The UNIVERSITY *of* NORTH CAROLINA *at* CHAPEL HILL

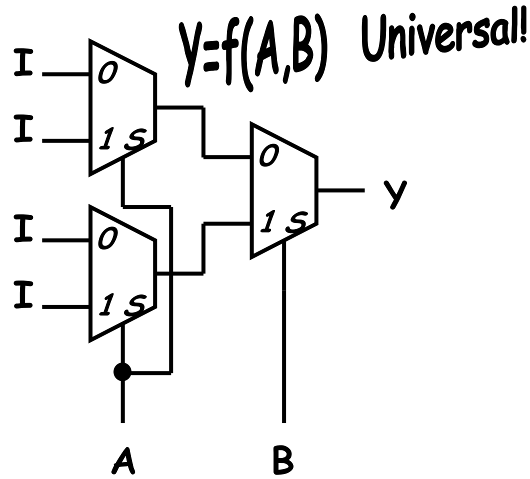
Comp 411 Computer Organization
Spring 2007

Problem Set #5
Issued Thursday, 2/22/07; Due Thursday, 3/08/07

Homework Information: Some of the problems are probably too time consuming to be done the night before the due date, so plan accordingly. Late homework will not be accepted. Feel free to get help from others, but the work you hand in should be your own.

Problem 1. Mux Madness

During a particularly boring Comp 411 lecture about the universality of NAND and NOR gates, Chris suddenly realizes that multiplexers are also universal. At the close of lecture he awakes and jots the following diagram on the back of his lecture notes:



Help explain Chris' insight.

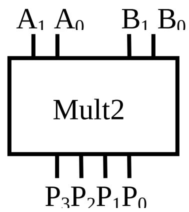
a) Give binary values for I_0, I_1, I_2, and I_3 which implement the following functions on the two inputs A and B: AND(A,B), OR(A,B), XOR(A,B), NAND(A,B), and NOR(A,B).
b) Can every 2-input Boolean function be implemented using Chris' structure? Explain why or why not.

The next day, in an effort to impress his TA, Chris attends office hours and explains his discovery. He decides to make his point by constructing several standard gates using his structure. Not to be out done, the TA claims that he could build each 2-input gate using only 2 multiplexers.

c) Show how to implement an inverter, as well AND, OR, XOR, NAND, and NOR using no more than 2-multiplexers to construct each one.

Problem 2. "Go Forth and Multiply"

a) Design logic to perform the multiplication of two, 2-bit unsigned integers producing a 4-bit result (Hint: write a truth table for each output bit). Draw a gate-level-circuit diagram.
b) Assume that the 2-bit multiplier that you designed in part a) is represented as the following function block:



Use this function block and single-bit full-adders to build a 4-bit multiplier (a multiplier that takes 2, 4-bit inputs and generates an 8-bit result).

c) Design logic to compute the square of a 2-bit unsigned integer. How does this circuit compare to the one you designed in part a)?