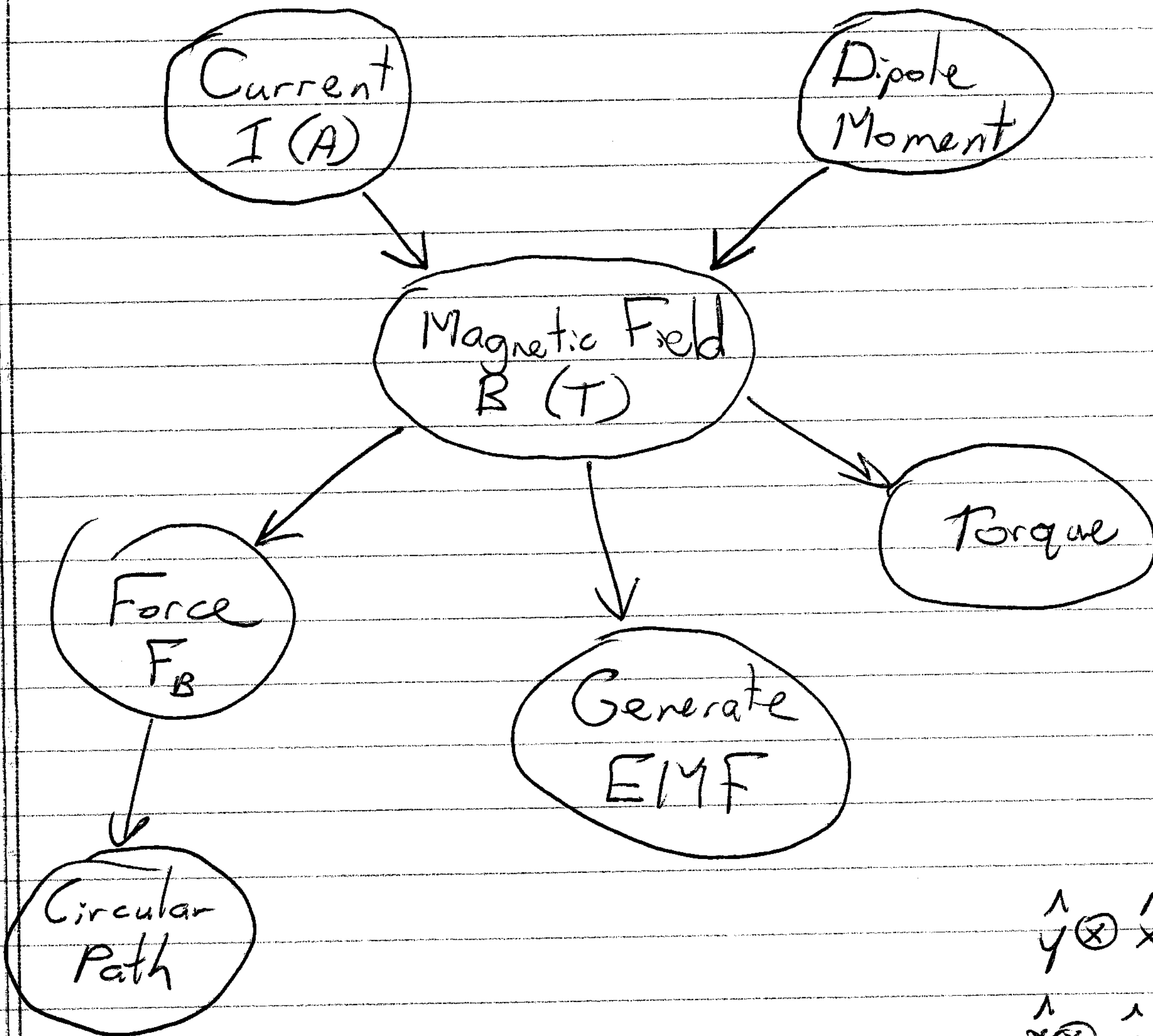
① Phys 2426 2015-10-13 Lec 14



$\hat{y} \otimes \hat{x} = -\hat{z}$

$\hat{x} \otimes \hat{y} = \hat{z}$

$\hat{y} \otimes \hat{z} = \hat{x}$

$\hat{z} \otimes \hat{x} = \hat{y}$

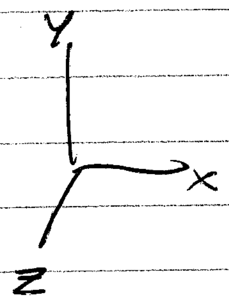
Review: $\vec{F_B} = q\vec{v} \otimes \vec{B}$

