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Problem 36.5 (RHK)

A uniform magnetic field is normal to the plane of a circular loop 10.4 cm *in diameter made out of copper wire* (*diameter* = 2.50 mm). (a) *We have to calculate the resistance of the wire*. (b) *We have to find the rate at which the magnetic field must change with time if an induced current of* 9.66 A *has to appear in the loop*.

Solution:

It is given that a uniform magnetic field is normal to the plane of a circular loop 10.04 cm in diameter.

We will first calculate the resistance of the copper wire.

Length of the wire,

$$l = \pi d = \pi \times 10.4 \times 10^{-2} \text{ m} = 32.67 \times 10^{-2} \text{ m}.$$

Cross-sectional area of the wire,

$$A = \pi d^2 / 4 = \pi \left(2.50 \times 10^{-3}\right)^2 / 4 \text{ m}^2 = 4.91 \times 10^{-6} \text{ m}^2.$$

Resistivity of copper, $\rho = 1.69 \times 10^{-8}\ \Omega$ m.

Resistance of the wire,

$$R=\frac{\rho l}{A}=\frac{1.69\times10^{-8}\times32.67\times10^{-2}}{4.91\times10^{-6}}\ \Omega=1.12\ \text{m}\Omega.$$

From Faraday’s law, the electromotive force in a circuit due to changing magnetic flux is given by the expression

$$\text{E}=-(\text{area of the loop})\times\frac{dB}{dt}.$$

The induced current in the circuit,

$i=9.66\ \text{A}.$

As $\text{E}=iR$,

we find

$$\frac{dB}{dt}=\frac{iR}{(\text{area of the loop})}=\frac{9.66\times11.24\times10^{-4}}{\left(\frac{\pi}{4}\times\left(10.4\times10^{-2}\right)^{2}\right)}=1.28\ \text{T s}^{-1}.$$