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E&M 3.

A circular wire loop with radius 0.10 m and resistance 50 Ω is suspended horizontally in a magnetic field of magnitude $B$ directed upward at an angle of 60° with the vertical, as shown above. The magnitude of the field in teslas is given as a function of time $t$ in seconds by the equation $B = 4(1 - 0.2t)$.

(a) Determine the magnetic flux $\Phi$ through the loop as a function of time.

$$\Phi = BA \cos(\theta)$$

$$A = \pi r^2$$

$$= 4(1 - 0.2t) \cos(60°) \pi (0.1)^2$$

$$\Phi = 0.0628(1 - 0.2t)$$

(b) Graph the magnetic flux $\Phi$ as a function of time on the axes below.

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(c) Determine the magnitude of the induced emf in the loop.

\[ E = -\frac{\Delta \phi}{\Delta t} = -0.0628 \left( 1 - \cos \theta \right) \left( -0.01256 \right) \]

\[ E = -\frac{0.0256}{0.01} = 0.01256 \text{ V} \]

(d)  

i. Determine the magnitude of the induced current in the loop.

\[ V = IR \]

\[ \frac{V}{R} = I = \frac{0.01256}{50} = 2.512 \times 10^{-4} \text{ A} \]

ii. Show the direction of the induced current on the following diagram.

![Diagram showing the direction of induced current with a loop, field lines, and angles.]

(e) Determine the energy dissipated in the loop from \( t = 0 \) to \( t = 4 \text{ s} \).

\[ P = IR \]

\[ \int P \, dx = \text{Energy} \]

\[ \int_0^4 I^2 R \, dx = \left( 2.512 \times 10^{-4} \right)^2 \cdot (50) \int_0^4 \, dx = \left( 3.015 \times 10^{-4} \right) \cdot 4 \]

\[ \text{Energy dissipated} = 1.262 \times 10^{-5} \text{ J} \]

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E&M 3.

A circular wire loop with radius 0.10 m and resistance 50 Ω is suspended horizontally in a magnetic field of magnitude $B$ directed upward at an angle of 60° with the vertical, as shown above. The magnitude of the field in teslas is given as a function of time $t$ in seconds by the equation $B = 4(1 - 0.2t)$.

(a) Determine the magnetic flux $\phi_m$ through the loop as a function of time.

$$\phi = \oint B \cdot \mathbf{dA} = \oint B \, dA \cos \theta = \frac{1}{2} B A = \frac{1}{2} B \cdot r^2$$

$$\phi = (4)(1 - 0.2t) \cdot 0.157$$

(b) Graph the magnetic flux $\phi_m$ as a function of time on the axes below.
(c) Determine the magnitude of the induced emf in the loop.

\[ \mathcal{E} = \frac{d\phi}{dt} = d \left( 0.028 \left(1 - 2t\right) \right) \]

\[ = 0.028 \times 2 = 0.056 \, \text{V} \]

(d) i. Determine the magnitude of the induced current in the loop.

\[ \frac{\mathbf{v}}{\mathbf{q}} = \frac{0.056}{50} = 2.5 \times 10^{-4} \]

ii. Show the direction of the induced current on the following diagram.

![Diagram showing the direction of induced current with a right-hand rule]

(e) Determine the energy dissipated in the loop from \( t = 0 \) to \( t = 4 \) s.

\[ \rho = I \mathbf{v} \]

\[ \rho \cdot t = \frac{\mathcal{E} - 0.85}{0.6} \times 4 = 1.26 \times 10^{-5} \]

GO ON TO THE NEXT PAGE.