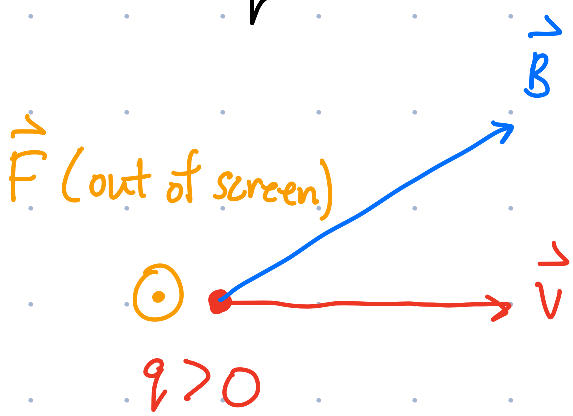
PHYS 121 March 24, 2025

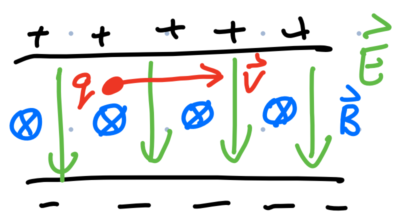
- Next PrairieLearn HW due Mar. 28
- Complete Pre-Lab #8 before the start of your lab.
- Office hours: 12:00–13:00 Tuesday (instead of 14:30–15:30 today).

Last Time: ■ Force on a charge moving through a magnetic field.

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



■ Velocity selector



q undeflected when $F_E = F_B \Rightarrow qE = qvB \Rightarrow v = \frac{E}{B}$

Today:

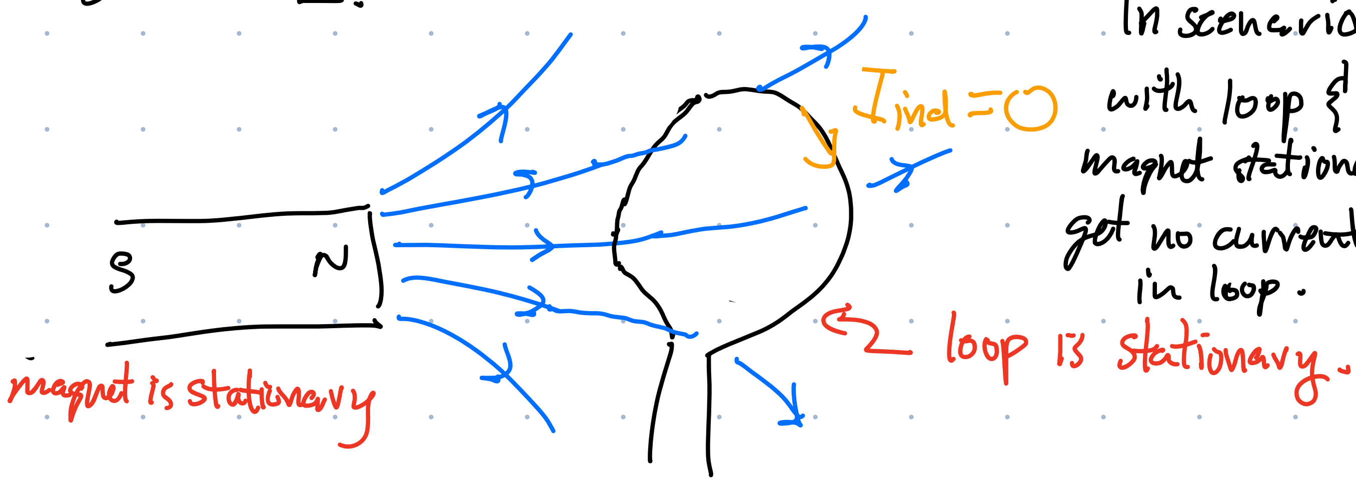
Start by discussing/motivating Lab #8

- changing dist'n of charge (currents) creates magnetic fields

- today, we will see that changing magnetic fields can create currents ⇒ Faraday's Effect.

