the order of magnitude of the velocity of sound in the metal.

(b) Assume the value of the frequency for sodium, roughly 6 GHz, is in agreement with your result. Estimate the number of ions per unit cell in oscillation if the equilibrium position is taken to be the center of the sphere of radius $r$ centered at the equilibrium position. If one ion is displaced a small distance $r$ from its equilibrium position, what is the restoring force? How can this be a model for metallic systems? The ions are assumed to be in a uniform sea of conduction electrons in a crystalline field.

4. Consider point ions of mass $m$ and charge $e$ immersed in a uniform sea of conduction electrons such as Hg.

This problem simulates a crystal of diatomic molecules such as H$_2$.

Sketch the dispersion relation based on your separation of the $n$ and $k$ at $k = 0$ and $\omega = 0$ for the $\alpha$ and $\beta$ branches of the $n = 0$ manifold. Also determine the nearest neighbors and their neighbors.

In class and in the text we discussed the case of crystal vibrations in the presence of a basis of lattice functions of two lattice sites. In this case we have used the dispersion relation for this problem.

\begin{equation}
\varepsilon_n \omega = \varepsilon_n (\omega \gamma \cos \theta - 1) + \varepsilon_n \omega \frac{p}{\gamma} + \varepsilon_n \omega \frac{1}{k}\varepsilon \varepsilon
\end{equation}

where $\varepsilon$ runs over all atoms.

\begin{equation}
\varepsilon_n (\omega \gamma \cos \theta - 1) + \varepsilon_n \omega \frac{p}{\gamma} + \varepsilon_n \omega \frac{1}{k}\varepsilon \varepsilon = E
\end{equation}

where $\varepsilon$ runs over all atoms.

Show that the total energy of the wave is:

(a) Show that the total energy of the wave is:

(b) Show that the total energy of the wave is:

(c) Show that the total energy of the wave is:

(d) Show that the total energy of the wave is:

(e) Show that the total energy of the wave is:

(f) Show that the total energy of the wave is:

(g) Show that the total energy of the wave is:

(h) Show that the total energy of the wave is:

(i) Show that the total energy of the wave is:

(j) Show that the total energy of the wave is:

(k) Show that the total energy of the wave is:

(l) Show that the total energy of the wave is:

(m) Show that the total energy of the wave is:

(n) Show that the total energy of the wave is:

(o) Show that the total energy of the wave is:

(p) Show that the total energy of the wave is:

(q) Show that the total energy of the wave is:

(r) Show that the total energy of the wave is:

(s) Show that the total energy of the wave is:

(t) Show that the total energy of the wave is:

(u) Show that the total energy of the wave is:

(v) Show that the total energy of the wave is:

(w) Show that the total energy of the wave is:

(x) Show that the total energy of the wave is:

(y) Show that the total energy of the wave is:

(z) Show that the total energy of the wave is:

Homework due Thursday February 23 at 5pm
\[
\begin{align*}
\sin^2 \left( \frac{2}{3} \theta \right) + \frac{2}{3} \cos^2 \left( \frac{2}{3} \theta \right) &= \\frac{3}{4} \sin^2 \theta - \frac{3}{4} \cos^2 \theta \\
\cos \left( \frac{4}{3} \theta \right) - \frac{3}{4} \sin^2 \left( \frac{2}{3} \theta \right) &= \frac{3}{4} \sin^2 \theta - \frac{3}{4} \cos^2 \theta \\
\cos \left( \frac{4}{3} \theta \right) &= \frac{3}{4} \sin^2 \theta - \frac{3}{4} \cos^2 \theta \\
\end{align*}
\]
\[ E = \frac{1}{2} M_0 \omega^2 - \frac{3}{2} \sin^2 \alpha \cdot \frac{1}{2} \cdot \frac{1}{2} C_2 \cdot \sin^2 \left( \frac{\alpha - \beta}{2} \right) \]

\[ \sin^2 \alpha = \frac{1}{2}, \quad \sin^2 \left( \alpha - \frac{\beta}{2} \right) = \frac{1}{2} \]

