① Phys 2426 2016-10-13 Lec 15

HW4a is posted - Don't Wait!

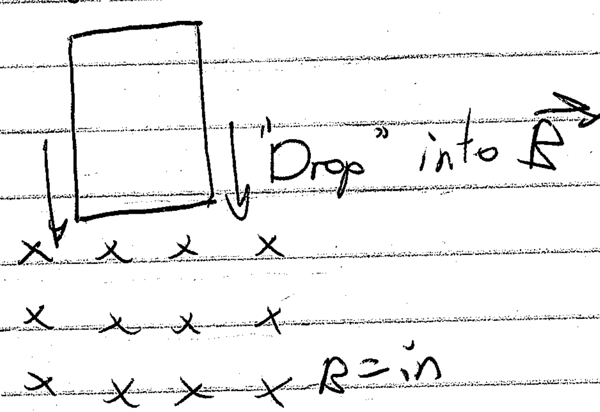
Faraday's Law $\mathcal{E} = -\frac{d\Phi_B}{dt}$

$\Phi_B = NBA\cos\theta$ Flux of whole coil

How can we generate voltage?

- Change A = Area

A = Area of overlap

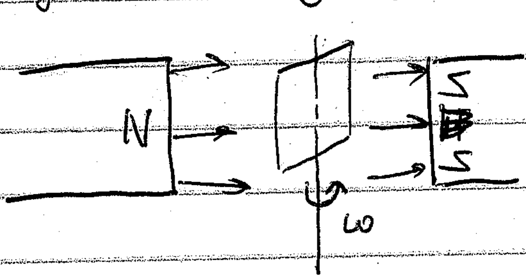


$\frac{dA}{dt} = W \cdot V$

width (W), speed (V)

$$\mathcal{E} = NBWV\cos\theta$$

- Change B = magnetic field
  - Move magnet into coil
  - Spin magnet near coil
- Change θ = angle



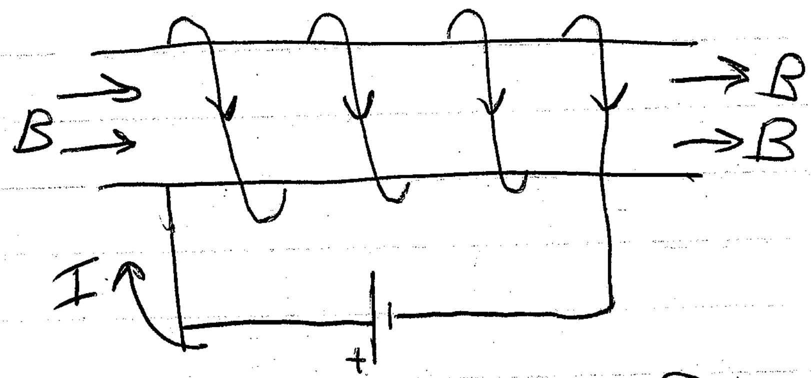
$\theta = \omega t$

$\Phi_B = NBA\cos\omega t$

$\mathcal{E} = \boxed{NBA\omega}\sin\omega t$

└ $\mathcal{E}_{max}$

② Solenoid Inductor



- Current causes magnetic field

$$B = \frac{\mu_0 N I}{l} = \mu_0 n I$$

N = # Loops
l = length
n = N/l

- B is "felt" as flux

$$\Phi_B = NBA = \frac{N \mu_0 N I A}{l} \qquad A = \pi r^2$$

$$= \left(\frac{\mu_0 N^2 A}{l}\right) I = L I$$

↑ inductance

Inductance (L) is measured in henries (H).

- Changing flux generates EMF.

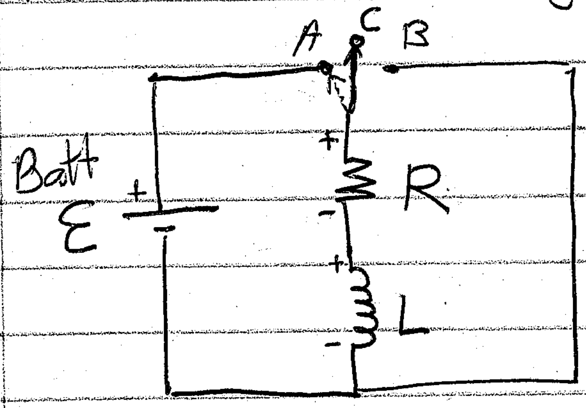
$$\mathcal{E} = -\frac{d\Phi_B}{dt} = -L\frac{dI}{dt}$$

