EE-302

FIELD THEORY

Time Allotted: 3 Hours | Full Marks: 70

The questions are of equal value.
The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

GROUP A
(Multiple Choice Type Questions)

Answer any *ten* questions. 10×1 = 10

(i) If $\vec{A} = \vec{a_x} + \alpha\vec{a_y} + \vec{a_z}$ and $\vec{B} = \alpha\vec{a_x} + \vec{a_y} + \vec{a_z}$ are normal to each other, α is

(A) –2 (B) $-\frac{1}{2}$ (C) 0 (D) 1

(ii) If the vector potential $\vec{A}$ is a polar vector, then the magnetic field $\vec{B} = \nabla \times \vec{A}$ is

(A) a polar vector (B) a scalar
(C) an axial vector (D) none of these

(iii) If non-zero vectors $\vec{A}$ and $\vec{B}$ are conservative then $\vec{C} = \vec{A} \times \vec{B}$ is

(A) solenoidal (B) conservative
(C) parallel to both $\vec{A}$ and $\vec{B}$ (D) none of these

(iv) In a uniform plane electro magnetic wave the impedance is given by

(A) EH (B) $\frac{H}{E}$ (C) $\frac{E}{H}$ (D) none of these

(v) The concept of displacement current was first introduced by

(A) Faraday (B) Lenz (C) Lorentz (D) Maxwell

(vi) Ohm's law is obeyed by

(A) conduction current (B) convection current
(C) conduction and convection current (D) none of these

(vii) Direction of propagation of EM wave is obtained from

(A) E×H (B) E·H (C) E (D) H

(viii) Relation among magnetic vectors B, M and H is

(A) $B = \mu_0 H + M$ (B) $B = \mu_0 H + M$ (C) $H = \mu B + M$ (D) $H = B/\mu_0 - M$

(ix) Poynting vector has the unit

(A) Wm^{-2} (B) Js^{-1} (C) W (D) Jm^{-2}

(x) Maxwell's equation $\nabla \times H = J + \partial D / \partial t$ represents

(A) magnetic vector potential (B) Gauss's law in magnetism
(C) generalized Ampere's Circuital law (D) Biot-Savart law

(xi) A transmission line is called distortionless line when

(A) R/L = G/C (B) R/G = C/L (C) RG = L/C (D) R/G = LC

(xii) Unit of magnetic field intensity is

(A) A/m (B) C/m^2 (C) V/m (D) Tesla

GROUP B
(Short Answer Type Questions)

Answer any *three* questions.

2. Given $\vec{A} = xy\hat{i} + yz\hat{j} + xz\hat{k}$, evaluate $\oint \vec{A} \cdot d\vec{S}$, where S is the surface of the cube defined by $0 \le x \le 1, 0 \le y \le 1, 0 \le z \le 1$. Hence verify Gauss's divergence theorem.

3. (a) Starting from Gauss's theorem of Electro-statics, derive the Poisson's and Laplace's equations.

(b) Point charge 5 nC and −2 nC are located at points (2, 0, 4) and (−3, 0, 5) respectively. 3

(i) Determine the force on 1 nC point charge located at (1, −3, 7)

(ii) Find the electric field at (1, −3, 7)

4. (a) Using Faraday's law of electromagnetic induction, find electric intensity vector in terms of scalar and vector potentials. 3

(b) Write down the difference between transformer emf and motional emf. 2

5. Define magnetization and magnetic susceptibility. Find out the relation between magnetic susceptibility and relative permeability. 2+3

6. A transmission line has characteristic impedance of 70 ohm and a phase constant of 3 rad/m at 100 MHz. Calculate inductance per meter and capacitance per meter of the line. 2+3

GROUP C
(Long Answer Type Questions)

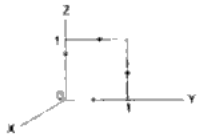
Answer any *three* questions. 3×15 = 45

7. (a) Derive the boundary conditions for a dielectric–dielectric boundary. 6

(b) Two homogenous dielectric regions 1 ($\rho \le 4$ cm) and 2 ($\rho \ge 4$ cm) have dielectric constants 3.5 and 1.5, respectively. If $D_2 = 12a_\rho - 6a_\phi + 9a_z$ nC/m^2, calculate 3+3+3

(i) E_1 and D_1 (ii) P_2 and ρ_{ps2} (iii) the energy density for each region

8. (a) Verify Stoke's theorem for $\vec{A} = (2xz + 3y^2)\hat{i} + 4yz^2\hat{k}$ for the square surface shown in the following figure: 6



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(b) Derive Biot-Savart's Law from magnetic vector potential. 5

(c) In a medium of dielectric constant 5, the maximum displacement current is equal to maximum conduction current at a frequency of 1 MHz. Find the conductivity of the medium ($\varepsilon_0 = 8.854 \times 10^{-12}$ F / m) 4

9. (a) Derive the propagation constant and characteristic impedance for a lossless transmission line from the transmission line equations. 5

(b) Derive an expression for the input impedance Z_{in} of a lossless transmission line in terms of relevant parameters when the line is terminated in load impedance (Z_L). 5

(c) A transmission line with air as dielectric has a characteristic impedance of 50 Ω and a phase constant of 4 rad/m at 50 MHz. Calculate the inductance per meter and the capacitance per meter of the line. 5

10. (a) Obtain the Poynting theorem for the conservation of energy in an electromagnetic field and explain the significance of each term in the resulting equation. 6

(b) In a non magnetic medium $\boldsymbol{E}(x, t) = 3\sin(2\pi \times 10^7 t - 0.6x)\boldsymbol{a}_z$ V/m 3+3+3

Find:

(i) ε_r and η

(ii) The time average power carried by the wave

(iii) The total power crossing a circular area of radius 5 m in the plane $x = 1$.

11. Write short notes on any *three* of the following 3×5

(a) Boundary condition of magnetic field

(b) Magnetization and hysteresis

(c) Method of images

(d) Propagation constant

(e) Distortionless transmission line

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