

JK LAKSHMIPAT UNIVERSITY, JAIPUR

INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination (Backlog), April-May 2016

B. Tech in Electronics & Communication Engineering, Semester III

Roll No.....

ECE 403: Electromagnetic Field Theory

Time: 3 hours

Max. Marks: 100

Instructions to students:

1. Do not write anything other than your roll number on question paper.
2. Assume suitable data wherever required and mention it clearly.
3. Writing appropriate units, nomenclature, and drawing neat sketches/schematics/ flow chart wherever, required are an integral part of the answer.
4. Anything written in **bold** must be treated as vector quantity

Q.1A All subparts of this question carry equal marks

10

- i. A very small, thin wire of length $\lambda/100$ has a radiation resistance of
(a) Nearly zero (b) 8.0Ω (c) 0.8Ω (d) 0.08Ω
- ii. In a good conductor, $\mathbf{E}$ and $\mathbf{H}$ are in time phase
(a) Sometimes (b) Always (c) Never (d) None of these
- iii. Identify which one of the following will NOT satisfy the wave equation.
(a) $50 e^{j(\omega t - 3z)}$ (b) $\sin [\omega(10z + 5t)]$ (c) $\cos(y^2 + 5t)$ (d) $\sin(x)\cos(t)$
- iv. The concept of displacement current was a major contribution attributed to
(a) Faraday (b) Lenz (c) Lorentz (d) Maxwell
- v. Two identical coaxial circular coils carry the same current I but in opposite directions. The magnitude of the magnetic field $\mathbf{B}$ at a point on the axis midway between the coils is
(a) Zero (b) Twice that produced by one coil (c) Half that produced by one coil (d) None of these
- vi. In a uniform plane wave, the value of $|\mathbf{E}|/|\mathbf{H}|$ is
(a) $\sqrt{\frac{\mu}{\epsilon}}$ (b) $\sqrt{\frac{\epsilon}{\mu}}$ (c) 1 (d) none of these
- vii. Where surfaces $\rho = 2$ and $z = 1$ intersects is
(a) An infinite plane (b) A circle (c) a semi-infinite plane (d) A cone
- viii. Two metal conductors, one larger than the other, are given the same charge. If both are spherical conductors, the charge density will be
(a) Same on both (b) More on larger sphere (c) more on smaller sphere (d) none of these
- ix. Which of the following is zero?
(a) Grad div (b) grad curl (c) div curl (d) curl grad
- x. Two potential functions V_1 and V_2 satisfy Laplace's equation within a closed region and assume the same values on its interface. V_1 must be equal to V_2 .
(a) True (b) False (c) Not necessarily



- Q.2 All subparts of this question carry equal marks 10
- Explain shielding in short.
 - Find the relation between $\mathbf{E}$ and $\mathbf{B}$ for a stationary loop in time varying magnetic field.
 - Why does an isolated magnetic charge not exist? Using this property derive Maxwell's fourth equation.
 - Calculate the distance between $(10, \pi/4, 3\pi/4)$ and $(1, 2, 3)$.

Q.3A Determine the flux of $\mathbf{D} = \rho^2 \cos^2 \Phi \mathbf{a}_\rho + z \sin \Phi \mathbf{a}_\Phi$ over the closed surface of the cylinder $0 \leq z \leq 1, \rho = 4$. Verify the divergence theorem for this case. 05

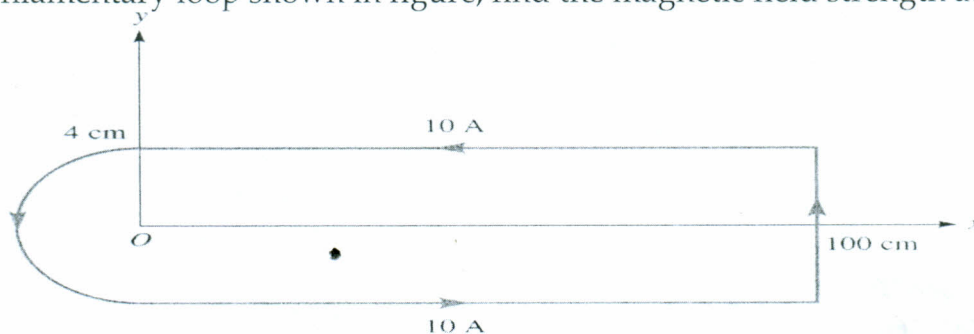
Q.3B If $\mathbf{D} = (2y^2 + z)\mathbf{a}_x + 4xy \mathbf{a}_y + x \mathbf{a}_z$ C/m², find 05

- The volume charge density at $(-1, 0, 3)$
- The flux through the cube defined by $0 \leq x \leq 1, 0 \leq y \leq 1, 0 \leq z \leq 1$

