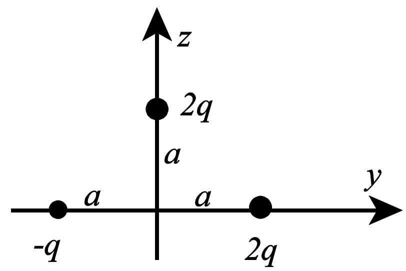
Phys 221 – E&M I – Test 3 – April 26, 2002

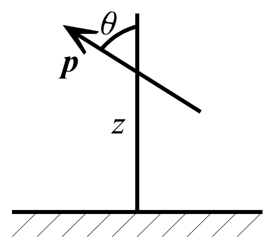
1. (25 pts) Three charges lie in the *yz* plane as shown. There is a charge $-q$ at $y = -a$, a charge $2q$ at $y = a$, and a charge $2q$ at $z = a$.



a) Calculate the monopole and dipole moments for this distribution.

b) Find the approximate potential at points far from the distribution. Give your results in spherical coordinates.

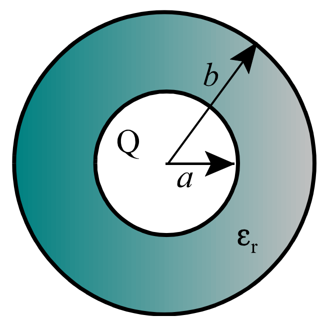
2. (25 pts) A dipole $\vec{p}$ is situated a distance *z* above an infinite <u>grounded</u> conducting plane. The dipole makes an angle θ with the perpendicular to the plane.



a) Draw the image dipole.

b) Find the torque on the dipole due to the image dipole.

3. (25 pts) A spherical <u>conductor</u>, of radius *a*, carries a charge *Q*. It is surrounded by linear dielectric material with a dielectric constant ε_r, out to a radius *b*.

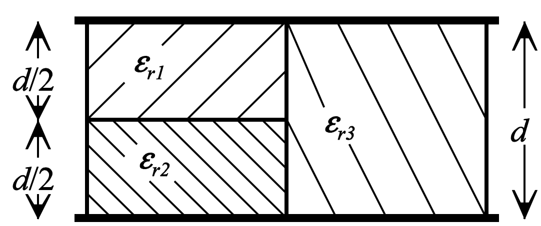


a) Determine the electric field in all three regions,
$r < a; \quad a < r < b; \quad r > b.$

b) Determine the polarization in all three regions.

c) Determine the bound volume and surface charge densities. Note that the dielectric material has both an inner and outer surface.

4. (25 pts) A parallel plate capacitor is filled with three dielectrics with dielectric constants ε_{r1}, ε_{r2}, and ε_{r3} as shown. Half the capacitor is filled with ε_{r3}. The other half is divided equally between ε_{r1} and ε_{r2}. The total area of a plate is *A* and *d* is the distance between the plates.



Determine the total capacitance of the arrangement in terms of the original capacitance C_0 with no dielectric material present $\left(C_0 = \varepsilon_0 A/d\right)$ if $\varepsilon_{r1} = 2$, $\varepsilon_{r2} = 3$, and $\varepsilon_{r3} = 4$.

Electric field due to a dipole $\vec{E} = \frac{k_e}{r^3}[3(\vec{p} \bullet \hat{r})\hat{r} - \vec{p}]$

Bound charge $\rho_b = -\vec{\nabla} \bullet \vec{P}$ $\sigma_b = \vec{P} \bullet \hat{n}$

$$\vec{D} = \varepsilon_0 \vec{E} + \vec{P} = \varepsilon_0 \vec{E} + \varepsilon_0 \chi_e \vec{E} = \varepsilon \vec{E} = \varepsilon_r \varepsilon_0 \vec{E}$$