PHY 103N: PHYSICS 2, (2007-2008, Semester -II)

Department of Physics, I.I.T. Kanpur

Assignment - 3 (4, 6, 7, 8 will be discussed in the tutorials)

1. If the vector field in some region is stated to be

$$\vec{E}(\vec{r}) = \frac{1}{r}\left(A\hat{r} + B\sin\theta\ \cos\phi\ \hat{\phi}\right),$$

is this a valid static electric field ? If so, find what would be the charge distribution that would be associated with it.

2. (Problem 2.36 of Griffiths) Two non-intersecting spherical cavities of radii, r_A and r_B are hollowed from a sphere of radius R. At the centre of these two cavities are kept two charges q_A and q_B.
   (a) Find the surface charge distributions on all the surfaces
   (b) Find the electric field everywhere
   (c) What is the force on the charge q_A and q_B
   (d) Which of these answers would change if a third charge were brought near the sphere?

3. Find the force of repulsion between the "northern" hemisphere and the "southern" hemisphere of a metal sphere of radius R and carrying a total charge Q.

4. Find the capacitance associated with two long conducting cylinders, if
   (a) they are concentric (coaxial) and have radii R_1 and R_2 $(R_2 > R_1)$. What is the associated energy?
   (b) their axes are parallel, with a distance d separating their centres (approximate that $d \gg R_1 + R_2$). Also obtain the equipotential surfaces in this case when they are held at potentials $+V$ and $-V$.

5. Using the method of images, compute the potential within a slab of thickness $2d$ (cavity) bound by semi-infinite conducting regions on both sides and when a charge q is placed in the cavity at a distance $a < d$ from the one of the conductors.

6. Using the method of images, find the force between a sphere of radius R held at potential V and a charge q as a function of of the distance from the centre of the sphere. Plot this dependence with distance for both signs of the charge $(\pm q)$.

7. (Problem 3.27 of Griffiths) The charges and locations of four particles are: $q:\ (0,0,-a)$, $-2q:\ (0,a,0)$, $-2q:\ (0,-a,0)$ and $3q:\ (0,0,a)$. Find the dipole and quadrupole moments. Find a simple approximate expression for the potential at large distances $(r \gg a)$.

8. (Problem 3.41 of Griffiths) Show that the average field inside a sphere of radius R due to all charge inside is

$$\vec{E}_{ave} = -\frac{1}{4\pi\varepsilon_0}\frac{\vec{p}}{R^3}$$

where $\vec{p}$ is the total dipole moment. Show that the average field due to all charges outside the sphere is the field they would produce at the centre.