M51A MIDTERM
– closed books and notes –
(6 problems, 110 minutes)

July 23, 1999

Name: _____

Problem	Points	Score
1	6	
2	5	
3	9	
4	5	
5	5	
6	10	
Total	40	

Problem 1. (6 points)

a) Show algebraically that the following expressions are equivalent.

$E_1(x_3, x_2, x_1, x_0) = x_2' x_0' + x_1' x_0 + x_2' x_1' + x_3 x_2 x_0$

$E_2(x_3, x_2, x_1, x_0) = \sum m(0, 1, 2, 5, 8, 9, 10, 13, 15)$

b) Give the product of maxterms for $E_1(x_3, x_2, x_1, x_0)$.

Problem 2. (5 points)

Determine if the following circuit is valid. If it is, obtain the switching function it implements. Assume the positive logic. Give a sum of product expression for the output. HINT: derive first expression for point X.

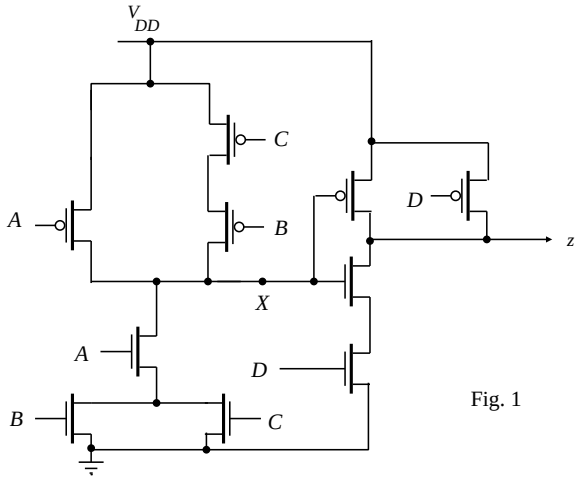

Fig. 1

Problem 3. (9 points)

a) With the help of Table 1, determine the worst case propagation delay of the network shown in Fig. 2. (Need to obtain Low to High and High to Low delays to determine the worst case.) Assume that each network output is connected to an input with load factor of 1.

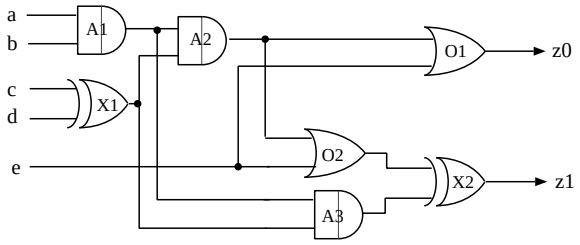

Fig. 2

Table 1: Characteristics of CMOS gates

Gate type	Fan-in	Propagation delays		Load factor	Size
		t_{pLH} [ns]	t_{pHL} [ns]	[standard loads]	[equiv. gates]
AND	2	$0.15 + 0.039L$	$0.18 + 0.019L$	1.0	2
OR	2	$0.14 + 0.039L$	$0.22 + 0.021L$	1.0	2
XOR	2	$0.32 + 0.038L$	$0.32 + 0.023L$	1.1	3

b) Determine the equivalent size of the network.

Problem 4. (5 points) Find minimal sum of products and product of sums expressions for the switching function specified as:

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

Show all your work. Does this function have a unique minimal sum of products? A unique product of sums?

Problem 5. (5 points)

Obtain a minimal two-level NAND-NAND network for the function implemented by the network shown below.

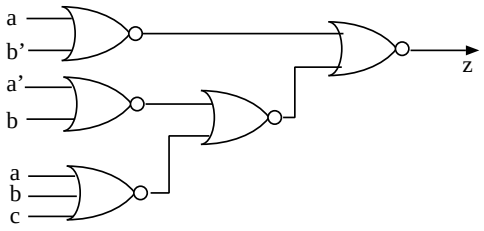

Fig. 3

Problem 6. (10 points)

Design a network to convert $x = (x_3, x_2, x_1, x_0)$ in BCD code, i.e., $x \in \{0, ..., 9\}$ to $y = (y_3, y_2, y_1, y_0)$ in Excess-3 code, i.e., $y \in \{3, ..., 12\}$

a) Derive minimal sum of products expressions for the outputs. Show all your work

b) Implement your expressions from part a) using NAND gates.