BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI (RAJ)

SEMESTER I 2023 - 2024

Electromagnetic Theory I (PHY F212): Midsem - PART B

Date : 9 Oct 2023 **Closed Book** **Marks: 60** **Duration max: 90 min**

All the parts should be answered together. All bold face characters represents vectors.

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1. (a) Define the Strokes theorem for a vector field $\mathbf{v}$.

   (b) Test the Strokes' theorem for the vector field $\mathbf{v} = (xy)\hat{\mathbf{x}} + (2yz)\hat{\mathbf{y}} + (3zx)\hat{\mathbf{z}}$ using the a trianglular shaded area shown in the Figure 1. **[2+11 = 13]**

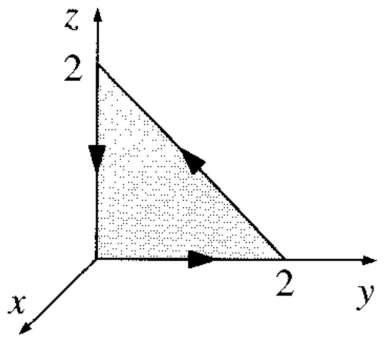

Figure 1:

2. A uniformly charged solid sphere of radius R and having a volume charge density ρ is surrounded by a thick concentric metal shell of inner radius a and outer radius b. The shell carries no net charge.

   (a) Find the surface charge density σ at a and b.

   (b) Find the electric field $\mathbf{E}(\mathbf{r})$ and potential $V(\mathbf{r})$ in the regions i) $r < R$, ii) $R < r < a$, iii) $a < r < b$ and iv) $r > b$.

   (c) Find the electrostatic pressure on all surfaces at R, a and b.

   (d) How σ, $\mathbf{E}$, V and the electrostatic pressure change if the outer surface of the shell is grounded. **[2 + 14 + 6 + 2 = 24]**

3. A point charge q is situated a distance a from the center of a grounded conducting sphere of radius R. The origin is located at the center of the sphere.

   (a) Obtain an expression for the potential at any point $V(r,\theta)$ outside the sphere in the usual spherical polar coordinates with the z axis along the line through q.

   (b) Find the induced surface charge density $\sigma(r,\theta)$ on the sphere, as a function of θ. Obtain the total induced charge.

   (c) Calculate the electrostatic energy of this configuration.

   (d) Find the monopole moment and the dipole moment of the system. **[7 + 6 + 5 + 5 = 23]**