CS 210 Homework 4

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DUE: Monday, April 30, 2012

This assignment serves as a midterm review. Expect topics such as the following on the test.

1. (a) Construct a circuit which implements the expression $ab+cd$ using only `NAND` gates. Give a clearly-labeled logic diagram drawn in Logisim. Be sure to label your input pins (a, b, c, d) and output pin ($ab + cd$).
   (b) Give the exact Boolean expression that your circuit diagram from 1a implements (note that "x `NAND` y" is represented by $(xy)'$).
   (c) Using algebraic inference, show that your expression from 1b is equivalent to $ab + cd$. **Justify** each step.
   (d) Using a truth table, show that your expression from 1b is equivalent to $ab + cd$.
   (e) Using the algorithm from page 19 of the notes, convert $ab + cd$ into a canonical sum of minterms (where the minterms have 4 literals each). Show your work.
   (f) Draw a 4-variable Karnaugh map for the expression $ab + cd$. Verify your answer to 1e by reading off the sum of minterms directly from the Karnaugh map.
2. (a) Convert $(-\texttt{42})_{10}$ to signed 2's complement form. Assume your numbers are represented by **8**-bit values. Verify your answer by converting the bit pattern back to base 10 (see page 7 of the notes).
   (b) Let your answer for 2a be M, and let N be represented in signed 2's complement by the bit pattern `11101110`. Compute $M - N$ using signed 2's complement arithmetic.
   (c) Verify your answer for 2b by converting the numbers to base 10 and checking that the difference is correct.
   (d) Compute the same difference as in 2b, but this time suppose that the bit patterns represent **unsigned** binary numbers, and subtract using the algorithm from page 6 of the notes. Verify your answer, and compare it to your result for 2c.
   (e) Compute the decimal values of the bit patterns for M, N, and $M - N$ from 2b assuming they represent numbers in **signed magnitude** format. Is the result of $M - N$ still correct in this interpretation?