Use this identity:

\[ \cos^2 2\theta = \frac{1 - \cos 4\theta}{2} \]

\[ \sin^2 \theta = \frac{1 - \cos 2\theta}{2} \]

\[ \frac{2e}{M} \left( 1 - \cos \left( \frac{\beta}{2} \right) \right) = \frac{M_0 \omega}{2} \]

\[ \omega^2 = \frac{2e}{M} \left( 1 - \cos \left( \frac{\beta}{2} \right) \right) \]

\[ \cos \left( \frac{\beta}{2} \right) = \frac{\mu_0^2}{2e} \]

\[ E_\theta = \frac{1}{2} M_0 \omega^2 \]

Hence:

\[ E_\theta = \frac{1}{2} M_0 \omega^2 \]
for $k = \frac{\mu}{e}$, $e^x = 0$, so $e^{-x} = 1$, so $e^{x} = -e^{-x}$.

Since both $u = 0$ and $v = e^{\gamma t}$, and $v = 0$.

Thus all answers are unclearly. In other words, if

both $u = 0$ and $v = e^{\gamma t}$, and $v = 0$.

Note that for $k = \frac{\mu}{e}$, we have $e^{x} = (e^{-x})^2$.
\[
W_{io}\ y = C (V_s + 10C_v s - V_s)
\]

Now, look for solution from: \(u = u_e \rightarrow s = -1 + t/s\)

\[
W_{io} = C (V_s + 10C_v s - V_s)
\]

\[
W_{io} = 10C (V_s - V_s) + C (u - V_s)
\]

\[
W_{io} = C \left(V_s - u + 10C_s (V_s - u)\right)
\]

We have the following:
\[
\left( \frac{2}{5} \right)_2 \cdot \sin \left( \frac{\pi}{5} \right)_2 \cdot \left( \frac{W}{5} \right)_1 \cdot \left( 1 - 2 \right) \cdot \left( \frac{W}{5} \right)_1 = 0
\]

\[
\frac{2 \cdot W^2}{Z_0} \times \frac{1}{Z_{MC} + 1} \left( \frac{Z_{MC}}{Z_0} \right) = 0
\]

\[
\begin{align*}
\frac{1}{2} W^2 + 2 \cos K_a & = 0 \\
12 \cos K_a & + 10 \cos K_a & = 0
\end{align*}
\]

\[
\left( \frac{1 + 10 e^{1/2 \theta}}{1 + 10 e^{-1/2 \theta}} \right) \left( \frac{1 + 10 e^{1/2 \theta}}{1 + 10 e^{-1/2 \theta}} \right) = 0
\]

Solution of \( \theta \) are given by:
\[ a = \frac{M v^2}{r} \]

So for a non-zero mass \( M \):

\[ F = \frac{M v^2}{r} = e \frac{d\phi}{dr} \]

\[ 0 = \frac{d\phi}{dr} \]

where \( \phi \) is the potential at the point \( r \). The potential is constant along the equipotential surface. The electric field at the nucleus is directed towards the center. A closed surface enclosing the charge is

\[ \oint \mathbf{E} \cdot d\mathbf{A} = \frac{Q}{\varepsilon_0} \]

where \( Q \) is the charge enclosed by the surface. The electric field at the nucleus is directed towards the center.
\[
\frac{\mu}{10^5 \text{ cm}^2/\text{Pa}} = 3 \times 10^5 \frac{\mu}{10^5 \text{ cm}^2/\text{Pa}}
\]
So \( v \approx \frac{(2.6 \times 10^{-1}) \times (3.6 \times 10^{-6})}{1} \)

When \( a = 3.6 \cdot 10^{-6} \)

\[
\frac{1}{2} v = 10^6
\]

Thus \( v = \frac{1}{2} \cdot 10^6 \)

A single atom or a \( k = \frac{50}{4} \) ion chain

Naturally, we can assume the more complex a

\( (c) \quad w = v/k \)

\[
\mu = 2.6 \times 10^{-10} \text{ Pa}
\]

\[
\frac{2^2}{2^2} \frac{10}{2^2} \text{ cm}^2 = \frac{(2.6 \times 10^{-11}) \times (2.6 \times 10^{-11})}{2^2}
\]

\[
W = \frac{2}{2^2}
\]

\( \rho = 2.08 \cdot 10^{-9} \)

\[
\frac{e^2}{2} = \frac{2.08 \cdot 10^{-9}}{2^2}
\]

\[
\rho = 2.05 \times 10^{-9} \text{ cm}
\]

For Na metal, density of continuum electrons is...