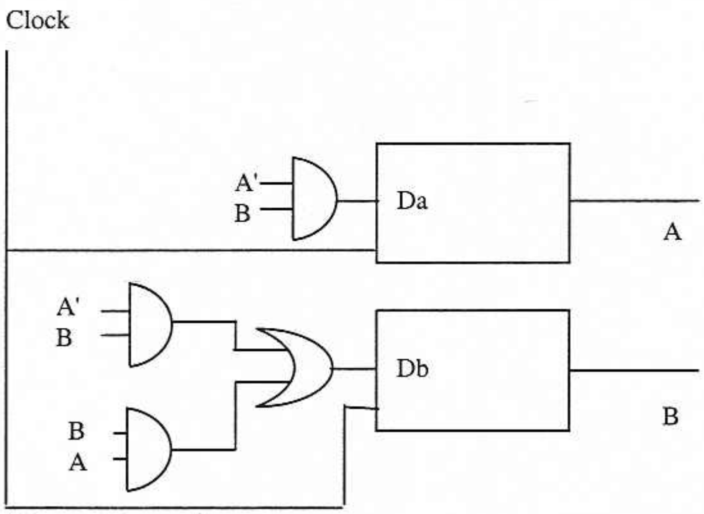
$= \cancel{a'c'd' + bc' + ac'd}$ $= a'c'd + bc'd + bcd' + acd'$

$= \cancel{c'(a'd' + b + ad)}$ $= c'd(a'+b) + cd'(a+b)$



(Clock)

[3] (f) Given the input sequence *X=011* and the initial state *AB=00,* write the output sequence ~~Z~~ A for the circuit below.



state 00 00 00

A = 0 0 0

[8] 4. Answer True of False [2 points each]. Write your answers next to the question; use the bottom of this page for your work.

T ✓ (a) An 8-1 MUX can implement any function of 3 variables.

T ✓ (b) $abc + ab'c' + b'cd + bc'd + ad = abc + ab'c' + b'cd + bc'd$

F ✓ (c) $(x+y)(y+z)(x+z) = (x'+y')(y'+z')(x'+z')$

F ✓ (d) If $f_1(a,b,c,d) = \sum m(1,3,5,7)$ and $f_2(a,b,c) = \sum m(1,3,5,7)$ then $f_1 = f_2$

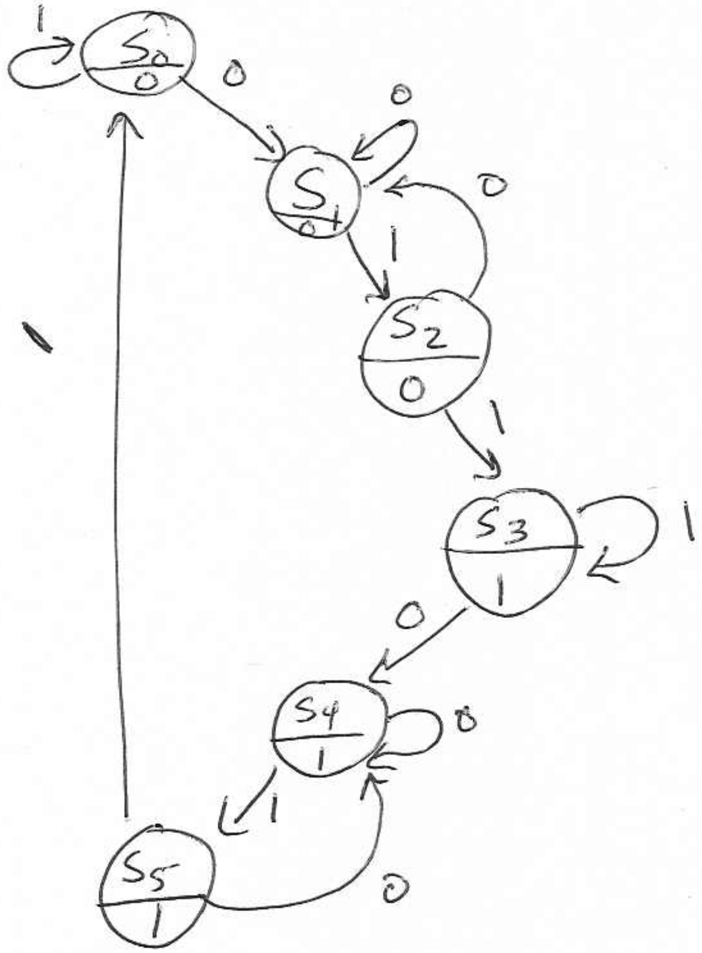
(b)

