Physics 167 **Problem Set 1** **Due: Wednesday, February 23, 2005**

Problem 1

Consider an electron gas in two dimensions with an effective mass m^*.

a) Find the relation between the Fermi wavevector k_F and the Fermi energy E_F.

b) Find the relation between the electron density n and the Fermi energy E_F.

c) Find the density of states $g(E)$ as a function of energy E.

Problem 2

Consider an intrinsic semiconductor with an effective mass for electrons in the conduction band $m_c = 0.2m$, where m is the electron mass in vacuum. Find the characteristic velocity of the thermal motion of electrons in the conduction band at room temperature.

Problem 3

Consider an isotropic two dimensional (xy plane) electron system in the presence of the magnetic field in the z direction. The relationship between the electric field and the electric current is

$$\begin{aligned} E_x &= \rho j_x - H R_H j_y \\ E_y &= H R_H j_x + \rho j_y \end{aligned} \tag{1}$$

In the Drude model of the electronic transport we showed that the conductivity

$$\sigma = \rho^{-1} = \frac{ne^2\tau}{m^*} \tag{2}$$

where n is the electron density, τ is the relaxation time, and m^* is the effective mass. Show that in the Drude model, the Hall coefficient is given by

$$R_H = -\frac{1}{ne} \tag{3}$$

Problem 4* (Extra credit)

Consider a system of two types of charge carriers in the Drude model. The two carriers have the same density (n) and opposite charge (e and $-e$), and their masses and relaxation times are m_1, m_2 and τ_1, τ_2, respectively.

a) Calculate the magnetoresistance $\Delta\rho = \rho(H) - \rho(0)$, where H is the magnetic field.

b) Calculate the Hall coefficient.