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Total Number of Pages : 02

Course: B.Tech

Sub_Code: REE4D001/ REL4D001/ REC4C001

4th Semester Regular/ Back Examination: 2022-23

SUBJECT: Electro-Magnetic Theory

BRANCH(S): EE, EEE, ETC, ECE

Time : 3 Hour

Max Marks : 100

Q.Code : M351/ M352

Answer Question No.1 (Part-1) which is compulsory, any eight from Part-II and any two from Part-III.

The figures in the right hand margin indicate marks.

Part-I

Q1 Answer the following questions: (2 x 10)

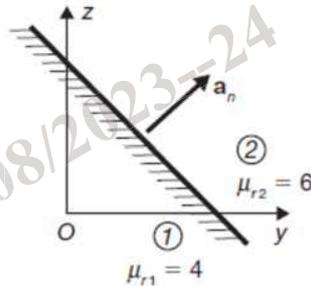
- Define an orthogonal system. A point P is represented by $(-2, 6, 3)$. Express the point P in other coordinate systems.
- Write the point form of Gauss's law. Derive the Poisson's equation from it.
- Considering the principle of charge conservation, derive the continuity equation.
- Write the Maxwell's equations both for static and time varying fields.
- What do you mean by polarization of a TEM wave? Define the penetration depth of a medium.
- Write the relation between transmission coefficient and reflection coefficient. How standing wave is formed?
- Name the parameters that characterize the dielectric separating the conductor of a transmission line. Define characteristic impedance of a transmission line.
- An air line has characteristic impedance of 70Ω and phase constant of 3 rad/m at 100 MHz . Calculate the capacitance per meter of the line.
- What are waveguides? What is dominant mode in a waveguide? In a rectangular waveguide for which $a = 1.5 \text{ cm}$, $b = 0.8 \text{ cm}$, $\sigma = 0$, $\mu = \mu_0$, $\epsilon = 4\epsilon_0$, and $H_x = 2 \sin\left(\frac{\pi x}{a}\right) \cos\left(\frac{3\pi y}{b}\right) \sin(\pi \times 10^{11} t - \beta z) \text{ A/m}$. determine the mode of operation.
- Write short note on half-wave dipole antenna.

Part-II

Q2 Only Focused-Short Answer Type Questions- (Answer Any Eight out of Twelve) (6 x 8)

- Express the unit vector which points from $z = h$ on the z axis toward $(r, \phi, 0)$ in cylindrical coordinates. A field is given as $G = \left[\frac{2x}{1+y^2}\right] a_x + (y+z+1)a_y + (5x-z^2)a_z$. Find (a) a unit vector in the direction of G at $P(1, 2, -3)$. (b) The angle between G and the $y = 0$ plane at $Q(2, 0, 4)$.
- Charge is distributed uniformly along an infinite straight line with constant density ρ_l . Develop the expression for E at the general point P. On the line described by $x = 2 \text{ m}$, $y = -4 \text{ m}$ there is a uniform charge distribution of density $\rho_l = 20 \text{ nC/m}$. Determine the electric field E at $(-2, -1, 4) \text{ m}$.
- Plane $z = 0$ and $z = 4$ carry current $K = -10 a_x \text{ A/m}$ and $K = 10 a_x \text{ A/m}$, respectively. Determine H at (a) $(1, 1, 1)$ (b) $(0, -3, 10)$
- An AWG #12 copper conductor has an 0.0808 inch diameter. A 50-foot long conductor of this type carries a current of 20 A . Find the electric field intensity E, drift velocity U, the voltage drop, and the resistance for the 50-foot length.

- e) Region 1, where $\mu_{r1} = 4$, is the side of the plane $y + z = 1$ containing the origin as shown in the figure below. In region 2, $\mu_{r2} = 6$. $B_1 = 2.0a_x + 1.0a_y$ (T). Find B_2 and H_2 .



- f) Derive the expression for Ampere's circuital law in point form showing the displacement current density.
- g) An electric field is represented by $E_y = 10 \cos(6\pi 10^8 t - \beta x)a_y$ is propagating through a lossless medium having $\mu_r = 1$, $\epsilon_r = 78$ at a frequency of 300 MHz. Find (a) the various parameters associated with the wave. (b) the corresponding magnetic field H.
- h) A perpendicularly polarized wave propagates from a region having $\epsilon_r = 8.5$, $\mu_r = 1$, $\sigma = 0$ to free space with an angle of incidence of 15° . The incident field is $1.0 \mu\text{V/m}$, find the reflected and transmitted electric field; incident, reflected and transmitted magnetic field.
- i) Calculate the conductivity and skin depth of polythene of dielectric constant 2 and loss tangent 0.0002 at 100 MHz.
- j) If a transmission line of characteristic impedance 50Ω is terminated in complex impedance $25 + j100 \Omega$, what will be the reflection coefficient and the VSWR of the line?
- k) Establish a relation between the wave phase velocity, the wave group velocity, and the wave dispersion. The cutoff wavelength of a waveguide is given as 69.70 mm. What should be the length of the guide in order to ensure that a signal at 8.6 GHz emerging out of the guide is delayed by $1 \mu\text{s}$ with respect to the signal that propagates outside the waveguide?
- l) A center-fed dipole antenna with a z-directed current has electrical length $\frac{l}{\lambda} \ll \frac{1}{30}$. (a) Show that the current distribution may be assumed to be triangular in form. (b) Find the components of the vector magnetic potential A.

Part-III

Only Long Answer Type Questions (Answer Any Two out of Four)

- Q3 Explain Gauss's law in electrostatics in point and integral form. What is the condition for finding the electrical field quantities? What are its applications? State the point form of Ohm's law. What is the analogous relation in static electric field? Describe Joule's law taking the case of a conductor of uniform cross sectional area. Mention its common form in electric circuit. Explain ampere's force law. What is the net force on a circular current loop in a uniform magnetic field? (16)
- Q4 Describe the electric and magnetic boundary conditions in various interfaces. (16)
- Q5 Derive the parameters related to oblique incidence of a plane wave. Extend it considering two special cases: one with the E field perpendicular to the plane of incidence, the other with the E field parallel to it. (16)
- Q6 Write the Maxwell's equations considering the time varying E and H fields. Derive, with the help of the relevant Maxwell's equation, the expression for the magnetic field H for a uniform plane wave propagating along z ($E_z = H_z = 0$; $\frac{\partial}{\partial x} = \frac{\partial}{\partial y} = 0$) in free space if the electric field is given by $E = (20a_x + 30a_y)\cos(3\pi \times 10^{10}t - 100\pi z)$. (16)