17th of September, 2008

1. A conducting sphere is kept at potential V_0. Show that if we embed the sphere in a dielectric that occupies the region $z < 0$ (figure 1, top), the potential $V(\mathbf{r})$ will stay exactly the same everywhere in space as in the absence of the dielectric! What about configurations (a) and (b) (figure 1, bottom)?

   How will $V(\mathbf{r})$ change if not the potential of the sphere, but its total charge Q is kept at a fixed value?

   (*Note:* Based on 4.35 and 4.36 in Griffiths's book.)

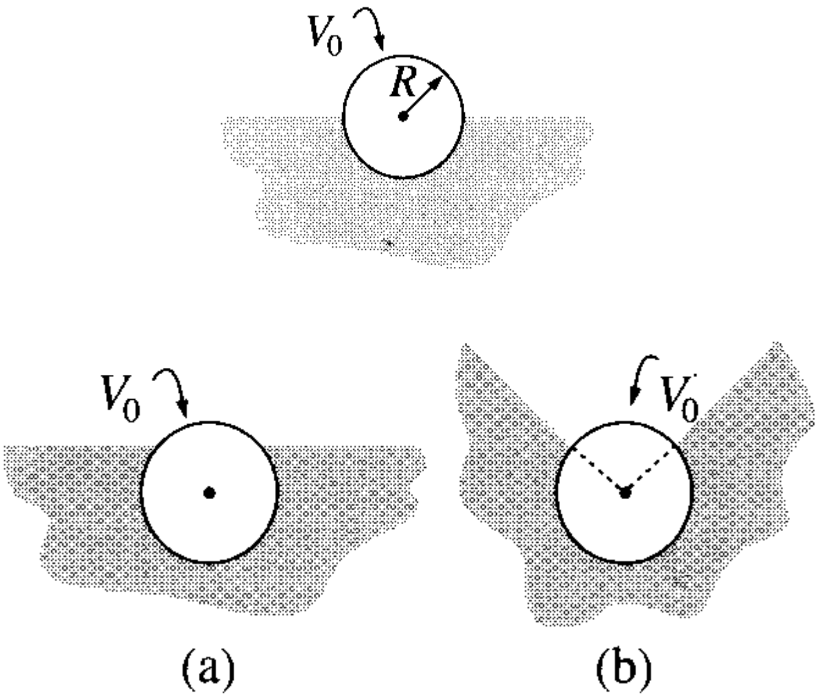


Figure 1: A conducting sphere embedded in a dielectric in various ways.

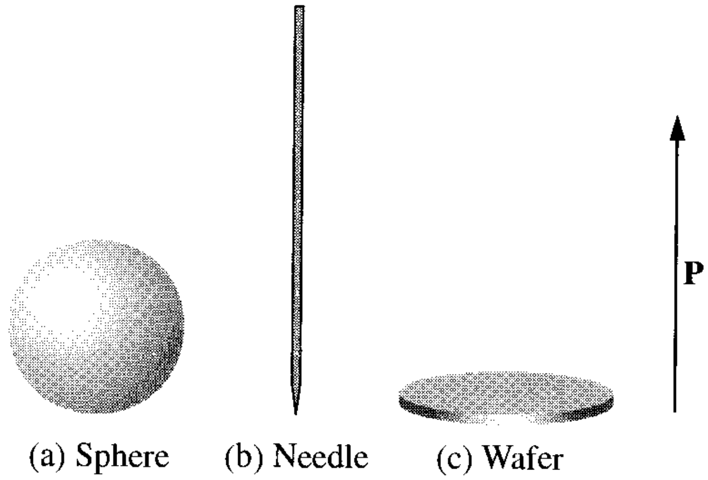
2. A dielectric slab is partially inserted between between planar capacitor plates. Find the force acting on the slab of dielectric!

3. A small cavity is carved inside a large piece of dielectric material. Suppose that there is a uniform electric field, $\mathbf{E}_0$, in the dielectric. Find the electric field inside the cavity in the following cases:

   (a) The cavity is spherical.

(b) A needle-shaped (long and thin) cavity, parallel to the field.

(c) A wafer-shaped cavity, perpendicular to the field.



(Problem 4.16 in Griffiths's book.)

4. An emulsion is a mechanical mixture of two unblendable fluids. Consider an emulsion where droplets of a fluid of permittivity ε_1 are dispersed in a fluid of permittivity ε_0. The droplets amount to a fraction β of the total volume of the emulsion. Find the net permittivity of the emulsion!

5. We have a magnetic field whose magnitude is linearly varying in a direction perpendicular to the field lines: $\mathbf{B} = (B_0 + kx)\hat{\mathbf{z}}$.

   (a) Qualitatively describe the motion of a charged particle in this field.

   (b) Find an approximate formula for the drift velocity. Assume that in the region where the particle is moving $|B - B_0| \ll B_0$.