Physics 140A: Homework Problem Set 4

Assigned 1/25/05. Due 2/1/05.

1. Diatomic Molecule Vibration. 10 points.
Consider two identical atoms of mass M connected by a spring of force constant K. Only the stretch mode ("bond stretching") motion is to be considered (no rotation). Thus this is a one-dimensional problem.
(a) Write the potential energy function.
(b) Write the Hamiltonian; transform to center of mass and relative coordinates.
(3) Solve for the vibrational frequency. Show work. The answer is in the text, so don't get it wrong.

2. Long Range Forces. 20 points.
Consider the 1D chain of equal mass atoms (first situation considered in the text), except there is a 2nd neighbor force constant K' in addition to the first neighbor one K.
(a) Write the equation of motion for the j-th atom.
(b) Asusming the usual form of wave-like solution, solve for the dispersion relation frequency vs. wavevector $\omega(k)$.
(c) plot the result for the three cases $K'/K = 0.2$, 1.0, and 5.0. Plotting on the same figure is good. Interpret the difference in physical terms.

3. 1D Diatomic Chain (revisited). 10 points.
Consider the solution of the diatomic chain given in the text (5.2) and discussed in class. Consider the cases when $M_1 << M_2$. Describe the resulting dispersion curves and interpret physically what they indicate. [Note: when given a condition like $M_1 << M_2$, look for quantities that involve M_1/M_2 (or rewrite them that way) and expand to lowest nonvanishing order to simply expressions.]