PHYS 446 Fall 2007

Homework Assignment 3 Due Oct 12th

1. The longitudinal and transverse sound velocities in diamond along [100] direction are 17.6 and 12.8 km/s, respectively. The longitudinal velocity in [111] direction is 18.6 km/s. The density of diamond is 3.52 g/cm^3. From these data, calculate elastic constants C_{11}, C_{12}, and C_{44}.

2. Consider the one-dimensional linear chain in which the force constants between nearest-neighbor atoms are alternately C and 10C. Let the masses be equal, and the nearest-neighbor separation is a/2. Find frequencies $\omega(q)$ at $q = 0$ and $q = \pi/a$. (This problem simulates a crystal of diatomic molecules such as H_2).

3. (a) From the dispersion relation for a monoatomic linear chain of N atoms with only nearest-neighbor interactions, wind the density of states $D(\omega)$. Express $D(\omega)$ through the maximum frequency ω_{max}.
   (b) Suppose an optical phonon branch has the form $\omega(q) = \omega_0 - Aq^2$ near $q = 0$ in all 3 dimensions. Find the expression for $D(\omega)$ for $\omega < \omega_0$ and $\omega > \omega_0$. (Here the function $D(\omega)$ is discontinuous)

4. Brillouin scattering of a monochromatic light, the wavelength $\lambda_i = 514.53$ nm, from water at room temperature leads to a Brillouin peak shifted from the excitation line by $\Delta\nu = 4.3\times10^9$ Hz at scattering angle 90°. The refractive index of water is 1.33. What is the sound velocity at this temperature?

5. From the zone-center longitudinal optical phonon frequency for NaCl (8 THz -> rad/sec) calculate the interatomic force constant and Young modulus for this material. From these data and density (2.18 g/cm^3) calculate the longitudinal sound velocity in NaCl.