PHYS 121 April 5, 2024

- The last PrairieLearn HW is due Thur, Apr. 11 @ 23:59
- If completing the Hands-On bonus project, send me the link to your YouTube video by Monday, Apr. 8 @ 23:59.
- Complete end-of-term survey by 23:59 on Wed. Apr. 10 to receive 0.5 towards final grade.
  Link to Survey is on PHYS 121 Canvas home-page.

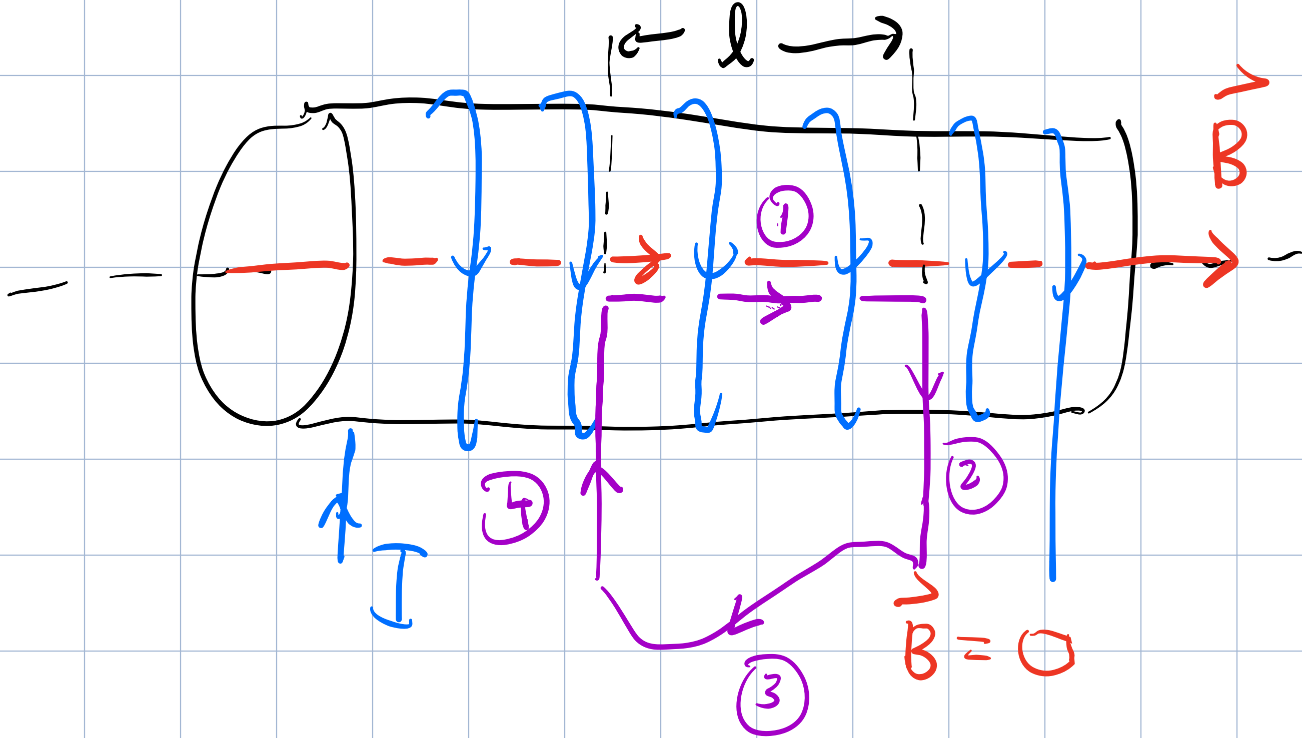
Last Time:

Ampere's Law

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{encl}$$

Used to determine $\vec{B}$ due to various configurations of current.

