Outline:

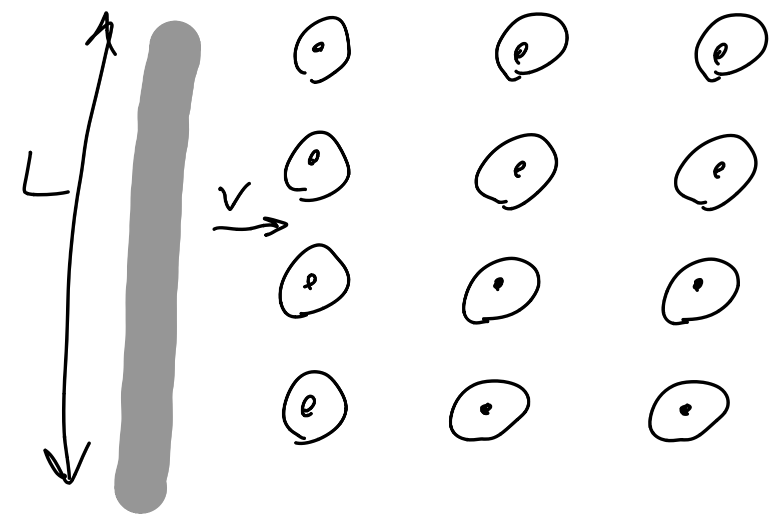
- Conductor moving in B field will polarize
- Connect this bar to a circuit it looks like a battery
- $\mathcal{E} = vBL$
- Battery drives current
- B field acts on current in $-\hat{v}$ direction
- Bar will eventually stop, unless some external force acts on it

$$F = ILB$$

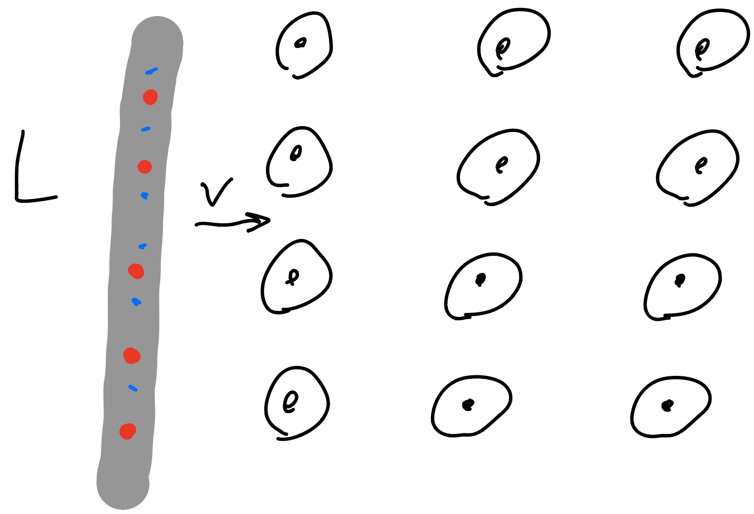
- $P = F \cdot v = IBLv = I\mathcal{E}$
- Generator
- more practical generators use rotational velocity

