Course Name	:	B.Sc. (Prog.) Physical Sciences
Semester	:	II
Paper Name	:	Electricity, Magnetism and Electromagnetic Theory
Unique Paper Code	:	42221201_OC (Old Course)
Paper	:	Set – B

Maximum Marks: 75

Instructions for Candidates

Attempt any **four** questions.
All Questions carry equal marks.

1. **(a)** Given two vectors $\vec{A} = 2\hat{i} + 3\hat{j} - 4\hat{k}$ and $\vec{B} = -6\hat{i} - 4\hat{j} + \hat{k}$. Find the component of $\vec{A} \times \vec{B}$ along the direction of $\hat{i} - \hat{j} + \hat{k}$

(b) Prove that $\nabla \times \nabla T = 0$, where T is a scalar function.

(c) State the Stokes' theorem of vectors.

(10 + 5 + 3.75)

2. **(a)** Define the electric potential. Show that electric potential can be expressed as a line integral of the electric field. Why can the potential be determined only up to an arbitrary constant? What is the physical significance of this result?

(b) The potential function at any point is given by $V = x(3y^2 - x^2 + z)$. Find the components of the electrostatic field for this potential.

(c) Derive expressions for electrostatic potential inside and outside of a uniformly charged spherical conductor shell.

(7.75 + 4 + 7)

3. **(a)** Derive an expression for Gauss's law in the presence of dielectric. What is polarization vector? What is the significance of polarization of dielectrics? Explain electric displacement vector.

(b) A thin dielectric rod of cross-section A extends along the z-axis from $z = 0$ to $z = h$. The polarization of the rod along z-axis is given by $P_z = 3z^2 + 2$. Find the bound volume charge density, the bound surface charge density and the total charge density.

(9.75 + 9)

4. **(a)** Calculate the magnetic field at the center of a current carrying circular loop of radius 'r' and at a distance 'z' above the center.

(b) A circular coil carrying a current of 0.5A of radius 8 cm has 100 turns. Find the magnitude of magnetic field at the center of the coil and at a distance of 18 cm from the center of the coil.

(9.75 + 9)

5. **(a)** Derive an expression for the energy stored in a magnetic field of a solenoid

(b) Consider two solenoids S_1 and S_2 of same length 'l' such that their axes are aligned and S_2 surrounds S_1 completely. If 'n_1' and 'n_2' are the number of turns per unit length of solenoids S_1 and S_2 respectively, derive an expression for the mutual inductance between two solenoids.

(c) Calculate the self-inductance of an air-core toroid of mean radius $20\ \text{cm}$ and circular cross-section of area $5\ \text{cm}^2$. It is given that the total number of turns on the toroid is 3000.

(7 + 7 + 4.75)

6. (a) Write the four Maxwell's equations in their integral and differential forms. Explain the physical significance of every equation.

(b) Derive the wave equation for the propagation of electromagnetic waves through an isotropic dielectric medium and show that electromagnetic waves are transverse in nature.

(c) The displacement current density for a material having $\sigma = 0, \epsilon = 3\epsilon_0, \mu = 4\mu_0$ is given by the following expression. Determine $\vec{D}$ and $\vec{E}$.

$$2\cos(\omega t - 6z)\,\hat{a_x}\ \ \mu\text{Am}^{-2}$$

(8 + 7.75 + 3)