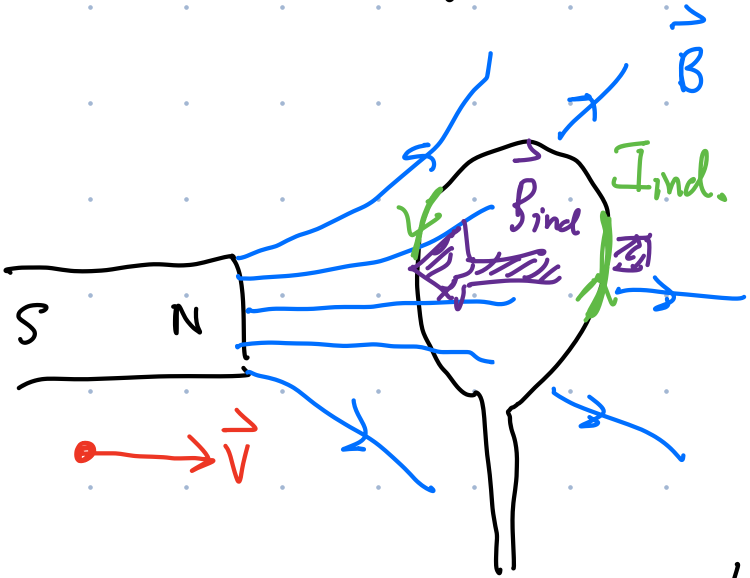
When a magnetic field passing through a loop of wire changes, get an induced current I_{ind} in the loop.

Scenario 1.



In scenario 1, with loop & magnet stationary, get no current in loop.

Scenario 2: Magnet moves towards the loop.

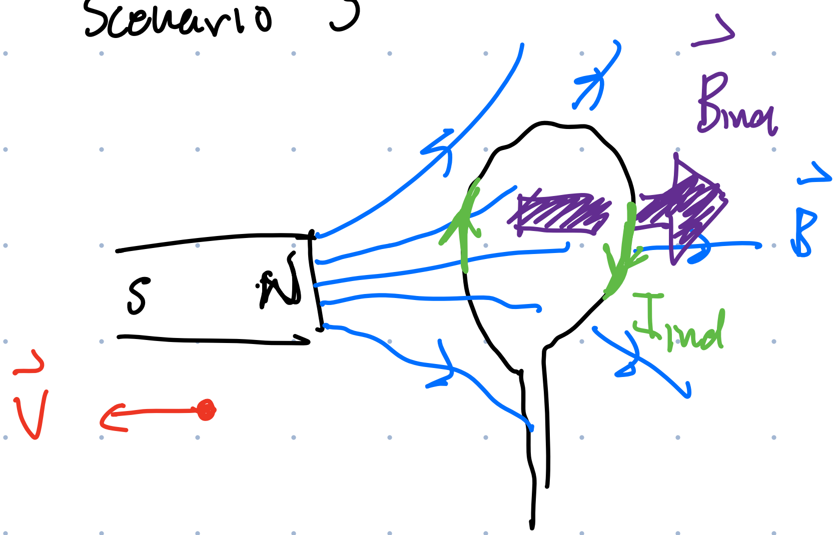


In this case, from the persective of an observer on the magnet, charges in the loop of wire a moving towards the bar magnet & through its magnetic field $\vec{B}$.

As a result, these charges experience a force & their motion gives rise to an induced current, I_{ind}.

I_{ind} creates $\vec{B}_{ind}$ that oppose the increase in $\vec{B}$ through the loop. → Faraday's Law.