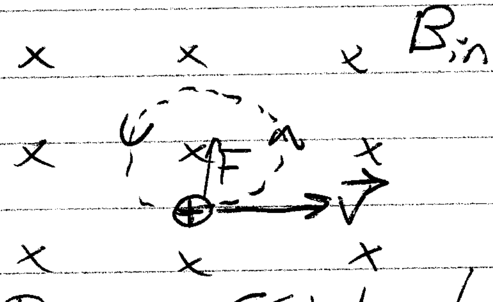
$q = + \sim$

$\vec{v} = \sim \hat{x}$

$\vec{B} = \sim (-\hat{z})$

$\vec{F_B} = ?$





⊕ goes CCW when viewing along $\vec{B}$

(2)

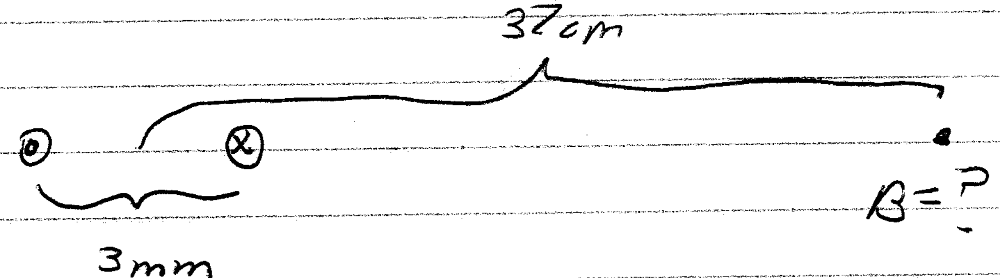
(21) B of a wire: $B = \frac{\mu_0 I}{2\pi r}$

B at 37 cm is 3 μT when $I = 6A$.

a) Where is $B = 0.3\ \mu T$?

$r = 370$ cm

b)



$$B = \frac{\mu_0 I}{2\pi(0.37+0.0015)} - \frac{\mu_0 I}{2\pi(0.37-0.0015)}$$

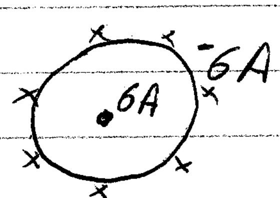
c)

$$B = \frac{\mu_0 I}{2\pi}\left(\frac{1}{r+\delta} - \frac{1}{r-\delta}\right)$$

$$\frac{2\pi B}{\mu_0 I} = \left(\frac{(r-\delta) - (r+\delta)}{r^2-\delta^2}\right)$$

$$= \frac{-2\delta}{r^2-\delta^2}$$

d)



$B = ? = 0$

③

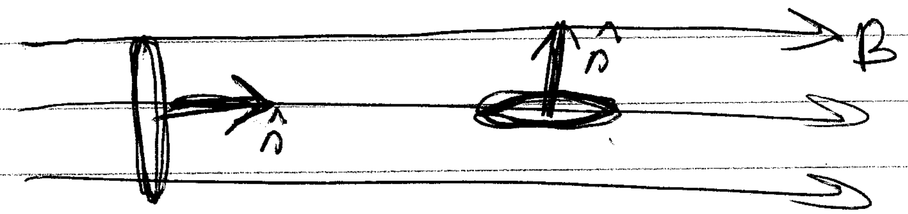
Induced EMF

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

EMF is caused by changing flux.
Flux is the "total amount" of B pointing through a coil.

$$\Phi_B = NBA\cos\theta \quad \text{Total flux of a coil.}$$

N = # loops of wire
B = mag field strength
A = Area of coil (πr^2?)
θ = Angle between $\vec{B}$ and $\hat{n}$
$\hat{n}$ = normal vector to coil



