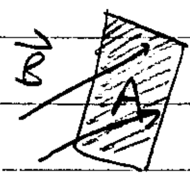
HW #6 - SOL^N - ADAM COHEN

Chapter 20 - Inductance

(2) $B = 5\times10^{-5}\,T$; $A = 20\,\cancel{cm^2}\left(\frac{1\,m}{100\,\cancel{cm}}\right)^2 = 0.002\,m^2$

a)



$\vec{B} \parallel$ to normal of surface

$\Rightarrow \cos\theta = \cos(0°) = 1$

so $\Phi_B = BA\cos\theta = BA(1) = (5\times10^{-5}\,T)(0.002\,m^2)$

$$\boxed{\Phi_B = 10^{-7}\ T\cdot m^2}$$

b) now if $\theta = 30°$ ($\measuredangle$ between $\vec{B}$ and $\hat{n}$)

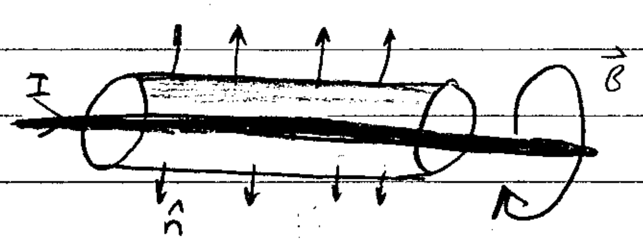
$$\Phi = [10^{-7}\,T\cdot m^2]\cos(30°) = \boxed{8.66\times10^{-8}\ T\cdot m^2}$$

c) is $\vec{B} \perp \hat{n}$ $\Rightarrow$ No field vector penetrate surface

$\Rightarrow \cos\theta = \cos 90° = 0$

$\Rightarrow \boxed{\Phi_B = 0}$

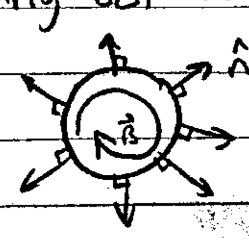
(4)



- $\vec{B}$ from a wire is circumferential (ie wraps around)

- all the normal vectors are radially outward
- so at all points, $\vec{B} \perp \hat{n}$ (ie $\vec{B}$ doesn't penetrate surface)

$\Rightarrow \boxed{\Phi_B = 0}$



cross-section of cylinder

(8) by Faraday's Law:

$$\text{induced emf} = \mathcal{E} = -N\frac{\Delta\Phi_B}{\Delta t}$$

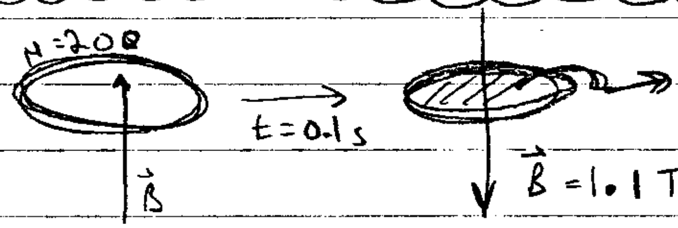
- here $\Delta t = 120\,ms = 0.120\,s$ in SI units
- the problem assumes $\vec{B} \perp \hat{n}$
  $\Rightarrow \cos\theta = 1$
- at $t=0$, $\Phi_B = 0$ since $\vec{B} = 0$
- at $t = 120\,ms$, $\Phi_B = BA = (1.5\,T)\pi(\underbrace{1.6\times10^{-3}\,m}_{\text{radius}})^2$
  $= 1.2\times10^{-5}\,T\cdot m^2$

so $\Delta\Phi_B = 1.2\times10^{-5}\,T\cdot m^2$
- there is just 1 loop $\Rightarrow N = 1$

so $|\mathcal{E}| = \left|-(1)\frac{(1.2\times10^{-5})}{(0.120)}\right| V = 0.0001\,V$

$$\boxed{|\mathcal{E}| = 0.1\,mV}$$

(16)



