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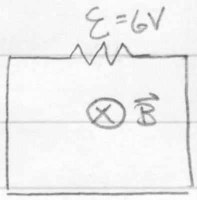

square loop, $\ell = 3.0m \perp \vec{B} = 2.0T$

light bulb $\mathcal{E} = 6V$, $\vec{B} \to 0$ over Δt

(a) What is Δt ?

$$\mathcal{E} = -\frac{d\phi_B}{dt} = -\frac{\Delta\phi_B}{\Delta t} \text{ for "steady reduction"}$$

$\Delta t = |-\Delta\phi_B/\mathcal{E}|$, absolute values because want Δt positive

$\Delta\phi_B = \phi_{B,initial} - \phi_{B,final} = BA - 0$, initially perpendicular, finally zero

$= (2.0T)(3.0m)^2 = 18Tm^2$

$\Delta t = |-(18Tm^2)/6V| = \boxed{3s}$

(b) $\vec{B}$ is into the page and decreasing; the induced current will try to counteract this change $\Rightarrow$ by the right hand rule, the current will $\boxed{\text{clockwise}}$

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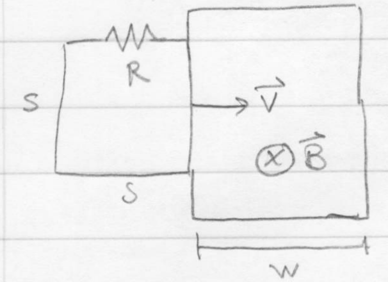


$s = 0.5m$, $R = 5.0\Omega$, $v = 0.25m/s$, $B = 1.0T$, $w = 0.75m$

Plot (a) current and (b) powerdissipation.

$$\mathcal{E} = -\frac{d\phi_B}{dt} \text{ and } I = \frac{\mathcal{E}}{R} = \frac{1}{R}\left(-\frac{d\phi_B}{dt}\right)$$

$$P = I^2R$$

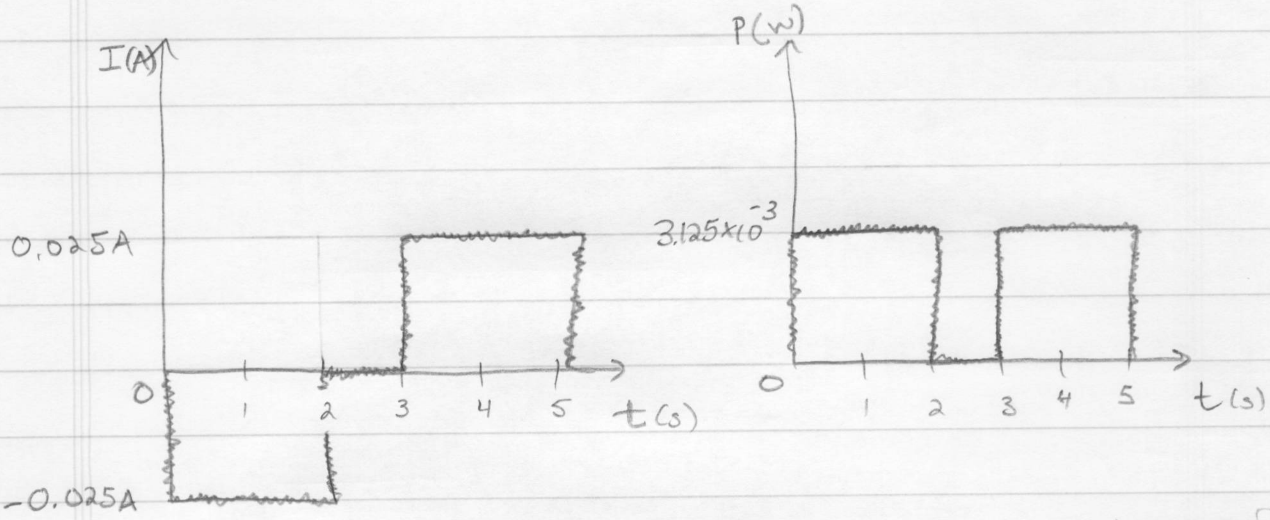
There will only be currents (and therefore power being dissipated) when $\frac{d\phi_B}{dt}$ is non zero, in other words when the circuit is moving onto or off of the region with magnetic field. These will be broken up in time by the instance when the loop is entirely inside the region (b/c $s < w$). The left edge of the loop will hit the left edge of the region at $t = s/v = .5m/.25m/s = 2s$ and the right edge of the loop will hit the right edge of the region at $t = w/v = 0.75m/0.25m/s = 3s$, so between 2s and 3s both I and P will be zero.