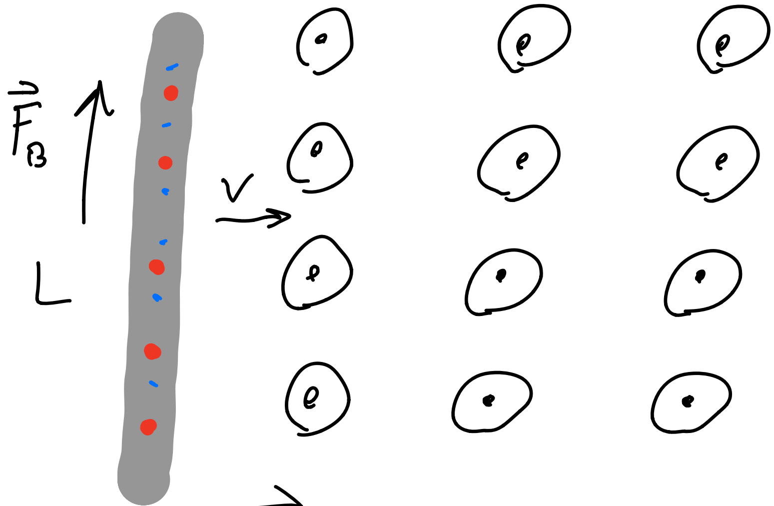
B field Polarization

Pose the question

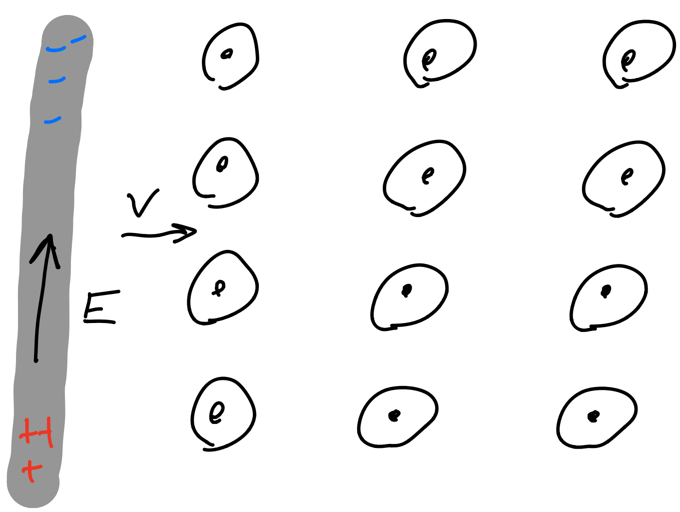


Micro View





$$\vec{F}_B = q\vec{v} \times \vec{B} = evB \uparrow$$



$$\vec{F}_{net} = evB - eE$$

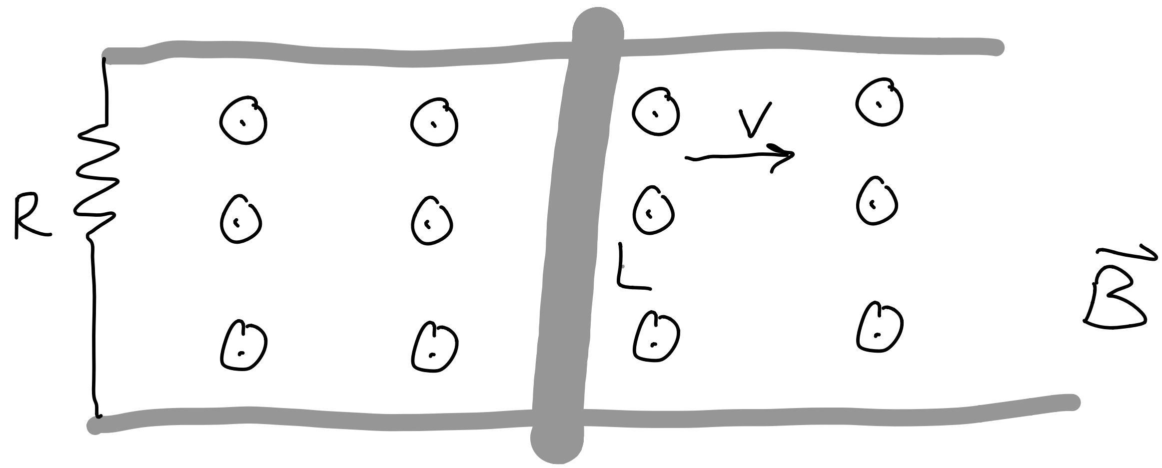
Continues until $evB = eE$

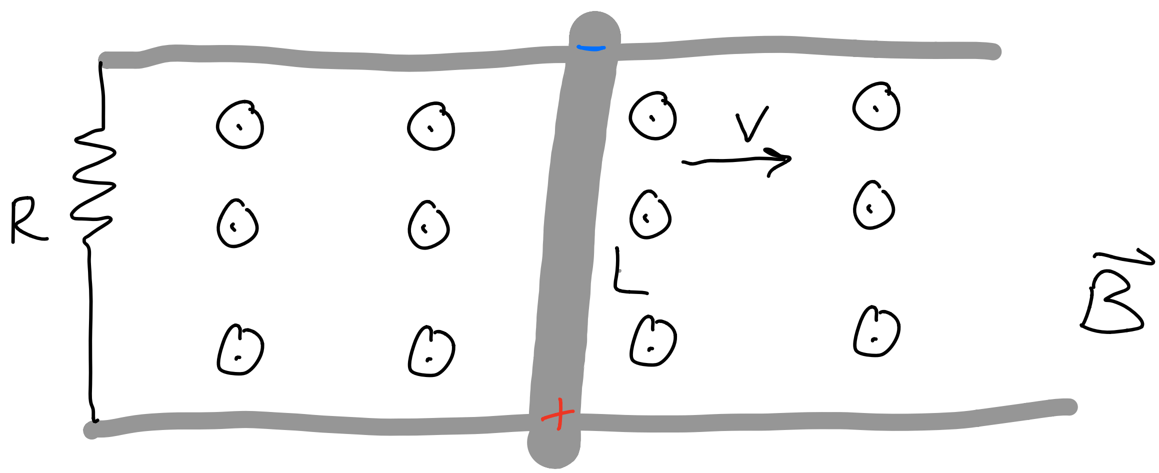
$$E = vB$$

