[This question paper contains 8 printed pages.]

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

**E**

**Sr. No. of Question Paper : 5714**

Unique Paper Code : 42221201

Name of the Paper : Electricity, Magnetism and EMT

Name of the Course : **B.Sc.**

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.
4. Attempt **four** questions from the rest of the paper.
5. Use of non-programmable calculator is allowed.

P.T.O.

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

(a) Given a vector $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$. Show that $\oiint_S \vec{r}.d\vec{S} = 3V$, where V is volume enclosed by surface S.

(b) Prove that the electric field at any point can be expressed as the negative gradient of potential at that point.

(c) Two concentric spheres of diameters 10 cm and 12 cm where medium between the spheres is air and the outer sphere is earthed make a spherical capacitor. Find the charge on the inner sphere if the potential difference between the spheres is 10,000 volt.

(d) Differentiate between diamagnetic and paramagnetic material (mention any two points). Give one example of each.

(e) In a coil an emf of 6 V is induced when the current in the coil changes at the rate of 100 Amp per second. Find coefficient of self-inductance of the coil.

(f) What is Lenz's law? Show that it is in accordance with the law of conservation of energy.

(g) How does the electric field produced by the varying magnetic field differ from the electric field of stationary charges?



2. (a) Find the directional derivative of $\phi = 4xz^3 - 3x^2y^2z$ at $(2, -1, 2)$ in the direction $2\hat{i} - 3\hat{j} + 6\hat{k}$. (5)

(b) Prove that $\nabla^2 r^n = n(n + 1)r^{n-2}$ where n is constant. (5)

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(c) Given $\vec{A} = \left(3x^2 + 6y\right)\hat{i} - 14yz\hat{j} + 20xz^2\hat{k}$. Evaluate the line integral from (0, 0, 0) to (1, 1, 1) along the following paths c: $x = t$, $y = t^2$, $z = t^3$. (5)

3. (a) Using Gauss's theorem, find an expression for the electric field due to an infinite line charge of uniform charge density X at a perpendicular distance 'a' from it. (5)

(b) Derive expressions for the electric potential due to a uniformly charged spherical shell at points inside and outside the shell. Show that the electric potential due to the shell at any point inside is equal to the value of the potential on its surface. (7)

(c) Show that the potential function $V = a(x^2 + y^2 + z^2)^{1/2}$ does not satisfy Laplace's equation. (3)

4. (a) What do you understand by polarization of a dielectric? Define three electric vectors $\vec{D}$, $\vec{E}$ and $\vec{P}$. Establish the relation between them. (7)

(b) How does the capacitance of a parallel plate capacitor change when a dielectric slab of dielectric constant K is inserted between the plates and it completely fills the space between the plates? (4)

(c) A parallel plate capacitor with plate area 1 $m^2$ is completely filled with a dielectric material of dielectric constant 5. The capacitor is charged to a potential of 200 volt. If the distance between the plates is 0.01 cm, find the energy stored in the capacitor. (4)

5. (a) Starting from Biot Savart's law, derive an expression for the magnetic vector potential at a distance $\vec{r}$ from the current element. (5)

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(b) Derive an expression for magnetic field of a small current loop. (5)

(c) Using Biot Savart's law calculate the magnetic field due to a finite current element. (5)

6. (a) Explain Faraday's law and Lenz's law of Electromagnetic induction. (4)

(b) Define coefficient of self-inductance. Derive an expression for self-inductance of a solenoid. (2+3=5)

(c) A solenoid of 80 cm length has 550 turns and 2 cm diameter. Calculate :

(i) the self-inductance of the solenoid.

(ii) the magnetic flux linked with coil when the current in the solenoid is 2 A.

(iii) the rate of change of current in the solenoid that will produce a self- induced emf of 0.3 volts. (6)

7. (a) Write Maxwell's equations for electromagnetic field in integral and differential form in free space. Obtain the wave equations for the electric and magnetic field vectors in vacuum. (7)

(b) An electromagnetic wave propagates along the x direction, the magnetic field oscillates at a frequency of $10^{10}$ Hz and has an amplitude of $10^{-5}$ T, acting along the y-direction. Write down the expression of the electric field and compute the wavelength of the wave. (4)

(c) Derive the equation of continuity using Maxwell's equation and give its significance. (4)

**Physical Constants :**

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

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

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

$e = 1.6 \times 10^{-1}$ m/s