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53 (EC 501) ELWV

2021

ELECTROMAGNETIC WAVES

Paper : EC 501

Full Marks : 100

Time : Three hours

**The figures in the margin indicate
full marks for the questions.**

Answer **any five** questions : $20 \times 5 = 100$

1. (a) Convert Points $P(1,3,5)$ from Cartesian to cylindrical and spherical coordinates.

- (b) Given the vector field

$$H = \rho z \cos \phi a_\rho + \rho^{-2} \sin \frac{\phi}{2} a_\phi + \rho^2 a_z$$

at point $\left(1, \frac{\pi}{3}, 0\right)$,

find —

(i) $H \cdot a_x$

(ii) $H \times a_\theta$



Contd.

(iii) The vector component of H normal to surface $\rho = 1$.

(iv) The scalar component of H tangential to the plane $z = 0$.

5+5+10

2. (a) Write down Maxwell's equation for time varying electromagnetic fields : When the media is homogeneous, source-free, loss-less, isotropic and linear.

(b) Obtain an expression of wave equation of a conducting medium.

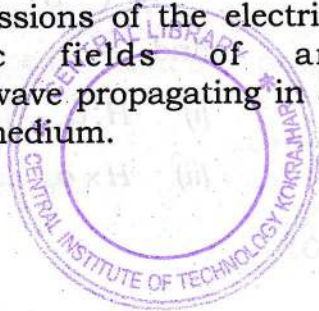
(c) What does perfect conductor mean ?

(d) Explain Maxwell's fourth equation of modified Ampere's circuital law. What is displacement current ?

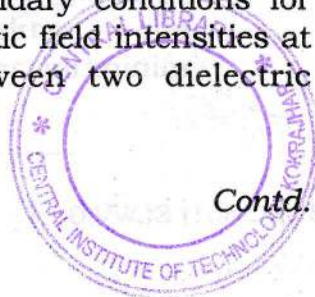
(e) A charge distribution in free space has $\rho_v = 2r \text{ nC/m}^3$ for $0 \leq r \leq 10 \text{ m}$ and zero otherwise Determine E at $r = 2 \text{ m}$.

4+4+2+5+5

3. (a) Derive the expressions of the electric and magnetic fields of an electromagnetic wave propagating in a lossy dielectric medium.



- (b) What do you understand by the term loss tangent and what is its physical significance ?
- (c) Obtain the Poynting theorem for the conservation of energy in an electromagnetic field and discuss the physical significance of each term in resulting equation. 11+3+6
4. (a) Derive the expressions for the reflection co-efficient & transmission co-efficient and their relationship when a plane wave propagating along the +z direction is incident normally on the boundary $z=0$ between medium 1 ($z < 0$) characterized by $\sigma_1, \epsilon_1, \mu_1$ and medium 2 ($z > 0$) characterized by $\sigma_2, \epsilon_2, \mu_2$.
- (b) In free space ($z \leq 0$), a plane wave with $H_i = 10 \cos(10^8 t - \beta z) a_x$ mA/m is incident normally on a lossless medium ($\epsilon = 2\epsilon_0, \mu = 8\mu_0$) in region $z \geq 0$. Determine the reflected wave H_r, E_r and the transmitted wave E_t, H_t . 10+10
5. (a) Establish the boundary conditions for electric and magnetic field intensities at the interface between two dielectric media.



- (b) Explain how these conditions will be modified, if one of the media is a perfect conductor.
- (c) Two extensive homogeneous dielectric meet on plane $z=0$. For $z > 0$, $\epsilon_{r1} = 4$ and for $z < 0$, $\epsilon_{r2} = 3$. A uniform electric field $E_1 = (5a_x - 2a_y + 3a_z)kV/m$ exists for $z \geq 0$.
Find —
- (i) E_2 for $z \leq 0$.
- (ii) the angles E_1 and E_2 make with interface. 8+4+8
6. (a) Derive an expression for the input impedance Z_{in} of a lossless transmission line, in terms of relevant parameters, when the line is terminated into impedance Z_L .
- (b) Deduce relation between reflection coefficient and VSWR.
- (c) A transmission line of characteristic impedance 50Ω is terminated by resistor of 100Ω . What will be the VSWR in the line? Calculate impedances at the voltage minimum and maximum positions. 10+5+5

