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Subject EMF

Final Assignment

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Q 1(a):- Determine the magnetic field at the center of the semicircular piece of wire with radius 0.20m. The current carried by the semicircular of wire is 150A.

Solution:-

The radius of semicircular piece of wire = 0.20 m

Current carried by the semicircular piece of wire = 150A.

Magnetic field is given as $B = \frac{\mu_0 N I}{2a}$

The differential from Biot-Savart law is given as: $dB = \frac{\mu_0 I}{4\pi} \frac{dI \sin\theta}{r^2}$

$$B = \frac{\mu_0}{4\pi} I \int \frac{dI \times \hat{r}}{r^2} = \frac{\mu_0}{4\pi} \frac{I}{r^2} \int dI$$

$$= \frac{\mu_0}{4\pi} \frac{I}{r^2} \pi r = \frac{\mu_0 I}{4r} = \frac{4\pi \times 10^{-7} T\cdot m/A (150A)}{4(0.20m)}$$

$$= 2.4 \times 10^{-4} T$$

Q1 (b): A circular coil of radius 5×10^{-2} m and with 40 turns is carrying a current of 0.25 A. Determine the magnetic field of the circular coil at the center.

Ans: The radius of circular coil $= 5\times10^{-2}$ m.
Number of turns of circular coil = 40.
Current carried by the circular coil
$= 0.25$ A.
Magnetic field is given as $B = \frac{\mu_0 NI}{2a}$

$$= \frac{4\pi\times10^{-7}\,T.m/A\,(40)\,0.25A}{2\ 50\times10^{-2}\,m}$$

$$= \boxed{1.2\times10^{-4}\ T}$$

Q2(a): Compute the magnetic field of a long straight wire that has a circular loop with a radius of 0.05 m. 2 amp is the reading of the current flowing through this closed loop.

Solution:- Given

$R = 0.05\,m$

$I = 2\,amp$

$\mu_0 = 4\pi \times 10^{-7}\,N/A^2$

Ampere's law formula as

$\oint \vec{B}\,\vec{dl} = \mu_0 I$ ∴ In case of long straight wire.

$\oint \vec{dl} = 2\pi R = 2 \times 3.14 \times 0.05 = 0.314$

$B \oint \vec{dl} = \mu_0 I$

$$\vec{B} = \frac{\mu_0 I}{2\pi R}$$

$$\vec{B} = \frac{4\pi \times 10^{-7} \times 2}{0.314} = 8 \times 10^{-6}\,T$$

Q 2(b) :- Within cylinder $\rho = 2, 0 < z < 1$, the potential is given by $V = 100 + 50\rho + 150\rho \sin\phi$ V. (a) Find V, E, D and ρ_v at $P(1, 60^\circ, 0.5)$ in free space. (b) How much charge lies within the cylinder?

Solution:- First substituting the given point, we find $V_P = 279.9$ V Then,

$$E = -\nabla V = -\frac{\partial V}{\partial \rho} a_\rho - \frac{1}{\rho}\frac{\partial V}{\partial \phi} a_\phi = -[50 + 150\sin\phi] a_\rho - [150\cos\phi] a_\phi$$

Evaluate the above at P to find $E_P = -179.9\, a_\rho - 75.0\, a_\phi$ V/m

Now $D = \epsilon_0 E$, so $D_P = -1.59\, a_\rho - .664\, a_\phi$ nC/m^2

Then,

$$\rho_v = \nabla \cdot D = \left(\frac{1}{\rho}\right) \frac{d}{d\rho}(\rho D_\rho) + \frac{1}{\rho} \frac{\partial D_\phi}{\partial \phi} =$$

$$\left[-\frac{1}{\rho}(50 + 150 \sin\phi) + \frac{1}{\rho} 150 \sin\phi\right] \epsilon_0 =$$

$$-\frac{50}{\rho} \epsilon_0 C$$

At P, this is $\rho_v P = \underline{-443 pC/m^3}$.

<u>part (B)</u>: We will integrate ρ_v over the volume to obtain.

$$Q = \int_0^1 \int_0^{2\pi} \int_0^2 -\frac{50\epsilon_0}{\rho} \rho \, d\rho \, d\phi \, dz = 2\pi(50)\epsilon_0(2)$$

$$= \boxed{-5.56 nC.}$$

Q 3 (a):- Given the time-varying magnetic field $B = (0.5a_x + 0.6a_y - 0.3a_z)\cos 5000t$ and square filamentary loop with its corners at $(2, 3, 0)$, $(2, -3, 0)$ and $(-2, 3, 0)$ and $(-2, -3, 0)$. Find the time-varying current flowing in the general a_ϕ direction if the total loop resistance is $400\,k\Omega$.

Ans: we write

$$emf = \oint E \cdot dL = -\frac{d\phi}{dt} = \frac{-d}{dt} \int\int_{\text{loop area}}$$

$$B \cdot a_z da = \frac{d}{dt} (0.3)(4)(6) \cos 5000t$$

* where the loop normal is chosen as positive a_z, so that the path integral for E is taken around the positive

a_ϕ direction. Taking the derivative, we find

$$emf = -7.2(5000)\sin 5000t$$ so that

$$I = \frac{emf}{R} = \frac{-36000 \sin 5000t}{400 \times 10^3}$$

$$= -90 \sin 5000t \text{ mA}$$