**8.511 Theory of Solids I** **Problem Set 6** **Due October 26, 2004**

1. (a) Calculate the period $\Delta\left(\frac{1}{B}\right)$ of the Shubnikov-deHaas oscillation of potassium assuming the free electron model.

   (b) What is the area in real space of the extremal orbit for $B = 1$ tesla?

2. Consider an energy band parametrized by anisotropic masses as follows

$$E(\mathbf{k}) = \frac{\hbar^2}{2}\left(\frac{k_x^2}{m_x} + \frac{k_y^2}{m_y} + \frac{k_z^2}{m_z}\right) .$$

Within the relaxation time approximation, we modify the semiclassical equation of motion by adding $\mathbf{k}/\tau$ to the left hand side:

$$\hbar\left(\frac{d\mathbf{k}}{dt} + \frac{1}{\tau}\mathbf{k}\right) = -e\left(\mathbf{E} + \frac{1}{c}\mathbf{v}\times\mathbf{B}\right)$$

   (a) Assuming time independent $\mathbf{E}$ and $\mathbf{B} = B\hat{z}$, and using $\mathbf{j} = -en\mathbf{v}$, calculate the DC conductivity tensor

$$\mathbf{j} = \overleftrightarrow{\sigma}\mathbf{E}$$

   where $\overleftrightarrow{\sigma}$ is a $3\times 3$ matrix. Write your answer in terms of $\omega_{cx} = eB/m_x c$ and $\omega_{cy} = eB/m_y c$.

   (b) Calculate the resistivity tensor

$$\mathbf{E} = \overleftrightarrow{\rho}\mathbf{j} .$$

   (c) Discuss the Hall conductivity and the Hall resistivity in the low $B$ and high $B$ limits.

   (d) Magnetoresistivity (or conductivity) is defined as the $B$ dependence of the diagonal components of the resistivity (or conductivity) tensor. Sketch the behavior of the magnetoconductivity and the magnetoresistivity in this model.