Name_____

Digital Logic Design
ECEN 3233

Exam 1
Spring 2003

Closed Book
One page, single sided, 8.5x11 inches,
handwritten (original) notes allowed

This exam consists of nine problems on eight pages
including the cover sheet. Be sure you have all the problems.

Read each question carefully. If something appears ambiguous, clearly state your assumptions. Clearly indicate each answer by enclosing it in a box. **Show <u>all</u> your work.**

By taking this exam you agree that all work is your own. All work is to be done on the attached sheets – use the backs only if necessary. Clearly identify your work. Write your name at the top of every sheet. Failure to follow instructions may result in a reduction in your score.

Start and stop work as instructed.

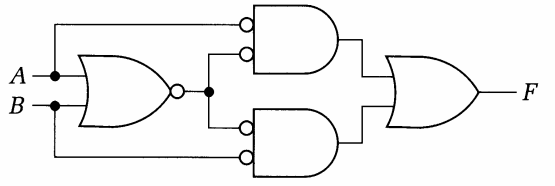
Do your own work!

Name_____

1. (20 points) Tell whether each of the following statements is either true (T) or false (F).

T	F	A NAND gate is equivalent to an OR gate with its inputs and its output complemented.
T	F	Karnaugh maps operate on the basis of the uniting theorem.
T	F	Multilevel circuit implementations will usually have more propagation delay than an equivalent SOP or POS implementation.
T	F	Any Boolean function can be represented using only NAND gates, only NOR gates, only XOR gates, or a combination of AND, OR and NOT gates, since these are all functionally complete.
T	F	Applying DeMorgan's law to a Boolean expression in POS form will give the complement of the expression in POS form.
T	F	The indices of a K-map are numbered using a gray code, which makes horizontal and vertical neighbors differ by exactly one bit.
T	F	The canonical POS and SOP forms of a Boolean expression result in at most a two level circuit.
T	F	Glitches are well described using Boolean algebraic equations.
T	F	The *fan-in* is the number of inputs a logic device can have, and *fan-out* is the number of inputs that a particular logic device can properly drive.
T	F	Static-1 hazards can occur in two-level SOP circuits.

2. (6 points) Using only AND, OR and NOT operations, write a Boolean expression in SOP form for *F*(A,B) as given in the circuit below. Do not perform any minimization.



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3. (8 points) Consider the Boolean expression for F below.

$$F(A,B,C) = AC' + AB'C + A(B+C)$$

Write F using standard canonical notation as a sum of minterms in this form: $F = \sum_{A,B,C,D}(?)$. Perform no minimization or simplification, just determine the *list* of minterms.

4. (8 points) Complete the truth table for G below.

$G = (AB + C)(AB'C + B'C')$

A	**B**	**C**	**G**
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

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5. (16 points) Given the four-variable K-map below:

CD \ AB	00	01	11	10
00	1	1	0	1
01	1	0	1	1
11	1	0	0	0
10	1	1	0	0

a) Write $\overline{F}(A,B,C,D)$ in minimized SOP notation.

b) Write $F(A,B,C,D)$ in minimized POS notation.

c) Write $\overline{F}(A,B,C,D)$ in minimized POS notation.

d) Write $F(A,B,C,D)$ in minimized SOP notation.

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6. (8 points) Consider the truth table below. W, X, Y, and Z are the inputs and A, B, C and D are the outputs. Determine minimized expressions for the output A in *sum of products* (SOP) form, and for the output B in *product of sums* (POS) form. Use the K-maps below. Show all your work.

INPUT				**OUTPUT**			
W	***X***	***Y***	***Z***	***A***	***B***	***C***	***D***
0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	1
0	0	1	0	0	0	1	0
0	0	1	1	0	0	1	1
0	1	0	0	0	1	0	0
0	1	0	1	x	x	x	x
0	1	1	0	x	x	x	x
0	1	1	1	x	x	x	x
1	0	0	0	0	1	0	1
1	0	0	1	0	1	1	0
1	0	1	0	0	1	1	1
1	0	1	1	1	0	0	0
1	1	0	0	1	0	0	1
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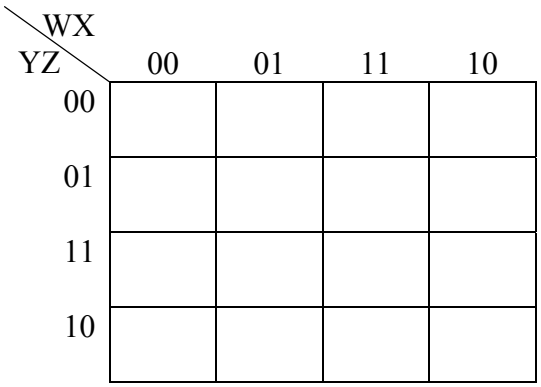
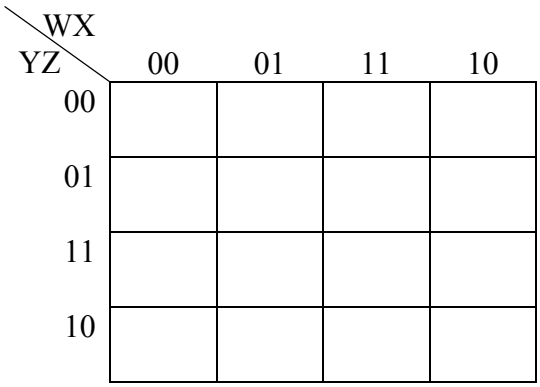
1	1	1	0	1	1	0	1
1	1	1	1	1	0	0	1



A =
(SOP)



B =
(POS)

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7. (10 points) Using the K-map below for some Boolean function G, show by example that the minimum SOP solution is not necessarily unique by finding two equivalent minimum solutions.

CD \ AB	00	01	11	10
00	1	0	0	1
01	0	X	0	1
11	1	1	X	0
10	1	1	1	1

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8. (10 points) Consider the four-variable function F(A,B,C,D), written in minterm form below. Determine a minimized hazard free SOP expression for F(A,B,C,D). Identify hazards and redundant prime implicants in the K-map, and clearly indicate any redundant terms in the solution by underlining them. Show your work.

$$F(A,B,C,D) = \sum m(0,1,4,5,6,11,14,15) + d(8)$$

CD \ AB	00	01	11	10
00				
01				
11				
10				

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9. (14 points) Use the Quine-McCluskey method to find the minimum sum of products form for the three-variable Boolean expression below. Show your work, including the tables you construct. Clearly indicate the prime implicants and essential prime implicants in the prime implicant chart. Do not use K-maps for any part of the solution.

$$f(A,B,C) = \sum m(0,1,2,3,5) + d(4)$$