Finally, the left edge of the loop will hit the right edge of the region when $t = s + w / v = 5\,s$, at which point we can stop monitoring the situation.

The magnetic field is uniform and the loop is perpendicular to the field, so we have $\phi_B = BA$ and $\frac{d\phi_B}{dt} = B\frac{dA}{dt} = Bsv$ for $0s < t < 2s$ and $3s < t < 5s$.

$$|\mathcal{E}| = \frac{d\phi_B}{dt} = Bsv = (1T)(0.5m)(0.25m/s) = 0.125V$$

$$I = \frac{|\mathcal{E}|}{R} = \frac{0.125V}{5.0\Omega} = 0.025A, \quad P = I^2R = (0.025A)^2(5.0\Omega) = 3.125\times10^{-3}\,J/s$$



always positive

Notice that I has a direction (or sign), while $P = I^2 R$ does not. In the problem it was stated that you were to assume clockwise currents were positive. Initially, ϕ_B is increasing so a ccw current will be induced to counteract this increase (given that $\vec{B}$ is into the page).

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solenoid, $l = 2.0\text{m}$, $d = 30\text{ cm}$, $N = 5000$, $I = \overset{85A}{I_o} \sin(\overset{210hz}{\omega} t)$

coil, $N_{coil} = 5$, $R = 180\Omega$

(a) what is the current through R?

$$\mathcal{E} = IR \text{ (Ohm's law)} \Rightarrow I = \frac{\mathcal{E}}{R} = \frac{1}{R}\left(-\frac{d\phi_B}{dt}\right) = -\frac{N_c A}{R}\frac{dB}{dt}$$

because the area is constant (A is crossectional area of solenoid).

$$B_{solenoid} = \mu_0 n I = \mu_0 (2500\text{m}^{-1})(85\text{A}) \sin(210\text{hz } t)$$

$$n = \frac{\text{turns}}{\text{length}} = 2500\text{ m}^{-1}$$

$$\frac{dB}{dt} = \mu_0 (2500\text{m}^{-1})(85\text{A})(210\text{hz}) \cos(210\text{hz } t)$$

$$I = -\frac{\overset{N_{coil}}{5}(\pi(.15\text{m})^2)}{180\Omega} \mu_0 (2500\text{m}^{-1})(85\text{A})(210\text{hz}) \cos(210\text{hz } t)$$

$$\boxed{= (-0.110\text{ A}) \cos(210\text{hz } t)}$$

(b) the peak magnitude is obtained by taking the absolute value and setting $\cos(210\text{hz } t) = 1$

$\boxed{0.110\text{ A}}$

(c) the solenoid current goes like $\sin(\omega t)$ and the resistor current goes like $\cos(\omega t)$

when $\sin(\omega t) = 1$, $\cos(\omega t) = \boxed{\text{zero}}$

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$$|\mathcal{E}| = \frac{d\varphi_B}{dt} = \underset{\substack{\uparrow \\ \text{\# coils}}}{N} \times \underset{\substack{\uparrow \\ \text{area}}}{A} \times \frac{dB}{dt} = 5000 \times \pi (1\times10^{-3} m)^2 \times \frac{450\times10^{-6} T}{1\times10^{-3} s}$$

$$= \boxed{7.07\times10^{-3} V}$$

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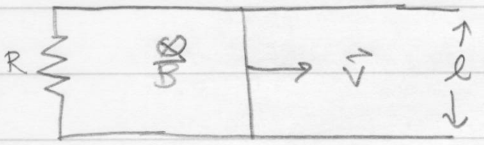

(a) what direction is the current?
φ_B is increasing, $\vec{B}$ into the page
right hand rule + counteraction
$\Rightarrow$ ccw I $\Rightarrow$ $\boxed{\text{down in R}}$

(b) Energy must be conserved and power (work/time) is being dissipated in the resistor due to the induced current according to $P = I^2R = \left(\frac{|\mathcal{E}|}{R}\right)^2 R$

$$= \frac{1}{R}\left(\frac{d\varphi_B}{dt}\right)^2 = \frac{1}{R}\left(B\frac{dA}{dt}\right)^2 = \boxed{\frac{1}{R}\left(Blv\right)^2}$$

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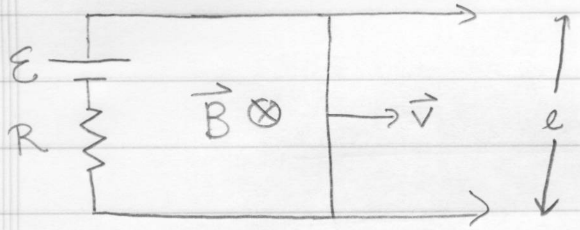

(a) The battery will cause a clockwise current which will interact in the bar with the magnetic field to accelerate it to the right by the right hand rule.

