31

ECE

Reg. No. :

Question Paper Code : 90473

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2022.

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. Define gradient of a scalar field.
2. A vector function, $F=(4y-c_1z)\,a_x+(c_2x-7z)\,a_y-(c_3y+5z)a_z$. Determine the constants C_1, C_2, C_3 if F is irrotational.
3. State Coulomb's law.
4. The electrostatic field intensity E is derivable as the negative gradient of a scalar electric potential V. Determine E at the point (2,3,1) if $V=V_o e^{-2x}\sin(\pi y/4)$
5. State Ampere's Circuital law.
6. Vector magnetic potential in free space is $A=(2x^2y-yz)a_x+(xy^2-xz^2)\,a_y-(6xy+2xy)\,a_z\,(Wb/m)$. Calculate magnetic flux density (B).
7. What is the difference between conduction current and displacement current?
8. Write the boundary conditions of electromagnetic fields at air – conductor interface.
9. Write the properties of Uniform Plane Wave for free space.
10. Find the intrinsic impedance of the medium with permittivity $\varepsilon=4\varepsilon_0$ and permeability $\mu=\mu_0$.

PART B — (5 × 13 = 65 marks)

11. (a) (i) A vector in cylindrical coordinates is given as $A = a_r A_r + a_\phi A_\phi + a_z A_z$. Derive the relation between the components of cylindrical coordinates and cylindrical coordinates. (7)

(ii) State and explain helmholtz's theorem. (6)

Or

(b) Verify the divergence theorem for the vector function $A = x^2 a_x + xy a_y + yz a_z$ over a cube one unit on each side. The cube is situated in the first octant of the cartesian coordinate system with one corner at the origin.

12. (a) Determine the Electric field intensity (E) of an infinitely long, straight, line charge of a uniform density ρ_1 in air medium.

Or

(b) A spherical capacitor consists of an inner conducting sphere of radius R_i and outer conductor with a spherical inner wall of radius R_o. The space between the conductors is filled with a dielectric of permittivity ε. Determine the capacitance of the capacitor.

13. (a) Derive the boundary conditions for the static magnetic field at the interface of two different magnetic medium with permeability μ_1 and μ_2.

Or

(b) An air coaxial transmission line has a solid inner conductor of radius a_1 and a very thin outer conductor of inner radius b_1. Determine inductance per unit length of the line.

14. (a) Derive the integral and point form of the maxwell's equations from gauss law, ampere's law and faraday's law.

Or

(b) Derive the wave equations from maxwell's equations and solve it for free space conditions.

33

15. (a) Derive the expression for attenuation and phase constant for an electromagnetic wave propagating in good conductor and dielectric medium.

Or

(b) Find the poynting vector on the surface of a long, straight conducting wire that carries a direct current I. The radius and conductivity of the conductor are b and σ respectively. Verify the poynting's theorem.

PART C — (1 × 15 = 15 marks)

16. (a) (i) A long, straight copper wire with 12 mm diameter carries a steady current of 10 mA. Determine the magnetic flux density and magnetic field intensity at 3 mm and 5 cm from the centre of the wire $\left(\mu = \mu_0 = 4\pi \times 10^{-7}\, H/m\right)$. (8)

(ii) A point charge of Q = 40 nC is located at the origin in cartesian coordinates. Find the electric flux density and electric field intensity at $(1, 3, -5)$. (7)

Or

(b) (i) A copper sheet is used as cover for electromagnetic shielding applications. What is thickness of copper sheet is required at 100 MHz, 500 MHz, 3 GHz and 30 GHz for the electromagnetic shielding applications? $\left(\mu = \mu_0 = 4\pi \times 10^{-7}\, H/m,\ \sigma = 5.8 \times 10^{7}\, S/m\right)$. (8)

(ii) The Electric field intensity in air medium is given by $E = 10 \sin(100\pi x) \cos(12\pi 10^{9} t - \beta z)\, a_y\, (V/m)$. Find the magnetic field intensity H and β. (7)