This question paper contains **4+1** printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **6476**

Unique Paper Code : **251405** **D**

Name of the Paper : **Electromagnetics—[ELHT-403]**

Name of the Course : **B.Sc. (Hons.) Electronics**

Semester : **IV**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *Five* questions in all, including

Question No. **1** which is compulsory.

Scientific calculator is allowed.

All questions carry equal marks.

1. Attempt any *five* : 5×3=15

(*a*) Find the curl of the following field :

$$\overline{F} = \frac{150}{r^2}\hat{a}_r + 10\hat{a}_\phi$$

(*b*) The finite sheet $0 \le x \le 1$ m, $0 \le y \le 1$ m on the $z = 0$ plane has a charge density :

$$\rho_0 = x\,y\left(x^2 + y^2 + 25\right)^{\frac{3}{2}} \text{ nC/m}^2.$$

Find total charge on the sheet.

P.T.O.

(*c*) State the equation of continuity. What is its physical significance ?

(*d*) Find the maximum torque on an 100 turn, rectangular coil of 0.2 m by 0.2 m carrying a current of 4 Amp in a field B = 6.5 T.

(*e*) Region $0 \leq z \leq 1$ m is occupied by an infinite slab of permeable material ($\mu_r = 2.5$). If

$$\vec{B} = 10y\ \hat{a}_x - 5x\ \hat{a}_y \text{ mWb/m}^2$$

within the slab, determine magnetisation $\vec{M}$.

(*f*) Differentiate between magnetic scalar potential and magnetic vector potential.

2. (*a*) Given that : 6

$$D = \frac{5r^2}{4}\hat{a}_r$$

in spherical co-ordinate. Verify Divergence Theorem for the volume enclosed between $r = 1$ and $r = 2$.

(*b*) A charge distribution with spherical symmetry has density : 9

$$\rho_v = \begin{cases} \dfrac{\rho_0 r}{R} & 0 \leq r \leq R \\ 0 & r > R \end{cases}$$

Determine $\vec{E}$ and V everywhere.

(*a*) Define the capacitance of a capacitor. Derive an expression for the capacitance for a parallel plate capacitor. Also express the energy stored in terms of the capacitance of the system. 8

(*b*) State and prove Uniqueness Theorem. Semi-infinite conducting planes $\varphi = 0$ and $\varphi = \frac{\pi}{6}$ are separated by an infinitesimal insulating gap as in figure 1. If :

$$V(\varphi = 0) = 0 \text{ and}$$

$$V\left(\varphi = \frac{\pi}{6}\right) = 100 \text{ V}$$

calculate V and $\vec{E}$ in the region between the plates. 7

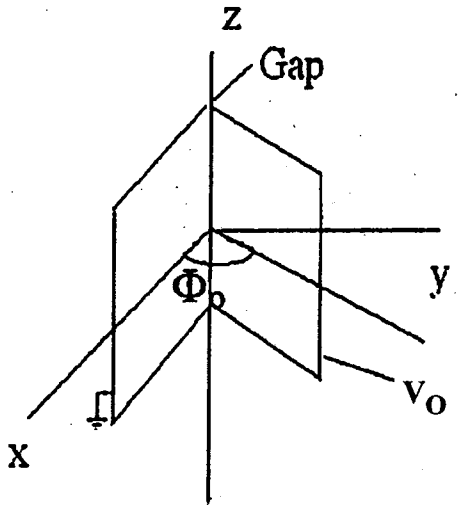

Fig. 1

4. (*a*) State and explain the boundary conditions that are applied to magnetostatic fields at an interface between two different media. 6

(*b*) Derive the Biot-Savart's law and Vector Poisson's equation using Magnetic Vector Potential. 6

(*c*) Calculate the total magnetic flux crossing the surface : 3

$$\varphi = \frac{\pi}{2}, 1 \leq \rho \leq 2 \text{ m}, \ 1 \leq z \leq 5 \text{ m}$$

for magnetic vector potential :

$$\vec{A} = -\frac{\rho^2}{4} \hat{a}_z \ \frac{\text{Wb}}{\text{m}}.$$

5. (*a*) What do you mean by Displacement current ? Explain why and how Maxwell modified the Ampere's circuital law. 6

(*b*) Write *four* Maxwell's equations in integral and point form. 4

(*c*) A circular conducting loop of radius 40 cm lies in x-y plane and has resistance 20 Ω. If the magnetic flux density in the region is given as :

$$\vec{B} = 0.2\cos 500t \ \hat{a}_x + 0.75 \sin 400t \hat{a}_y + 1.2\cos 314t \ \hat{a}_z \text{ T}$$

Determine the value of the induced current in the loop. 5

6. (*a*) Potential is given by : 8

$$V = 2(x + 1)^2 (y + 2)^2 (z + 3)^2 \text{ V}$$

in free space. At a point P(2, –1, 4), calculate :

(*i*) Electric field intensity $\vec{E}$ at point P

(*ii*) Flux density $\vec{D}$ at point P

(*iii*) Volume charge density ρ at point P.

(*b*) Calculate the induced surface charge density for a given charge +Q placed at a distance *h* from a grounded conducting plane of infinite extent. 7

7. (*a*) Determine the self-inductance of a co-axial cable of inner radius *a* and outer radius *b*. 10

(*b*) A cylindrical conductor of radius 10^{-2} m has an internal magnetic field :

$$\vec{H} = \left(4.77 \times 10^4\right)\left(\frac{r}{2} - \frac{r^2}{3 \times 10^{-2}}\right)\hat{a}_\varphi\left(\frac{A}{m}\right)$$

What is the total current in the conductor ? 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.