Midterm Exam # 2, Physics 217
November 28, 2001, 8.30 am – 9.50 am

Problem 1 (35 points)

A certain coaxial cable consists of a copper wire, of radius a, surrounded by an infinitesimal thin concentric copper tube of radius c (see Figure 1). The charge on the wire is λ C/m and the charge on the tube is $-\lambda$ C/m. The space between the wire and the tube is partially filled (from b to c) with a linear dielectric of susceptibility χ_e.

a) What is the magnitude and direction of the electric displacement in the three regions $a < r < b$, $b < r < c$, and $c < r$?

b) What is the magnitude and direction of the electric field in the three regions $a < r < b$, $b < r < c$, and $c < r$?

c) What is the capacitance per unit length of this cable?

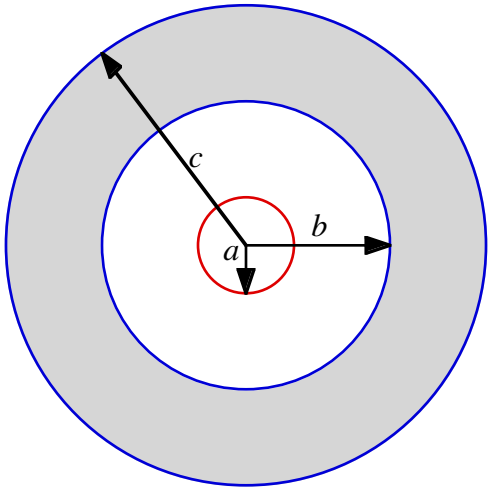

Figure 1. Problem 1.

Problem 2 (35 points)

Consider a circular current loop of radius R, lying in the xy plane, and carrying a current I in the direction indicated (see Figure 2).

a) Find the exact magnetic field (magnitude and direction) a distance z above the center of the current loop.

b) What is the magnetic dipole moment of the current loop?

c) Verify that for $z \gg R$ the exact magnetic field calculated in a) is consistent with the field of a magnetic dipole.

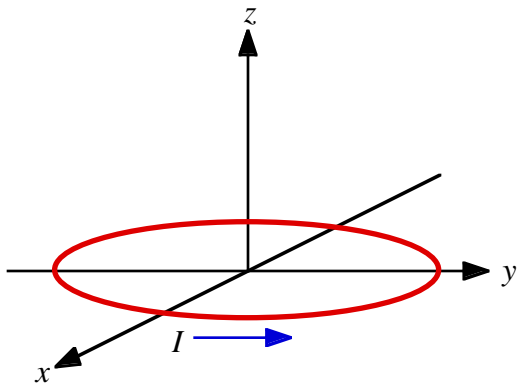

Figure 2. Problem 2.

Problem 3 (35 points)

A uniform line charge λ is placed on an infinite straight wire, a distance d above a grounded conducting plane. The wire runs parallel to the x axis and directly above it. The conducting plane is the xy plane.

a) Find the potential in the region above the grounded plane.

b) Find the charge density σ induced on the conducting plane.

Note: The potential generated by a uniform line charge λ on an infinite straight wire is equal to

$$V(r) = -\frac{\lambda}{2\pi\varepsilon_0}\ln r$$

where r is the distance from the line charge.