Homework # 4; due Thursday, March 21

16. A raw chicken egg, when put into a large pot with boiling water usually cooks in about five minutes. An ostrich egg has about the same shape as a chicken egg, but its linear size is three times larger. Approximately how long does it take to cook an ostrich egg?

17. Recall the definitions of the *phase velocity* and *group velocity* of a harmonic wave and the expressions for these quantities in terms of the dispersion relation $\omega(k)$. Find the phase and group velocities for phonon waves in a crystal with a diatomic basis (discussed in class) in both the long- and short-wave limits (the latter corresponding to the boundary of the first Brillouin zone). Assume that we are dealing with a case where the problem can be reduced to a 1-dimensional one. Is it physically possible for either phase or group velocity to exceed the speed of light c?

18. Textbooks usually state that for solids, specific heat at constant volume is about the same as specific heat at constant pressure. Using numerical data for a solid of your choice (diamond would be mine), check this assertion. Assume that the solid is near room temperature and at normal atmospheric pressure.

19. Work through the Einstein model for specific heat in solids. Explain what the major successes of the model were, and what were its significant failures. Please explain which assumptions of the model are not quite correct.

20. In class, we discussed the following plot (courtesy Prof. Steve Simon):

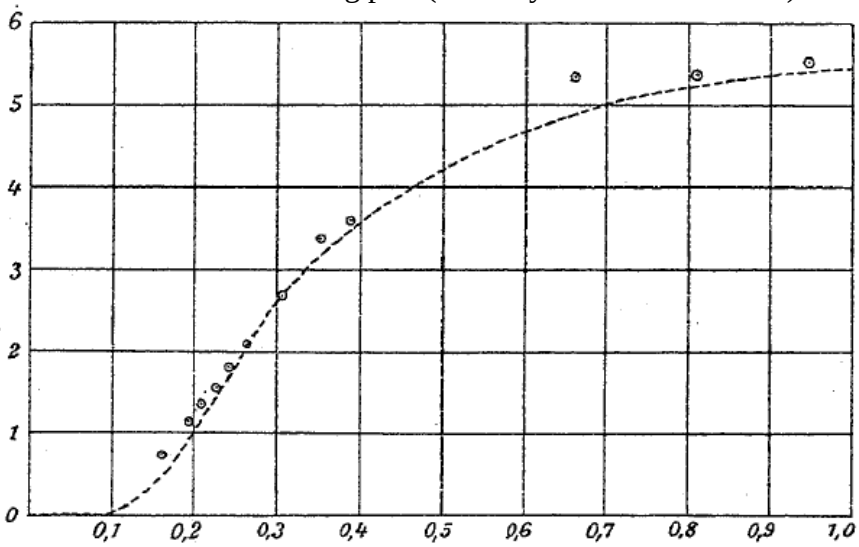

Figure 2.2: Plot of Molar Heat Capacity of Diamond from Einstein's Original 1907 paper. The fit is to the Einstein theory. The x-axis is k_BT in units of $\hbar\omega$ and the y axis is C in units of cal/(K-mol). In these units, $3R \approx 5.96$.

Figure out some way to calibrate the horizontal axis in kelvin (which could involve, for instance, looking up the original article, or finding the data from an independent source, or maybe something even cleverer).