2019

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.*

1. Express the vector $B = \dfrac{10}{r} a_r + r \cos \theta\, a_\theta$ in cylindrical and Cartesian co-ordinates. Evaluate $B(-3,4,0)$ and $B(5, \dfrac{\pi}{2}, -2)$.   20

2. (a) For a uniformly charged sphere derive the expression of electric flux density for $0 < r \leq a$ and $r \geq a$, where 'a', is the radius of the sphere. Also sketch the variation of flux density with distance.

(b) A line charge $P_l = 50 nc/m$, is located along the line $x=2$, $y=5$, in free space.

(i) Find E at $P(1, 3, -4)$

(ii) If the surface $x = 4$ contains a uniform surface charge density $\rho_s = 18 nc/m^2$, at what point in the $z = 0$ plane is $E_{total} = 0$?   10+10

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

(b) What does loss tangent mean 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.   9+3+8

4. (a) State and prove the uniqueness theorem in electrostatics.

(b) In free space $(z \leq 0)$, a plane wave with $H = 10\cos\left(10^8 t - \beta z\right)a_x \, mA/m$ 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 transmitted wave H_t, E_t.   10+10

5. (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 by a load of impedance z_L.

(b) At a frequency of 80 MHz, a lossless transmission line has a characteristic impedance of 300Ω and a wavelength of 2·5m.

(i) Find L (ii) Find C (iii) if the line is terminated with the parallel combination of 200Ω and 5PF, determine Γ and SWR.   10+10

6. (a) What does a lossless and distortion less line mean?

(b) Derive the necessary condition for a transmission line to become distortionless line.

(c) Prove that a distortionless line is not necesarily a lossless line but a lossless line is a distortionless line.

(d) An airline has characteristic impedance of 70Ω and phase constant $3\,rad/m$ at $100\,MHz$. Calculate the inductance per meter and the capacitance per meter of the line.   4+8+3+5

7. Short notes on : *(any four)*   5×4=20

(a) Skin depth

(b) Modified Ampere's circuit law

(c) Smith Chart

(d) Magnetic vector potential

(e) Conduction and convection current

(f) Divergence theorem in electrostatics.