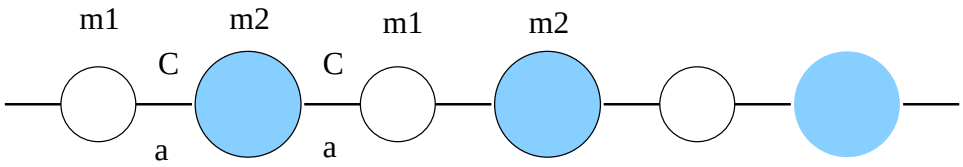
NAME: _____

33-448 Solid State Physics Midterm #2 Wednesday, March 16, 2016

Consider the diatomic chain illustrated in the figure, with alternating masses $m_1 < m_2$ connected by springs of equilibrium length a and spring constant C. Most of the following questions should be answered using approximations whose nature you should explain in words or formulas as appropriate. Each question can be answered independently of the others.



In case you wish to know it, here is the dispersion relation for a *monatomic* chain:

$$\omega(K) = 2\sqrt{\frac{C}{m}}\sin\frac{Ka}{2}.$$

DO NOT SOLVE THE EXACT EQUATIONS OF MOTION OR OBTAIN THE EXACT DISPERSION RELATION FOR THE DIATOMIC CHAIN!!

1. What is the speed of sound at low frequency?

2. Determine the contribution of the acoustic phonons to the heat capacity at low temperature. Your answer should include correct powers of sound speed v and temperature T, but you need not worry about any other details.

3. Let $m_1 \ll m_2$ and determine the contribution of the optical phonons to the heat capacity at low temperature (hint: treat these in the Einstein model. I am primarily interested in the dependence on the Einstein frequency ω_E and the temperature T).

4. Describe the motions of the atoms for zone boundary phonon modes and determine their *exact* frequencies for all $m_1 < m_2$.

5. Describe two interesting things that happen to the dispersion relation at the diatomic chain zone boundary in the limit $m_2 \to m_1$, and briefly explain why they occur.