Total number of printed pages–4

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 :* 20×5=100

1. *(a)* Convert Points $P(1,3,5)$ from Cartesian to cylindrical and spherical co-ordinates.

   (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) $H.a_x$

   (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 $\rho_v = 2r\,nC/m^3$ for $0 \le r \le 10\,m$ and zero otherwise Determine E at $r = 2\,m$.

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 $\sigma_1, \varepsilon_1, \mu_1$ and medium 2 $(z>0)$ characterized by $\sigma_2, \varepsilon_2, \mu_2$.

(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 $(\varepsilon = 2\varepsilon_0, \mu = 8\mu_0)$ 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 $z>0$, $\varepsilon_{r_1}=4$ and for $z<0$, $\varepsilon_{r_2}=3$. A uniform electric field $E_1=\left(5a_x-2a_y+3a_z\right)kV/m$ 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 co-efficient 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