

Problem Sheet - 3(Electrostatics)

1. Use the method of images to calculate the force felt by a point charge $+Q$, situated at a distance 'a' from the centre of an earthed conducting sphere of radius 'r', when $a \gg r$.
2. What is the volume density of charge in a region of space where electrostatic potential is given by

$$V = a - b(x^2 + y^2) - c \log(x^2 + y^2)$$

where a,b,c are constants.

3. Check which of the following functions may be possible electrostatic fields.

- $\vec{E} = (4y\vec{i} - 2x\vec{j} - \vec{k})A$
- $\vec{E} = (2xz\vec{i} - yz^2\vec{j} - \vec{k} - y^2z\vec{k})A$

where A is a constant with suitable dimensions. For the field which you find permissible, find how the charge density changes with position. (Use Poisson's equations)

4. Explain the physical meaning of Earnshaw's theorem. Assuming Gauss' theorem obtain Poisson's equation.
5. What is meant by polarisation of dielectrics? Obtain the transverse component of the field due to an electric dipole at a point (r, θ) in free space.
6. A dielectric sphere of radius 'a' has a polarisation $\vec{P} = k\vec{r}$, where k is a constant and the origin is at the centre. Where do polarisation charges appear as far as this sphere is concerned? For this sphere, calculate the surface density of the polarisation charges and their volume density. What is the field intensity outside the sphere due to its polarisation?
7. A uniformly charged sphere of radius 'a' carries a total charge Q and a volume density of charge ρ . Show that the electrostatic energy is

$$U = \frac{3Q^2}{20\pi a \epsilon_0}$$