[This question paper contains 6 printed pages.]

**Your Roll No.....**

**Sr. No. of Question Paper : 2333** **IC**

Unique Paper Code : 42221201

Name of the Paper : Electricity, Magnetism and EMT

Name of the Course : **B.Sc. (Prog.)**

Semester : II

Duration : 3 Hours Maximum Marks : 75



**Instructions for Candidates**

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **Five** questions in all.
3. Question No. **1** is compulsory. Attempt **four** questions from the rest of the paper.
4. Use of non-programmable scientific calculator is allowed.

1. Attempt any **five** of the following :

   (a) If $\varphi(x,y,z) = 3x^2y - y^3x^2 + z^2$, calculate gradient of $\varphi$ at the point $(1, -2, -1)$.

   (b) Can the following be a possible electrostatic field?

$$\vec{E} = xy\hat{i} + 2yz\hat{j} + 3xz\hat{k}$$

P.T.O.

(c) State Poynting theorem and explain what do you understand by the Poynting vector.

(d) If $\vec{A}$ and $\vec{B}$ are irrotational, prove that $\vec{A} \times \vec{B}$ is solenoidal.

(e) Prove that $\vec{\nabla}.\vec{B} = 0$ and explain its physical significance.

(f) Distinguish between dia-, para- and ferro-magnetic materials.

(g) Discuss the difference between induced electric field and electric field due to static charges.

(5×3=15)

2. (a) Find the work done in moving a particle in the force field

$$\vec{F} = (2x + y^2)\hat{i} + (3y - 4x)\hat{j}$$

along the straight lines from (0,0) to (2,0), then to (2,1), then to (0,0).

(b) Show that the following function is a sink field

$$\vec{V} = \frac{-x\hat{i} - y\hat{j}}{\sqrt{x^2 + y^2}}$$

(c) Prove that $\vec{\nabla}.\left(\vec{\nabla}\times\vec{A}\right)=0$. (6,6,3)

3. (a) Use Gauss's law to find the electric field inside, outside and on the surface of a uniformly charged solid sphere having charge density $\rho$.

(b) Derive an expression for an electrostatic potential due to a uniformly charged spherical shell at a point inside and outside the shell.

(c) The electric potential at any point (x,y,z) is given by $V = x(3y^2 - x^2 + z)$. Find the electric field at that point. (6,6,3)

4. (a) Derive $Q_p = Q\left(1-\frac{1}{k}\right)$ for a capacitor with dielectric between the parallel plates, where $Q_p$ is the induced charge and k is dielectric constant. Calculate the capacitance of a parallel plate capacitor of plate area 5 $cm^2$ and separated by dielectric of dielectric constant 4 and thickness 1 cm.

(b) What is meant by polarization of a dielectric? Obtain generalized form of Gauss's law for a polarized dielectric.

P.T.O.

(c) The magnetic field $\vec{B}$ due to a current carrying circular loop of radius 10 cm at its centre is $0.2 \times 10^{-4}$ T. Find the magnetic field due to this loop at a point on the axis at a distance of 6 cm from the centre. (6,6,3)

5. (a) State and explain Biot-Savart's law. Derive an expression for the magnetic field at a point due an infinitely long straight current carrying conductor using Biot-Savart's law.

(b) State and prove Ampere's Circuital law. Starting from Ampere's circuital law, establish the relation

$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}.$$

(c) Define $\vec{B}$, $\vec{M}$ and $\vec{H}$. Establish the relation

$$\vec{B} = \mu_0 \left( \vec{H} + \vec{M} \right).$$ (6,6,3)

6. (a) State the Faraday's law of electromagnetic induction. Show that

$$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

(b) Show that if the two coils having coefficient of self inductance $L_1$ and $L_2$ are mutually coupled together so that the whole of the flux from one coil links with the other, then the mutual inductance between the two coils is given by

$$M = \sqrt{L_1 L_2}\ .$$

(c) Derive the expression for the energy stored in the magnetic field of an inductor. Find the energy stored in the magnetic field of a 50 mH coil carrying a current of 2 A. (6,6,3)

7. (a) The magnetic field in a region is given by $\vec{B} = 3\hat{i} + 4\hat{k}$ tesla. Calculate the magnetic flux across the surfaces each of area 2 $m^2$ in

(i) $x-y$ plane (ii) $y-z$ plane (iii) $z-x$ plane.

(b) Write the four Maxwell's equations in an isotropic dielectric medium.

(c) Derive the wave equation for electric field and magnetic field vectors in an isotropic dielectric medium and hence obtain the velocity of electromagnetic wave in this medium. (6,3,6)

P.T.O.

**Physical Constants:**

$\varepsilon_0 = 8.854 \times 10^{-12}$ $C^2/N\text{-}m^2$

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

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

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