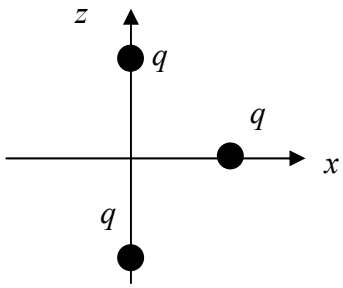
Phys 221 – Electrodynamics I -- Test 3 (April 18, 2007)



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

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

b) The quadrupole moment for this distribution is given by $\vec{\vec{Q}} = 3qa^2 \begin{bmatrix} 0 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$. What is the approximate electric potential at points far from the distribution? Keep all three terms and give your results in spherical coordinates.

Recall: $V(\vec{r}) = k_e \left\{ \frac{Q}{r} + \frac{\vec{p} \bullet \hat{r}}{r^2} + \frac{\vec{r} \bullet \vec{\vec{Q}} \bullet \vec{r}}{2r^5} + \cdots \right\}$

2.(25 pts) A certain coaxial cable consists of a copper wire , radius *a*, surrounded by a concentric copper tube of inner radius *c*. The space between *a* and *b* is filled with material of dielectric constant ε_r and the space between *b* and *c* is air ($a < b < c$). Assume there is a charge per unit length λ at $s = a$ and $-\lambda$ at $s = c$.

a) Determine the displacement $\vec{D}$, the electric field $\vec{E}$, and the polarization $\vec{P}$ in all four regions, *i.e.*, $s < a$, $a < s < b$, $b < s < c$, and $s > c$.

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

b) Find the capacitance per unit length of the coaxial cable.

3.(25 pts) a) In 1897 J. J. Thompson "discovered" the electron by measuring the charge-to-mass ratio of "cathode " rays, *i.e.,* an electron beam. First he passed the beam through uniform crossed electric and magnetic fields (mutually perpendicular, and both perpendicular to the beam), and adjusted the electric field until he got zero deflection. What, then, was the speed of the particles (in terms of E and B)?

b) Then he turned off the electric field , and measured the radius of curvature, *R*, of the beam as deflected by the magnetic field alone. In terms of *E, B,* and *R*, what is the charge-to-mass ratio (q / m)of the particles?

4.(25 pts) a) A phonograph record carries a uniform surface density σ. If it rotates at an angular velocity ω, what is the vector surface current density $\vec{K}$ at a distance *s* from the center?

b) A current *I* flows down a hollow wire of inner radius *a* and outer radius *b*. If it is distributed in such a way that the volume current density is inversely proportional to the square of the distance from the center of the wire, determine *J*.