[This question paper contains 4 printed pages.]

Sr. No. of Question Paper : 1809 **C** **Roll No.....**

Unique Paper Code : 251405

Name of the Course : B.Sc. (H) Electronics

Name of the Paper : ELHT-403 : Electromagnetics

Semester : IV

Duration : 3 Hours Maximum Marks : 100 (75+25 IA)

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all, including Question No. **1** which is compulsory.
3. Scientific Calculator is allowed.
4. **All** questions carry equal marks.

1. Attempt any **five :**

   (a) Prove that $\vec{A} = yz\hat{a}_x + zx\hat{a}_y + xy\hat{a}_z$ is solenoidal as well as irrotatational.

   (b) Three point charges Q_1 = 30 nC, Q_2 = 150 nC and Q_3 = –70 nC are enclosed by surface S. How much net electric flux crosses the surface S ?

   (c) Find the current in circular wire if current density is

   $$\vec{J} = 15\left(1 - e^{-1000r}\right)\hat{a}_z \, A/m^2$$

   Given the radius of wire is 2 mm.

   (d) Two point charges in a dielectric medium where $C_r = 5.2$ interact with a force of 8.6×10^{-3} N. What force is expected if charges were in free space ?

   (e) Show that for a parallel plate capacitor; conduction current is equal to the displacement current.

P.T.O.

(f) What is a magnetic dipole ? How does a magnetic dipole differ from an electric dipole ? (3×5=15)

2. (a) A circular ring of radius *a* carries a uniform charge ρ_l C/m and is placed on the xy plane with the axis the same as the z-axis

(i) Show that electric field intensity is

$$\vec{E}(0,0,h) = \frac{\rho_L a h}{2 \epsilon_0 \left(h^2 + a^2\right)^{\frac{3}{2}}} \hat{a}_z$$

(ii) If the total charge on the ring is Q, find $\vec{E}$ as $a \to 0$. Explain the result.

(b) Given that $\vec{D} = \frac{10x^3}{3} \hat{a}_x \frac{C}{m^2}$, prove the divergence theorem for the volume of a cube 2 m on an edge, centred at the origin and with edges parallel to the axes. (9+6)

3. (a) Conducting spherical shells with radius a=10 cm and b=30 cm are maintained at a potential difference of 100 V such that V(r=b) = 0 and V(r=a)=100 V. Determine V and $\vec{E}$ in the region between the shells. If $\epsilon_r = 2.5$ in the region, determine the total charge induced on the shells and the capacitance of capacitor.

(b) Two extensive homogenous isotropic dielectric medium meet on the plane z=0. For $z \geq 0$, $\epsilon_{r1} = 4$ and $z \leq 0$, $\epsilon_{r2} = 3$.

A uniform electric field $\vec{E}_1 = 5\hat{a}_x - 2\hat{a}_y + 3\hat{a}_z$ KV/m exists for $z \geq 0$. Find

(i) $\vec{E}_2$ for $z \leq 0$

(ii) The angle $\vec{E}_1$ and $\vec{E}_2$ make with the interface. (9+6)

4. (a) A coaxial cable consists of a long cylindrical conductor of radius *a* surrounded by a cylindrical shell of inner radius b and outer radius c. The inner conductor and outer shell each carry equal and opposite current I uniformly distributed

through the conductor. Obtain expression for magnetic field intensity in each of the regions

(i) $\rho \leq a$ (ii) $a \leq \rho \leq b$

(iii) $b \leq \rho \leq c$ (iv) $\rho \geq c$

Give a sketch of $|\vec{H}|$ versus ρ graph.

(b) A radial field $\vec{H} = \frac{2.39 \times 10^6}{r} \cos\emptyset \, \hat{a}_r$ Amp/m exists in free space. Find the magnetic flux crossing the surface defined by $-\frac{\pi}{4} \leq \phi \leq \frac{\pi}{4}$ and $0 \leq z \leq 1$m. (10+5)

5. (a) Derive the Lorentz Gauge condition relating electrostatic potential V and magnetic vector potential $\vec{A}$ for time varying fields.

(b) Write the differential and integral form of four Maxwell's equations and explain their physical significance. (9+6)

6. (a) Show that in a polarized dielectric, an equivalent bound volume charge density ρ_{bv} is formed throughout the dielectric while an equivalent bound surface charge density ρ_{bs} is formed over the surface of dielectric. Comment on total bound charge of the dielectric material.

(b) Calculate and locate the number of image charge/charges if a point charge is placed between two semi-infinite conducting sheets inclined at an angle 60° to each other.

(c) A spherical conducting shell of radius a, centred at the origin, has a potential field

$$V = \begin{cases} V_0 & r \leq a \\ \frac{V_0 a}{r} & r > a \end{cases}$$

With the zero reference at infinity. Find an expression for the stored energy that this potential represents. (6+4+5)

P.T.O.

7. (a) Derive Biot- Savart's Law and Ampere's circuital law using the concept of magnetic vector potential $\vec{A}$.

(b) The circular loop conductor in the z=0 plane has the radius of 0.10 m and a resistance of 5.0 Ω. Determine the induced current. Given that $\vec{B} = 0.20 \sin 10^3 t \hat{a}_z$ T.

(c) Obtain an expression for the self inductance of a toroid of circular cross-section with N closely spaced turns. (6+4+5)

Relevant Physical Constant :–

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

$\varepsilon_0 = 8.85 \times 10^{-12}$ F/m

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

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