Homework Assignment #8v2
Due in the box labeled 42/100 on the 1st floor of Cory, 5pm Wednesday, 4/17/2013
Make sure to clearly label your Name, Student ID, Class, and Discussion sections on the homework.

1. How many bits do you need to represent the number of seconds in: a minute, hour, day, month, year, millenium, and since the big bang (estimated to be around 14 billion years)?

2. Look on the datasheet for the 74LV04 Hex inverter chip (http://www.ti.com/product/sn74lvc04a) and find
   a. under Recommended Operating Conditions, the high-level (logic 1) input voltage $V_{IH}$ and low-level (logic 0) input voltage $V_{IL}$ for operation from a supply of $V_{CC}=1.65$ to 1.95V (this will be a percentage of $V_{CC}$, as described in class)
   b. under Electrical Characteristics, what is the guaranteed minimum output high-level voltage $V_{OH}$ and maximum output low-level voltage $V_{OL}$ from -40 to +125C when the chip is run from 1.65 to 3.6V with an output current ($I_{OH}$ or $I_{OL}$) smaller in magnitude than 100$\mu$A?

3. You have an ADC that samples at 1kS/s (sample per second). You sample a 1.1kHz sine wave with an amplitude of 1.
   a. What are the first six samples that you take?
   b. Can you tell from those samples that this is a 1.1kHz sine wave?
   c. If not, what does it look like?

4. You have built a pressure sensitive input on a musical toy. The sensor is in a resistive voltage divider (as discussed in class) where the pressure sensitive resistor is roughly 2k$\Omega$, and the reference resistor is the same size. You only care about slow input signals from the user (1Hz or less), so you write the software on a microprocessor to sample this signal three times per second.
   a. What is the Nyquist frequency, below which you can reconstruct the user's input?
   b. With an oscilloscope you measure the voltage on the output of the bridge, and find that in addition to the desired signal, there's about 10mV of noise at 60Hz. This noise comes from the power supply, and you should assume that it has the worst possible phase relative to your ADC sampling. Will the noise affect what the software gets from the ADC, and if so, why and how (be specific, e.g. "worst case a 1mV sine wave at 27Hz")?
   c. You add a capacitor on the output of the voltage divider to act as an anti-aliasing filter. What value should you choose to put a pole at 1Hz (note: Hz, not rad/sec)?
   d. When playing the instrument, sometimes the user pushes down and then varies the pressure. This results in a signal that is 10mV+10mVsin(2$\pi$t), and you still have the 10mV of noise at 60Hz. What is the output of the anti-aliasing filter (write an expression with three terms: DC, 1Hz, 60Hz)?
   e. What signal does the software see after the ADC has sampled the signal in part d? If this signal is used directly to control the sound from the instrument, do you think that anything here will bother the user?

5. The unit cell in the silicon crystal has 8 atoms (4 internal, 1/2 on each of six faces, and 1/8 in each of 8 corners) as shown for example in Figure 1-2 of Prof. Hu's book (linked from syllabus). Using this, and the size of the unit cell from the figure, calculate the number of silicon atoms in a cubic micron, and the approximate spacing of atoms on one of the faces of the cube (center atom to corner atom).

6. Take a look at the TEM (transmission electron microscope) cross-section of the Intel 22nm FinFET in figure 8 of this link: http://www.electroiq.com/blogs/chipworks_real_chips_blog/2012/04/intel-s-22-nm-trigate-transistors-exposed.html FinFET technology, developed and patented by Cal professors in EECS, has been in production for over a year now. Now looking at my silicon crystal model, http://www-bsac.eecs.berkeley.edu/~pister/crystal.pdf you should be able to identify which face you’re looking at just from the arrangement of the atoms. Estimate the width of the fin at the base, in atoms, and nanometers.