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

ad

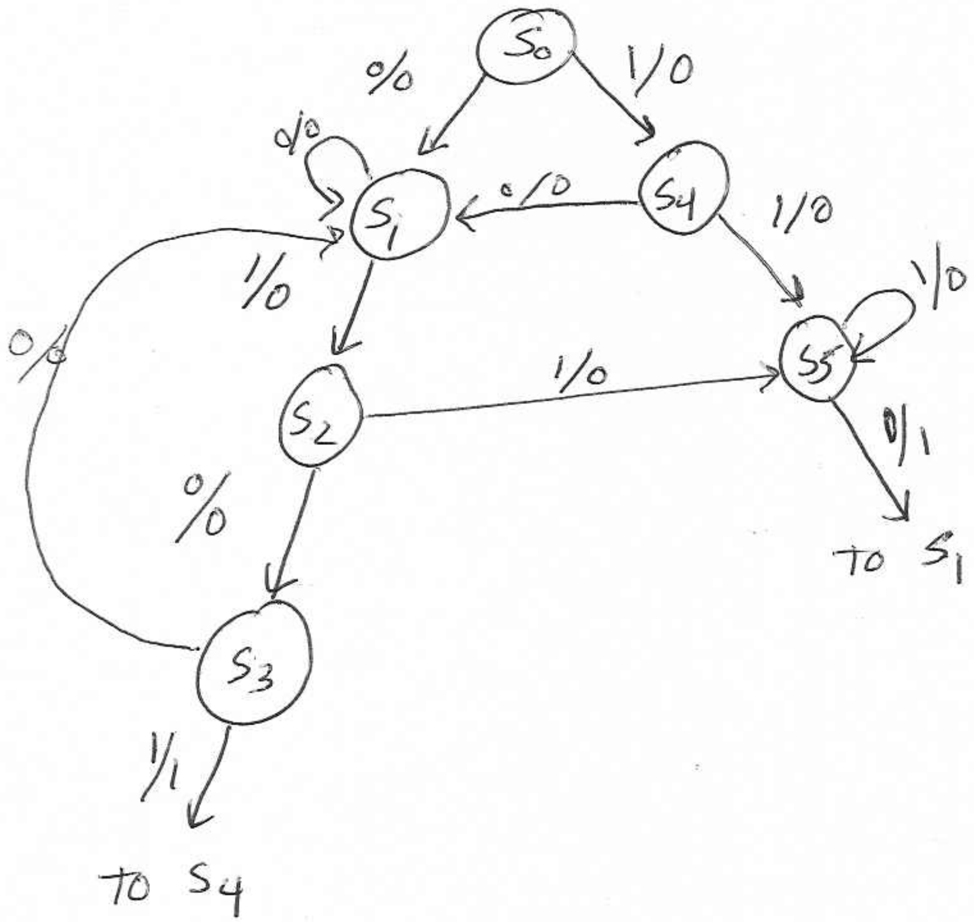
[15] 5. Design the following state machines. You need only draw a state graph and state table that meets the description.

[7] (a) Design a Moore machine that has one output bit (Z) and one input bit (X). When the input sequence 011 occurs, the output becomes 1 and remains 1 until 011 occurs again; at which time the output returns to 0. The output remains 0 until 011 is detected again, etc. You should be able to design this with 6 states.



	Next		output
S0	S1	S0	0
S1	S1	S2	0
S2	S1	S3	0
S3	S4	S3	1
S4	S4	S5	1
S5	S4	S0	1

[8] (b) Design a Mealy machine that detects the sequences 0101 and 110 simultaneously.



