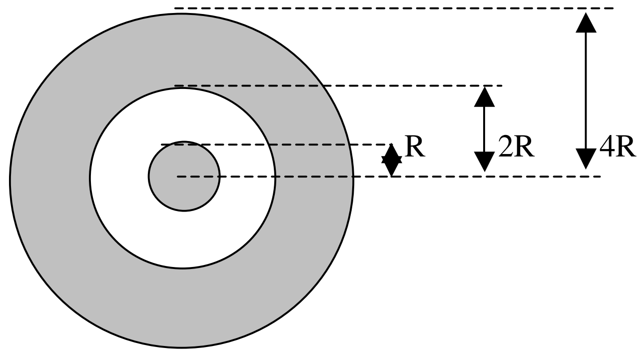
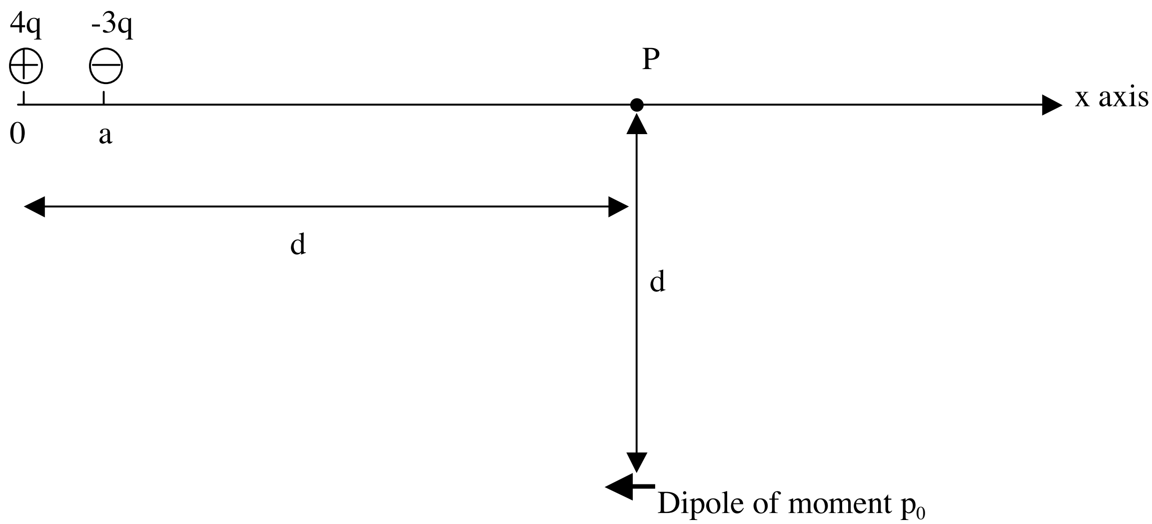
PHYSICS 4C QUIZ 1 (open book) Fall QUARTER 2011
PROF. HIRSCH OCTOBER 7

Problem 1 (10 pts)



The figure shows a non-conducting sphere of radius R and uniform charge density ρ, surrounded by a concentric non-conducting spherical shell of inner radius 2R, outer radius 4R, and the same uniform charge density ρ. In-between there is vacuum.
(a) Give an expression for the electric field at radius R, E_R, in terms of ρ, R, and ε_0.
(b) Give the value of the electric field at radius 2R, E(2R), in terms of E_R only.
(c) Give the value of the electric field at radius 3R, E(3R), in terms of E_R. (Note that 3R is inside the outer shell halfway between its surfaces).
(d) Make a plot of E(r) versus r for r ranging from 0 to 5R indicating on the r axis the points where there are changes in the behavior (slope) of E(r).

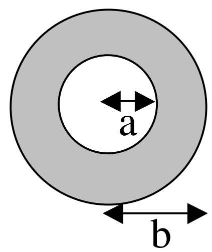
Problem 2 (10 pts)

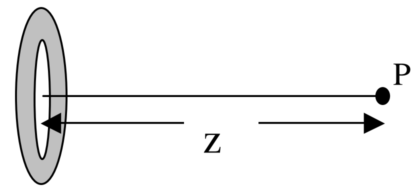


There is a charge 4q at the origin and a charge -3q at position a along the x axis. The point P is on the x axis at distance d from the origin. At a distance d from P in direction perpendicular to the x axis there is a dipole of moment p_0 pointing in the -x direction, as shown in the figure. The electric field at point P is found to be $E_P = \frac{q}{4\pi\varepsilon_0}\frac{1}{d^2} + O(\frac{1}{d^4})$ pointing in the positive x direction. Assume d>>a.
Find the value of the dipole p_0 in terms of q and a.
<u>Hint:</u> don't guess. Use the binomial expansion $(1+\alpha)^m \sim 1+m\alpha$. Show your work.

PHYSICS 4C QUIZ 1 (open book) Fall QUARTER 2011
PROF. HIRSCH OCTOBER 7

Problem 3 (10 pts)





The annulus in the figure has inner radius a and outer radius b and charge per unit area σ. We would like to calculate the electric field at a point P at distance z from the center along the axis perpendicular to the annulus (see figure on the right).
We derived in class that for a ring of radius r and total charge q the electric field at distance z along the perpendicular axis is

$$E = \frac{q}{4\pi\varepsilon_0}\frac{z}{(z^2+r^2)^{3/2}}$$

Use that result to do this problem. First, write an expression for the contribution to the electric field at point P from the part of the annulus that has radius between r and r+dr.
(a) Then, do an integral and find a formula for the electric field at point P, E(z), in terms of σ, z, a, b, and ε_0. Your answer should not contain the letters q nor r.
(b) Find from your formula the value E(z=0). Does it make sense? Explain.
(c) Take in your formula the limit a-->0 and then the limit z-->0 and give the value of E in that case. Does it make sense? Explain why.
(d) Find from your formula the limit E(z) for z very large (z>>a, z>>b). (not E=0!). (Use that $(1+x)^m \sim 1+mx$ for small x). Explain how you can tell that the answer you get is correct.

Justify all your answers to all problems