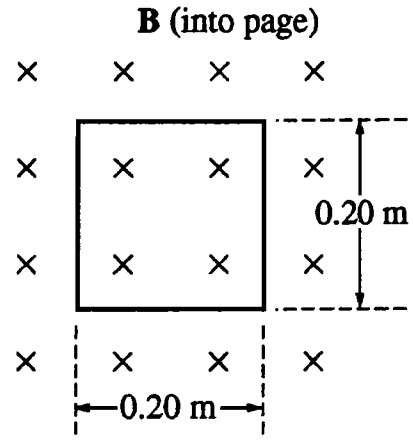
AP® Physics B (Operational)
2004 Sample Student Responses

A1



3. (15 points)

A square loop of wire of side 0.20 m has a total resistance of 0.60 Ω. 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.

$\phi = BA$

$A = bh$

$A = 0.2m \times 0.2m$

$A = 0.04m^2$

$\phi = 0.03T\,(0.04m^2)$

$\phi = 1.2\times10^{-3}\,T\cdot m^2$

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.

$\mathcal{E} = \frac{\Delta\phi}{\Delta t}$

~~$\mathcal{E} = \frac{(0.2T - 1.2\times10^{-3}T)}{}$~~

$\phi = 0.2T\,(0.04m^2)$

$\phi = 8\times10^{-3}\,T\cdot m^2$

$\mathcal{E} = \frac{(8\times10^{-3}T\cdot m^2 - 1.2\times10^{-3}T\cdot m^2)}{0.5s}$

$\mathcal{E} = \frac{6.8\times10^{-3}T\cdot m^2}{0.5s}$

$\mathcal{E} = 1.36\times10^{-2}\,V$

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A2

(c)

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

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

$V = IR$

$V = \mathcal{E}$

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

$I = 22.67\,mA$

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

____ Clockwise _X_ 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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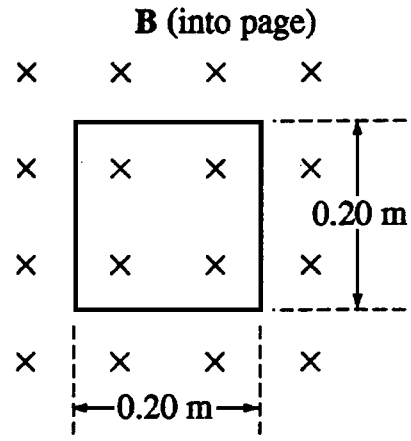
B1



3. (15 points)

A square loop of wire of side 0.20 m has a total resistance of 0.60 Ω. 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.

$\phi = BA$

$= (.03\ T)(.04\ m^2)$

$\phi = .0012\ T \cdot m^2$

$A = s^2$

$= .2^2$

$A = .04\ m^2$

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.

$$\mathcal{E} = -\frac{\Delta\phi}{\Delta t} = \frac{B_f A_f - B_i A_i}{t_f - t_i}$$

$$\mathcal{E} = -\frac{(.2\ T)(.04\ m^2) - (.03\ T)(.04\ m^2)}{.5}$$

$$= -\frac{.008 - .0012}{.5}$$

$$= -\frac{.0068}{.5}$$

$$\mathcal{E} = -.0136\ V$$

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(c)

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

$V = IR$

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

$.0226\ \text{amps} = I$

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

X 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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