$\mathcal{E}$ proportional to change in current

$$V_L = L\frac{dI}{dt} \qquad \text{"Voltage Drop"}$$

③

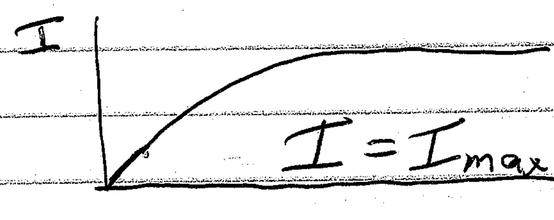
How does inductor fight change in current?



$$\mathcal{E} = V_R + V_L$$

$$\mathcal{E} = IR + L\frac{dI}{dt}$$

C → A : Batt tries to push current
L won't let current increase too fast.



$I_{max} = \mathcal{E}/R$

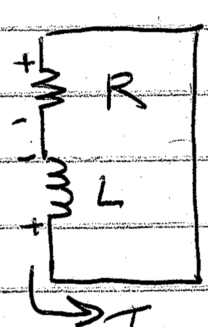
$$I = I_{max}\left(1 - e^{-t/\tau}\right)$$

$\tau = L/R$

Initially $\frac{\mathcal{E}}{L} = \frac{dI}{dt}$

Eventually $\frac{\mathcal{E}}{R} = I$

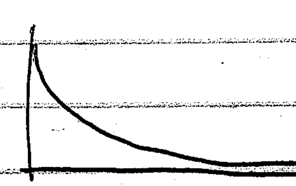
A → B : Inductor keeps current flowing



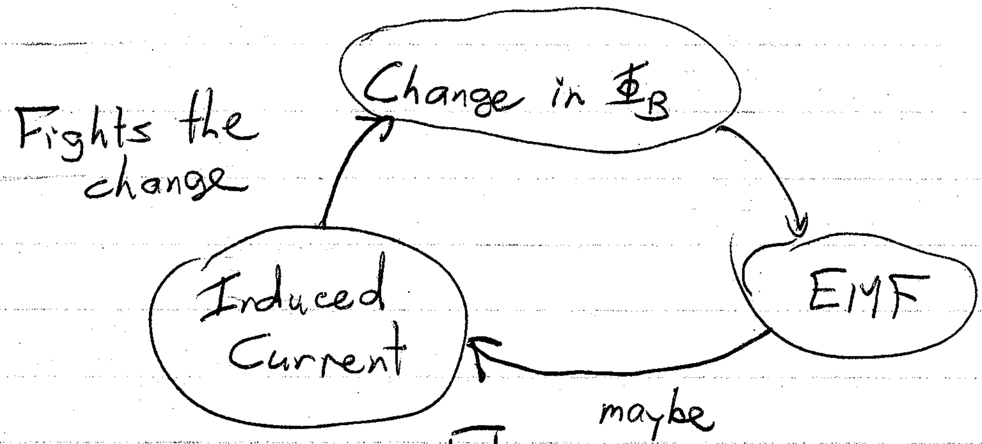
$$-L\frac{dI}{dt} = IR$$

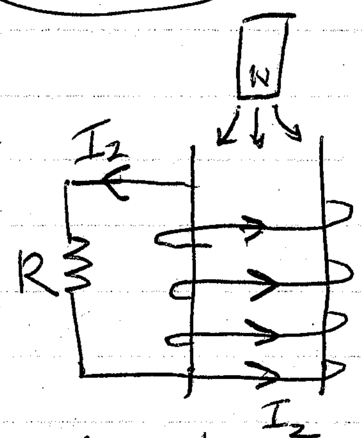
($-L\frac{dI}{dt}$: negative; IR: positive)

$$I = I_0 e^{-t/\tau}$$



Lenz's Law - Direction of EMF





B_1 = field of magnet

B_2 = induced field of coil

1. Drop magnet into coil.
2. B_1 points downward and flux is increasing.
3. To fight the increase, B_2 points upwards.
4. In the coil, I_2 flows rightward in front.
5. In the resistor, I_2 flows downward.

1. Magnet exits the bottom.
2. B_1 is down, Φ_B is decreases
3. To fight the decrease, B_2 = down
4. I_2 is Leftward across front.
5. I_2 is up thru R.