

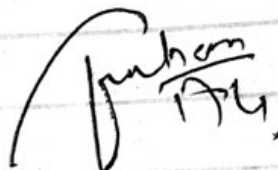
Electromagnetic field theory

4th Semester

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Solve the following short question

Q1

Part (a) :-

Determine the magnetic field at the center of the semicircular piece of wire with radius of 0.20m. The current carried by the semicircular wire is 150A.

Solution :-

The radius of the semicircular piece of wire = 0.20m.
Current carried by the semicircular piece of wire = 150A

Magnetic field is given as: $B = \frac{\mu_0 NI}{2a}$

The differential form of Biot-Savart law is given as:

$$dB = \frac{\mu_0 I}{4\pi} \frac{dL \sin\theta}{r^2}$$

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

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

$$= \frac{\mu_0}{4\pi} \frac{I}{r^2} \pi r = \frac{\mu_0 I}{4r} = \frac{4\pi \times 10^{-7} \text{ T}\cdot\text{m/A} (153\text{A})}{4(0.20\text{m})}$$

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

Part (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 at the center.

Solutions:-

the radius of the circular coil $= 5 \times 10^{-2}$ m
 number of turns of the circular coil $= 40$
 Current carried by the circular coil $= 0.25$ A

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

$$= \frac{4\pi \times 10^{-7} \text{ T}\cdot\text{m/A} (40) 0.25 \text{ A}}{2 \times 5 \times 10^{-2} \text{ m}}$$

$$= 1.2 \times 10^{-4} \text{ T}$$

Q 2:-

Part (a):-

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

Solution:-

Given:-

$$R = 0.05\text{m}$$

$$I = 2\text{amp}$$

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

Ampere's Law formula is

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I$$

In the case of long straight wire

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

$$B \oint d\vec{l} = \mu_0 I$$

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

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

Part (B) :-

Within the 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?

(a) :-

Substituting the given point, we find $V_p = 279.9$ V
then.

$$E = -\nabla V = -\frac{\partial V}{\partial \rho} a_\rho - \frac{1}{\rho} \frac{\partial V}{\partial \phi} a_\phi =$$

$$- [50 + 150 \sin\phi] a_\rho - [150 \cos\phi] a_\phi$$

~~Q~~Evaluate the above at P to find

$$E_p = -179.9 a_p - 75.0 a_\phi \text{ V/m}$$

$$\text{Now } D = \epsilon_0 E, \text{ so } D_p = -1.59 a_p - 664 a_\phi \text{ nC/m}^2$$

then

$$P_v = \nabla \cdot D = \left(\frac{1}{P}\right) \frac{d}{dP} (P D_p) + \frac{1}{P} \frac{\partial D_\phi}{\partial \phi} =$$

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

$$\text{At } P, \text{ this is } P_{vp} = -443 \text{ pC/m}^3$$

B :-How much charge lies within the cylinder? we will integrate P_v over the volume to obtain.

$$Q = \int_0^1 \int_0^{2\pi} \int_0^2 -\frac{50 \epsilon_0}{P} P \, dP \, d\phi \, dz =$$

$$-2\pi (50) \epsilon_0 (2) = -5.56 \text{ nC}$$

Q3:-

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

Solution:-

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

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

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

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$$\text{emf} = 7.2 \cos 500t \text{ so that } I = \frac{\text{emf}}{R}$$

$$= \frac{-36000 \sin 500t}{400 \times 10^3}$$

$$= -90 \sin 500t \text{ mA.}$$