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Paper Code : PC-EE303/PC-EEE303 Electromagnetic Field theory

UPID : 003521

Time Allotted : 3 Hours *Full Marks :70*

The Figures in the margin indicate full marks.

Candidate are required to give their answers in their own words as far as practicable

Group-A (Very Short Answer Type Question)

1. Answer any ten of the following : [1 x 10 = 10]

(I) An accelerated charge can produce emf.

(II) The direction of propagation of an electromagnetic wave is parallel. to both the electric and magnetic field

(III) What is the phase difference between electric field intensity E and magnetic field intensity H in free space?

(IV) An orthogonal system is one in which the coordinates are $\perp^r$ to each other.

(V) Gradient of a scalar function results in 0

(VI) Electro static field **E** is $-\nabla \cdot \vec{V}$

(VII) The potential V due to an electric dipole located at a distance 'r' from the dipole is $V = \frac{1}{4\pi} \frac{P(r_2 - r_1)}{|r_0 - r|^3}$.

(VIII) Write the expression of Lorentz force for a point charge in motion in external electric and magnetic field.

(IX) Can Wb s-1 be the unit of emf?

(X) For the propagation of electromagnetic wave in a good conductor the "skin depth" δ ↑ with the increase of frequency f

(XI) Given $\vec{A} = 2\,\hat{a}_x + \alpha\hat{a}_y + 2\hat{a}_z$ and $\vec{B} = \alpha\hat{a}_x + \hat{a}_y + \hat{a}_z$. If $\vec{A}$ & $\vec{B}$ are normal to each other, then α is

$2\alpha + \alpha + 2 = 0$

$3\alpha = -2$

$\alpha = -2/3$

(XII) What is the gradient of the magnitude of the position vector **r** ?

$r = 0$

Group-B (Short Answer Type Question)

Answer any three of the following [5 x 3 = 15]

2. Find the curl $\vec{H}$ at origin, where $\vec{H} = 2y\hat{a}_x - (x^2 + y^2)\hat{a}_y + 3y\hat{a}_z$. [5]

3. Starting with Gauss's law obtain Poisson's and Laplace's equation. [5]

4. Find $\vec{\nabla}\left(\frac{1}{r}\right)$, where $\vec{r} = x\hat{a}_x + y\hat{a}_y + z\hat{a}_z$. [5]

5. Derive an expression for electric field **E** due to an infinite plane sheet of charge of surface density σ_S. [5]

6. Explain the term skin depth and show that in case of a suitable conducting solid, the skin depth $\delta = \left[\frac{2}{\omega\sigma\mu}\right]^{1/2}$. [5]

Group-C (Long Answer Type Question)

Answer any three of the following [15 x 3 = 45]

7. (a) Show that $\nabla.(\nabla \times \vec{A}) \equiv 0$ and $\nabla \times (\nabla\phi) \equiv 0$ [5]

(b) Find the divergence of a vector field $\vec{F} = 2xy\hat{a}_x + z\hat{a}_y + yz^2\hat{a}_z$ at the point (2,-1, 3). [5]

(c) Given φ = xy + yz + xz, find gradient φ at point (1, 2, 3) [5]

8. (a) State Gauss's law of electrostatics and write the mathematical expression of the law in integral and differential forms. [6]

(b) Starting from Gauss's law of electrostatics derive the expression of electric field E at any internal and external point of a charged sphere of uniform charge density. [9]

9. (a) Derive the conditions that the magnetic field intensity and magnetic flux density must satisfy at the boundary between two different media. [7]

(b) Two magnetic materials are separated by a surface $z = 0$; having permeabilities $\mu_1 = 4\mu_0 H/m$ for the region 1 where $z > 0$ and $\mu_2 = 7\mu_0$ for region 2 where $z < 0$. There exists a surface current density $\vec{K}_s = 60\hat{a}_x A/m$ at the boundary $z = 0$. For the field vector $\vec{B}_1 = (\hat{a}_x - 2\hat{a}_y - 3\hat{a}_z)mT$ in the region 1, find the flux density $\vec{B}_2$ in the region 2. [8]

10. (a) Show that the energy stored in an electrostatic field in $\frac{1}{2}\int_v \vec{E} . \vec{D} dv$. [5]

(b) Three point charges - 1 nC, 4 nC, and 3 nC are located at (0, 0, 0), (0, 0, 1), and (1, 0, 0), respectively. Find the energy in the system. [5]

(c) Show that the electric field should be irrotational under static conditions. [5]

11. (a) Why a small filamentary current loop is usually referred to as a magnetic dipole? What is the magnetic dipole moment for such a loop? [5]

(b) Write down Lorentz force equation. Hence obtain the expression of force acting on a straight conductor of length L in a uniform magnetic field B. [5]

(c) Determine the self-inductance of a co-axial cable of inner radius 'a' and outer radius 'b'. [5]