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COURSE E.M.F

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Q6(b) The radius of a circular coil = 5×10^{-2} m

Number of turns of the circular coil = 40

Current carried by the circular coil = 0.25A.

Magnetic field is given by:

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

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

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

Q2 (a)

Given:-

$R = 0.05m$

$I = 2amp$

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

Ampere's law formula is

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

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

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

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

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

Q 2b

First substituting the given point we find $V_P = 279.9V$. Then,

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

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

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 $\rho_{vP} = -443 \ pC/m^3$

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

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

$$= 5.56 nC.$$

Q3.

We write

$$emf = \oint E \cdot dl = -\frac{d\Phi}{dt} = -\frac{d}{dt}\iint_{loop\ area} B \cdot a_z da = \frac{d}{dt}(0.3)$$

$$(4)(6)\cos 5000t.$$

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. Taking the derivative, we find.

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

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

$$= -90 \sin 5000t \ mA.$$