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Question Paper Code : 30143

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2023.

Fourth Semester

Electronics and Communication Engineering

EC 3452 — ELECTROMAGNETIC FIELDS

(Common to : Electronics and Telecommunication Engineering)

(Regulations 2021)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is divergance of a vector field?
2. Calculate the curl of gradient of the scalar field, $V = 3xy - yz$.
3. Define Gauss's Law.
4. What is the significance of Laplacian Operator?
5. Define Ampere's Law.
6. What is the significance of magnetic vector potential?
7. What is the displacement current?
8. What is the significance of Continuity Equation?
9. Define skin depth
10. "X-rays can penetrate the human body, but light cannot". Justify.

PART B — (5 × 13 = 65 marks)

11. (a) Explain different type of coordinate systems along with examples of their use.

Or

(b) Explain Gradient, Divergence and Curl in detail along with examples. (3 + 5 + 5 = 13)

12. (a) Determine the net electric flux leaving through closed surface defined by: $\rho = 4, 0 \le z \le 1$, if electric flux density is given by: $D = \rho^2 \cos^2 \varphi \, a_\rho + z \sin \varphi \, a_\varphi C/m^2$.

Or

(b) Derive the expression for Electric Field Intensity, E at a distance, r due to a volume charge as sphere of radius, R carrying charge density, $\rho_v C/m^3$. Consider

(i) $r < R$ (6.5)

(ii) $r > R$. (6.5)

13. (a) Find the magnetic field intensity, H and magnetic flux density, B at the centre of the circular loop carries a current of I Amperes in the clockwise direction at $z = 0$ plane. Assume the diameter of the circular loop is $2a$.

Or

(b) For a current distribution in free space, magnetic vector potential is given by : $A = \left(2x^2z + yz\right)a_x + \left(xy^2 - xz^3\right)a_y - \left(6xyz - 2x^2y^2\right)a_z Wb/m$.

Calculate :

(i) magnetic flux density, B and (5)

(ii) the flux crossing through the surface described by $x = 1, 0 < y < 2$, $0 < z < 2$. (8)

14. (a) Explain in detail Maxwell's equations in integral and differential form for time varying fields.

Or

(b) Explain the phenomenon of EM wave propagation in free space using Maxwell's Equations.

15. (a) The electric field intensity of a uniform plane wave in an unknown medium is given by :

$$E(y,t) = 25 \sin\left(10^8 t - y\right)a_z V/m.$$

Calculate :

(i) nature of the medium, (2)

(ii) attenuation constant (α), (2)

(iii) phase constant (β), (2)

(iv) phase velocity (v_p) and (2)

(v) derive the expression for magnetic field intensity, H. (5)

Or

(b) In a certain lossy medium, an EM wave travels for a distance of 10 m where its amplitude decays to $1/e$ times of its initial value. If the phase shift for the same period is 60°, then Calculate the propagation constant of the medium.

PART C — (1 × 15 = 15 marks)

16. (a) Three infinite sheets with charge density of 18 nC/m², 9 nC/m² and –24 nC/m² are located at $x = 4$, $y = -3$ and $z = 0$ respectively. Find the electric field intensity at

(i) (8, 0, 6) and (7.5)

(ii) (–2, –7, 1). (7.5)

Or

(b) An EM wave travels from a free space to a dielectric medium with dielectric constant $(\varepsilon_r) = 4$ and it incidents normally on the interface. If the electric field of incident wave in free space is given by :

$E_i = E_0 \cos(\omega t - \beta z) a_y V/m$, where $\omega = 3 \times 10^9 \pi$ and $\beta = 10\pi$.

Then, calculate the value of

(i) reflection coefficient (Γ_E), (3)

(ii) transmission coefficient (τ_E), (3)

(iii) the fraction of power transmitted into the dielectric medium and, (3)

(iv) derive the expression for electric field of the transmitted wave (E_T). (6)