Physics 240B **M. L. Cohen** **Spring2008**
Problem Set #1 **Due: 02/12/08**

(20) 1. As a review, treat a metal as a free electron gas and calculate:

(a) the density of states as a function of wave vector and as a function of energy,
(b) the density of states at the Fermi level in terms of n and E_F,
(c) the electronic heat capacity,
(d) the paramagnetic spin susceptibility,
(e) the thermal conductivity,
(f) the electrical conductivity,
(g) the Wiedeman-Franz ratio.

(20) 2. Find an expression for the electronic contribution to the heat capacity of a semimetal at very low temperatures for electrons of mass m_e and holes of mass m_h. Let E_e be the energy of the bottom of the electron band and E_h be the energy of the top of the hole band.

(20) 3. Consider an electron on the Fermi surface of Na with initial motion in the xy plane.
What is the orbital radius in an applied magnetic field of 10^4 gauss?
How is the area of the orbit in real space related to the k-space orbit?

(20) 4. Consider the problem of an extremal cyclotron orbit in the k_xk_y plane of the Fermi surface for a nonisotropic solid. The equation for the Fermi energy is $E = (Ak_k^{\ 2} + Bk_y^{\ 2})$. Apply a magnetic field along z and describe the rate at which $\vec{\mathbf{k}}$ changes during an orbit when A and B are unequal. Describe the orbit performed in real space for this situation.

(20) 5. (a) What are Friedel oscillations?
(b) Show that the induced charge density arising from an impurity in a metal is proportional to r_{-3} cos $(2K_Fr)$ at large r (calculate).
(c) What is the Friedel sum rule? Derive it.
(d) Discuss the Kohn effect from the point of view of screening; that is, discuss the influence of the behavior of the Lindhard dielectric function at $q = 2k_F$ on the phonon spectrum of a metal.