**B.A./B.Sc. 1ˢᵗ Semester (Batch 2021-24)**

**PHYSICS**

**Paper—B**

**(Electricity and Magnetism)**

Time Allowed—3 Hours]     [Maximum Marks—35

**Note :**— Attempt *five* questions by selecting at least *one* question from each section, **fifth** question can be attempted from any section. Each question carries equal marks.

**SECTION—A**

1. (a) What is physical significance of divergence of vector field ? Drive its expression in terms of the Cartesian coordinates and the DEL operator.                                                                5+2

   (b) Prove that $\vec{\nabla} \cdot \left( \dfrac{\vec{r}}{r^3} \right) = 0$.

2. (a) State Gauss's law. Under what conditions this law is especially useful in determining the electric field intensity of a charge distribution ? By applying it find the electric field due to a uniformly charged spherical shell.

   (b) What is value of $\vec{\nabla} \cdot \vec{B}$ and $\vec{\nabla} \times \vec{B}$ for a point outside the current loop ?                                                                5+2

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## SECTION—B

3. (a) Prove that the electrical potential due to a quadrupole varies inversely as the cube of the distance.

   (b) Discuss the electric potential variation due to a spherical distribution of charges.

   (c) The electrical potential at any point in the X-Y plane is given by $\varphi = 5x(x^2 + y^2)^{1/2} + y(x^2 + y^2)^{-1/2}$. Find the Cartesian components of the electric field intensity at that point.  2+3+2

4. (a) Show that the potential due to arbitrary charge distribution at far off points can be written as the sum of potentials due to monopole, dipole and quadrupole.

   (b) Calculate the potential difference between the centre and the surface of a sphere of radius R with uniform charge density $\rho$ within it.  5+2

## SECTION—C

5. Explain the method of electrical images. A point charge q is placed in front of a conducting plane of infinite line maintained at zero potential. Calculate :

   (a) The potential and electric field at any point

   (b) The surface density of induced charge on the conducting plane. What is the total induced charge on it ?  7

6. (a) Derive an expression for electrical conductivity from Ohm's law. Also discuss the limitations of Ohm's law.

   (b) A silver wire 1 mm in diameter carries a charge of 90 coulombs in 1 hour and 15 minutes. Silver contains $5.8 \times 10^{22}$ free electrons per $cm^3$, calculate (i) the current in the wire in amperes (ii) the drift velocity of the electrons in meters/sec.  5+2

## SECTION—D

7. (a) Derive and discuss the relation of the interaction of a moving charge on other moving charge and also obtain the expression for force between parallel currents.

   (b) Write a short note on magnetic substances.  5+2

8. (a) Derive the expression for the orbital magnetic moment induced in an atom.

   (b) A 5 MeV proton moves vertically downward through a magnetic field of induction 1.5 weber/$m^2$ pointing horizontally from south to north. Calculate the force acting on the proton. Mass of the proton is $1.6 \times 10^{-27}$ kg.  5+2