For a solenoid,



we found

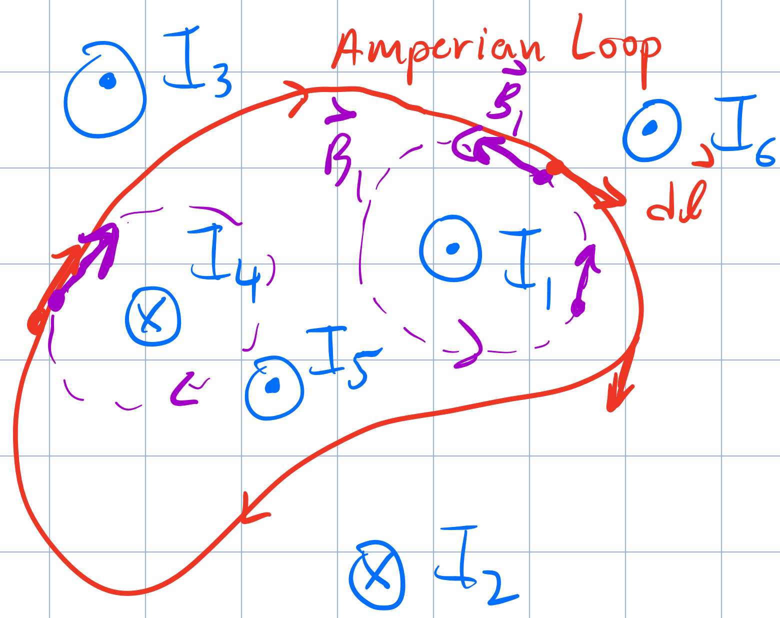
$$\oint \vec{B}\cdot d\vec{l} = \int_{①} \vec{B}\cdot d\vec{l} = B l$$

$$I_{encl} = N I$$

$$\boxed{\Rightarrow \quad B = \mu_0 \left(\frac{N}{l}\right) I = \mu_0 n I}$$

where $n = N/l$ is the number of turns per unit length.

Eg.



What is the result of $\oint \vec{B}\cdot d\vec{l}$ for the red integration path/Amperian loop?

$$\oint \vec{B}\cdot d\vec{l} = \mu_0 I_{encl} \rightarrow \text{Ampere's Law.}$$

$$I_{encl} = ?$$

Only currents passing through loop contribute (I_1, I_4, I_5). I_2, I_3, & I_6 make no contribution.

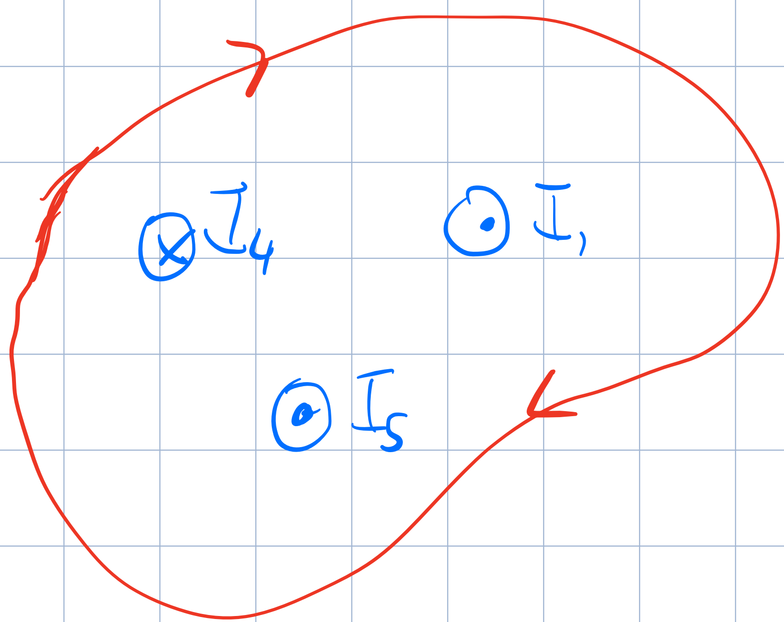
Since $\vec{B}_1$ tends to be antiparallel to integration dir'n, it makes a neg. contribution to I_{encl} / $\oint \vec{B}\cdot d\vec{l}$.

On the other hand I_4 make pos. contributions.

