Systems I
Fall 2012
Sample mid-term exam

This is a closed-book, closed-note exam. Answer all of the questions **clearly, completely, and concisely**. You have 50 minutes, so be sure to use your time wisely. All work should be written in your blue book. If a question's intent is ambiguous, then **don't make assumptions; rather, ask me to clarify the question** for you.

1. Recall that we devised, in class, a function capable of "remembering" a value, such that its output Q would be **set** ($Q = 1$ when $S = 1$), **reset** ($Q = 0$ when $R = 1$), or retain its old value when neither S nor R is asserted (Q is whatever it was). Specifically, we created a truth table that used Q as both input and output:

Q	R	S	Q
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	x
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	x

   We then wrote the *disjuntive normal form (DNF)* of this function. I then claimed that this function was equivalent to a pair of cross-coupled NOR gates. **Show, *algebraically*, that the DNF expression of this function above is equivalent to the cross-coupled NOR gates**.

2. In a recent lab, you built a multiplier that was based on *sequential logic*—that is, a clocked sequence of logic operations calculated the product of two 4-bit, unsigned values. Now, you must **design a combinational multiplier**. That is, you must **draw a circuit** that uses no registers and no clock, but rather computes the product of two 4-bit, unsigned values via a circuit that takes an input and calculates its output in a single, direct step.

   Assume that you have, at your disposal, high-level components such as 4-bit adders, multiplexers, etc.

3. Your friends have been breaking into your dorm room and pulling pranks on you: stealing all of your clothes while you were in the shower was the last straw. Locking the door doesn't work, since one of them has a lock-pick set and knows how to use it. You want to add a deadbolt, but Physical Plant won't let you drill a hole in their nice door. So, you've decided to go the homebrew electronic route.

   You have powerful magnets that can hold the door shut. You want to design your own circuit that will allow you to enter a passcode to disable the magnets, thus unlocking the door when you need to get in. You mount, outside your door, a single toggle switch (labeled 0 and 1) and a single button. To unlock the door, you want a circuit that will require a person to enter a sequence of 1-bit numbers, where entering a number requires setting the switch to 0 or 1 and then pressing the button.

   Specifically, when your circuit emits a 0, the magnets remain active and the door remains locked. To unlock the door, you want a person to have to enter a sequence of k 1-bit values. As soon as the k^{th} value is correctly entered, your circuit sets its output to 1, disabiling the magnets. You choose $k = 8$, and specifically choose the sequence: $0, 1, 1, 0, 0, 1, 0, 1$.

   (a) Design and draw this circuit, based on the description above. Again assume that you have appropriate high-level components available to use.

   (b) Is $k = 8$ big enough for this locking mechanism to really help you? If not, what would make a better k?