Motion in a B field has produced an E field

Attach to circuit

Connect this bar to a circuit it looks like a battery



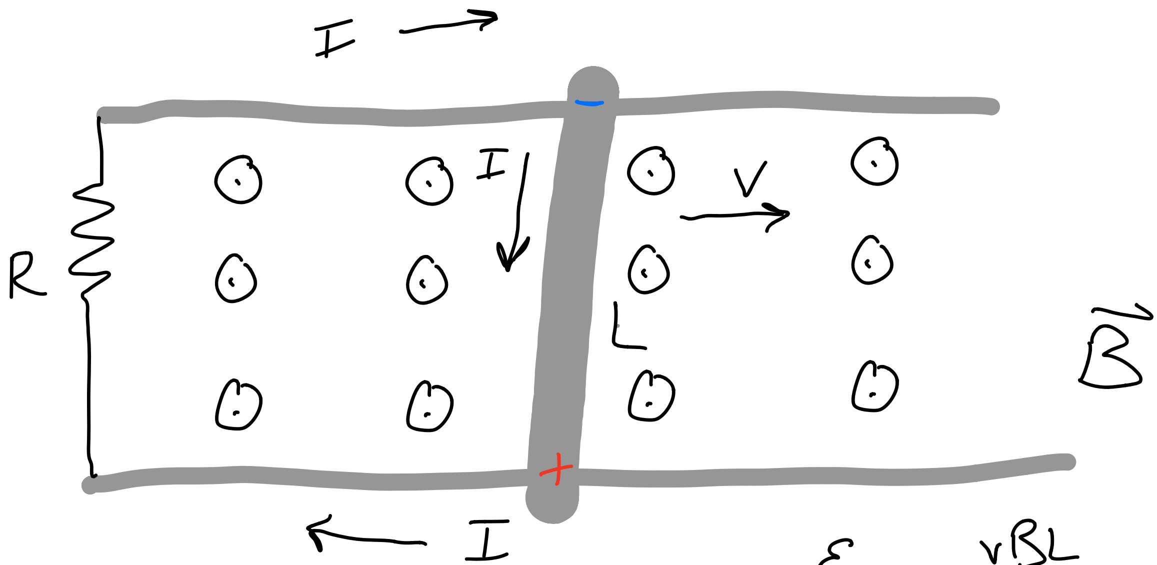


Looks like a battery!

EMF: $\Delta V = EL = vBL$

$$\mathcal{E} = vBL$$

$\mathcal{E} = vBL$



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

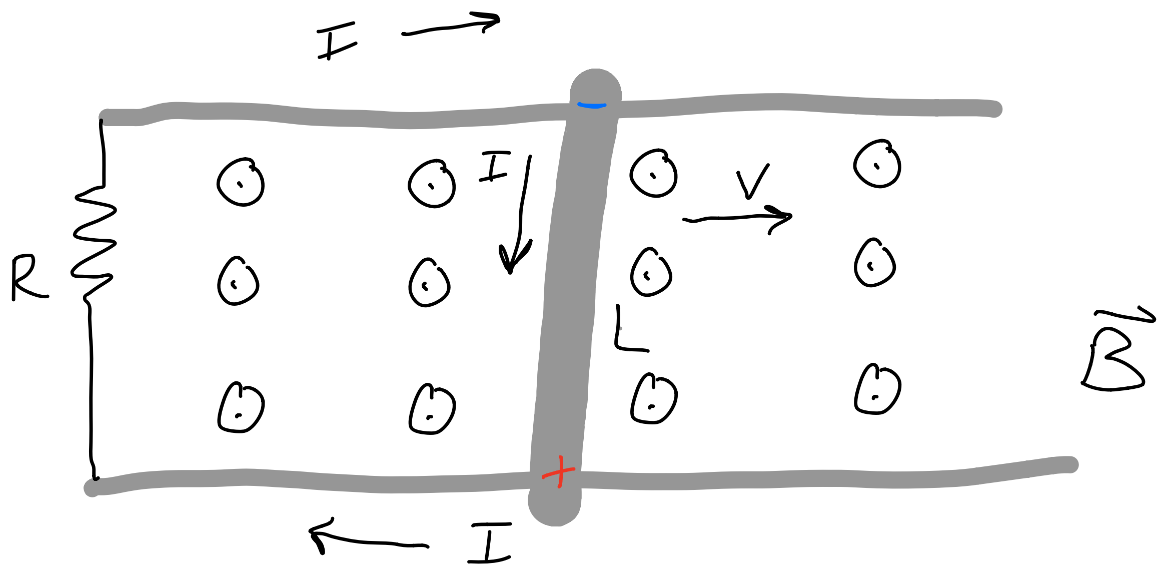
Loop Rule!

