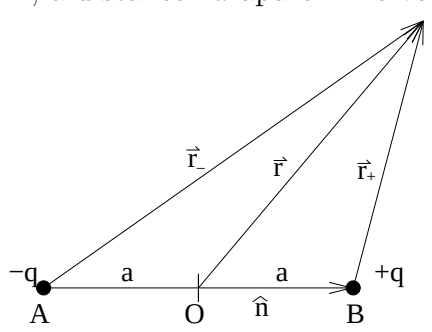
PHY6938 Proficiency Exam Spring 2003
March 28, 2003
E & M

1. In the diagram below, an electric dipole has a charge $-q$ at point A and $+q$ at point B, a distance $2a$ apart. The vector $2a\hat{n}$ points from point A to point B.

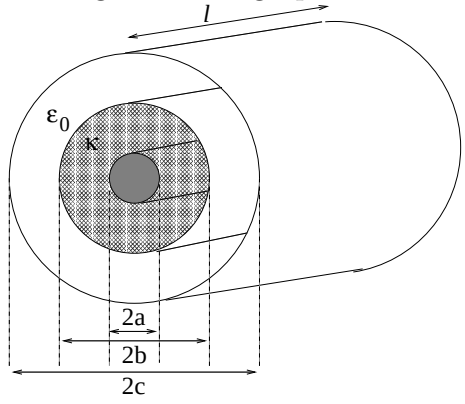


Assuming that $a << r$, show that the electric potential $\Phi(\vec{r})$ at point P is given by

$$\Phi(\vec{r}) = \frac{\vec{p} \cdot \hat{r}}{4\pi\epsilon_0 r^2},$$

where $\vec{p} = q2a\hat{n}$ is the electric dipole moment, and $\hat{r}$ is the unit vector pointing in direction of P from the origin O.

2. A coaxial capacitor of length l consists of an inner conductor of radius a, a cylindrical dielectric with dielectric constant κ of inner radius a and outer radius b, and a shell of free space of inner radius b and outer radius c. There is a conducting surface holding total charge q at the radius c. The inner conductor carries charge $-q$.



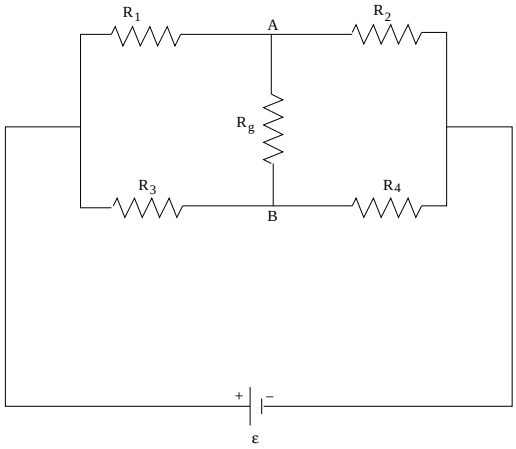
(a) Find the radial component of the electric field **E** in all regions of space.

(b) Find the potential V in each region and the total potential across the capacitor (ignore all edge effects).

(c) Find the capacitance.

(d) Find the stored energy in the capacitor. Is the energy greater than or less than the energy stored in a similar capacitor with no dielectric?

3. Consider the Wheatstone bridge resistor circuit shown in the diagram below.



(a) Use Kirchhoff's laws to derive a condition for the values of R_1, R_2, R_3 and R_4, under which the galvanometer does not measure a current and the Wheatstone bridge is "balanced".

(b) What is the total resistance of the circuit ?