



AP[®] Physics B (Operational) 2004 Sample Student Responses

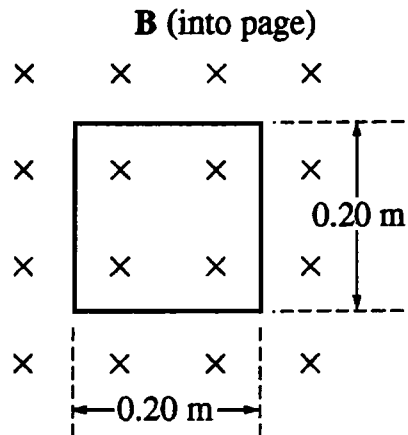
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3. (15 points)

A square loop of wire of side 0.20 m has a total resistance of 0.60Ω . The loop is positioned in a uniform magnetic field B of 0.030 T. The field is directed into the page, perpendicular to the plane of the loop, as shown above.

(a) Calculate the magnetic flux ϕ through the loop.

$$\phi = BA$$

$$\phi = 0.03 \text{ T} (0.04 \text{ m}^2)$$

$$A = bh$$

$$A = 0.2 \text{ m} \times 0.2 \text{ m}$$

$$A = 0.04 \text{ m}^2$$

$$\phi = 1.2 \times 10^{-3} \text{ T} \cdot \text{m}^2$$

The field strength now increases uniformly to 0.20 T in 0.50 s.

(b) Calculate the emf \mathcal{E} induced in the loop during this period.

$$\mathcal{E} = \frac{\Delta \phi}{\Delta t}$$
~~$$\mathcal{E} = \frac{(0.2 \text{ T} - 1.2 \times 10^{-3} \text{ T})}{0.5 \text{ s}}$$~~

$$\phi = 0.2 \text{ T} (0.04 \text{ m}^2)$$

$$\phi = 8 \times 10^{-3} \text{ T} \cdot \text{m}^2$$

$$\mathcal{E} = \frac{(8 \times 10^{-3} \text{ T} \cdot \text{m}^2 - 1.2 \times 10^{-3} \text{ T} \cdot \text{m}^2)}{0.5 \text{ s}}$$

$$\mathcal{E} = \frac{6.8 \times 10^{-3} \text{ T} \cdot \text{m}^2}{0.5 \text{ s}}$$

$$\mathcal{E} = 1.36 \times 10^{-2} \text{ V}$$

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(c)

- i. Calculate the magnitude I of the current in the loop during this period.

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

$$V = IR$$

$$V = \mathcal{E}$$

$$1.36 \times 10^{-2} \text{ V} = I (0.6 \Omega)$$

$$I = 22.67 \text{ mA}$$

- ii. What is the direction of the current in the loop?

Clockwise Counterclockwise

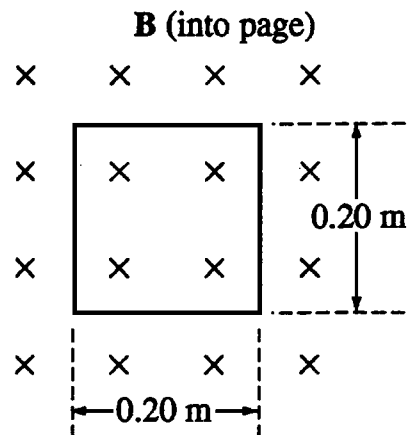
Justify your answer.

Since the B -field is directed into the page, the movement of current has to be directed in a ~~clockwise~~ counterclockwise direction, according to the right hand rule.

- (d) Describe a method by which you could induce a current in the loop if the magnetic field remained constant.

Rotate the loop about an axis that is perpendicular to the B -field (parallel to the page)

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3. (15 points)

A square loop of wire of side 0.20 m has a total resistance of 0.60Ω . The loop is positioned in a uniform magnetic field B of 0.030 T. The field is directed into the page, perpendicular to the plane of the loop, as shown above.

(a) Calculate the magnetic flux ϕ through the loop.

$$\begin{aligned} \phi &= BA & A &= s^2 \\ &= (0.03 \text{ T})(0.04 \text{ m}^2) & &= .2^2 \\ \phi &= 0.0012 \text{ T}\cdot\text{m}^2 & A &= 0.04 \text{ m}^2 \end{aligned}$$

The field strength now increases uniformly to 0.20 T in 0.50 s.

(b) Calculate the emf \mathcal{E} induced in the loop during this period.

$$\begin{aligned} \mathcal{E} &= - \frac{\Delta \phi}{\Delta t} = \frac{B_f A_f - B_i A_i}{t_f - t_i} \\ \mathcal{E} &= - \frac{(0.2 \text{ T})(0.04 \text{ m}^2) - (0.03 \text{ T})(0.04 \text{ m}^2)}{0.5} \\ &= - \frac{0.008 - 0.0012}{0.5} \\ &= - \frac{0.0068}{0.5} \\ \mathcal{E} &= -0.0136 \text{ V} \end{aligned}$$

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(c)

i. Calculate the magnitude I of the current in the loop during this period.

$$V = IR$$

$$\frac{.0136 \text{ V} = I(.6 \Omega)}{.6 \Omega}$$

$$.022\bar{6} \text{ amps} = I$$

ii. What is the direction of the current in the loop?

 Clockwise Counterclockwise

Justify your answer.

According to the right-hand rule, current in a loop of wire will flow clockwise when the magnetic field is oriented like it is in this problem.

(d) Describe a method by which you could induce a current in the loop if the magnetic field remained constant.

In order to induce a current, the magnetic flux has to change. Since $\Phi = BA$, if the magnetic field is constant then the area of the wire must change. This can be accomplished by changing the shape of the loop of wire.

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