This question paper contains **8** printed pages]

Your Roll No.....

51931)

B.Sc. (Prog.) PHYSICAL SCIENCES/IV Sem. B

Paper PHPT-404

(Electricity, Magnetism and Electromagnetic Theory)

Time : 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.

Note : Use of non-programmable scientific calculator is allowed.

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

   (*a*) A charge of 3×10^{-9} C is located at the origin of a Cartesian co-ordinate system. Find the electric field vector $\vec{E}$ and electric displacement vector $\vec{D}$ at a point (1, 2, 2) ?

P.T.O.

(*b*) State Faraday's laws of electromagnetic induction. What is the fundamental difference between the electric field induced due to a changing magnetic flux and the electric field due to static charges ?

(*c*) Which of the following expressions for field, in which a is a constant, represents an electrostatic field :

(*i*) $\vec{F} = a\left[xy\,\vec{i} + 2yz\,\vec{j} + 3xz\,\vec{k}\right]$

(*ii*) $\vec{F} = a\left[y^2\,\vec{i} + (2xy + z^2)\,\vec{j} + 2yz\,\vec{k}\right]$

(*d*) Define charge sensitivity and current sensitivity of a ballistic galvanometer. How are they related to each other ?

(*e*) Explain in brief why a current loop placed in a uniform magnetic field behaves as a magnetic dipole.

(*f*) A ray of light is incident on the surface of a glass plate of refractive index 1.5 at polarising angle. Calculate (*i*) the Brewter angle, and (*ii*) the angle of refraction for the ray.

(*g*) Write the generalised form of Maxwell's equations taking into account the volume charge density and both the conduction and displacement current densities. How these equations get modified for the case of a dielectric ?

(*h*) What do you understand by polarisation of electromagnetic waves ? Describe how circularly polarised and elliptically polarised waves can be obtained from two linearly polarised waves.

2. (*a*) State and prove Gauss' law in electrostatics. 9

(*b*) Use Gauss' law to find the electric field due to a uniformly charged solid conducting sphere at a point lying (*i*) inside, and (*ii*) outside the sphere. 3

(*c*) An electric field given by $\vec{E} = 6\vec{i} + 3\vec{j} + 4\vec{k}$ acts in a region of space. Calculate the electric flux due to this electric field through the surfaces each of area 0.1 m^2 lying in the :

(*i*) *x-y* plane

(*ii*) *y-z* plane and

(*iii*) *z-x* plane. 3

3. (*a*) Define electric potential. Obtain a generalised expression for the electrostatic potential energy of a system of *n*-point charges. 6

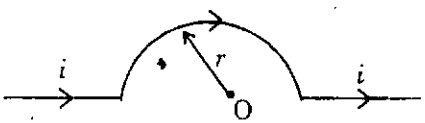
(*b*) What do you understand by the energy density of an electric field ? Show that, in free space, it is given by $\bar{U} = \frac{1}{2} \epsilon_0 E^2$, where the symbols have their usual meanings. 6

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

4. (*a*) State Biot-Savart law. Use this law to find the magnetic field at a point lying on the axis of a current-carrying circular coil. 9

(*b*) A test charge of 3×10^{-9} C is moving with a velocity $\vec{V} = 2\vec{i} + 3\vec{j}$ ms^{-1} in an electric field $\vec{E} = 3\vec{i} + 6\vec{j} + 2\vec{k}$ Vm^{-1} and a magnetic field $\vec{B} = 2\vec{j} + 3\vec{k}$ tesla. Find the magnitude and direction of the Lorentz force acting on the test charge. 3

(*c*) A straight conductor partly bent in the shape of a semicircle of radius *r*, as shown in the figure, carries a current *i*. Calculate the magnetic field at the centre O of the semicircle : 3



5. (*a*) State two points of difference between a dead beat and a ballistic galvanometer. 3

(*b*) Discuss in detail the conditions under which the motion of a moving coil galvanometer is :

(*i*) dead beat

(*ii*) ballistic, and

(*iii*) oscillatory. 9

(*c*) The windings of a solenoid of length 1 m and mean radius 10 cm consists of 1000 turns of wire. Calculate the magnetic field along the axis of the solenoid when a current of 20 A passes through its windings. 3

6. (*a*) Prove that relation $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{dt}$, where the symbols have their usual meanings. 6

(*b*) Define mutual inductance. What are its units ?

A long solenoid of length l, area of cross-section A and having n_1 turns has wound around its centre a small coil having n_2 turns. Calculate the mutual inductance between the solenoid and the coil. 6

(*c*) The current passing through an inductance decreases from 6A to 2A in 0.2 s. If the e.m.f. induced in the coil is 0.4 V, calculate the self-inductance of the coil. 3

7. (*a*) Starting from Maxwell's equations for electromagnetic field, obtain the wave equations for the electric and magnetic field vectors in a homogeneous and isotropic dielectric medium. 7

(*b*) Prove that the electromagnetic waves are transverse in nature. 5

(*c*) What is displacement current ? Taking the example of a parallel-plate capacitor, show that the concept of displacement current serves to preserve the notion of continuity of current. 3

8. (*a*) Show that the tangential component of the electric field vector $\vec{E}$ and the normal component of the electric displacement vector $\vec{D}$ are continuous at an interface between two linear isotropic dielectrics. 5

(*b*) Derive Fresnel's relation for reflection and transmission of a plane electromagnetic wave incident normally at a plane interface separating two dielectrics. 8

(*c*) An electromagnetic wave propagates through a non-magnetic dielectric medium having a relative permittivity value of 4. Calculate the phase velocity of the electromagnetic wave through the dielectric. 2