Electromagnetic Induction

$\vec{B}$ does <u>not</u> produce I

$\frac{d\Phi_\mathrm{B}}{dt}$ produces I

Faraday's Law:

$$\varepsilon_\mathrm{ind} = -\frac{d\Phi_\mathrm{B}}{dt}$$

Induces I produces a second B field that counteracts the changing Φ_B

Lenz Law

is about opposing B-field

In Class HW

29.8

$\Phi_B = \vec{B} \cdot \vec{A}$

$\Phi_B = 1.4e^{-0.057t}(\pi r^2)\sin(60°)$

$\varepsilon_\mathrm{ind} = -\frac{d\Phi_B}{dt}$

$\varepsilon_\mathrm{ind} = -1.4\pi r^2 \sin(60°)(-0.057e^{-0.057t})$

$\varepsilon_\mathrm{ind} = 0.122e^{-0.057t}$

Part B

t = ? when E_ind = 1/16 (.122)

$\frac{1}{16} = e^{-0.057t}$

$t = \frac{\ln(16)}{0.057}$

29.4

$\varepsilon_\mathrm{av} = \frac{\Delta\Phi_B}{\Delta t} = \frac{\Phi_f - \Phi_0}{\Delta t} = \frac{\Phi_0}{\Delta t} = \frac{NBA\cos(0°)}{\Delta t}$

$I_\mathrm{avg} = \frac{\varepsilon_\mathrm{avg}}{R}$

$Q = I_\mathrm{avg}\Delta t$

29.7

Part A

B at r?

$\mathrm{B} = \frac{\mu_0 i}{2\pi r}$

Direction: $i \times r$

Part 3

Flux through narrow shaded strip?

$$d\Phi_B = B\,\mathrm{d}A\cos(0°)$$

$$d\Phi_B = \frac{\mu_0 i}{2\pi r} L(\mathrm{d}r)$$

$$\Phi_B = \int_a^b \mathrm{d}\Phi_B = \frac{\mu_0 i L}{2\pi} \int_a^b \frac{\mathrm{d}r}{r}$$

$$\Phi_B = \frac{\mu_0 i L}{2\pi} \ln\left(\frac{b}{a}\right)$$

Part E

Induced EMF?

Only current changing with time

Want **magnitude**

$$\varepsilon_{\text{ind}} = \frac{\mathrm{d}\Phi_B}{\mathrm{d}t} = \frac{-\mu_0 L \ln\left(\frac{b}{a}\right)}{2\pi} \frac{\mathrm{d}i}{\mathrm{d}t}$$

29.16

Current is constant so B-field is const at each point

Movement of loops causes change in flux

Φ_B decreases for A, $\varepsilon_{\text{ind}} = 0$, I_{ind} is CCW to create B-field that in opposite direction

net force wire exerts on loop

$$\vec{F}_m = I\left(\vec{l} \times \vec{\mathrm{B}}\right)$$

Side forces equal in magnitude

Closer force (up/down) is stronger

No induced current means no net force

No change in mag flux means no induced emf means no induced current

Motional EMF

$$\varepsilon_{\text{ind}} = \frac{\mathrm{d}}{\mathrm{d}t}(BA\cos(0°)) = B\frac{\mathrm{d}A}{\mathrm{d}t}$$

$$\varepsilon_{\text{ind}} = Bl\frac{\mathrm{d}x}{\mathrm{d}t}$$

$$\varepsilon_{\text{ind}} = Blv \text{ IMPORTANT}$$

29.28

$$\sum \vec{F} = m\vec{a}$$

$$ILB = -m\frac{\mathrm{d}v}{\mathrm{d}t}$$

$$\frac{\varepsilon_{\text{ind}}}{R}LB = -m\frac{\mathrm{d}v}{\mathrm{d}t}$$

$$BLvL\frac{B}{R} = -m\frac{\mathrm{d}v}{\mathrm{d}t}$$

$$\frac{B^2L^2}{mR}\,\mathrm{d}t = -\frac{\mathrm{d}v}{v}$$

$$\frac{B^2L^2}{mR}\int_0^t \mathrm{d}t = -\int_{v_0}^{v_f}\frac{\mathrm{d}v}{v}$$

$$\frac{-B^2l^2t}{mR} = \ln\left(\frac{v_f}{v_0}\right) = k$$

$$e^k = \frac{v_f}{v_0}$$

$$v_f = v_0 e^{\frac{-B^2l^2t}{mR}}$$

29.31

$$\varepsilon_{\text{ind}} = BLv = I_{\text{ind}}R$$

$$v = \frac{I_{\text{ind}}R}{LB}$$