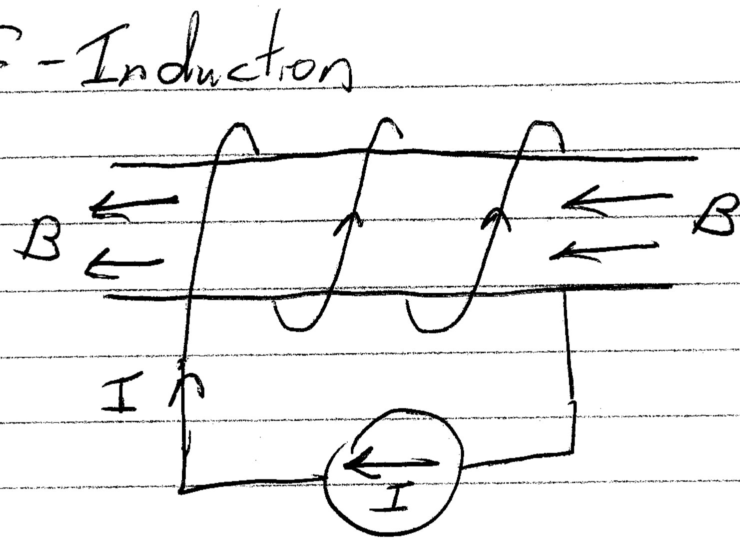
$\theta = 0$	$\theta = 90°$
$\cos\theta = 1$	$\cos\theta = 0$
$\Phi = NBA$	$\Phi = 0$

How do we change Φ_B?

- Change θ — rotate the coil
- Change A — $\mathcal{E} = B v l$
- Change B — Change I
- Change N — ?

(4)

Self-Induction



I is known/set by the current source.
I causes $\vec{B}$.

$$B = \mu N I / l$$

- μ_0 for air
- 1000 x bigger for steel
- 0 for superconductor

B forms flux

$$\Phi_B = NBA\cancel{\cos\theta}^{1} = \underbrace{\frac{\mu_0 N^2 A}{l}}_{\text{Inductance (L) in henries (H)}} I$$

$$\Phi_B = LI$$

Change I → Changes Φ → makes $\mathcal{E}$

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

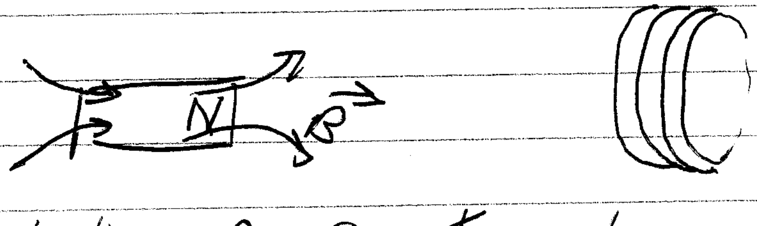
opposes change in current

$$V_L = L\frac{dI}{dt} \qquad V_R = IR \qquad V_C = \frac{Q}{C} = \frac{1}{C}\int I\,dt$$

Lenz's Law - tells us dir of $\mathcal{E}$.

Coils hate change.

- Change B - coil generates B to oppose.

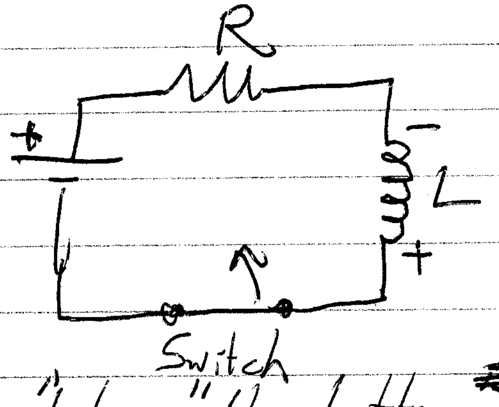


Initially $B = 0$, Φ pointing right $= 0$

Insert the magnet

- B points strongly to right.
- Φ_B is positive to the right.
- Coil makes $B_{ind} =$ (left).
- Induced $I =$ (up front)

- Change I in a coil



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

Open the switch:

- dI/dt is strong, ⊖.
- $\mathcal{E}_L =$ Large, ⊕

here ⊕ means, it is "helping" the battery.

This is "inductive kick".