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17EC36

Third Semester B.E. Degree Examination, July/August 2021
Engineering Electromagnetics

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions.

1 a. State and explain Coulomb's law in vector form. **(06 Marks)**

b. Point charge $Q_1 = 300\ \mu c$ located at (1, −1, 3) experiences a force $F = 8a_x - 8a_y - 4a_z$ N due to charge Q_2 at (3, −3, 2). Find Q_2. **(06 Marks)**

c. Find the total charge within the volume indicated:

i) $\rho_v = 10z^2e^{-0.1x}\sin \pi y$, $1 \le x \le 2$; $0 \le y \le 1$; $3 \le z \le 3.6$

ii) $\rho_v = 4xyz^2$, $0 \le \rho \le 2$; $0 \le \phi \le \frac{\pi}{2}$; $0 \le z \le 3$ **(08 Marks)**

2 a. Derive the expression for electric field intensity 'E' at any point due to uniform line charge of density ρ_ℓ c/m. **(07 Marks)**

b. Two uniform surface charge densities of density ρ_s c/m^2 are located at x = ±4m. Determine the electric field at all the points. **(06 Marks)**

c. Given $D = 5x^2a_x + 10za_z$ c/m^2, find the net outward flux for the surface of a cube of 2m on an edge centered at origin. The edges of the cube are parallel to coordinate axes. **(07 Marks)**

3 a. State and prove Gauss law in integral form. **(06 Marks)**

b. Find the numerical value of Divergence of D at the point indicated if:

(i) $D = 20xy^2(z+1)a_x + 20x^2y(z+1)a_y + 10x^2y^2a_z$ c/m^2 at P_A(0.3, 0.4, 0.5)

(ii) $D = 4\rho z \sin\phi a_\rho + 2\rho z\cos\phi a_\phi + 2\rho^2\sin\phi a_z$ c/m^2 at $P_B\left(1, \frac{\pi}{2}, 2\right)$ **(06 Marks)**

c. Given $D = \left(\frac{5r^2}{4}a_r\right)$ c/m^2 in spherical coordinates evaluate both sides of divergence theorem for the volume enclosed between r = 1 m and r = 2 m. **(08 Marks)**

4 a. Define scalar electric potential. Derive the expression for potential due to a point charge. **(06 Marks)**

b. Find the work done in moving a 5 μc point charge from origin to p(2, −1, 4) through the field $E = 2xyza_x + x^2za_y + x^2ya_z$ V/m via the path:

(i) Straight line segments (0, 0, 0) to (2, 0, 0) to (2, −1, 0) to (2, −1, 4)

(ii) Straight line x = −2y; z = 2x **(08 Marks)**

c. Given $V = 50x^2yz + 20y^2$ v in free space,

(i) Find voltage at P(1, 2, −3)

(ii) Field strength E at P. **(06 Marks)**

5 a. Using Laplace equation derive the expression for capacitance of a co-axial cylindrical capacitor. The boundary conditions are $V = V_0$ at ρ = a and V = 0 at ρ = b, b > a. **(10 Marks)**

b. In spherical coordinates V = 865 V at r = 50 cm and E = 748.2 a_r V/m at r = 85 cm. Determine the location of voltage reference if the potential depends only on 'r'. **(10 Marks)**

6 a. State and explain Biot-Savart's law. **(05 Marks)**

b. Find 'H' at origin due to an infinite conductor carrying a current of 5A in a_y direction and located at x = 2 and z = −2. **(07 Marks)**

c. Given $H = \frac{x+2y}{z^2}a_y + \frac{2}{z}a_z$ A/m, find J. Find total current passing through z = 4; $1 \le x \le 2$; $3 \le y \le 5$. **(08 Marks)**

7 a. The point charge Q = 18 nc has a velocity of 5×10^6 m/s in the direction $a_v = 0.60a_x + 0.75a_y + 0.30a_z$. Calculate the magnitude of force exerted on the charge by:
(i) $B = -3a_x + 4a_y + 6a_z$ mT (ii) $E = -3a_x + 4a_y + 6a_z$ KV/m **(06 Marks)**

b. Derive the expression for the force on a differential current element moving through a steady magnetic field. **(08 Marks)**

c. The field $B = -2a_x + 3a_y + 4a_z$ mT is present in free space. Find vector force exerted on a straight wire carrying 12 A in a_{AB} direction, given A(1, 1, 1) and (i) B(2, 1, 1) (ii) B(3, 5, 6). **(06 Marks)**

8 a. Define Magnetization. Given a ferrite material which is operating in a linear mode with B = 0.05 T and $\mu_r = 50$. Calculate χ_m, M and H. **(06 Marks)**

b. Derive the boundary conditions for magnetic fields B, H and M for the interface between the different magnetic media. **(07 Marks)**

c. Let $\mu_1 = 4$ μH/m in region 1 where z > 0 while $\mu_2 = 7$ μH/m in region 2 where z < 0, K = 80 a_x A/m on the surface z = 0. If $B_1 = 2a_x - 3a_y + a_z$ mT in region 1, find B_2. **(07 Marks)**

9 a. An area of 0.65 m^2 in z = 0 plane is enclosed by a filamentary conductor. Find the induced voltage given $B = 0.05\cos 10^3 t\left[\frac{a_y + a_z}{\sqrt{2}}\right]$T. **(06 Marks)**

b. What is inconsistency of Ampere's law with continuity equation? How it was modified by Maxwell? Derive the modified equation. **(06 Marks)**

c. Given $E = E_m \sin(\omega t - \beta z)a_y$ V/m in free space, find D, B, H. Sketch E and H at t = 0. **(08 Marks)**

10 a. Prove that the intrinsic impedance of a perfect dielectric $\eta = \frac{|E|}{|H|} = \sqrt{\frac{\mu}{\epsilon}}$ **(06 Marks)**

b. Derive expressions for attenuation constant 'α' and phase constant 'β' for any conducting media. **(06 Marks)**

c. Calculate attenuation constant, wave velocity and intrinsic impedance in sea water for a uniform plane wave at 10 GHz. The constants are $E_r = 80$, $\mu_r = 1$, σ = 4 Mho s/m. **(08 Marks)**

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