Electromagnatic 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 0.20m. the current carried by the semicircular of wire is 150 A.

Solution:-

the radius of the semicircular piece of wire = 0.20m

Current carried by the semicircular piece of wire = 150 A

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

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

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

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

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

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

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

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.

Solution:-

the radius of the circular Coil $= 5\times10^{-2}$ m

number of turns of the circular coil = 40

Current carried by the circular coil = 0.25 A

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

$$= \frac{4\pi\times10^{-7}\,T\cdot m/A\,(40)\,0.25\,A}{2.50\times10^{-2}\,m}$$

$$= 1.2\times10^{-4}\,T.$$

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:-

Givens:-

$R = 0.05m$

$I = 2amp$

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

Amperes law formula is

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

In the case of long straight wire

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

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

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

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

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 $P(1, 60°, 0.5)$ in free space.

(b) How much charge lies within the cylinder?

(a):-

Substituting the given point, we find $V_P = 279.9V$

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~~
Evalute the above at P to find

$E_p = -179.9 a_\rho - 75.0 a_\phi$ V/m

Now $D = \epsilon_0 E$, so $D_p = -1.59 a_\rho - .664_\phi$ 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 $\rho_{vp} = -443$ pC/m^3.

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

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

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

Q3 :-

Given the time-verying magnetic field $B = (0.5a_x + 0.6a_y - 0.3a_z)$ ~~at~~ $\cos 5000t$ 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 400kΩ.

Solution:-

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

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

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 $= 7.2 (5000t$ so that $I = \frac{emf}{R}$

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

$= -90 \sin 5000t$ mA.