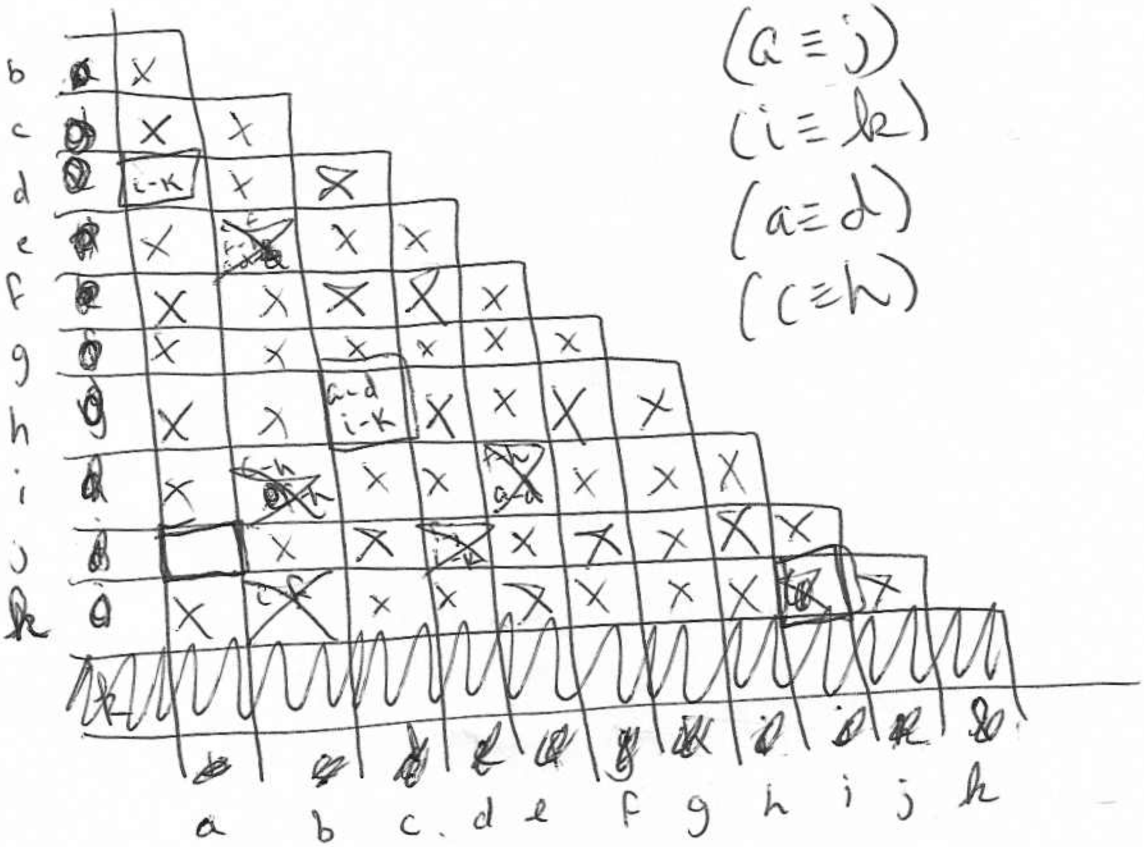
	Next		Output	
S_0	S_0	S_1	0	0
S_1	S_1	S_2	0	0
S_2	S_3	S_5	0	0
S_3	S_1	S_4	0	1
S_4	S_1	S_5	0	0
S_5	S_1	S_5	1	0

[19] 6. Given the state table

Present State		Next State					Output			
		X=00	X=01	X=10	X=11		X=00	X=01	X=10	X=11
a		a	a	g	~~k~~ i		1	0	0	0
b		c	f	g	~~d~~ a		0	0	0	0
c		g	c	a	i		1	0	0	0
~~d~~		~~a~~	~~d~~	~~g~~	~~i~~		1	0	0	0
e		f	~~h~~ c	g	a		0	0	0	0
f		~~d~~ a	c	~~d~~ a	~~K~~ i		1	0	0	0
g		c	a	g	e		0	1	0	0
~~h~~		~~g~~	~~h~~	~~d a~~	~~k i~~		1	0	0	0
i		~~h~~ c	~~d~~ c	g	~~d~~ a		0	0	0	0
~~j~~		~~j~~	~~j~~	~~g~~	~~k~~		~~1~~	~~0~~	~~0~~	~~0~~
~~k~~		~~c~~	~~e~~	~~g~~	~~d~~		~~0~~	~~0~~	~~0~~	~~0~~

✓

[9] (a) Find the minimum number of states and write the minimal state table.



(a ≡ j)
(i ≡ k)
(a ≡ d)
(c ≡ h)

[6] (b) Find a 'good' assignment of flip-flop outputs to states and explain your work.

[4] (c) Draw the circuit resulting from this assignment.