C455A - Homework 5
Due Mon Oct 30 at **5PM in the Professor's MAILBOX**

Circle your answers. Submit your problems in order. *Staple your work together*.

Text Problems

Q7.2 – concepts on 2D rotation
Q7.6 - concepts on SHO wave functions
P7.13 Comparing mean square displacement with bond length.
P7.16 – S.H.O. energies compared to KE of gas
P7.22 – orthogonality of rotational eigenfunctions
P7.23 – angular momentum operators and their commutator
P7.24 – populations of vibrational and rotational states at room temperature.
P7.28 – Compute commutators for angular momentum. Also answer, *what does this tell you about our ability to measure projections of angular momentum about two separate axes simultaneously?*

Additional Problems

1) Use Excel or another computer package to plot the Morse potential and the corresponding H.O. potential on the same graph. (in other words, make your own Fig. 7.1).

2) Check that the spherical harmonics are solutions to the 'particle on a sphere' problem for (l=0, m=0), and (l=1,m=1) by substituting them into the time-independent Schrödinger equation for the particle on a sphere. Verify that the energies in each case are given by $E = \frac{\hbar^2}{2I} l(l+1)$

3) Show that the spherical harmonics are eigenfunctions of L^2 and L_z (l=0, m=0), and (l=1,m=1) cases. Show that the eigenvalues are $\hbar^2 l(l+1)$, and $m\hbar$ in each case. (pg 115)

4) When we worked the particle in the 3D box (p74 of the text), we encountered degenerate energy levels for the first time. The particle on a sphere is a similar "high symmetry" problem, so we should again expect to encounter degeneracy.
a) Make an energy level diagram for the spherical harmonics as a function of m and l for l=0 to l=3. What is the degeneracy of each level?
b) Make a sketch (plotting absorbance vs. wavenumber) of what a rotational spectrum of a gas at room temperature might look like.

5) The l=0 to l=1 transition for carbon monoxide ($^{12}C^{16}O$) occurs at a microwave frequency of 1.153×10^5 MHz. Using the rigid rotor approximation and this information, calculate the bond length of carbon monoxide.