Physics 322a-2007 Solid State Physics Walter F. Smith Haverford College

Assignment 6
Due: Friday, Oct. 26 at 4 pm (Turn in to envelope outside my office.)
Reading: Livingston Ch. 12

Assigned exercises (except as noted, these are group problems, i.e. you may work on them with other students in small groups)

Livingston 1-1 (individual problem) (use the Fermi velocity for silver, 1.39_{6} m/s, instead of the thermal velocity) *Note: The abbreviation "mol" stands for "mole", i.e.* 6.022_{23} *atoms. The abbreviation "cc" stands for "cubic centimeters".*

6A. For the setup of problem 1.1, calculate the drift velocity. Express this as a percentage of the Fermi velocity.

Livingston 1.4 (Individual problem)

6B. (Adapted from Livingston 1-7) A composite material is made of alternating thin layers of copper (resistivity 1.69_{-6} Ω-cm) and a niobium-titanium alloy (resistivity 7_{-5} Ω-cm) of equal thickness. Assume the layers are parallel to the x-y plane.
a. What is the resistivity of this composite for current flowing in the x-direction?
b. For current flowing in the x-direction, what fraction of the current is carried by the copper?
c. For current flowing in the x-direction, how do the electric fields in the two phases compare?
d. What is the resistivity of this composite for current flowing in the z-direction?
e. For current flowing in the z-direction, how do the electric fields in the two phases compare?
f. Under what conditions will the applied electric field and the current be non-parallel for this composite? Explain.

Livingston 1-11 (Individual problem)

6C. Individual problem. The sheet resistance, $R_\square$. Consider a square sheet of material, with side length L, thickness d, and electrical resistivity ρ. The resistance measured between opposite edges of the sheet is called the sheet resistance, $R_\square$. It is also called "R per square".
a. Find an expression for $R_\square$ in terms of the other quantities above, and show that it is independent of L. *(Hint: this is pretty trivial.)* This property is what makes $R_\square$ a handy tool for characterizing a thin film of material.
b. If the sheet is very thin, then the surfaces of the sheet become the dominant sources of elastic scattering. In this limit, $\tau \approx \frac{d}{v_F}$, where v_F is the Fermi velocity. Show that, in this limit, the Drude model gives $R_\square \approx \frac{m v_F}{N_e d^2 e^2}$.