- Bar will eventually stop, unless some external force acts on it

$$F = ILB$$

Does this continue forever?

No, otherwise we would get free energy



Recall:

Force on current-carrying wire:

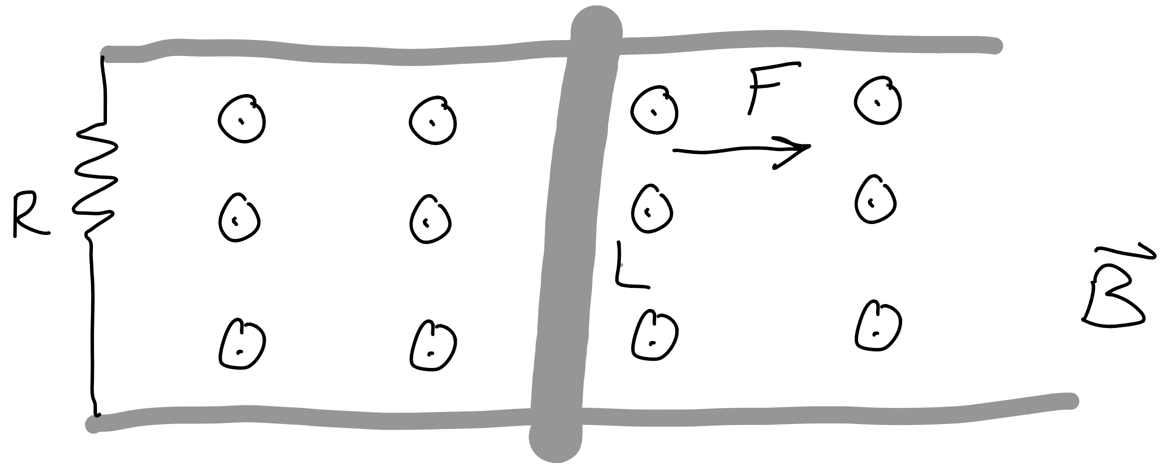
$$\vec{F} = I\vec{L} \times \vec{B} = ILB$$

Creates a force opposing $v \longrightarrow$

This force gradually slows the bar, decreasing ε + I until $v = 0$

$v = 0$, $\varepsilon = vBL = 0$, $I = \frac{\varepsilon}{R} = 0$

$\vec{B}$ did not do work, it converted mechanical energy into electrical energy



- Apply constant force F to the right
- Bar will accelerate

  gains velocity v

  $\mathcal{E} = BLv$

  $I = \frac{BLv}{R}$

- $\mathcal{E}$ drives current, which creates $\vec{F}_{mag}$ opposing F

$F_{mag} = ILB$

$$F_{mag} = ILB = \frac{BLv}{R} LB$$

- v, I continue to increase until $F_{mag} = F$

$$ILB = F$$

Pull with force $F = ILB$

How much energy?