$A = 100\,cm^2 = 100\times10^{-4}\,m^2$

initially, $\Phi_B = BA = (1.1)(100\times10^{-4})\,T\cdot m^2$
$= 0.011\,T\cdot m^2$

clearly at $t = 0.1\,s$, $\Phi_2 = -0.011\,T\cdot m^2$

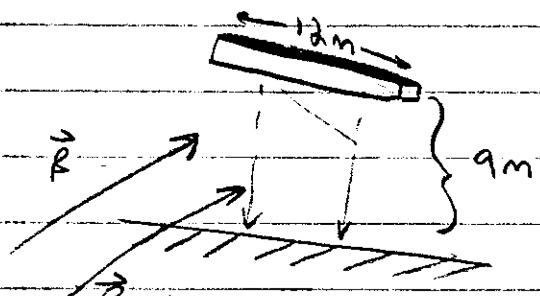
so $|\Delta\Phi_B| = 0.022\,T\cdot m^2$

$\Rightarrow |\mathcal{E}| = N\frac{\Delta\Phi_B}{\Delta t} = \frac{200\,(0.022)}{0.1}\,V = 44\,V$

by Ohm's Law, $I = \frac{\mathcal{E}}{R} = \frac{44V}{5\Omega}$

$$\boxed{I = 8.8\ A}$$

(20)



$\vec{B} = 18\,\mu T = 18\times10^{-6}\ T$

The motional Emf is used here.

$$|\mathcal{E}| = B\ell v$$

- we know B and ℓ, we need to find v.
- the bar is in free-fall ⇒ $a = 9.8\,m/s^2$
- recall the eq^{n}:

$$V_f^2 = \cancel{V_i^2}^{\,0} + 2a\,\Delta y$$

$$V_f = \sqrt{2(9.8)(9)}\ m/s = 13.3\ m/s$$

so $\mathcal{E} = (18\times10^{-6}\ T)(12\ m)(13.3\ m/s)$

$$\boxed{\mathcal{E} = 0.00287\ V}$$

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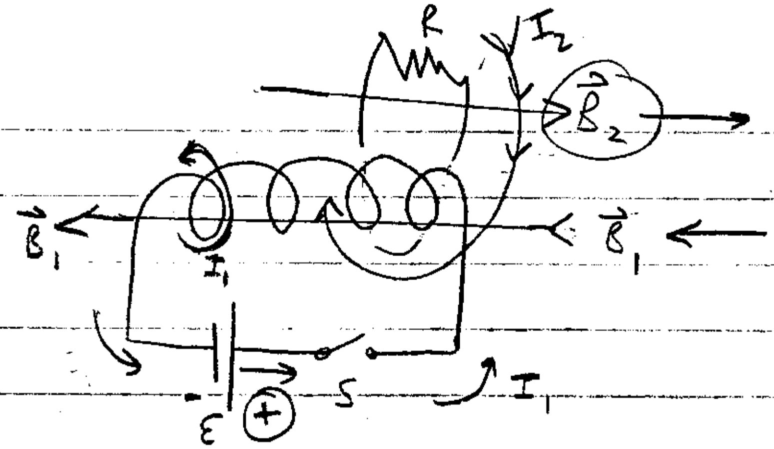

- when switch is closed, current flows CCW around loop
- by RHR, $\vec{B}_1$ points to the left
- the second circuit wants to oppose this new flux by making its own $\vec{B}_2$-field (to the right), by Lenz's Law
- by RHR, I_2 must flow CW to produce such a $\vec{B}_2$-field
- So current flows from Left to Right accross the resistor.

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How does the right coil effect the left coil?

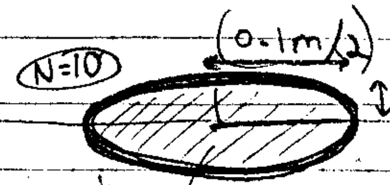
a) • Switch is closed
• current goes around circuit
• by RHR, leftward $\vec{B}$-field is formed
• the right coil wants to counteract this increasing flux (by Lenz's Law), so creates its own rightward field
• by RHR, current flows $\boxed{\text{right to left}}$ across resistor

b) • If $R \downarrow$, by ohm's law ($\mathcal{E} = IR$), $I \uparrow$.
• for solenoid, $B \propto I \Rightarrow$ magnitude of B increases.
• as part (a), current flows $\boxed{\text{right to left}}$ in through resistor

c) • If the distance is increased, the strength of B decreases. To oppose the decrease, coil tries to "make up the difference" by forming its own leftward field $\Rightarrow$ current flows $\boxed{\text{left to right}}$ by RHR.

d) the switch is closed $\Rightarrow$ B decreases w/ time
• as in part (c) current flows $\boxed{\text{left to right}}$

(33)