I_5, like I_1, makes a neg. contribution.

$$I_{encl} = I_4 - I_5 - I_1$$

$$\boxed{\therefore \oint \vec{B} \cdot d\vec{l} = \mu_0 (I_4 - I_5 - I_1)}$$



RHR for ampere's law:

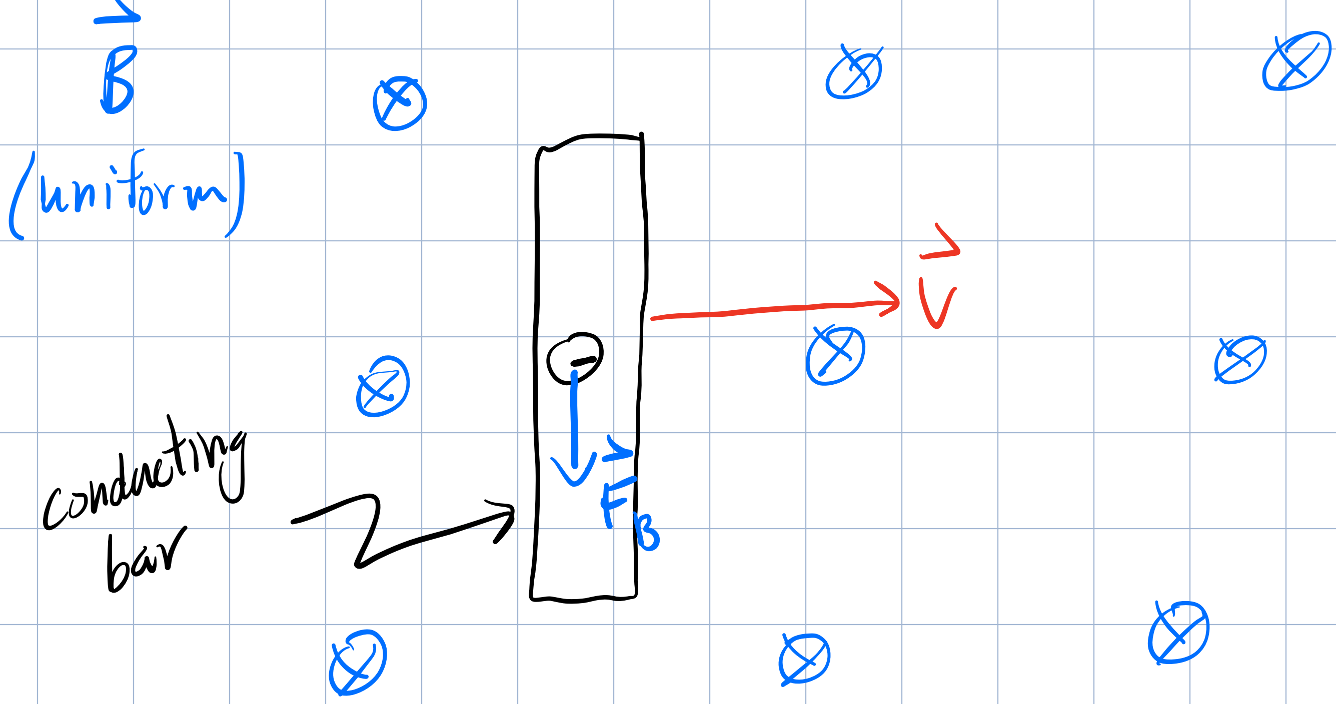
- curl fingers of right in dir'n of integration.

- currents in dir'n of thumb make pos. contribution.

Chapter 13 Sec. 3 of OSUPv2

Motional Emf → Induced Voltages

"electro-motive force"



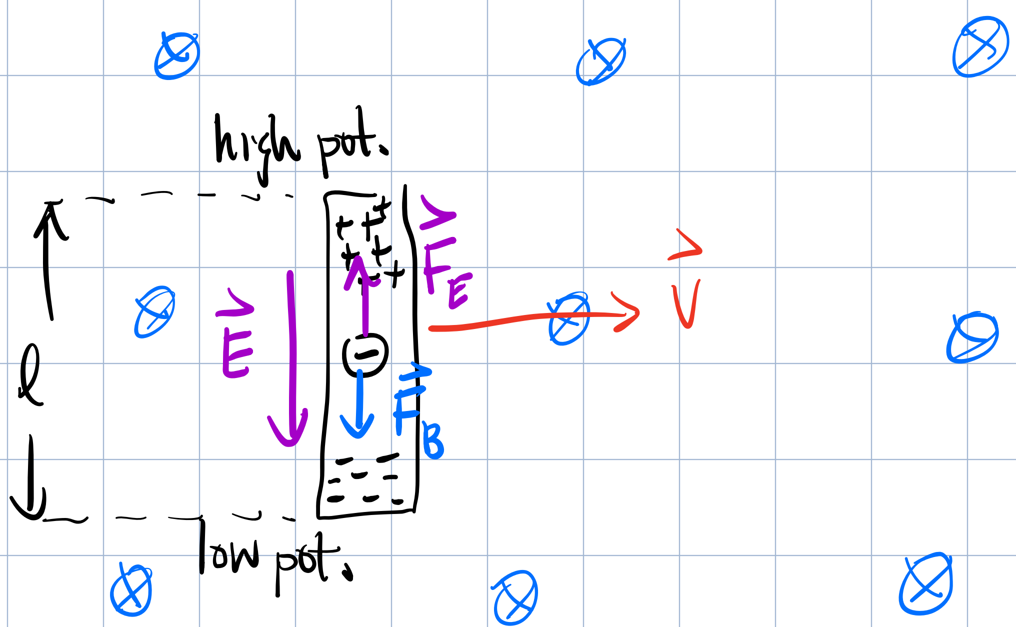
Pull a conducting bar perpendicularly through a uniform magnetic field w/ speed v.