$$\Delta W = \vec{F} \cdot \Delta \vec{r}$$

$$= F v \Delta t$$

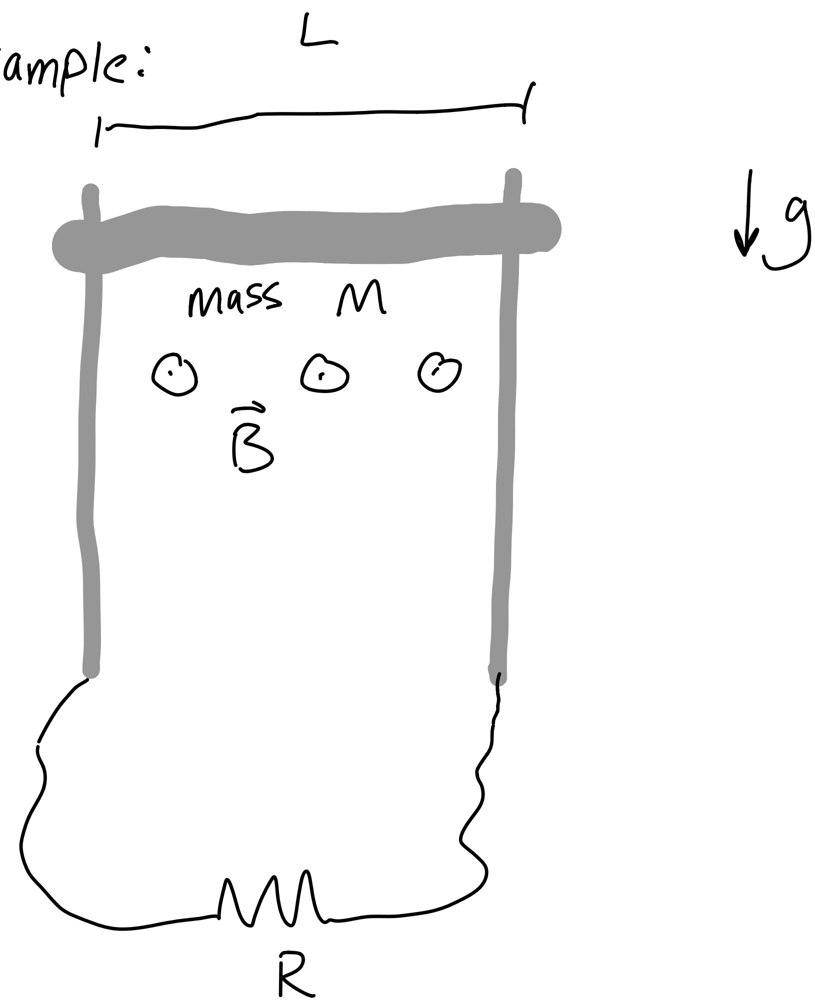
$$\frac{\Delta W}{\Delta t} = ILBv$$

$$P = I(BLv)$$

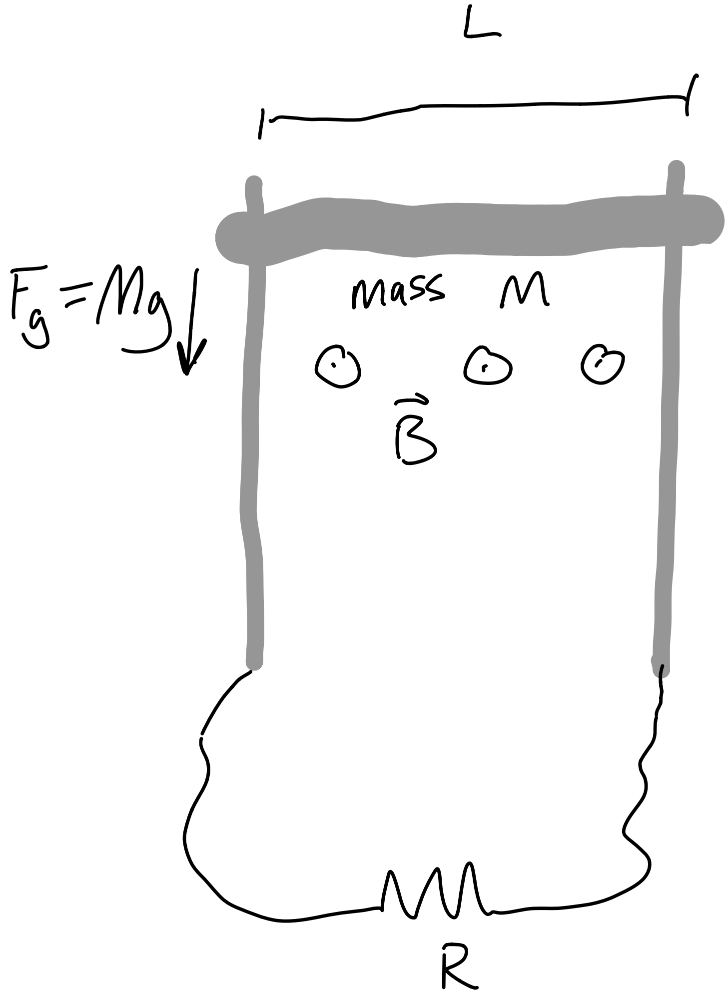
$$P = I\mathcal{E} = I\Delta V$$

Mechanical work $\longrightarrow$ electrical work

Example:



Maximum Power generated in R?



