Department of Electrical Engineering

Final Assignment

Date 23-06-2020

Course Details

Course title: Electro magnatic field theory.

Module:- 4th

Instructor:- Dr Engr Rafiq Mansoor

Total Marks:- 50

Student Details

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

Sol:

The radius of the semicircular piece of wire = 0.20 m.

Current carried by the semiciralar 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:

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

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

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

$$B = \frac{\mu_0 I}{4r} \rightarrow (*)$$

Now put values in (*) we get,

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

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

(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.

Sol. 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 $= 0.25A$
Magnetic field is given as:

$$B = \frac{\mu_0 NI}{2a}$$

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

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

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

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

$$\oint \vec{dl} = 2\pi R$$

$$= 2 \times 3.14 \times 0.05 = 0.314$$

$$B \oint dl = \mu_0 I$$

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

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

$$\boxed{\vec{B} = 8 \times 10^{-6}\,T}$$

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(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 mush charge lies within the cylinder?

(a) 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

$$E_P = -179.9 a_\rho - 75.0 a_\phi \text{ V/m}$$

Now,

$$D = \epsilon_0 E \quad \text{so,}$$

$$D_P = -1.59 a_\rho - .664 a_\phi \text{ nC/m}^2.$$

then,

$$\rho_v = \nabla \cdot D$$

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

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

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

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

(b) We will integrate ρ_v over the volume to obtain How much charge lies within the cylinder.

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

$$Q = -2\pi (50) \epsilon_0 (2)$$

$$\boxed{Q = -5.56 \text{ n/C}}$$

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Q:-3 (a) 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) and (-2, -3, 0), find the time-varying current flowing in the general a_ϕ direction if the total loop resistance is $400k\Omega$.

Sol:-

$$emf = \oint E \cdot dL$$

$$= -\frac{d\phi}{dt}$$

$$= -\frac{d}{dt}\iint_{loop\ area} B \cdot a_z\, da$$

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

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

Now Taking the derivative, we find

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

so that

$$I = \frac{emf}{R}$$

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

$$\boxed{I = -90 \sin 5000t \ mA}$$

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THE END

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