The mobile electrons in the conductor also move to the right w/ speed v. ∴ they experience a magnetic force $\vec{F}_B = q\vec{v} \times \vec{B}$

Force on our electrons will be downwards.

$$|\vec{F}_B| = qvB\underbrace{\sin 90^\circ}_{1} \Rightarrow F_B = qvB$$

As we keep pulling the rod, electrons pile up near the btm & leave behind excess pos. charge due to the atomic nuclei near the top of the rod.



Separation of charge establishes an electric field $\vec{E}$ inside the rod.

The electric force on the electrons opposes the magnetic force.

In equil., the two force balance & charge stops migrating.

Equil. Condition: $F_E = F_B$

$$\cancel{q}E = \cancel{q}vB$$

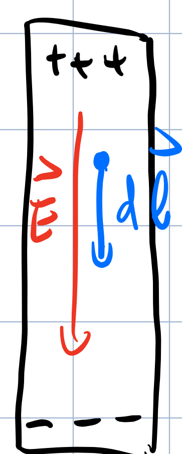
$$\therefore \boxed{v = \frac{E}{B}}$$

similar to what we had for velocity selector.

Solving for E, we get $\boxed{E = vB}$ ①

To calculate the voltage difference across rod, we use

$$\Delta V = -\int \vec{E} \cdot d\vec{l}$$



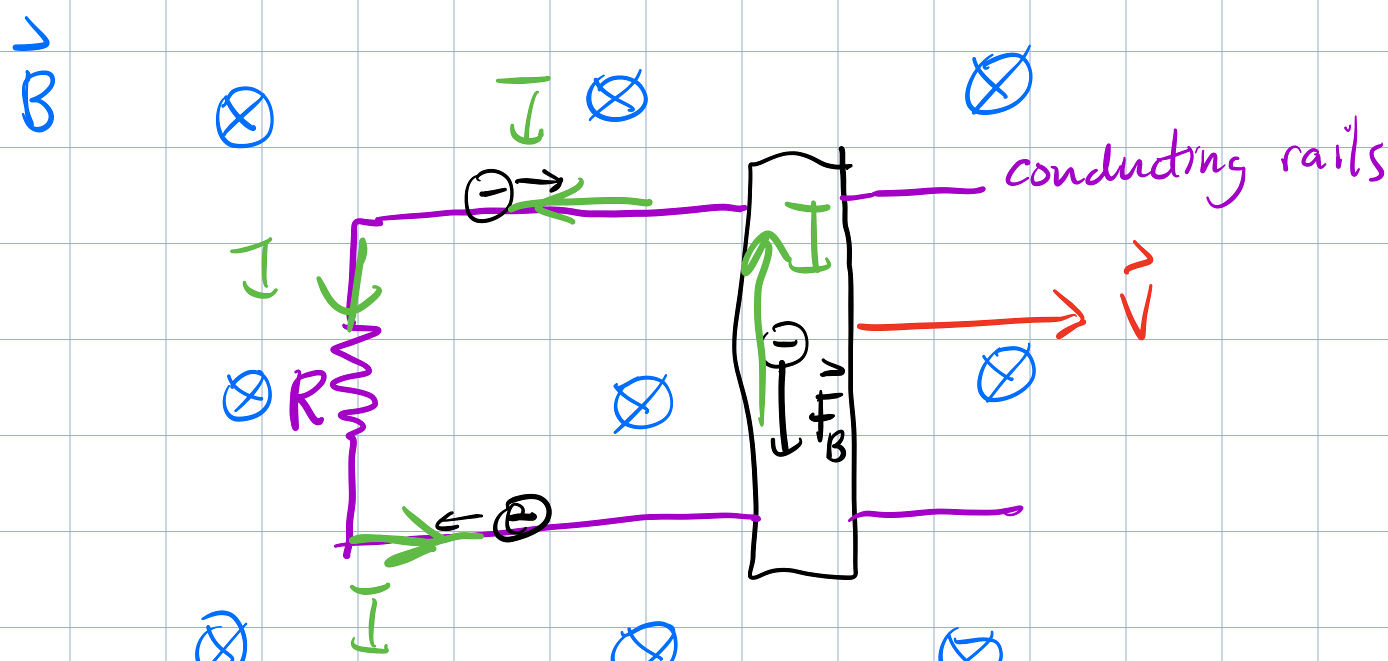
$d\vec{l} \parallel \vec{E}$ & assume E in const.