(b) As the bar moves to the right, ϕ_B increases and an $\varepsilon = -\frac{d\phi_B}{dt}$ is induced that opposes the battery. Eventually the current due to the battery and the induced ε will exactly cancel and the bar will drift with a constant speed.

(c) $\varepsilon_{battery} \underset{\uparrow}{=} B\ell v \Rightarrow \boxed{v = \frac{\varepsilon_{battery}}{B\ell}}$

this is the "long time" case discussed in (b)

The resistance does not change the final speed, but higher resistance ⇒ lower current from battery ⇒ smaller magnetic force on bar ⇒ slower acceleration ⇒ $\boxed{\text{longer time to reach final speed}}$.

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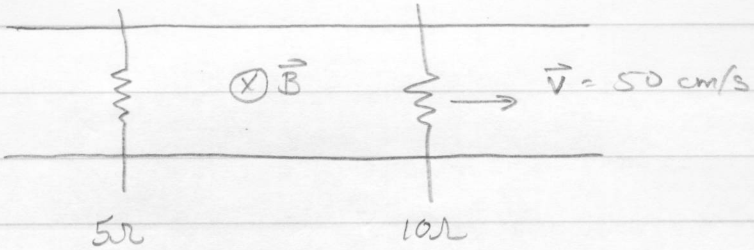

How does the 5Ω resistor move and what is its final speed?

Moving the 10Ω resistor to the right will serve to increase ϕ_B and, therefore, a current will be induced in the circuit. The current will be ccw by the right hand rule to oppose the existing $\vec{B}$. That means that the current will be down in the 5Ω resistor and $\vec{F} = I\vec{\ell} \times \vec{B}$ gives a force to the right. The 5Ω resistor will accelerate to the right until ϕ_B is not changing anymore $\Rightarrow$ final speed = $\boxed{50 \text{ cm/s}}$

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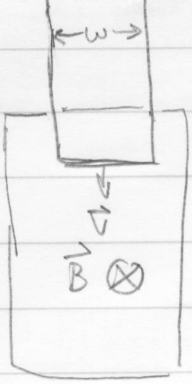

(a) As long as ϕ_B is changing, there will be an induced emf in the loop and the current's interaction w/ the magnetic field will oppose gravity.

(b) $mg = IwB = \frac{\mathcal{E}}{R} wB = \frac{Bwv}{R} wB = \frac{B^2 w^2 v}{R}$

$$\Rightarrow \boxed{v = mgR/B^2 w^2}$$

(c) The ϕ_B is increasing and the existing $\vec{B}$ is into the page $\Rightarrow$ $\boxed{\text{CCW}}$ by right hand rule.

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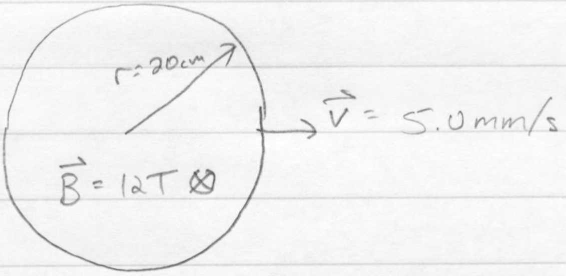

$$\mathcal{E} = -\frac{d\phi_B}{dt} = -B\frac{dA}{dt} = -B\frac{d}{dt}\left(\pi r^2(t)\right)$$

$$r(t) = 20\text{cm} + 0.5\text{cm/s}\ t$$

$$r^2(t) = 0.04\text{m}^2 + 0.002\text{m}^2 t + 2.5\times10^{-5}\text{m}^2 t^2$$

$$\frac{d}{dt}\left(r^2(t)\right) = 0.002\text{m}^2 + 5\times10^{-5}\text{m}^2 t$$

$$\mathcal{E} = -12\text{T}\,\pi(0.002\text{m}^2 + 5\times10^{-5}\text{m}^2 t)$$

$$\mathcal{E}(1) = \boxed{-7.73\times10^{-2}\text{V}}$$

$$\mathcal{E}(10) = \boxed{-9.42\times10^{-2}\text{V}}$$