

Problem Set 6

Physics 240B

Due Tuesday March 3, 2009
Late HW accepted until class on Thursday, March 5

Do A&M 23.2 and 23.3, and the following:

1. Consider a 2-dimensional crystal with a square lattice structure. Model it as a system of masses and springs, with the springs connecting nearest neighbor atoms (spring constant K_1) and next nearest neighbors (spring constant K_2).
 - a) Write the equations of motion for a mass at position (ma, na) . Keep only first-order terms in the displacements.
 - b) If $K_1 = K_2$, find the frequencies of the modes with $\mathbf{k} = \frac{k}{\sqrt{2}}(1, 1)$.
 - c) Repeat b) for $K_1 = 2K_2$.
 - d) Show that for $K_1 = 2K_2$, polarization in the x direction is impossible. (That is, $\epsilon_{\mathbf{k}\nu} \neq \hat{\mathbf{x}}$.)
2. Find a simple expression for the zero-point energy contribution to the total energy of a solid in the following two cases.
 - a) Assume a 3D Debye model with one atom per cell and all acoustic modes degenerate.
 - b) Assume a 3D Einstein model with one atom per cell and all three modes degenerate.
3. From the graph below, estimate the Debye temperature of diamond.