

Electromagnetic Induction

\vec{B} does not produce I

$\frac{d\Phi_B}{dt}$ produces I

Faraday's Law:

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

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

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

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

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

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

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

Part B

t = ? when $\varepsilon_{\text{ind}} = 1/16$ (.122)

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

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

29.4

$$\varepsilon_{\text{av}} = \frac{\Delta\Phi_B}{\Delta t} = \frac{\Phi_f - \Phi_0}{\Delta t} = \frac{\Phi_0}{\Delta t} = \frac{NBA \cos(0^\circ)}{\Delta t}$$

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

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

29.7

Part A

B at r?

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

Direction: $i \times r$

Part 3

Flux through narrow shaded strip?

$$d\Phi_B = B \, dA \cos(0^\circ)$$

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

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

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

Part E

Induced EMF?

Only current changing with time

Want **magnitude**

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

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

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

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

$$\varepsilon_{\text{ind}} = \frac{d}{dt}(BA \cos(0^\circ)) = B \frac{dA}{dt}$$

$$\varepsilon_{\text{ind}} = Bl \frac{dx}{dt}$$

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

29.28

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

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

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

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

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

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

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

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

$$v_f = v_0e^{\frac{-B^2l^2t}{mR}}$$