

# JK LAKSHMIPAT UNIVERSITY, JAIPUR

## INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination (Bachelors), November 2016  
B. Tech in Electronics & Communication Engineering, Semester IV

Roll No.....

ECE 403/303: 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<br>(a) Nearly zero (b) $8.0 \Omega$ (c) $0.8 \Omega$ (d) $0.08 \Omega$                                                                                                                                       |    |
| ii.   | In a good conductor, E and H are in time phase<br>(a) Sometimes (b) Always (c) Never (d) None of these                                                                                                                                                                                     |    |
| iii.  | Identify which one of the following will NOT satisfy the wave equation.<br>(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<br>(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 B at a point on the axis midway between the coils is<br>(a) Zero (c) Half that produced by one coil<br>(b) Twice that produced by one coil (d) None of these |    |
| vi.   | In a uniform plane wave, the value of $ E / H $ is<br>(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<br>(a) An infinite plane (c) a semi-infinite plane<br>(b) A circle (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<br>(a) Same on both (c) more on smaller sphere<br>(b) More on larger sphere (d) none of these                                                     |    |
| ix.   | Which of the following is zero?<br>(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 $V_2$ .<br>(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  $(1, 2, 3)$ .

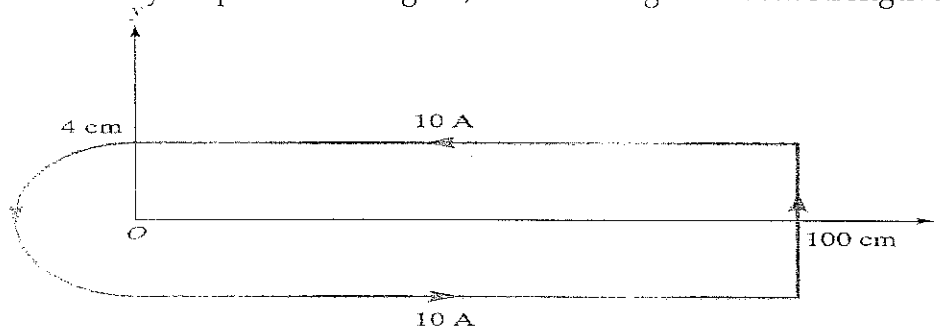
- Q.3A Determine the flux of  $\mathbf{D} = \rho^2 \cos^2 \Phi \mathbf{a}_\rho + z \sin \Phi \mathbf{a}_\Phi$  over the closed surface of the cylinder  $0 \leq z \leq 1, \rho = 4$ . Verify the divergence theorem for this case. 05

- Q.3B If  $\mathbf{D} = (2y^2 + z)\mathbf{a}_x + 4xy \mathbf{a}_y + x \mathbf{a}_z$  C/m<sup>2</sup>, 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  $\rho_v$ . 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  $\int \nabla \times \mathbf{A} dv = - \oint \mathbf{A} \times d\mathbf{S}$  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  $-5 < z < 5$ . 05

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/m<sup>2</sup>. 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  $\mathbf{E} = A \sin(4\pi \times 10^6 t - \beta z) \mathbf{V/m}$ , find  $\beta, \mathbf{a}_k$ , 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

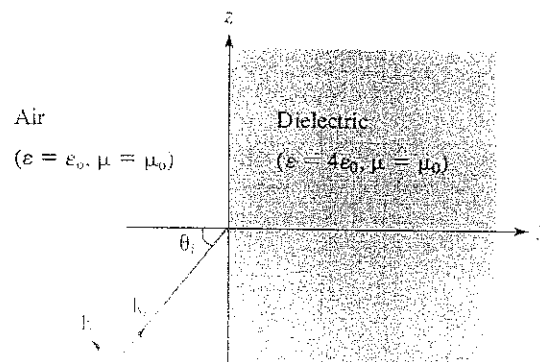
$$\mathbf{E} = \frac{V_o}{\rho \ln(\frac{b}{a})} \cos(\omega t - \beta z) \mathbf{a}_\rho$$

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

(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 impinges a dielectric half-space as shown in the figure. Find (a) the incidence angle  $\theta_i$ , (b) the time-average power in air ( $\mu = \mu_0$ ,  $\epsilon = \epsilon_0$ ), (c) the reflected and transmitted  $\mathbf{E}$  fields. 10



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