Lecture Section: _____

Student Name or **ID Number**

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DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

ENEL 353 - Digital Circuits

Midterm Examination

Thursday, November 3, 2005
Time: 5:00 - 6:30 PM

Instructions:

- Time allowed is 90 minutes.
- The examination is closed-book.
- Non-programmable calculators are permitted.
- The maximum number of marks is 50, as indicated; the midterm examination counts 15% toward the final grade.
- Please use a pen or heavy pencil to ensure legibility.
- Please answer questions in the spaces provided; if space is insufficient, please use the back of the pages.
- Please show your work; marks will be awarded for proper and well-reasoned explanations.

Name: ______________________________, *ID:* __________________

1. **[10 marks total.]**

   (a) **[6 marks.]** Represent the following numbers using 6-bit 2's-complement format and perform the addition. Indicate in each case if an overflow occurs, and why.

   (i) $(-12_{10}) + 13_{10}$

   (ii) $(-14_{10}) + (-32_{10})$

   (b) **[2 marks.]** Consider the number -37_8. Give the 6-bit sign-magnitude and 2's-complement binary representations of this number.

   (c) **[2 marks].** Add the decimal numbers 91 and 19 using BCD arithmetic.

2. **[8 marks total (4 marks each).]** Consider the following two logic expressions:

$$f = (x + y)(x' + z)$$
$$g = xz + x'y$$

Prove or disprove that f and g are equivalent in the following two ways.

(a) By expanding each expression to its canonical SOP form (f and g are equivalent if there canonical forms are identical).

(b) By direct algebraic manipulation *without* using a K-map, a truth table, or your canonical forms from part (a).

3. **[20 marks total.]** A function F of four variables x_1, x_2, x_3 and x_4, is given by the Karnaugh map:

x_3x_4

$x_1x_2 \backslash$

1	0	0	1
0	1	0	0
0	0	1	0
1	0	0	1

(a) **[2 marks.]** Find a minimal SOP algebraic expression using this map.

(b) **[2 marks.]** Find a minimal POS expression using this map.

Note: *For this and all remaining parts of this problem, you may assume that the variables and their complements are available to your circuit.*

(c) **[4 marks.]** Draw the logic diagram of an *AND-OR* circuit implementation corresponding to the simplest (i.e., lowest "cost") of your answers to parts (a) and (b) above. Use only 2-input gates in your drawing.

(d) **[4 marks.]** Using algebraic transformations and/or circuit manipulation, implement the circuit you drew in part (c) using 2-input NAND gates only (inverters are not available).

(e) **[4 marks.]** Using algebraic transformations and/or circuit manipulation, implement the circuit you drew in part (c) using 2-input NOR gates only (inverters are not available).

(f) **[4 marks.]** Implement the logic function F using 2-to-4 decoders. You may use any additional AND, OR, and NOT gates as necessary.

4. **[12 marks total.]** Design a circuit with four inputs x_3, x_2, x_1, x_0 (x_3 is the MSB) and four outputs y_3, y_2, y_1, y_0 (y_3 is the MSB) that implements a BCD-to-Gray code conversion.

   (a) **[4 marks.]** Create the truth table for the circuit's four outputs.

   (b) **[8 marks.]** For your answer to part (a), give minimal SOP expressions for each output suitable for the simplest-possible multiple-output circuit implementation. Carefully indicate shared product terms (if any) that can be used. (It is not necessary to draw the circuit.)