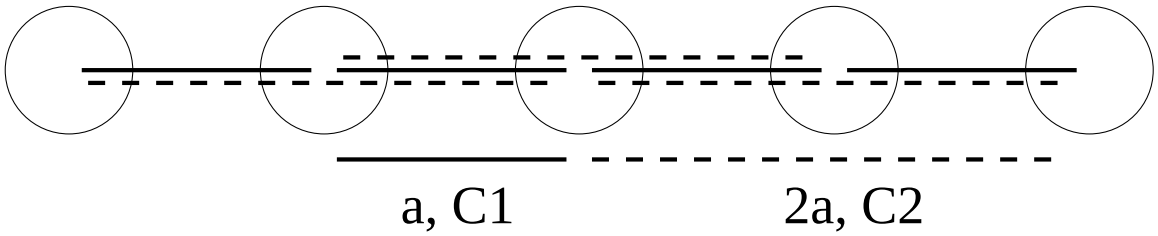
NAME: _____

33-448 Solid State Physics Midterm #2 Monday, March 27, 2017

Please read each question carefully before answering. Do not do unnecessary work - it will waste time and might cost you points. Be sure to attempt every part, as some can be solved independently of others.

1. Dispersion relation for next-nearest neighbor chain (adapted from Simon #9.3)

A monatomic chain of atoms with mass m has nearest neighbor springs of unstretched length a and spring constant C_1, and second neighbor springs of unstretched length $2a$ and spring constant C_2.



(a) Write down the equation of motion for the n^{th} atom in the chain.

(b) Determine the dispersion relation $\omega(k)$. Hint: the solution is almost trivial if you remember that the functional form of normal modes is governed by the symmetries of the system under consideration.

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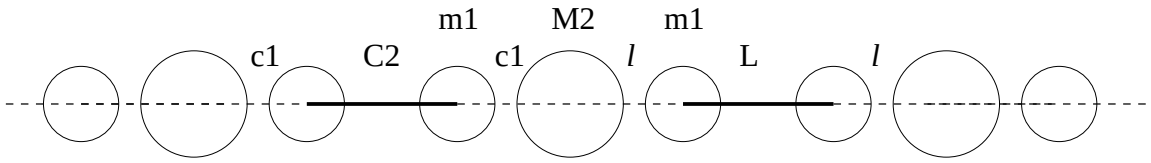
(c)

i. What is the sound speed v_s?

ii. Discuss the relative proportions of C_1 and C_2 in your expression for v_s.

2. Triatomic chain

(a) Consider the triatomic chain illustrated below. The masses are m_1 and $M_2 > m_1$, the bond lengths are ℓ and $L > \ell$, and their spring constants are c_1 and $C_2 > c_1$. Sketch the atomic displacements in the highest frequency mode using arrows below all the atoms. Derive (in the simplest way possible!) the frequency of this mode. What is its wavenumber k?



(b) Use the sound speed $v_s = a\sqrt{C/m}$ of a monatomic chain to write down (without calculation) the sound speed of this triatomic chain. Justify your answer in words, using physical insight instead of equations. Hint: How do spring constants add in series?