Vedant Milind Athavale
181090071
TY BTech EXTC

Athavale

EWE - MST

Q1.] $A = x^2 y\, a_x + y^2 x\, a_y - 5yz^2 a_z$ Wb/m (Given)

a) Here, we need to calculate B at (-2, 3, 5)

We know that $B = \nabla \times A$

$$\therefore B = \begin{vmatrix} a_x & a_y & a_z \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ x^2 y & y^2 x & -5yz^2 \end{vmatrix}$$

By solving the determinant, we get

$$B = a_x(-5z^2 - 0) - a_y(0-0) + a_z(y^2 - x^2) \quad \text{Wb/m}^2$$

$$\left[\because \frac{\partial}{\partial x}(y^2 x) = y^2 ;\ \frac{\partial}{\partial y}(x^2 y) = x^2 ;\ \frac{\partial}{\partial y}(-5yz^2) = -5z^2 ;\ \frac{\partial}{\partial z}(y^2 x) = 0 ;\ \frac{\partial}{\partial x}(-5yz^2) = 0 ;\ \frac{\partial}{\partial z}(x^2 y) = 0\right]$$

Hence, $B = a_x(-5(5)^2) - a_y(0) + a_z(9 - 4)$ Wb/m^2

$\Rightarrow$ $\underline{B = -125\, a_x + 5\, a_z \quad \text{Wb/m}^2}$

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b) Here, we need to calculate the flux through the surface defined by $z=1$, $0 \le x \le 1$, $-1 \le y \le 4$

$$\therefore \quad \Psi = \oint \vec{B} \cdot \vec{ds} \qquad (\Psi \text{ denotes flux})$$

$$= \int_{-1}^{4} \int_{0}^{1} 0 + 0 + (y^2 - x^2) \, \partial x \, \partial y$$

$$= \int_{-1}^{4} y^2 \, \partial y - \int_{0}^{1} x^2 \, \partial x$$

$$= \left. \frac{y^3}{3} \right|_{-1}^{4} - \left. \frac{x^3}{3} \right|_{0}^{1}$$

$$= \frac{64}{3} + \frac{1}{3} - \left(\frac{1}{3} - 0 \right)$$

$$\Rightarrow \quad \boxed{\Psi = \frac{64}{3} \text{ Wb}}$$

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Q2] a.) Here, $\eta_1 = \eta_0$

Now, $E_t = E_{to} \sin(\omega t - 4x)\, a_E$

$$E_{to} = H_{to} \cdot \eta_0 = 6 \times 120\pi = 720\pi$$

$\because a_E \times a_H = a_K$

$\therefore a_E \times a_y = a_x$

Hence, $a_E = -a_z$

$\therefore E_t = -720\pi \sin(\omega t - 4x)\, a_z \quad (\because a_E = -a_z)$

$$\eta_2 = \sqrt{\frac{\mu}{\varepsilon}} = \sqrt{\frac{\mu_0}{4\varepsilon_0}} = \frac{120\pi}{\sqrt{4}} = 60\pi$$

$$\Gamma = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} = \frac{60\pi - 120\pi}{60\pi + 120\pi} = \frac{-1}{3}$$

$$\tau = 1 + \Gamma = \frac{2}{3}$$

$$E_{r_0} = \Gamma E_{i_0} = \frac{-1}{3} \times -720\pi = 240\pi$$

$\therefore E_r = 240\pi \sin(\omega t + 4x)\, a_z$

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$$E_1 = E_t + E_r$$

$$= -720\pi \sin(\omega t - 4x) + 240\pi \sin(\omega t + 4x)$$

$$= -2.261 \sin(\omega t - 4x)\, a_z + 0.754 \sin(\omega t + 4x)\, a_z \quad kV/m$$

b.) Here, we need to calculate the time-average power density in the plastic region.

$$\because \quad E_{to} = \tau E_o$$

$$= \frac{2}{3} \times 720\pi = 480\pi$$

Now,

$$P = \frac{E_{to}^2}{2\eta_2} a_x = \frac{(480\pi)^2}{2 \times 60\pi}$$

$$= \frac{(480)^2 \pi}{120} a_x$$

$$\therefore \underline{P = 6.032\, a_x \; kV/m}$$

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c) For standing wave ratio,

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$$S = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$, here S is the standing wave ratio

$$\therefore \quad S = \frac{1 + 1/3}{1 - 1/3} = \frac{4/3}{2/3} = 2$$

$$\therefore \boxed{S = 2}$$

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