PROBLEM SET – 1
Tuesday, November 6th, 2007

Problem 1.
An aluminum wire with a square cross-section 2 mm on a side is carrying a current of 1.5 amps. Aluminum has a resistivity of 2.69×10^{-6} ohm-cm and an atomic volume of 10 cc/mol. Assuming aluminum has three free electrons per atom, calculate the (a) Hall coefficient, (b) electron mobility, (c) drift velocity, (d) collision time, (e) electric field, (f) power dissipated (heat generated) per cm length, and (g) the Hall voltage across the wire in a transverse magnetic field of 1 tesla.

Problem 2.
A wire of length L and resistivity ρ has a circular cross section with a diameter that tapers linearly from d_1 at one end to d_2 at the other end. Derive a formula for the electric resistance along this length of wire.

Problem 3.
Given the differential equation for drift velocity, v_D as:

$$F = ma = m\frac{dv_D}{dt} = -eE - \frac{mv_D}{\tau}$$

(a) At t = 0, we suddenly increase the electric field from zero to a finite value. For this situation, solve the above equation and get a general expression for the time dependence of drift velocity for t > 0. (b) How does velocity vary with time for times short compared to the collision time? (c) How does velocity vary with time for times long compared to the collision time? (d) Which of these limits corresponds to Ohm's law?

Problem 4.
A plane wave of red light ($\lambda = 0.65$ μm in vacuum) enters a nonmagnetic metal ($\mu = \mu_o = 1.26 \times 10^{-6}$ h/m) with a conductivity of 10^7 S/m. (a) By how much would the electric and magnetic fields of this wave be attenuated in traveling through 10 nm of this metal? (b) How much of the intensity in this wave will remain after traveling through 30 nm of this metal? (c) Recalculate (a) and (b) for the case where this metal is also ferromagnetic with a relative permeability of 300 ($\mu = 300\mu_o$).

Problem 5.
By extensive plastic deformation, you decrease the mean-free path in high-purity copper by 10%. What will be the resulting changes in (a) the mobility, (b) conductivity, (c) Hall coefficient, (d) skin depth, and (e) plasma frequency?