This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **1531**

Unique Paper Code : **222463** **E**

Name of the Paper : **Physics-IV : Electricity, Magnetism and Electromagnetic Theory (PHPT-404)**

Name of the Course : **B.Sc. (Physical Sciences)**

Semester : **IV**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *Five* questions in all.

Question No. **1** is compulsory. Attempt *four* questions from the rest of the paper.

Use of non-programmable scientific calculator is allowed.

1. Attempt any *five* of the following : 5×3=15

   (*a*) Show that $\vec{E} = E\hat{i}$ is an irrotational vector.

   (*b*) Draw and compare the electric field lines for :

   (*i*) Equal and opposite charges separated by a distance '*d*' and

   (*ii*) Equal positive charges separated by a distance '*d*'.

   (*c*) Differentiate between circularly and elliptically polarised light.

   (*d*) Prove that reciprocity theorem for coefficients of mutual inductance.

   (*e*) A current of 2 A flowing through a coil is cut-off completely in 0.2 s. Calculate the e.m.f. induced in the coil if it has a self-inductance of 0.06 H.

P.T.O.

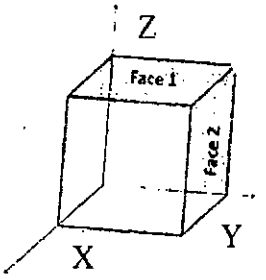
(*f*) Derive the continuity equation and discuss what it signifies.

(*g*) A light ray is incident from 'air' into 'paraffin'. Find the Brewster's angle. (Refractive index of paraffin is $\sqrt{3}$)

2. (*a*) Derive the differential form of Gauss's law. How would you interpret it to understand that electric charges act as sources and sinks of electric field lines when placed in some volume ? 6

(*b*) A long solid cylinder carries a charge density proportional to the distance from its axis as $\rho = kr$, for some constant k. Find the electrostatic field somewhere inside the cylinder. 5

(*c*) The electric field in a region is given by $\vec{E} = 3\hat{i} + 2\hat{j}$. Calculate the electric flux due to this field through the face 1 and face 2 for a cube of side 0.5 m : 4



3. (*a*) Write the expression for electric field at a point P lying inside and outside a uniformly charged sphere of radius R having a total charge Q at a distance r from its center. Calculate the electric potential at P (inside and outside) from it. 7

(*b*) Determine the electrostatic potential energy of a system of n-point charges. 5

(*c*) The electric potential at a point (x, y, z) is given by $V = 3xz - y^2$. Find the corresponding electric field $\vec{E}$. 3

4. (*a*) Using the Biot-Savart's law, find the force per unit length between two long parallel wires carrying current I_1 and I_2 in the same direction separated by a distance '*a*'. 7

(*b*) A circular wire of radius r = 3 cm carries a current I = 20 A in clockwise direction. What magnetic field will be observed at a distance d = 4 cm along the axis from the center of the wire ? 4

(*c*) A charge q moving initially with velocity $3\hat{k}$ m/s enters a region with electric field, $\vec{E} = 10\alpha\,\hat{i}$ V/m and magnetic field, $\vec{B} = 20\,\hat{j} + 100\,\hat{k}$ T. What value of α will the Lorentz force on the charge be zero ? 4

5. (*a*) A Ballistic Galvanometer is given a current i for a short time duration Δt. Show that the deflection θ_0 is given by :

$$\theta_0 = \frac{NABQ}{\sqrt{cI}}$$

where N is the number of turns of the coil, A is area of the coil, B is the magnitude of the magnetic field, Q is the total charge delivered by the transient current, I is the moment of inertia of the BG coil and c is the Ballistic constant. Hence, define the charge sensitivity. 5

(*b*) A rectangular coil of length l and breadth b free to rotate about the x-axis is placed in a uniform magnetic field with direction along the y-axis. If a constant current i is now passed through the coil, find the total force and the total torque exerted on the coil by the magnetic field. 7

(*c*) A magnetic vector potential $\vec{A}$ is given by $3x^2\,\hat{j}$. Obtain $\vec{B}$, the magnetic field at a point (2, 3, 1) 3

P.T.O.

6. (*a*) Prove that :

$$\text{curl } \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

What is the significance of Lenz's law ? 5

(*b*) Show that the energy density associated with each point in space where the magnetic field is $\vec{B}$ is given by :

$$U_m = \frac{1}{2\mu_0} B^2$$

where symbols have the usual meanings. 6

(*c*) Find the energy stored in the magnetic field of a section of length *l* of a long solenoid. 4

7. (*a*) Explain the inconsistency of Ampere's Circuital Law and explain how it can be removed. What is displacement current ? 6

(*b*) Using Maxwell's equations in dielectric medium obtain the wave equations for the electric and magnetic field vectors and find the expression for the velocity of EM wave in the medium. 6

(*c*) Prove that the electromagnetic waves are transverse in nature. 3

8. (*a*) Obtain the boundary conditions for $\vec{E}, \vec{D}, \vec{B}$ and $\vec{H}$ at the interface between two dielectrics. 8

(*b*) Derive Fresnel's relations for reflection and transmission of a plane electromagnetic wave incident normally at a plane interface separating the two dielectrics. 7

Physical Constants :

$\epsilon_0 = 8.85 \times 10^{-12}$ C^2/Nm^2

$\mu_0 = 4\pi \times 10^{-7}$ Wb/Am

$c = 3 \times 10^8$ m/s

$e = 1.6 \times 10^{-19}$ C