PHYS 4392
Fall 2014
TE Coan
Due: 12 Sep '14 6:00 pm

Homework 2

1. Verify the operator equation $\frac{d}{dx}\text{sgn}(x) = 2\delta(x)$, where the function signum(x), meaning "sign of x,"and abbreviated sgn(x), is defined by

$$\text{sgn}(x) = \begin{cases} 1, & x > 0, \\ -1, & x < 0. \end{cases}$$

Hint: Recall how we determined δ-function properties in lecture.

2a. Find the electric field **E** a distance z above the center of a flat circular disk of radius R which carries a uniform surface charge density σ (i.e., $[\sigma] = \text{C/m}^2$).

b. What is the value of **E** in the limit $R \to \infty$?

c. What is the value of **E** in the limit $z \gg R$? (Note that this condition for z is **very different** from the condition $z \to \infty$!)

3. What is a good estimate for the number of seconds T in a single year? Your answer should be written in the form $T = a \times 10^b$, where a is a very well known geometric constant. This value of T is worth committing to memory. Be sure to include the unit of time in your answer.

4. What is the magnitude e of the charge of an electron in the MKSA system of units? (This is the system of units used in Griffiths and elsewhere.) I only need 2 or 3 significant figures and your answer should be positive even though the charge of the electron is negative.

5. Two identical thin plastic rods of length L carry equal charges Q distributed uniformly along their lengths. The rods are aligned, with a distance d between their nearest ends. Calculate the magnitude of the repulsive force F that each rod exerts on the other. Do not be afraid to change variables to make integrations easier.

6. Two spheres, each of radius R and carrying uniform charge densities $+\rho$ and $-\rho$, are placed so that they partially overlap. See the figure below. Label the vector from the positive center to the negative center **d**. Show that the electric field **E** in the region of overlap is constant *and* find its value.

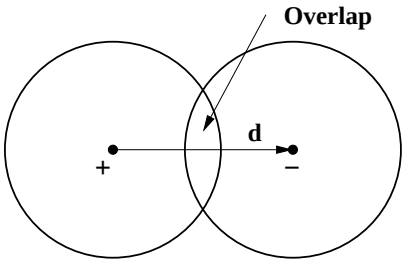

Figure 1:
Side view of overlapping spheres.

7. A sphere of radius R_0 carries a uniform charge density ρ throughout its volume. A smaller, hollow sphere of radius R_s is then made inside the original sphere by discarding some of its material. Suppose the hollow sphere is a distance a away from the center of the original sphere. Show that the value of the electric field $\mathbf{E}$ inside the cavity is constant and find its value. The figure below may help. Hint: Think superposition and pick a point inside the cavity to evaluate the electric field. This problem is less difficult than you might think if you keep your wits about you!

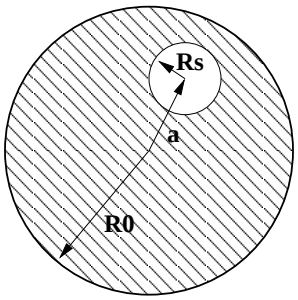

Figure 2:
Sphere with spherical cavity.