PHY 303 : Assignment 3

Submit by 10 October 2024 midnight

1. The surface of a sphere of radius R is maintained at a potential $V_0 \cos(2\theta - \phi)$. Find out the potential outside the sphere and inside the sphere.

2. Using the definition of q_{lm} and the definition of dipole moment $\mathbf{p} \equiv \int d^3\mathbf{r}\mathbf{r}\rho(\mathbf{r})$, write down p_x, p_y and p_z in terms of q_{lm}. For two bodies of charge density distribution $\rho_1(\mathbf{r})$ and $\rho_2(\mathbf{r})$, find out the electrostatic force expression upto dipole term.

3. A dielectric sphere of radius R and permittivity ϵ is put in an electric potential $\phi(x, y, z) = \alpha(x - y)$ with a constant α. Find out the net electric field inside the sphere and outside it.

4. Inside a dielectric media of permittivity $\epsilon = \epsilon_r \epsilon_0$ prove that the polarization vector satisfies $\nabla \cdot \mathbf{P} = (\epsilon_r - 1)\rho/\epsilon$. If a sphere of radius a of the same dielectric media is kept in an empty space having electric field $E_0\hat{\mathbf{z}}$, find out the change in electric field energy compared to the case when the sphere was not put in.

5. Find the magnetic field at a point situated at a height h from the center of a square loop of size a along the which a charge q moves with a speed v_0. If magnetic moment is placed at that point, find out the period of small oscillations as a function of v_0.