PHYS-505: ELECTROMAGNETIC THEORY III
HOMEWORK III

Due 10.05.2014

Q1: Find
a) the electric dipole moment of a thin ring lying in the $x - y$ plane centered on the origin bearing line charge $\rho = \lambda\delta(r-a)\delta(z)cos\phi$.
b) the electric dipole moment of a thin charged rod bearing charge density $\rho = \lambda z\delta(x)\delta(y)$ for $z \in (-a, a)$.
c) the quadrupole moment of a square whose edges, taken in turn, have alternating charges $\pm q$ uniformly distributed over each as illustrated in Figure 1.
d) the quadrupole moment of a rod of length L bearing charge density $\rho = \eta(z^2 - \frac{L^2}{12})$, with z measured from the midpoint of the rod.

Q2: Three point charges with charges $-q_0$, $-q_0$ and $2q_0$ are held on xy-plane at positions $(a, 0, 0)$, $(-a, 0, 0)$ and $(0, 0, 0)$, respectively.
a) Find the electric potential on the z axis.
b) Using the electric potential, find the electric field on the z axis. What is your result for $z \gg a$?
c) What is the electric potential energy of this configuration?
d) Find the electric potential everywhere using multipole moments.

Q3: Two concentric conducting spheres of inner and outer radii a and b, respectively, carry charges $\pm Q$. The empty space between the spheres is half-filled by a hemi-hemispherical shell of dielectric (of dielectric constant $\frac{\epsilon}{\epsilon_0}$), as shown in the figure 2.
a) Find the electric field everywhere between the spheres.
b) Calculate the surface-charge distribution on the inner sphere.
c) Calculate the polarization-charge density induced on the surface of the dielectric at $r = a$.

Q4: A very long, right circular, cylindrical shell of dielectric constant $\frac{\epsilon}{\epsilon_0}$ and inner and outer radii a and b, respectively, is placed in a previously uniform electric field E_0 with its axis perpendicular to the field. The medium inside and outside the cylinder has a dielectric constant of unity. Determine the potential and electric field in the three regions, neglecting end effects.

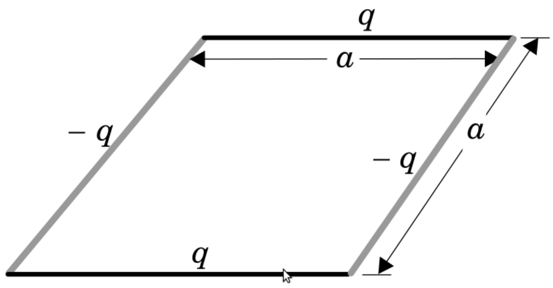

Figure 1:

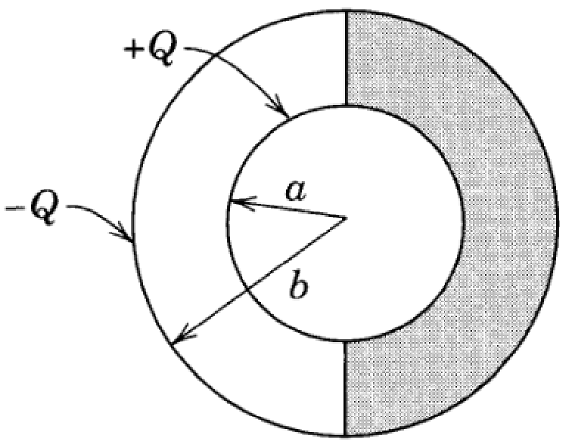

Figure 2: