DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

3.225 Electronic and Mechanical Properties of Materials

Summer Term 2002

Problem Set #1
Due: Day #2

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.

2. A composite material is made of alternating thin lamellae of copper (resistivity $1.69\ 10^{-6}$ ohm-cm) and a niobium-titanium alloy (resistivity $7\ 10^{-5}$ ohm-cm) of equal thickness. (a) What is the resistivity of this composite measured parallel to the lamellae? If current is passed through the composite in this direction, what fraction of the current will be carried by the copper? How will the electric fields in the two phases compare? (b) What is the resistivity of this composite measured perpendicular to the lamellae? If current is passed through in this direction, what will be the ratio of the electric field in the alloy to that in the copper? (c) At a temperature of 4.2 K, the resistivity of the copper has decreased to $1\ 10^{-8}$ ohm-cm, and the niobium-titanium alloy has become superconducting. Answer questions (a) and (b) for this situation.

3. Light entering a thin metallic film has approximately equal intensities of extreme red ($\lambda = 700$ nm in vacuum) and extreme blue ($\lambda = 400$ nm in vacuum) light. The intensity of the red light decreases by a factor of ten after penetrating 10 nm of the film. By how much has the intensity of the blue light decreased after penetrating this distance? By how much has the intensity of the red and blue light waves decreased after penetrating 20 nm?