$$\mathcal{E} = BLv$$

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

$$F_{net} = F_g - ILB$$
$$= Mg - ILB$$

$$F_{net} = Mg - \frac{\mathcal{E}}{R} LB$$

$$F_{net} = Mg - \frac{BLv}{R} LB$$

$$F_{net} = mg - \frac{B^2 L^2 v}{R}$$

v increases until $F_{net} = 0$

$$mg = \frac{B^2 L^2 v}{R}$$

$$v_{max} = \frac{mgR}{B^2 L^2}$$

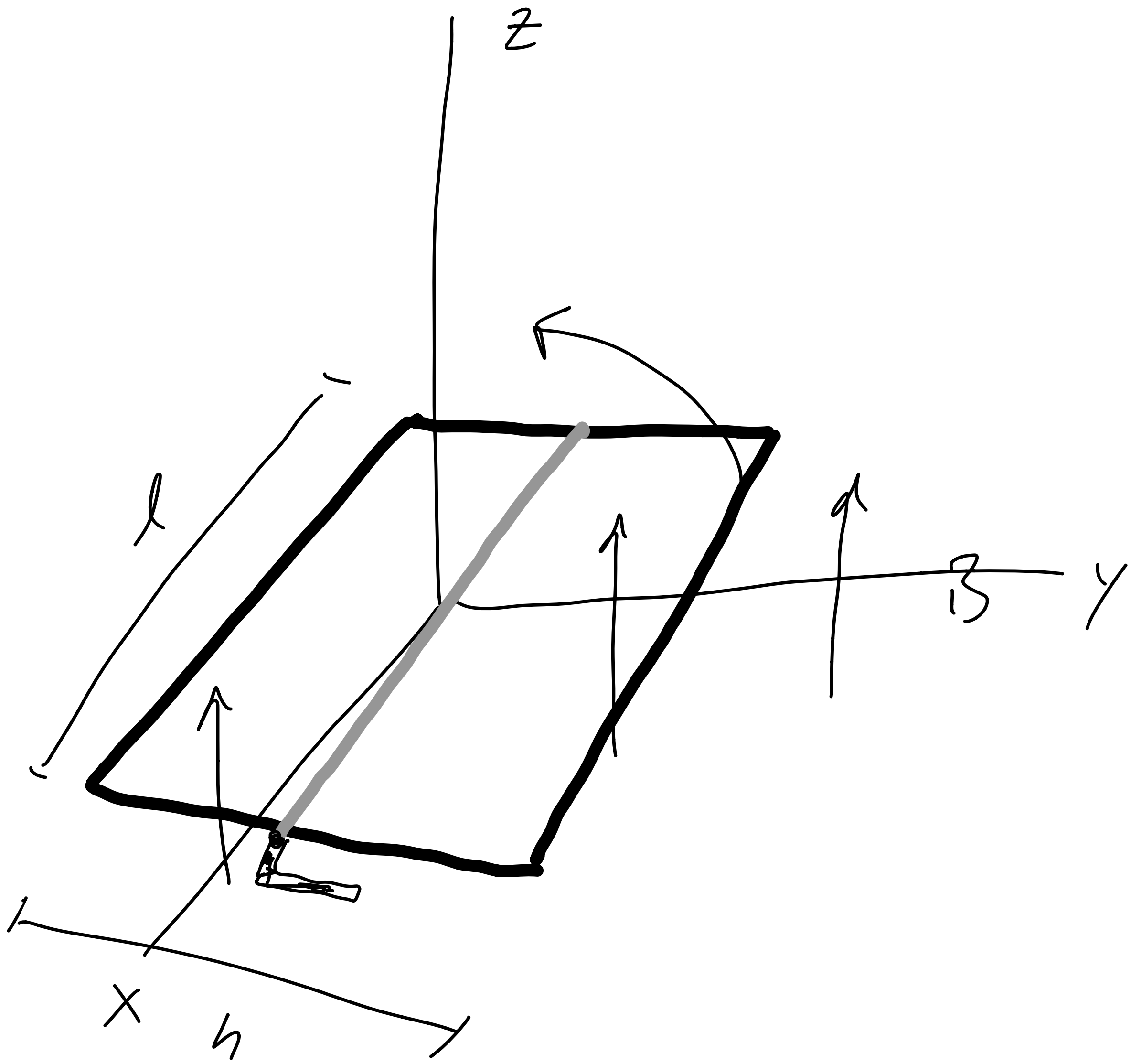
$$\mathcal{E} = BLv = \frac{mgR}{BL}$$

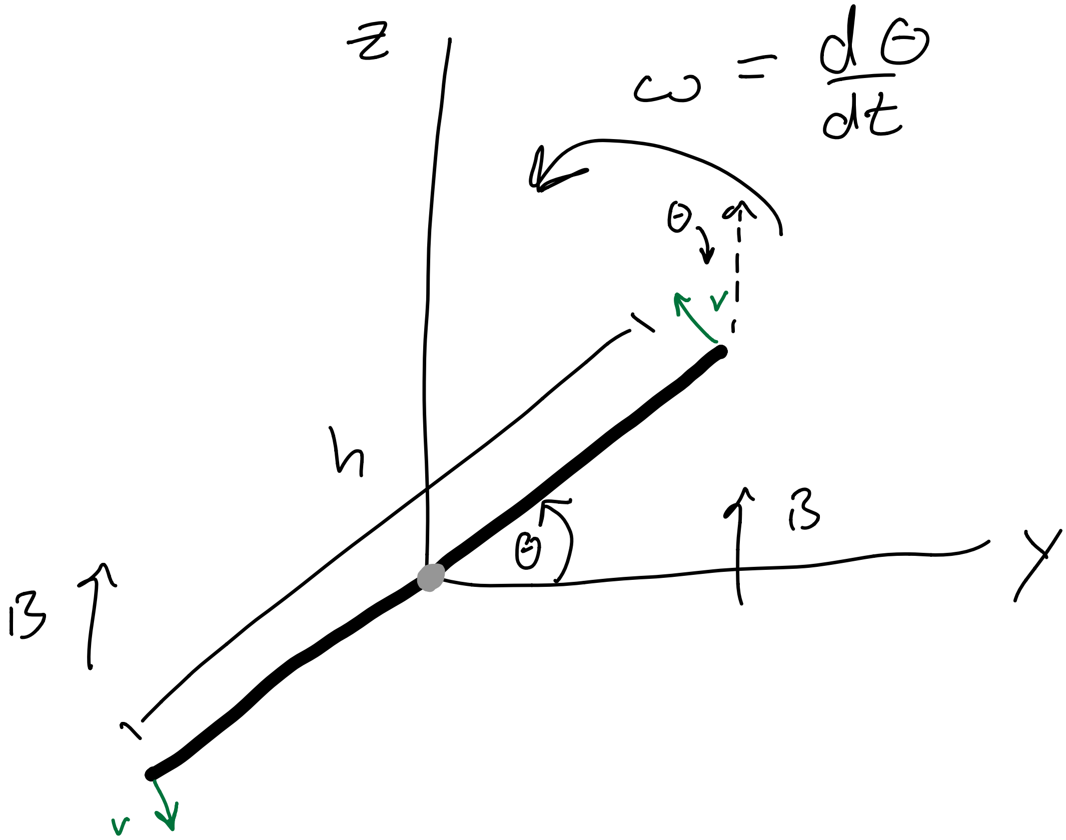
$$I = \frac{\mathcal{E}}{R} = \frac{mg}{BL}$$

$$P = I^2 R = \left(\frac{mg}{BL}\right)^2 R = mg\,v_{max}$$

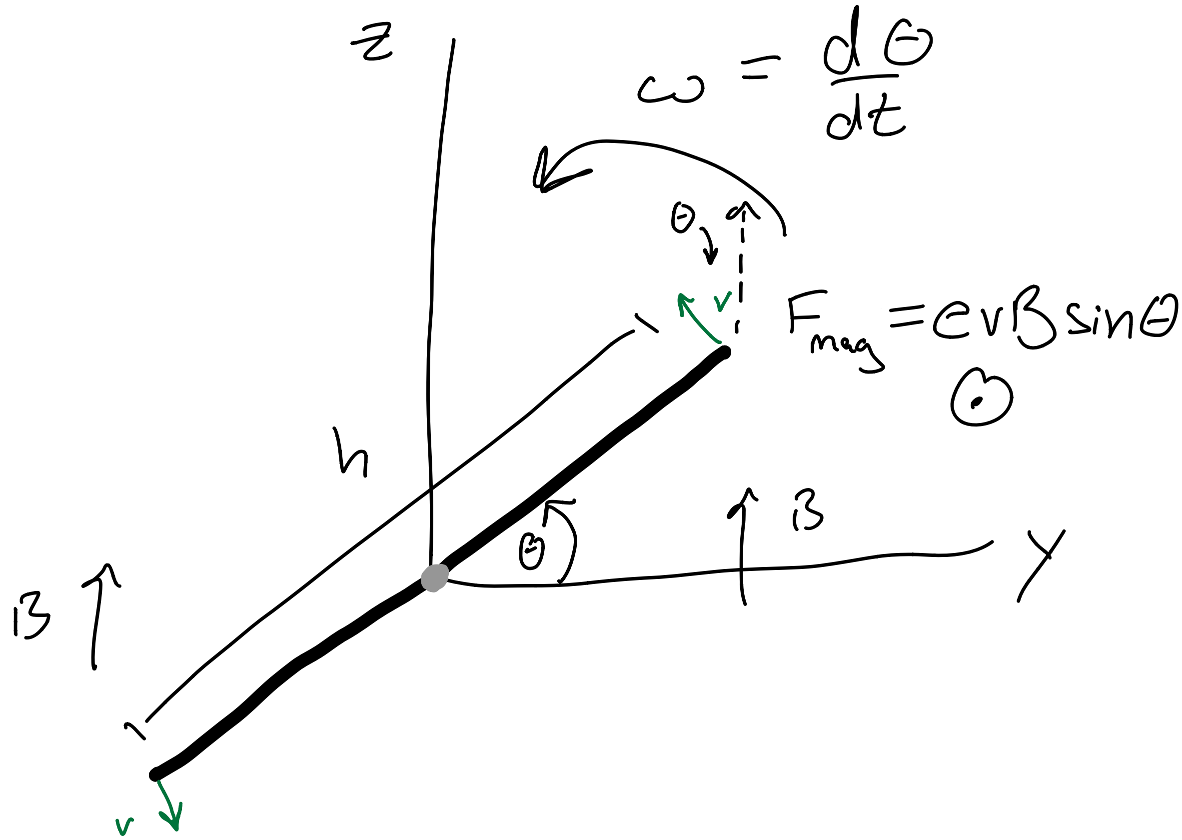
Rotating Loop

A more practical generator:

