PH631 Fall 2015 **Problem Set #8** ***Due: Fri Dec 4, 2015***

1. An electron (charge e) is buried a distance d under the surface of a glass slab. There is no other free charge in the universe. The surface of the glass is covered in water. Glass has a relative dielectric constant of 4. Water has a relative dielectric constant of 80. Using equations that we discussed in class, find the electric potential on the surface of glass.

2. 3. and **4.** A collection of problems from Griffiths.

Problem 4.35 A point charge q is imbedded at the center of a sphere of linear dielectric material (with susceptibility χ_e and radius R). Find the electric field, the polarization, and the bound charge densities, ρ_b and σ_b. What is the total bound charge on the surface? Where is the compensating negative bound charge located?

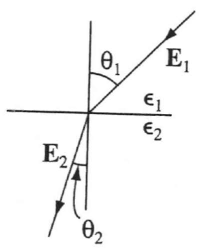


FIGURE 4.34

Problem 4.36 At the interface between one linear dielectric and another, the electric field lines bend (see Fig. 4.34). Show that

$$\tan\theta_2 / \tan\theta_1 = \epsilon_2/\epsilon_1, \tag{4.68}$$

assuming there is no *free* charge at the boundary. [*Comment:* Eq. 4.68 is reminiscent of Snell's law in optics. Would a convex "lens" of dielectric material tend to "focus," or "defocus," the electric field?]

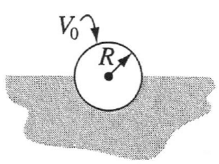


FIGURE 4.35

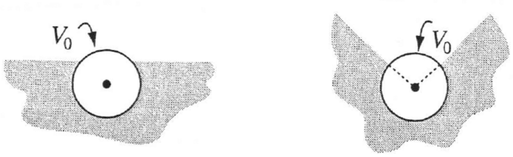
Problem 4.39 A conducting sphere at potential V_0 is half embedded in linear dielectric material of susceptibility χ_e, which occupies the region $z < 0$ (Fig. 4.35). *Claim:* the potential everywhere is exactly the same as it would have been in the absence of the dielectric! Check this claim, as follows:

(a) Write down the formula for the proposed potential $V(r)$, in terms of V_0, R, and r. Use it to determine the field, the polarization, the bound charge, and the free charge distribution on the sphere.

(b) Show that the resulting charge configuration would indeed produce the potential $V(r)$.

(c) Appeal to the uniqueness theorem in Prob. 4.38 to complete the argument.

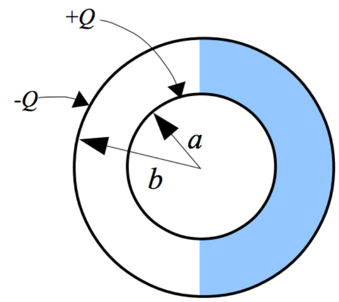
(d) Could you solve the configurations in Fig. 4.36 with the same potential? If not, explain *why.*



(a) (b)

FIGURE 4.36

5. (*From Jackson Chpt 4*) Two concentric conducting spheres of inner and outer radii a and b, respectively, carry charges $\pm Q$. As always, the potential must be constant on each conductor, but the charge density is not necessarily constant. Half the empty space between the spheres is filled by a polarizable material (the light blue shaded region).



(a) The electric potential in the empty space between the spheres (the white region) can be described by a sum of orthogonal functions. Identify any A_l or B_l coefficients that must be zero.

(b) Find the electric field everywhere between the spheres (make use of the boundary conditions at a dielectric interface).

(c) Calculate the surface-charge distribution on the inner sphere.

(d) Calculate the surface bound charge, σ_b, induced on the surface of the dielectric at $r = a$.