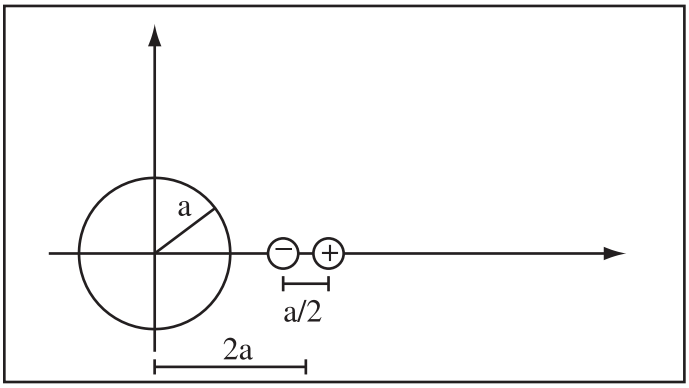
Electricity and Magnetism - Practice Test 2

Work four of the six problems. Place the problems in the order you wish them graded. The first two problems form the first half test; the second two problems form the second half test.

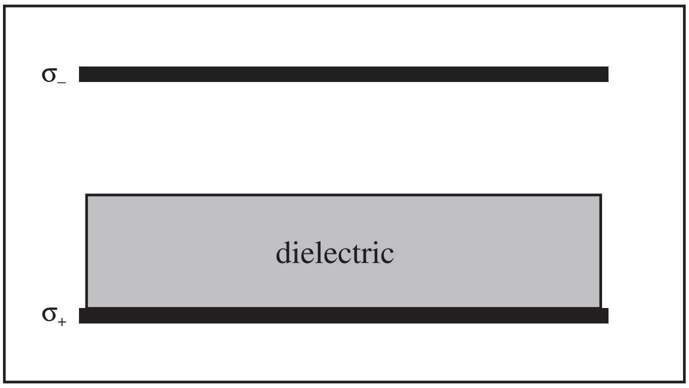
Problem 2.1 A spherical object with radius a has a potential at its surface that has value V_0 for a small patch with $0 < \theta < \pi/8$ at its north pole. The potential of the rest of the object is 0. Compute first two non-zero terms of the potential inside the sphere.

Problem 2.2 A dipole is place outside of a grounded conducting sphere with radius a with its dipole moment pointing in a direction normal to the sphere, as drawn. The charge on the two ends of the dipole are $\pm q$. The center of the dipole is a distance $2a$ from the center of the sphere. The distance between the two charges of the dipole is $a/2$. Compute the force the sphere exerts on the positive charge in the dipole. (I initially wanted the force on the dipole but it was too annoying.)



Problem 2.3 A infinite conducting cylinder of radius a has a surface charge density $\sigma(\phi) = \sigma_0(\sin^2(\phi) - \frac{1}{2})$. Compute the potential outside the cylinder.

Problem 2.4 A linear dielectric slab with dielectric constant ϵ_r is placed between two infinite parallel planes of charge with charge density $\pm\sigma$. Find $\vec{D}$, $\vec{E}$, $\vec{P}$, and ρ_b in the dielectric, and the bound charge density on the top and bottom surface of the dielectric.



Problem 2.5 A potential of $V_0 \cos(\theta)$ is established on the inner surface of a spherical dielectric with inner radius a and outer radius b. The dielectric constant of the material is ϵ_r. Find the potential for $r > a$. You may report a system of equations that needs to be solved to find the coefficients of the potential functions. Actually solving these equations turns out to be quite messy. These equations should be a set of simple linear, non-differential equations.

Problem 2.6 A spherical system has polarization $\vec{P} = \gamma r^2 \hat{r}$ for radius $r < a$ and $\vec{P} = 0$ for $r > a$. Find the electric field everywhere.