Introduction to Electric and Magnetic Fields B38EM

Tutorial 3 - Problems

$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{Fm^{-1}}$, $q_{e^-} = 1.6 \times 10^{-19}\ \mathrm{C}$

1. Half a sphere of centre *O* is charged superficially with a constant surface charge density σ. Calculate the expression of the electric field at point *O*.

2. Find the electric field inside a sphere which carries a charge density proportional to the distance from the origin. In other words, if ρ is the charge density, $\rho = kr$, where k is a constant and r is the distance from the origin.

3. distance from the origin of the sphere. In other words, there is void for r ranging from 0 to a, then matter between a and b, then void again for r greater than b.

   Find the electric field intensity in the three regions (i) $r<a$, (ii) $a<r<b$ and (iii) $r>b$. Plot the magnitude of the electric field **E** as a function of r.

4. Consider five point charges enclosed in a cylindrical surface (S). The charges are $Q_1 = 3\,\mathrm{nC}$, $Q_2 = -2\,\mathrm{nC}$, $Q_3 = 2\,\mathrm{nC}$, $Q_4 = 4\,\mathrm{nC}$ and $Q_5 = -1\,\mathrm{nC}$. Calculate the flux through the closed surface.

5. A line charge with linear charge density $\lambda = 10^{-12}$ C/m passes through the centre of a sphere. If the flux through the surface of the sphere is $1.13\ 10^{-3}$ Vm, calculate the radius *R* of the sphere.

6. We know that the E-field at a distance *r* from an infinitely charged line of linear charge density λ is given by: $\mathbf{E} = \frac{1}{2\pi\varepsilon_0}\frac{\lambda}{r}\mathbf{n}$, where **n** is the vector radial to the line of charge. Calculate the electric flux passing through a cylinder of radius r and height H surrounding a portion of this infinite line. Verify that the enclosed charge is λH.

7. Using Gauss's law, demonstrate that the normal component of the electric flux density, **D**, is continuous across the interface between two dielectric regions (i.e. have no charge) of permittivity ε_1 and ε_2.