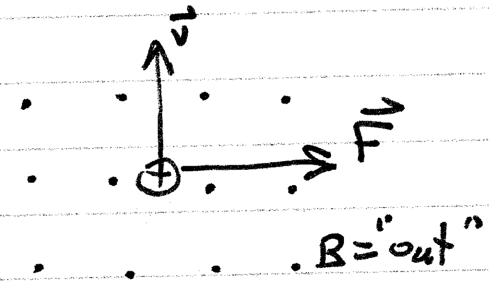
① Phys 1402 2014-10-09

Magnetic Forces

$$F_B = qvB_\perp = qv_\perp B = qvB \sin\theta$$

Ex of RHR



Force on a wire

$$F_B = I\ell B_\perp$$

Ex: 20-gauge wire $\frac{m}{\ell} = 0.00586$ kg/m

1-m length $m = 0.00586$ kg

$F_g = mg = 0.0574$ N

To levitate with magnetism

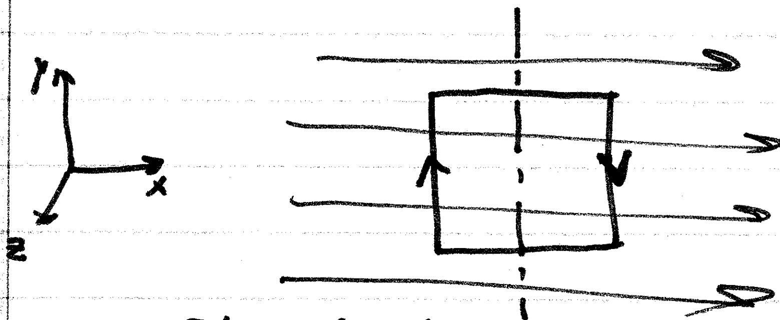
$$F_B = I\ell B = F_g$$

Maximum $I = 2$ A.

How much B is needed?

$$B = \frac{F_B}{I\ell} = \frac{0.0574\text{ N}}{(2\text{A})(1\text{ m})} = 0.0287\text{ T}$$

(2)



Rect. loop of wire In a B Field.

The left side has I in $\hat{y}$ direction. $\vec{F}$ in $(-\hat{z})$

The top & bottom feel no force. $F=0$

The right side has I in $(-\hat{y})$. $\vec{F}$ in $+\hat{z}$

So, one side is pulled up while the other is pushed down. This is a torque.

Each force is $F = I\ell B$

The lever arm is $d = w/2$

There are $2N$ segments of wire.

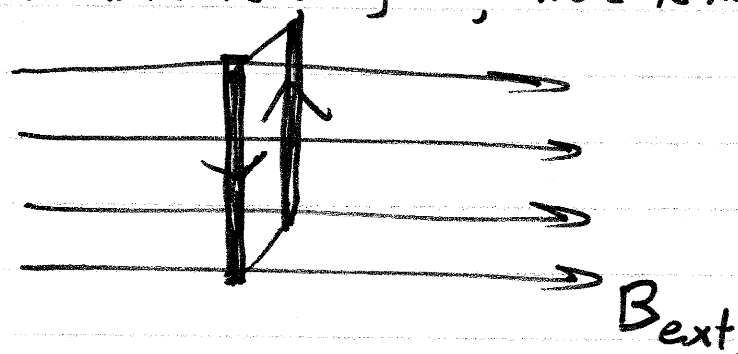
$$\text{Total } \tau = NB(\ell w)I$$

$$\tau = \underbrace{NBA}_{\text{Maximum magnetic Flux}} I$$

In a motor, we push I, and the motor uses τ to spin.

In a generator, we spin it to generate voltage. If we use current I, the torque resists our pushing effort.

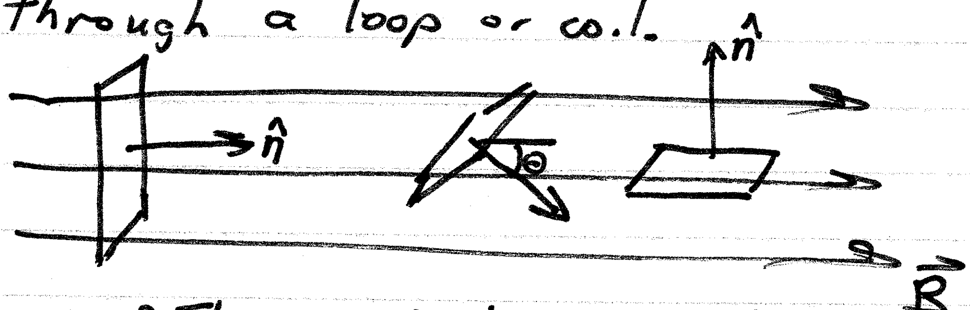
If the coil axis is along B, there is no torque.



Front segment is pulled frontward
$I = \text{down} = -\hat{y}$ $\quad F = +\hat{z}$
Back segment is pushed backward.
$I = \text{up} = +\hat{y}$ $\quad F = -\hat{z}$
The torque disappears.

$$\tau_{max} = NBAI$$

<u>Magnetic Flux</u> - total mag field going through a loop or coil.



Lots of Flux — In Between — No Flux

$\Phi_B = NBA$ $\qquad \Phi_B = 0$

$$\Phi_B = NBA\cos\Theta$$

$\Theta = 0$ $\qquad \Theta = \pi/2$

$\hat{n}$ = "normal vector" is perpendicular to plane of loop
Θ = angle between $\hat{n}$ and $\vec{B}$

Any change in the Φ_B of a coil will generate a voltage.

$$\Phi_B = NBA \cos\theta$$

How?

- Change the area
- Change the angle
  - Spin the loop
  - Spin the magnetic source
- Change the B

If we spin the loop, we can say

$\theta = \omega t$ or $\omega = \Delta\theta / \Delta t$ in rad/s

Then, the voltage peaks at:

$$\mathcal{E}_{max} = NBA\,\omega$$

$$\mathcal{E} = \text{EMF} = \text{voltage}$$

In a generator, we push it around to generate $\mathcal{E}$.

In a motor, we push the current to make it spin. If the motor spins, its voltage opposes us. This is "Back EMF". It saves us energy.

When the motor spins freely, I is low.

When the motor bogs down, I increases.

(5)

Transformer: One coil creates $\vec{B}$.
The other coil generates $\mathcal{E}_{out}$.

Inductor: Current in a coil creates $\vec{B}$.
Change in I changes B.
Change in B changes Φ_B.
Change in Φ_B generates $\mathcal{E}$.
The voltage opposes the initial change in I.