$$|\Delta V| = E\ell \quad \text{sub ① for } E$$

$$\boxed{|\Delta V| = vB\ell}$$ motional emf, usually denoted $\mathcal{E}$

$$\boxed{\Delta V = \mathcal{E} = vB\ell} \quad ②$$

We can use the voltage due to motional emf to power circuits



Rod slides on a pair of conducting tracks that are joined on one end by resistor R.

e^- flow CW around our circuit

$\rightarrow$ CCW current I.

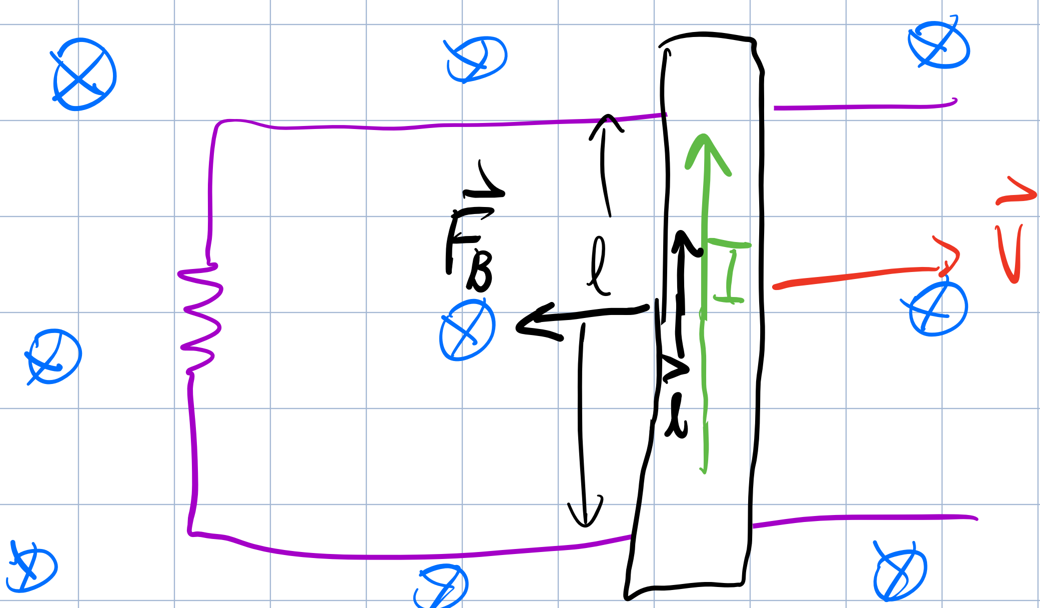
$$\boxed{I = \frac{\Delta V}{R} = \frac{vBl}{R}} \quad (3)$$

Induced current due to motion of rod through $\vec{B}$.

Power dissipated by resistor:

$$P = I^2 R$$

$$= \underbrace{\left(\frac{vBl}{R}\right)^2}_{\text{from (3)}} R = \boxed{\frac{(vBl)^2}{R}} \quad (4)$$



Now we have a current in our rod &
currents in magnetic field experience a
force

$$\vec{F}_B = I\,\vec{\ell} \times \vec{B}$$

By RHR this force is to the left.
Magnitude of the force is

$$F_B = I \ell B$$