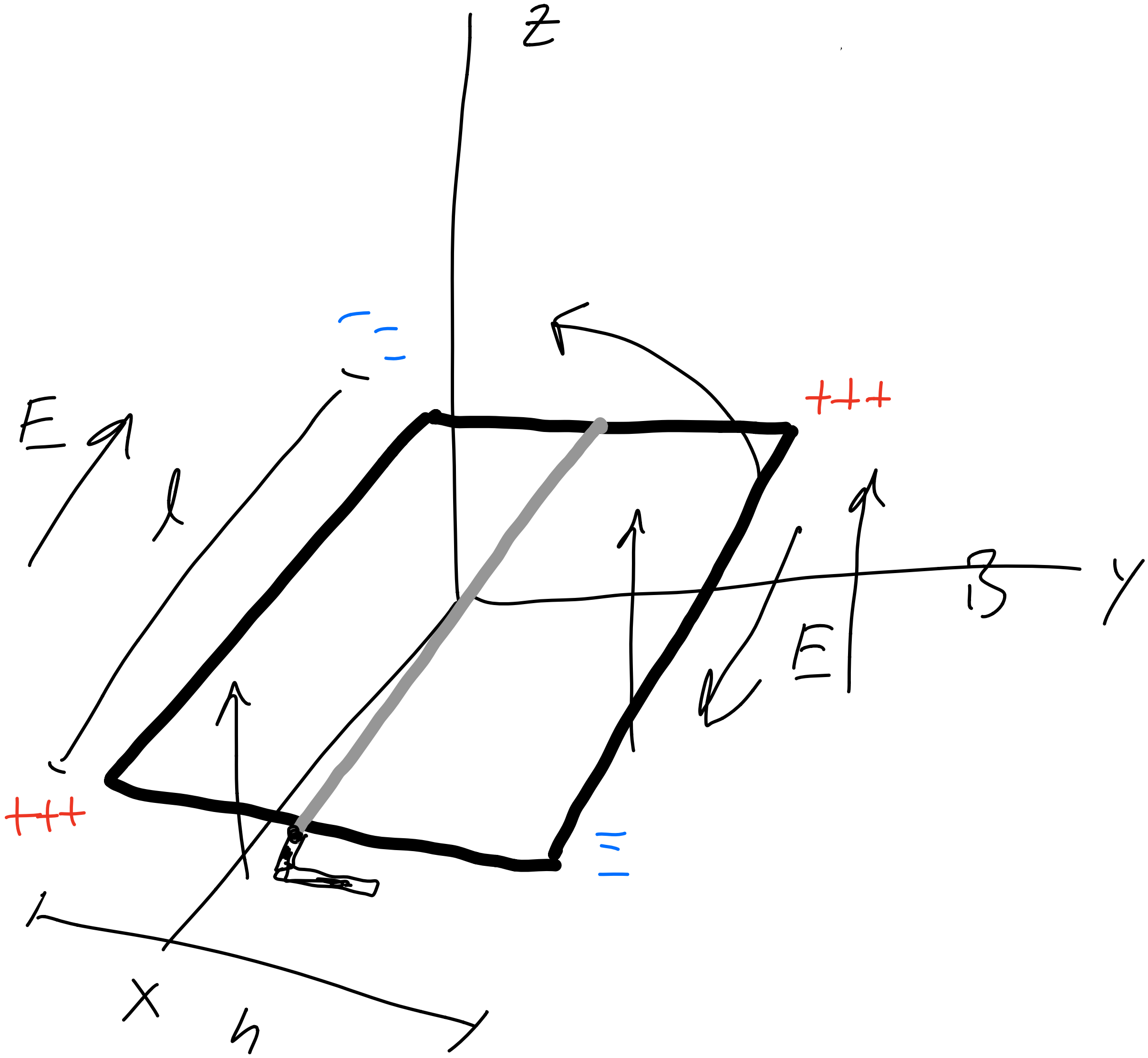




$$\vec{F} = q\vec{v} \times \vec{B}$$



$F = evB\sin\theta \otimes$



$$E = vB\sin\theta$$

$$\mathcal{E} = 2vBl\sin\theta$$

$$v = \frac{h}{2}\omega$$

$$\mathcal{E} = hl\omega B\sin(\omega t)$$

$$I(t) = \frac{hl\omega B\sin(\omega t)}{R}$$