

(Following Paper ID and Roll No. to be filled in your Answer Book)

PAPER ID : 3081

Roll No.

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B.Tech.

FOURTH SEMESTER EXAMINATION, 2005-2006

ELECTROMAGNETIC FIELD THEORY

Time : 3 Hours

Total Marks : 100

- Note :** (i) Attempt *ALL* questions.
(ii) All questions carry equal marks.
(iii) In case of numerical problems assume data wherever not provided.
(iv) Be precise in your answer.

1. Attempt *any four* parts of the following : (5x4=20)

- (a) Verify that vector field $\vec{A} = yz \vec{i}x + zx \vec{i}y + xy \vec{i}z$ is irrotational and solenoidal.
- (b) If Q_1, Q_2 are charges located at distances r_1, r_2, \dots from the point P, then the electric - intensity \vec{E} at point P will be :

$$\vec{E} = \frac{1}{4\pi\epsilon} \sum_{i=1}^{i=n} (Q_i / r_i^2) \hat{i}r_i$$

- (c) An infinite sheet with surface charge $Q = 12\epsilon_0 \text{ cm}^{-2}$ is lying in the plane $x - 2y + 3z = 4$. Find an expression for the field-intensity on the side of the plane containing the origin.

- (d) Two charges of opposite sign and magnitude $1 \mu\mu\text{C}$ are located 1 m apart. Find the potential at a point located midway between the two charges and 50 cm from the line connecting the charges. What shall be potential if the charges have similar sign ?
- (e) A total charge of 10^{-8} C is distributed uniformly along a ring of radius 5 m. Calculate the potential on the axis of the ring at a point 5 m from the centre of the ring. If the same charge is uniformly distributed on a disc of 5 m radius, what will be the potential on its axis at 5 m from the centre ?
- (f) Relate Electric flux ψ_e and Electric flux density \vec{D} with Electric Field \vec{E} . Three point charges are located in air : $+0.008 \mu\text{c}$ at $(0, 0)\text{m}$, $+0.005 \mu\text{c}$ at $(3, 0) \text{ m}$, and at $(0, 4) \text{ m}$ there is a charge of $-0.009\mu\text{c}$. Compute total flux over a sphere of 5 m radius with centre $(0, 0)$

2. Attempt *any two* parts of the following : (10x2=20)

- (a) A capacitor of two large horizontal parallel plates has an internal separation 'd' between plates. A dielectric slab of relative permittivity ϵ_r and thickness a is placed on the lower plate of capacitor. Neglect edge effects. If the potential difference between the plates is ϕ , show that the electric - field intensity E_1 in the dielectric is

$$E_1 = \frac{\phi}{\epsilon_r d \cdot a (\epsilon_r - 1)}$$

and capacitance C of the arrangement will be :

$$\frac{\epsilon_0 A}{d} \left[\frac{\epsilon_r}{\left(1 - \frac{a}{d}\right) \epsilon_r + \frac{a}{d}} \right] \text{ where } A \rightarrow \text{Area of the plate.}$$

- (b) Determine the energy stored in the electric field in a concentric spherical shell.
- (c) Calculate the potential at any point between two grounded semi-infinite parallel electrodes separated by a distance 'b' and a plane electrode at potential V_0 .

3. Attempt *any two* parts of the following : (10x2=20)

- (a) A No 10 copper wire carries a conduction current of 1 amp at 60Hz. What is the displacement current in the wire? For copper assume

$$\begin{array}{l} \epsilon = \epsilon_0 \\ = \frac{1}{36\pi} \times 10^9 \\ \text{farad/meter} \end{array} \left| \begin{array}{l} \mu = \mu_0 \\ = 4\pi \times 10^{-7} \\ \text{henry/m} \end{array} \right| , \sigma = 5.8 \times 10^7 \text{ U/m}$$

- (b) Discuss wave propagation in Good Dielectrics and Good conductors. Show that angle of characteristic impedance is always 45° for good conductors.

- (c) A current sheet with surface current density k is given by $\vec{k} = k \hat{1}_z \text{ Am}^{-1}$ where k is a constant coincides with the xz plane as shown in fig (c). Find a general relation for flux - density.

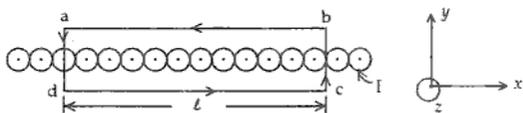


Fig - (c)

4. Attempt *any two* parts of the following : (10x2=20)

- (a) Discuss reflection of plane electromagnetic wave incident normally on a perfect dielectric and obtain expressions for the two reflection coefficients of Electric and Magnetic fields.
- (b) Find α , β , γ , λ , ν and η for damp soil at 10^6 Hz given that for damp soil $\epsilon_r = 12$, $\sigma = 2 \times 10^{-2} \text{ U/m}$, $\mu_r = 1$. The symbols carry their usual meaning.
- (c) A 10 GHz plane wave travelling in free space has an amplitude $E_x = 10 \text{ v/m}$. Find :
- Phase velocity, wavelength and propagation constant.
 - Characteristic Impedance of Medium.
 - Amplitude and direction of the magnetic - filed intensity.

5. Attempt *any two* parts of the following : (10x2=20)

- (a) Find cut off wavelength, for the dominant mode, in a rectangular waveguide whose breadth is 10 cm. For a 2.5 GHz signal propagated in this waveguide in the dominant mode, calculate the guide wavelength, the group and phase velocities and the characteristic impedance.
- (b) Why a TEM wave fails to propagate within a single conductor waveguide ? Which factors decide selection of waveguide and its dimensions ?
- (c) Find at what transmission both TE and TM modes are possible at 3 GHz in a hollow rectangular waveguide of inner dimensions 6 cm \times 4 cm. Find phase constant, phase velocity and group velocity for any mode which can be propagated.

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