E&M Problem Set 8
Due Friday, March 14 at 4pm

1. **Griffiths Problem 4.16 (tweaked):** Suppose the electric field inside a large piece of dielectric is $\vec{E}_0$, so that the electric displacement is $\vec{D}_0 = \epsilon_0 \vec{E}_0 + \vec{P}$. Imagine cavities are hollowed out of the material. Assume the cavities are small enough that $\vec{P}$, $\vec{E}_0$, and $\vec{D}_0$ are essentially uniform. For each of the following cavity shapes, find the electric field $\vec{E}$ at the center of the cavity in terms of $\vec{E}_0$ and $\vec{P}$ and the displacement $\vec{D}$ at the center of the cavity in terms of $\vec{D}_0$ and $\vec{P}$. **HINT:** Carving out a cavity is the same as superimposing an object of the same shape but opposite polarization.

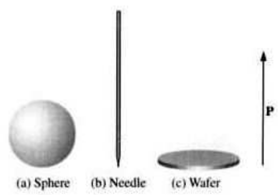

Figure 4.19

   (a) Find $\vec{E}$ and $\vec{D}$ at the center of a small spherical cavity (Figure 4.19a, above). **NOTE:** We derived the electric field of a uniformly polarized spherical dielectric in Example 4.2. This might come in handy.

   (b) Do the same for a long needle-shaped cavity (assume 'needle' here is the same as 'thin, long cylinder') running parallel to $\vec{P}$ (Figure 4.19b, above). **HINT:** For this problem, consider the location of bound charges in the spherical cavity and remember the cavity is *long*. Very little math is involved if you make this assumption.

   (c) Do the same for a thin wafer-shaped cavity perpendicular to $\vec{P}$ (Figure 4.19c, above). **HINT:** Consider where the bound charge accumilates. You must successfully determine the bound surface charge density at the upper/lower surface. Since this wafer is much thinner than it is wide, what you basically have here is a capacitor. The electric field within a capacitor was discussed in Example 2.5.

2. **Griffiths Problem 5.01 (tweaked):** A particle of charge q enters a region of uniform magnetic field $\vec{B}$ (pointing *into* the page). The field deflects the particle a distance d above the original line of flight, as shown in Figure 5.8 (shown below).

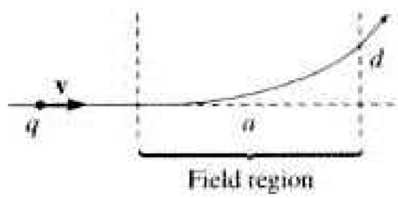

Figure 5.8

   (a) If $\vec{B}$ is uniform, what is the shape of the path the charged particle follows while in the $\vec{B}$ field assuming no electric fields are present? Relate a and d to a property of that shape.

   (b) Is the charge positive of negative? In terms of a, d, B, and q, find the momentum of the particle.

3. **Griffiths Problem 5.04:** Suppose the magnetic field in some region has the form

$$\vec{B} = kz\hat{x} \tag{1}$$

   (where k is a constant). Find the force on a square loop (side a), lying in the yz plane and centered at the origin, if it carries a current I, flowing counterclockwise, when you look down the x axis. **HINT:** Draw the situation described here, showing your view looking down the x-axis (that is, so the x-axis is pointing right at your eye).

4. **Griffiths Problem 5.08:**

   (a) Find the magnetic field at the center of a square loop, which carries a steady current I. Let R be the distance from center to side (Figure 5.22 [below]).

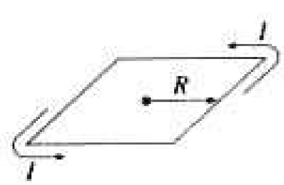

Figure 5.22

(b) Find the field at the center of a regular n-sided polygon, carrying a steady current I. Again, let R be the distance from the center to any side.

(c) Check that your formula reduces to the field at the center of a circular loop, in the limit $n \to \infty$.

HINT: Using the general results of Example 5.5 for the magnetic field due to a *segment* of straight uniform current will make this a very easily managable problem.

5. **Griffiths Problem 5.09:** Find the magnetic field $\vec{B}$ at point P for each of the steady current configurations shown in Fig. 5.23 (below).

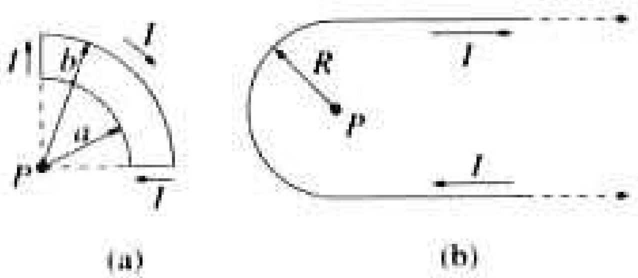

Figure 5.23

HINT: Since $\vec{B}$ is a vector field, direction must be stated in the correct answer. Also, for part (b), start by using the same general solution for the magnetic field due to a *segment* of straight uniform current in Example 5.5 you used to solve the Griffiths 5.08.

6. **Griffiths Problem 5.15:** Two long coaxial solenoids each carry current I, but in opposite directions, as shown in Fig. 5.42 (below). The inner solenoid (radius a) has n_1 turns per unit length, and the outer one (radius b) has n_2. Find $\vec{B}$ in each of the three regions: (i) inside the inner solenoid, (ii) between them, and (iii) outside both.

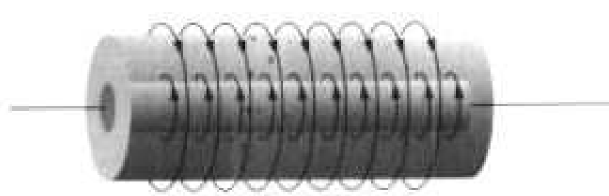

Figure 5.42