Vidyasagar College for Women
Department of Physics
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B.Sc. (Physics Hons)
Semester - II

Assignment-2

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Electrostatics (Electric field and Gauss's law)

2.1 The electric field strength in a region is given by $\vec{E} = a\left(x\hat{i} + y\hat{j}\right)/\left(x^2 + y^2\right)$. Find the flux of the electric field through a sphere of radius R with its centre at the origin of the co-ordinate system.

2.2 A ball of radius R carries a positive charge whose volume charge density depends on a separation r from the ball's centre as $\rho = \rho_0\left(1 - \frac{r}{R}\right)$, where ρ_0 is a constant.

a) Find the magnitude of the electric field strength as a function of distance r both inside and outside the ball.

b) Determine the $r = r_m$ at which the field strength is maximum and find the maximum intensity $E_{\max}$.

2.3 Consider that the field at a point due to a point charge q is $\vec{E} = \frac{q}{4\pi\varepsilon_0}\frac{\hat{r}}{r^{2+\alpha}}$ instead of $\frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}$, where $\alpha << 1$. Calculate $\nabla \cdot \vec{E}$ *and* $\nabla \times \vec{E}$ *for* $r \neq 0$.

2.4 Two spheres each of radius R carrying uniform charge densities $+\rho$ and $-\rho$ respectively, are placed so that they partially overlap. Call the vector from the positive centre to negative centre $\vec{d}$. Show that the field in the region of overlap is constant.

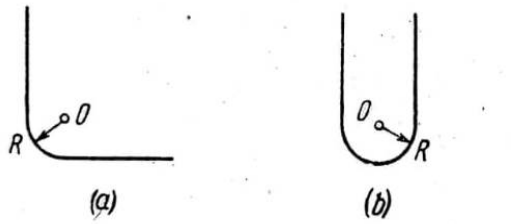
2.5 A point charge q is placed on the top of a cone of semi vertex angle θ. Find the electric flux through the base of the cone.

2.6 A hemispherical surface of radius R has uniform charge density σ on it. Calculate the field at the centre of the sphere of which the hemisphere is a part.

2.7 A thin non-conducting ring of radius R has a linear charge density $\lambda = \lambda_0 \cos\phi$, where λ_0 is a constant, ϕ is the azimuthal angle. Find the magnitude of the electric field strength a) at the centre of the ring b) on the axis of the ring as a function of the distance z from its centre. Study the case for $z >> R$.

2.8 A very long straight uniformly charged thread carries a charge λ per unit length. Find the magnitude and direction of the electric field strength at a point which is at a distance y from the thread and lies on the perpendicular passing through one of the thread's ends.

2.9 A thread carrying a uniform charge λ per unit length has the configurations shown in the figure (a) and (b). Assuming the curvature radius R to be considerably less than the length of the thread, find the magnitude of the electric field strength at the point O.



(a) (b)