EECS 277C *Nanotechnology*
Problem Set #1

1) Using Moore's law, and available empirical data from Moore's most recent ISSCC presentation, calculate the year in which the size of a transistor will be the size of a single atom. Do you expect this to occur in your lifetime?

2) Compare the number of bits that are contained in a single human cell in the form of DNA to the amount of memory in you home computer. Which has more information storage capacity, a single cell or your home computer? Which has more information density?

3) Estimate the gate capacitance of a modern transistor. Now, calculate how much energy it costs to add one electron to the gate (e^2/C). Is this energy larger or smaller than a typical thermal energy (k_BT)?

4) Calculate the density of states in a 2 dimensional world.

5) Calculate the density of states in a 1 dimensional world.

6) Calculate the probability for an electron to tunnel through a 1 nm barrier that is 10 eV high. This is a good approximation for the tunnel junction shown in class.

7) Calculate the Fermi energy for a piece of aluminum. Calculate the quantum mechanical wavelength of an electron with energy equal to the Fermi energy. (Hard unless you know quantum mechanics).

8) For a 2 dimensional electron gas in GaAs with a density of 10^{11} cm^{-2}, calculate the Fermi energy and the Fermi wavelength. (This will be important when we discuss quantum dots and quantum point contacts.)

9) In figure 4 of Giaver's Phys Rev paper, the I-V curve is not a straight line. Can you think of reasons why?

10) How does the R_T C time of a tunnel junction depend on the area of the junction?

11) Estimate the R_T C time for the tunnel junction measured in class.

12) For a tunnel junction which exhibits Coulomb blockade at 1K, estimate the R_T C time.