Physics 842 – Fall 2012
Classical Electrodynamics II

Problem Set #2 – due Tuesday September 25

1. A parallel-plate capacitor has dimensions L × W × d, where L is the length, W is the width, and d is the spacing between the plates. A conducting box of dimensions L × W × a, with a < d, slides partway into the capacitor, sticking in a distance x along the length direction L.
   a) Calculate the capacitance as a function of x, neglecting edge effects.
   b) The capacitor is charged, with charge Q on the top plate and –Q on the bottom plate. Draw a picture of the whole capacitor, showing a few electric field lines. Is the electric field pulling the box in or pushing it out?
   c) Calculate the force on the conducting box. Is the box being pulled in or pushed out by the electric field? (Verify that your calculation and your picture give the same result!)
   d) Now the capacitor is held at fixed potential ϕ by a battery. Calculate the force on the conducting box. Again, is the box being pulled in or pushed out by the electric field?

2. Work out problem 6 at the end of Section 3 of Landau & Lifshitz. First, calculate the force acting on the dipole, then integrate the force starting with the dipole an infinite distance away to get the potential energy. Explain why the answer in the book is incorrect by exactly a factor of 2.

3. Look at problem 1 at the end of section 3, where Landau & Lifshitz calculate the potential everywhere in space for a conducting sphere placed in a uniform electric field. Calculate the change in field energy with the sphere present, compared to the situation with the sphere absent. (The uniform field has infinite energy when integrated over all space; that is why I am asking you to calculate the energy difference.) Compare your answer with Eqn. (2.12) in L&L. The two answers differ in both sign and magnitude. This problem demonstrates the danger of subtracting two infinite quantities to get a finite answer.

4. Estimate the polarizability of a hydrogen atom using a simple model of the atom as a point charge +e surrounded by a uniformly charged sphere of radius a = 1 Angstrom and charge –e. When the atom is subjected to an electric field E = 30,000 V/cm, by what distance is the nucleus displaced with respect to the center of the sphere? What is the value of the polarizability (in cgs units)? Watch your units!!

Quiz #2

The quiz on Thursday, September 27, will consist of one of the following problems:

- Problems 1 to 4 on Problem Set #2
- Problems 1 to 3 at the end of Section 5