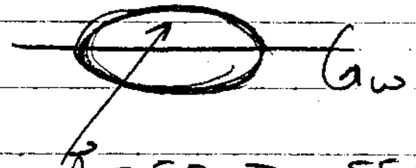
$\omega = 100\,\text{rpm}$

$= \left(100 \frac{\text{rev}}{\text{min}}\right)\left(\frac{2\pi\,\text{rad}}{1\,\text{rev}}\right)\left(\frac{1\,\text{min}}{60\,\text{sec}}\right)$

$\omega = 10.5\ \text{rad}/\text{sec}$

$A = \pi ab = \pi \left(\frac{0.1}{2}\right)\left(\frac{0.04}{2}\right) m^2 = 0.003\,m^2$

(a)



$\vec{B} = 55\,\mu T = 55 \times 10^{-6}\,T$

- the maximum induced Emf is:

$$\mathcal{E}_{max} = N B_\perp A \omega$$

- where $B_\perp$ is the component of $\vec{B}$ $\perp$ to axis of rotation
- here, all of B is $\perp$ to that axis so $B_\perp = 55 \times 10^{-6}\,T$

so $\mathcal{E}_{max} = (10)(55 \times 10^{-6}\,T)(0.003\,m^2)(10.5\,\frac{\text{rad}}{\text{s}})$

$= 1.8 \times 10^{-5}\,V$

$= \boxed{18\,\mu V}$

(b)

here $\vec{B} \parallel$ to axis of rotation

$\Rightarrow B_\perp = 0$

(so the flux is the loop $\Phi_B = 0$ at all times)

$\Rightarrow \boxed{\mathcal{E}_{max} = 0}$

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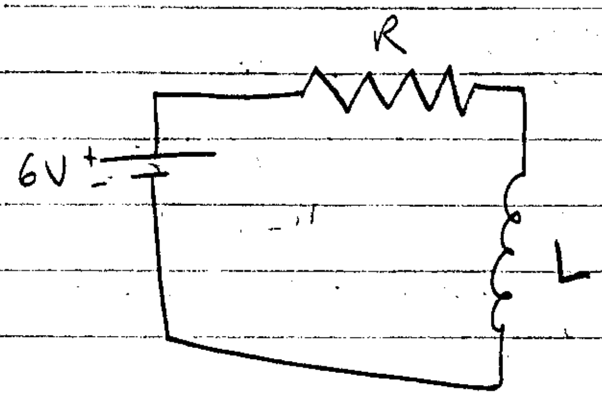

$$\left\{\begin{array}{l} \tau = \frac{L}{R} = 600\,\mu s = 600\times10^{-6}\,s \\ I_{max} = 300\,mA = 300\times10^{-3}\,A \end{array}\right.$$

$L = ?$

the max current is given by Ohm's Law:

$$\mathcal{E} = I_{max} R \Rightarrow R = \frac{\mathcal{E}}{I_{max}} = \frac{6V}{0.3A} = 20\,\Omega$$

the time constant is given as (for RL circuit):

$$\tau = \frac{L}{R} \Rightarrow L = \tau R = (6\times10^{-4}\,s)(20\,\Omega)$$

$$= 1.2\times10^{-2}\,H$$

$$\boxed{L = 12\,mH}$$

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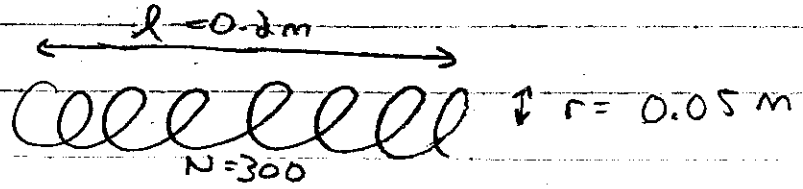

· for a solenoid, the inductance L is:

$$L = \frac{\mu_0 N^2 A}{l}$$

here $A = \pi r^2 = \pi (0.05\,m)^2$

$N = 300$

$l = 0.2m$

μ_0 = Const, which you'll look up

$$\Rightarrow \boxed{L = 4.44 \times 10^{-3}\ H}$$

· when $I = 0.5\,A$, the stored energy is:

$$PE_L = \tfrac{1}{2} L I^2$$

$$= \tfrac{1}{2}(4.44 \times 10^{-3}\ H)(0.5\,A)^2$$

$$= \boxed{5.55 \times 10^{-4}\ J}$$