Homework Assignment #5
Due in the box labeled 42/100 on the 1st floor of Cory, 5pm Friday, 3/8/2013
Make sure to clearly label your Name, Student ID, Class, and Discussion sections on the homework.

1. DC-DC converter. You have 10 capacitors, each 1F. If you charge them in parallel from a 5V power supply, and then disconnect them and reconnect them in series:
   a. What is the equivalent capacitance seen by the power supply while charging?
   b. What is the equivalent capacitance of the series combination?
   c. What is the voltage across the equivalent series capacitor?
   d. How much charge can the series combination deliver to a load (such as a resistor) before the voltage drops by 10%?
   e. Assume that you have a bunch of switches that let you change between the parallel and series configurations quickly, and that the switching time and charging time are negligible. If you charge and discharge 10 times per second, what is the average current that you would deliver to a load with the constraint from part d?

2. The two RC circuits below are driven by a voltage step from 0 to 1V at t=0. If R=1kΩ and C=1nF, sketch the step response of each circuit on three different time scales: 1ns, 1μs, 1ms.

3. Digital integrated circuits often have very non-uniform current requirements which can cause voltage noise on the supply lines. Here's a simple model for a power supply and digital circuit.

The current source is modeling the "spikey" nature of digital circuit current consumption. The resistor represents the sum of the source resistance of the supply and any wiring resistance between the supply and the load. The capacitor is added to try to minimize the noise on VDD. Assuming that V_S=3V, R=1Ω, i_o=1A, T=10ns, and t_p=1ns
   a. Sketch the voltage VDD vs. time for one or two periods T assuming that C=0.
   b. Calculate the total charge consumed in each current spike, and the average current consumption.
   c. Sketch the voltage VDD vs. time for one or two periods T for each of three different capacitor values: 1pF, 1nF, 1μF.

4. On a single sheet of graph paper with a logarithmic horizontal axis from 1rad/sec to 10^9 rad/sec, and a logarithmic vertical axis from 1Ω to 1GΩ, carefully draw the magnitude of the impedance vs. frequency for a 1kΩ and 1MΩ resistor, inductors of values 1H, 1mH, and 1μH, and capacitors of values 1uF, 1nF, and 1pF.

5. For the circuits in problem 2, if the input is a 1V sine wave with a frequency of 1Mrad/s, sketch a single cycle of the input and output waveforms.