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

Department of Physics, I.I.T. Kanpur

Assignment - 2 (3, 5, 6, 8, 9, 10 will be discussed in the tutorials)

---

1. Prove that $\delta(x-a)$ is the derivative of the Heaviside set-function,

$$\theta(x-a) = \begin{cases} 1 & \forall \quad x > a \\ 0 & \forall \quad x < a \end{cases}$$

2. (Problem 1.58 of Griffiths) Verify the divergence theorem for the function

$$\vec{v} = \hat{r}r^2 \sin\theta + \hat{\theta}4r^2 \cos\theta + \hat{\phi}r^2 \tan\theta$$

over the volume of an "ice-cream"(inverted) cone (with a spherical top surface with radius R) and a half-cone angle of 30^o.

3. Represent the charge densities using the Dirac δ functions:

   (a) A uniformly charged spherical thin shell of radius R containing a total charge Q.

   (b) Uniform charge density of σ on the sides of a cone of angle 30^o.

   (c) A physical dipole consisting of charges $\pm q$ at a distance of $2a$ along the z axis.

   (d)A line charge in the $x-y$ plane making an angle of 45^o to the x axis.

4. Use Gauss's law and find the electric field everywhere for:

   (a) A uniformly charged sphere with charge density ρ and of radius R .

   (b) An infinitely long cylindrical shell of radius R and with unifrom surface charge density σ.

   (c) An infinite (in the transverse directions) slab of thickness d and uniform charge density ρ.

5. Consider an infinite plane with a spatially uniform surface charge density σ with a circular hole of radius R. Find the electric field at points on the axis of the hole (above and below the plane).

6. Consider two uniformly charged spheres of radius R and but with opposite charges density ($\pm\rho$). If they overlap such that the distance between their centres is $s < 2R$, then obtain the electric field in the region of overlap.

7. Consider a long charged cylinder of radius R with volume charge density ρ. If a cylindrical region with radius $R/2$ is hollowed out from within this cylinder, such that the centre of the hollowed region lies at distance $R/2$ of the original cylinder, obtain the electric field within the hollowed out region.

8. Find the electrostatic potential function for the charge configurations of Problem (4).

9. A charge $-q/2$ is placed at $(a, 0, 0)$ and another charge $+q$ is placed at $(4a, 0, 0)$. Show that the equipotential surface for zero potential is a sphere – determine its radius and centre.

10. Prove Earnshaw's theorem which states that in a charge free region an external charge cannot be held in stable equilibrium using electrostatic forces alone. Think of a counter example in the presence of a volume charge distribution.