Homework 1: **Due TUESDAY Oct. 2 at 5pm in my mailbox (in the chemistry mail room on the first floor of Bagley just outside the main office)**

For some of you this will be review. For others parts will be new. You should still work all of it.

Note: All Levine Problems reference the *5th Edition*

All students should make sure they have 24 hours access to a copy of Maple ASAP. See: http://www.washington.edu/computing/software/sitelicenses/maple/
I VERY STRONLGY recommend you run it in "Classic Worksheet Maple" mode rather than the Document worksheet mode (it is faster AND more stable). On some versions (e.g. Mac) this means running it in "Worksheet" rather than "Document" mode. If you have a choice of using a Mac or a PC—USE A PC. Undergraduates will need their own copy of Maple, or (as a secondary, less desirable alternative) finding a campus lab with Maple that is open during hours compatible with their class schedule.

Levine Problems: (Use Maple whenever possible)

Problems: 1.7, 1.8, 1.29

Additional Problems: from basic units to Diff Eqns and Fourier Series, don't judge them all by the first few

1) a) Calculate ν, and the energy (in eV) per photon for radiation of wavelength 500 nm.
   b) What is the wavelength of a photon with twice this energy?
   c) For the waves in (a) and (b) express the units in terms of reciprocal centimeters (cm^{-1} [sometimes still called wavenumbers])
   d) What 'color' are these photons?
   e) What is the energy in eV of a photon that would be absorbed by a C=O carbonyl stretch?
   f) What kind of instrument would you use to record a spectrum containing the peak in part e)?
   g) What are general (easily memorized) formulae for converting
      i) a photon energy in nm to an energy in eV?
      ii) a photon energy in cm^{-1} to an energy in eV?

2) Suppose that a 100W source radiates 600 nm light uniformly in all directions. Assuming that the human eye can detect this light if only 20 photons per second enter a dark-adapted eye with a 7-mm diameter pupil. How far from the source can the light be detected under these conditions? Why do you think can't we see this far in the "real world"?

3) Qualitatively explain what limits the resolution of an optical microscope. Explain why an electron microscope can image objects with higher-resolution than an optical microscope? Estimate (with a De Broglie calculation) to within about a factor of ~10 the best resolution that could be expected from a transmission electron microscope (TEM) that accelerates electrons with a potential of 200 kV assuming the microscope optics are 'perfect.' If you don't know special relativity you have the option of ignoring relativistic effects for this problem--although these electrons are traveling fast enough that an accurate calculation would account for special relativity. In the real world TEM resolution is limited by aberrations in the electromagnetic lenses, stray electromagnetic fields, vibrations and other practical considerations. Interesting reading on this topic is available at:
http://www.physik.tu-dresden.de/iapd/downloads/publications/lichte.2000.3a.pdf
http://www.lbl.gov/today/2004/May/21-Fri/MAOkeefe_lab_design.pdf

4) The equation of motion for the classical simple harmonic oscillator is given by:

$$\frac{d^2x}{dt^2} + \omega^2 x(t) = 0 \quad (\text{where } \omega = \sqrt{\tfrac{k}{m}})$$

Solve this differential equation to find $x(t)$ for the time $t=0$ initial (boundary) conditions $x(0)=A$, $x'(0)=v_0$

5) The classical 1D wave equation (i.e. which described the motion of a 1D guitar string) is:

$$\frac{\partial^2\psi(x,t)}{\partial x^2} = \frac{1}{c^2}\frac{\partial^2\psi(x,t)}{\partial t^2}$$

Where $\psi(x,t)$ is the classical wave-function giving the amplitude of the wave at position x and time t, and c is the speed of the wave.

5a) Use the method of the separation of variables to find the solution to the classical wave equation.

5b) Consider a string with c=1 m/s with ends fixed a x=0 and x=6π m. At time t=0, someone stretches the string into the square bump described by:

$\psi = 0$ |x-3π| > π/2 m

$\psi = \frac{1}{\sqrt{\pi}}$ |x-3π| < π/2 m

Given the solution to the classical wave equation. Find the coefficients of the Fourier series solution describing this initial state. Plot the square of the coefficients versus frequency.

5c) Use the Maple **animate** command to generate a movie of the resulting wave motion. Include printouts of the wave at different times.