Q.4A In free space, $V = 6xy^2z + 8$. At point $P(1, 2, -5)$, find $\mathbf{E}$ and ρ_v . 05

Q.4B Transform vector $\mathbf{F} = 2xy \mathbf{a}_x - x^2 \mathbf{a}_y$ into cylindrical coordinates. 05

Q.5 For the filamentary loop shown in figure, find the magnetic field strength at O. 10



Q.6A An infinitely long filamentary wire along the z-axis carries current 20 A along $\mathbf{a}_z$. If $V_m = 0$ at $(2, 0, 5)$, find V_m at $(6, \pi/4, 0)$. 05

Q.6B Verify the vector identity $\int \nabla \times \mathbf{A} dv = -\oint \mathbf{A} \times d\mathbf{S}$ 05
for $\mathbf{A} = 5x^2y \mathbf{a}_x + 3xy^2 \mathbf{a}_y$ and the volume defined by $0 < x < 2, -1 < y < 1$, and $-5 < z < 5$.

OR

Q.6B A conducting circular loop of radius 20cm lies in the $z = 0$ plane in a magnetic field $\mathbf{B} = 10 \cos 377t \mathbf{a}_z$ mWb/m². Calculate the induced voltage in the loop. 05

Q.7A The ratio J/J_d (Conduction current density to displacement current density) is very important at high frequencies. Calculate the ratio at 1 GHz for: 05

- Distilled water ($\mu = \mu_0, \epsilon = 5\epsilon_0, \sigma = 2 \times 10^{-3}$ S/m)
- Seawater ($\mu = \mu_0, \epsilon = 81\epsilon_0, \sigma = 25$ S/m)
- Limestone ($\mu = \mu_0, \epsilon = 5\epsilon_0, \sigma = 2 \times 10^{-4}$ S/m)

Q.7B If the $\mathbf{H}$ and $\mathbf{E}$ fields in air are given by $\mathbf{H} = -0.3 \sin(4\pi \times 10^6 t - \beta z) \mathbf{a}_x$ A/m and $\mathbf{E} = A \sin(4\pi \times 10^6 t - \beta z) \mathbf{a}_y$ V/m, find β , $\mathbf{a}_k$, and A . 05

OR

Q.7B A medium has the following constitutive parameters: 05
 $\mu = \mu_0, \epsilon = 9\epsilon_0, \sigma = 5 \times 10^{-9}$ mhos/m. Calculate the wavelength of a wave at 1 GHz propagating through the medium. Should the medium be regarded as free

space, lossy dielectric, lossless dielectric, or good conductor?

Q.8A Determine $\mathbf{H}$ field and $\mathbf{E}$ field for Hertzian dipole at far field. Also find out time average power density (P_{ave}) and time averaged radiated power (P_{rad}). 10

Q.9A The inner and outer conductors of a coaxial cable have radii a and b , respectively. In the cable, 10

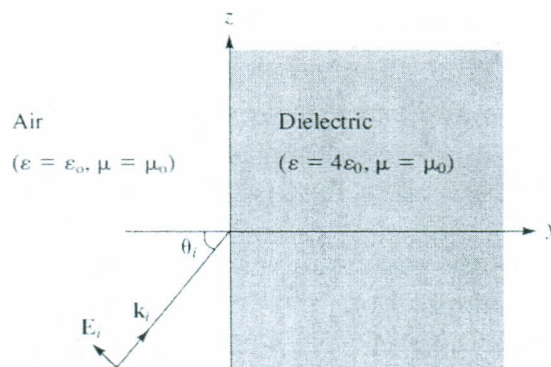
$$\mathbf{E} = \frac{V_0}{\rho \ln\left(\frac{b}{a}\right)} \cos(\omega t - \beta z) \mathbf{a}_\rho$$

$$\mathbf{H} = \frac{I_0}{2\pi\rho} \cos(\omega t - \beta z) \mathbf{a}_\phi$$

(a) Obtain the Poynting vector.

(b) Find the time-average power flow in the cable.

Q.9B A parallel-polarized wave in air with $\mathbf{E} = (8\mathbf{a}_y - 6\mathbf{a}_z) \sin(\omega t - 4y - 3z)$ V/m 10
impinges a dielectric half-space as shown in the figure. Find (a) the incidence angle θ_i , (b) the time-average power in air ($\mu = \mu_0$, $\epsilon = \epsilon_0$), (c) the reflected and transmitted $\mathbf{E}$ fields.



OR

Q.9B Two infinitely long cylinders of radii a and b ($b > a$) carry surface charges $+\lambda$ and $-\lambda$ respectively. Find the $\mathbf{E}$ field in the region inside the inner cylinder, between cylinders, and outside the cylinders. 10

