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Subject: ElectroMagnetic Field

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Module: Final Exam

Date: 23.june.2020

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Q1 (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.

Ans

The radius of the semicircular piece of wire = 0.20m

current carried by the semicircular piece of wire = 150A

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

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

$$dB = \frac{\mu_0}{4\pi} \frac{dI \sin\theta}{r^2} \quad B = \frac{\mu_0}{4\pi} I \int \frac{dI \times \hat{r}}{r^2} = \frac{\mu_0}{4\pi} \frac{1}{r^2} \int dI$$

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

$$= \frac{4\pi \times 10^{-2}\ T.m/A\ (150A)}{4(0.20m)}$$

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

Q 1 (b)

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

Ans

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: $B = \frac{\mu_0 N I}{2a}$

$$= \frac{4\pi \times 10^{-7}\ T.m/A\ (40)\ 0.25A}{2.50 \times 10^{-2}\ m}$$

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

Q 2 (a)

Compute the magnetic field of a . . . long straight . . . . radius of 0.05m. 2amp is the . . closed loop.

Ans

Sol:

given:

$R = 0.05 m$

$I = 2 amp$

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

Ampere's law formula is

$$\oint \vec{B} \, \vec{dL} = \mu_0 I$$

In the case of long straight wire

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

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

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

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

Q2 (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.

Ans

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 to find $E_P = -179.9a_\rho - 75.0a_\phi$ V/m

Now $D = \epsilon_0 E$, so $D_P = -1.59a_\rho - .66a_\phi$ 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 $\rho_{vP} = -443$ pC/m^3

Q2 (b). b

How much charge lies with in the cylinder.

Ans:

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

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

Q3

Given the time-varying Magnetic field $B(0.5a_x + 0.6a_y - 0.3a_z)\cos 5000T$ and a Square filamentary loop ...... total loop resistance is $400k\Omega$.

Ans

$$emf = \oint E \cdot dL = -\frac{d\phi}{dt} = -\frac{d}{dt}\iint_{loop\ area} B \cdot a_z\, da = \frac{d}{dt}(0.3)(4)(6)(\cos 5000t)$$

where the loop normal is chosen 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 $I = \frac{emf}{R}$

$$I = -\frac{36000 \sin 5000t}{400 \times 10^3} = -90 \sin 5000t \text{ mA}$$