1. Suppose we have a chain of similar atoms, all mass M separated by a distance $a/2$. However, the spring constants vary between nearest-neighbor atoms alternately from K to $10K$. Find $\omega(k)$ at $k = 0$ and $k = \pi/a$. Sketch the dispersion relation by eye. This model is a good approximation for diatomic molecule crystals such as N_2.

   Answer: For $k = 0$, $\omega = 0$ or $\sqrt{22K/M}$. For $k = \pi/a$, $\omega = \sqrt{2K/M}$ or $\sqrt{20K/M}$.

2. Hook and Hall 2.1

3. *For 20 points Extra Credit!*: Consider a simple, monoatomic, two-dimensional square N by M lattice that is modeled as balls and springs as shown below. The lattice spacing is a, the mass on the balls is m, the spring constant of the nearest neighbors (along the edges of the squares) is K_1 and the spring constant for the next nearest neighbors (along the diagonals of the squares) is K_2. All other interactions are negligible.

   (a) Sketch and describe the displacements for the longitudinal and transverse oscillations for $\vec{k} = (\pi/a, 0)$. (This is a special value for the wave-vector and you should be able to describe the motion easily. It is not necessary to solve the dispersion relation completely to do this.)

   (b) For both the longitudinal and transverse oscillations, write down the total energy (kinetic plus potential) of the system in terms of the velocity of the atoms ($\dot{u}$) and their displacements (u).

   (c) From the form of the total energy, write down by inspection what the frequency of oscillation is for each oscillation.