Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 30530

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2024.

Fourth Semester

Electronics and Communication Engineering

EC 8451 — ELECTROMAGNETIC FIELDS

(Common to : Electronics and Telecommunication Engineering)

(Regulations 2017)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. State Helmholtz's theorem.

2. In XY plane, $Q_1 = 100\mu C$ at (2,3), experiences a repulsive force of 7.5 N because of Q_2 at (10,6). Find charge Q_2.

3. Write Gauss's law in integral and differential forms.

4. Write Poisson and Laplace's equations.

5. Write Biot-Savart law.

6. Define Self and Mutual Inductance.

7. Write Ampere's circuital law.

8. What are harmonic fields?

9. Define Group velocity.

10. Define Poynting vector.

PART B — (5 × 13 = 65 marks)

11. (a) Explain rectangular, cylindrical and spherical coordinate systems and give their relations. (13)

Or

(b) Write the fundamental theorems of Gradient, Divergence and Curl with example. (13)

12. (a) Find the electric field a distance 'z' above the center of a flat circular disc of radius R, which carries a uniform surface charge σ. What does your formula give in the limit $R \to \infty$? Also check the case $z >> R$. (13)

Or

(b) A pair of 200 mm long concentric cylindrical conductors of radii 50 and 100 mm is filled with a dielectric, $\varepsilon = 10\varepsilon_0$. A voltage is applied between the conductors to establish an electric field $\mathbf{E} = (10^6 / r)\hat{r}(V/m)$ between the cylinders.

Calculate the energy stored. Determine the capacitance. Find the applied voltage between the cylinders. (13)

13. (a) Find the magnetic field a distance 's' from a long straight wire carrying a steady current I, using Biot-Savart law and Ampere's law. Also find the magnetic field at the center of a square loop, which carries a steady current I. Let R be the distance from center to side. Find the field at the center of a n-sided polygon, carrying a steady current I. Again, let R be the distance from the center to any side. Find the formula in the limit n (number of sides) tends to infinity. (13)

Or

(b) A spherical shell, of radius R, carrying a uniform surface charge σ, is set spinning at an angular velocity ω. Find the magnetic vector potential it produces inside and outside. (13)

14. (a) State Faraday's law. Write Maxwell's equations in differential and integral forms. (13)

Or

(b) Derive the wave equations for electric and magnetic fields in vacuum and in matter. (13)

15. (a) Derive Poynting's Theorem. Find the Poynting vector on the surface of a long, straight conducting wire (of radius 'b' and conductivity σ) that carries a direct current I. Verify Poynting's theorem. (13)

Or

(b) Analyze the reflection and transmission of waves at boundaries under oblique incidence and derive the Fresnel's equation and Brewster's angle. (13)

PART C — (1 × 15 = 15 marks)

16. (a) The electric filed intensity of a linearly polarized uniform plane wave propagating in the +z direction in seawater is $\vec{E} = 100\cos(10^7 \pi t)\hat{i}\,V/m$ at $z = 0$. The constitutive parameters of seawater are $\varepsilon_r = 72$, $\mu r = 1$ and $\sigma = 4$ S/m. Determine the attenuation constant, phase constant, intrinsic impedance, phase velocity, wavelength and skin depth. Also find the distance at which amplitude of E is 1% of its value at $z = 0$. Write the expression for $E(z,t)$ at $z = 0.8$ m as a function of t. (15)

Or

(b) A 1.8 kHz wave propagate in a medium characterized by $\mu_r = 1.6$, $\varepsilon_r = 25$ and $\sigma = 2.5$ S/m. The electric field intensity in the region is given by $\vec{E} = 0.1e^{-\alpha z}\cos(2\pi ft - \beta z)\hat{i}\,V/m$. Determine the attenuation constant, propagation constant, intrinsic impedance, phase velocity skin depth and wavelength of the wave. Obtain an expression for the H field. Find the average power density in the medium. (15)