Problem 3.1.2

A coil, diameter 1 m, is coaxial with Earth B-field line.

\# turns, \( N = 25 \) : In \( \Delta t = 0.2 \text{s} \), flip coil.

\[ B_{\text{flip}} = 6.4 \text{A} \left( 5 \text{mT} \times 10^{-5} \text{T/m} \right) \]
\[ = 3.92 \times 10^{-5} \text{ T} \]
\[ B_{\text{flip}} = \frac{\Phi_{B}}{A} \]
\[ \Phi_{B} = 2 \text{ cm} \text{ coil}, n = 10^3 \text{ m}^{-1} \]
\[ B_{\text{flip}} = \frac{2 \text{ cm} \times 10^3 \text{ m}^{-1}}{0.2 \text{s}} \]
\[ = 9.8 \times 10^{-5} \text{ V} \]

Problem 3.1.10

coil \( N = 15 \) turns

\[ B_{\text{sol}} = \mu_0 N I \Rightarrow \Phi_B = B_{\text{sol}} \left( \frac{A}{\mu_0} \right) \]
\[ = \mu_0 N I \frac{A}{\mu_0} \]

We can use Faraday's Law:

\[ \mathcal{E} = -N \frac{d}{dt} \left( \mu_0 n_0 I \right) \]
\[ = -1.42 \times 10^8 \frac{\text{Tm}^2}{\text{m}^2} \times 5 \text{A} \sin 120\pi t \]
\[ = -14.2 \text{ mV} \cos (20\pi t) \]
Motional Emf

$E$ induced in a conductor moving thru a constant $B$ field.

straight conductor
velocity, $v \perp B$
electrons feel force
\[
\overrightarrow{F} = q \overrightarrow{B} \times \overrightarrow{v}
\]
electrons to bottom

$\overrightarrow{E}$ always up, $\overrightarrow{E}$ field upwards

across ends of conductor, charge accumulates until

$\overrightarrow{E} = \frac{q \overrightarrow{v}}{q} = \overrightarrow{E}$

$F = q \overrightarrow{E}$ is equilibrium condition

Loop in a $B$ field

A rectangular loop pulled out of a magnetic field with velocity, $v$

$\Phi_{B}$ thru loop changes with time (since $x = x(t)$)

$\Phi_{B} = BA = Blx$

Using Faraday's Law

$E = \frac{d\Phi_{B}}{dt} = B \frac{dx}{dt} \frac{dx}{dt} = B \Delta x$

Forces caused by loop in $B$

$F + F_3$ equal & opposite: cancel

$F_1$ counters our effort to move loop

$F = I \overrightarrow{I} \overrightarrow{B} \sin 90^\circ$ (since currents in same direction)

$F = B^2 \overrightarrow{A} \overrightarrow{A}$
Generators + Motors

Electric generators
- energy by work transferred out by electrical transmission

AC generator
- loop of wire located in a B field

\[ \Phi_B = B A \cos \omega t \]

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So

\[ -N \frac{d\Phi_B}{dt} = -NBA B \omega \sin \omega t \]

\[ = -NBA B \omega \sin \omega t \] (\omega = 2\pi f)

Self Induction

- Consider circuit with current + emf

When throw switch
- \( I = 0 \) \( \Rightarrow \) \( I_{\text{max}} \)
- \( B = 0 \) \( \Rightarrow \) \( B = B_{\text{max}} \)
- \( \Delta \Phi_B > 0 \)

B out of page
- This means we will have induced emf + current

From Lenz's Law, induced emf will try to keep \( \Phi_B = 0 \) + so an opposing emf results: "back emf"

\[ I(t) < I_{\text{max}} = \frac{\Phi}{\pi} \]

\[ \{ \text{Note: This different than the AC circuit phenomenon which also} \}
\[ \text{causes } I(t) < I_{\text{max}} \} \]