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

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

1. Find the expressions for the potential at points far away from the localized charge distributions (along the z axis):
   (a) Surface charge $\sigma \cos\theta$ on a sphere of radius R
   (b) Charge density $\rho \cos 2\theta$ within a sphere of radius R.

2. Prove that the electric field at any point $\vec{r}$ due to a dipole with moment $\vec{p}$ placed at the origin is

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\left[\frac{3(\vec{p}\cdot\hat{r})\hat{r} - \vec{p}}{r^3}\right]$$

   Now find the average of this field over a sphere of radius R centred on the dipole. Check if your result is consistent with the problem -8 of assignment -3. If not, how would you rectify this ? (See problem 3.42 of Griffiths book).

3. Find the force between an uncharged conducting sphere of radius a and a dipole of moment $\vec{p}$ when the distance between them is r. Can you ascribe a polarizability to the conducting sphere and calculate it?

4. A point charge q is located at ta distance r from a neutral atom which has a polarizability α. Find the force between them.

5. At a planar interface between two dielectric media with dielectric permittivities ε_1 and ε_2, if the electric field in medium-1 makes an angle θ_1 with the normal to the interface and the electric field in medium -2 makes an angle θ_2, show that

$$\frac{\tan\theta_2}{\tan\theta_1} = \frac{\varepsilon_2}{\varepsilon_1}$$

   Assume there are no free charges on the boundary (Problem 4.33 of Griffiths book).

6. The space between the plates of a prallel plate capacitor is filled with two slabs of linear dielectric media with a thickness a each so that the distance between the plates is $2a$. If the two slabs have relative dielectric permittivities of 2 and 1.5, and the externally applied charge density on the capacitor plates are $\pm\sigma$, find
   (a) The displacement field in each slab
   (b) the electric field in each slab
   (c) the polarization field in each slab,
   (d) the potential difference between the two plates
   (e) the location and amounts of all bound charge
   (d) the capacitance of the parallel plate capacitor.