53 (EC 501) ELMW

2017

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. *(a)* State and prove divergence theorem in electrostatics.

   (b) Write down the physical significance of divergence and curl.

   (c) Given a vector $\vec{A} = 5a_x + a_y + 3a_z$. Find the magnitude of the vector and the unit vector originating from the origin. Convert $\vec{A}$ in cylindrical and spherical co-ordinate systems. 5+5+10

2. (a) Write down Maxwell's equations 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 a Perfect Conductor mean ?

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

5+6+2+7

3. (a) Prove that the electric field at a point ($r > a$) due to a uniformly charged sphere of radius 'a' is the same as the whole charge is located at the center of the sphere.

(b) A circular disc of radius 'a' uniformly charged with $\rho s\ C/m^2$. If the disc lies on the $z = 0$ plane with its axis along the z-axis,

(i) show that at point $(0, 0, h)$

$$E = \frac{\rho s}{2 \epsilon_0} \left\{ 1 - \frac{h}{\left(h^2 + a^2\right)^{1/2}} \right\} a_z$$

(ii) from this derive the E field due to an infinite sheet of charge on the $z = 0$ plane.

(iii) if $a << h$, show that E is similar to the field due to a point charge. 8+12

4. (a) Establish the relation $\nabla \times H = J + \frac{\partial D}{\partial t}$, where symbols have their usual meaning.

(b) Explain the concept of skin depth and find out an expression for that.

(c) State and prove the Uniqueness theorem. 5+5+10

5. (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. 9+3+8

6. *(a)* State and explain Faraday's law.

(b) Derive the induced emf when a stationary loop is in the time varying B fields.

(c) Determine the magnetic field intensity at a point P due to a current carrying filamentary conductor AB carrying current I along z axis with its lower and upper ends subtending angles α_1 and α_2 respectively.

6+6+8

7. *(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) Show that for a lossless transmission line the input impedance of a line repeat over every $\lambda/2$ distance.

(c) A transmission line operating at $500 mrad/s$ has $L = 0{\cdot}5 \mu H/m$, $C = 32 pF/m$, $G = 100 \mu$ mho/m and $R = 25 \Omega/m$. Calculate values for $\gamma, \alpha, \beta, v, \lambda$ and Z_0.

9+4+7