Physics 842 – Fall 2011
Classical Electrodynamics II

Problem Set #4 – due Tuesday October 11

1. A capacitor consists of two concentric conducting spherical shells with radii a and b, centered at the origin. The space between the shells is half-filled (for $z > 0$) with a dielectric material with dielectric constant ε. The inner shell carries total charge Q, and the outer shell –Q.

   a) Find the electric field E and everywhere between the shells.

   b) Find the surface charge distribution on the inner shell, and the bound charge density induced on the inner surface of the dielectric material. Comment on their sum.

2. A point charge q is located in free space a distance d from the center of a dielectric sphere of radius a ($a < d$) and dielectric constant ε. (This problem cannot be solved in closed form using the method of images.)

   a) Find the potential at all points in space as an expansion in spherical harmonics. (If you have forgotten how to expand the potential due to a point charge not at the origin in spherical harmonics, look it up in a book.)

   b) Verify that, in the limit $\varepsilon \to \infty$, your result is the same as that for a point charge near a conducting sphere.

   c) In the limit of very large d, calculate the electrostatic interaction energy between the sphere and the charge in the following way: Multiply the point charge by the part of the potential due to the sphere alone, at the position of the point charge. Is your answer equal to $-\frac{1}{2}$ pE, where p is the total dipole moment of the sphere, and E is the field at the center of the sphere due to the point charge? Comment on why it should be or shouldn't be.

Quiz #4

The quiz on Thursday, October 13, will consist of one of the following problems:

- Problems 1 and 2 on Problem Set #4
- The problem at the end of Section 11
- Problem 5 at the end of Section 12
- Problem 1 at the end of Section 13

  (Note that I solved this in class two weeks ago without using **D**.)