Scenario 3

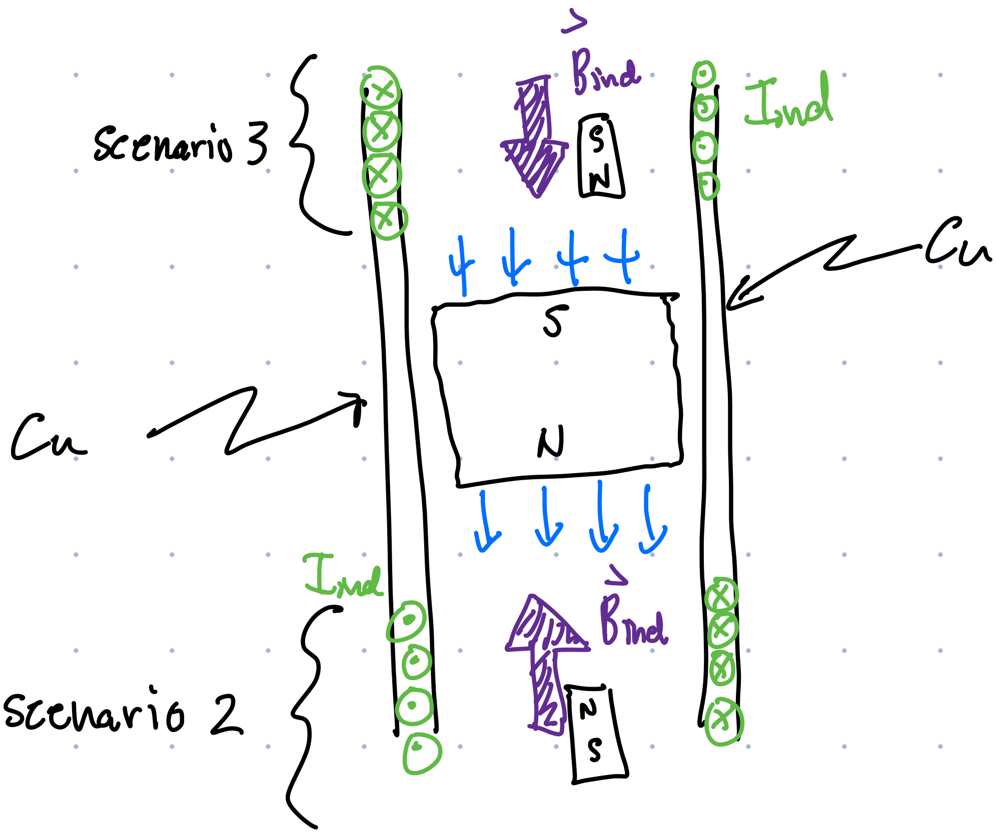


In this case, I_{ind} creates a $\vec{B}_{ind}$ to oppose the decreasing magnetic field through the loop.

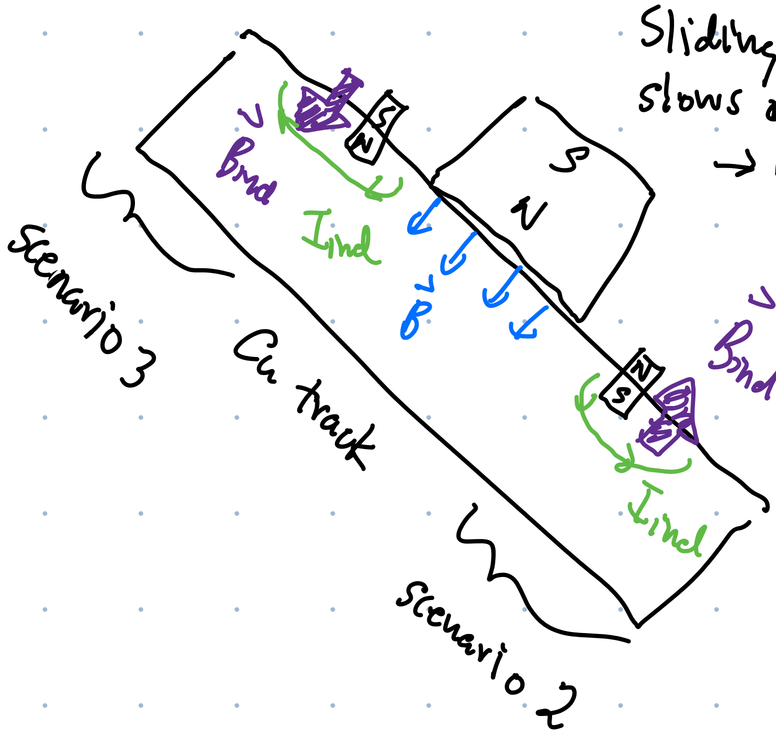
$\vec{F} = q\vec{v} \times \vec{B}$

For a magnet falling through a copper tube...

cross-section



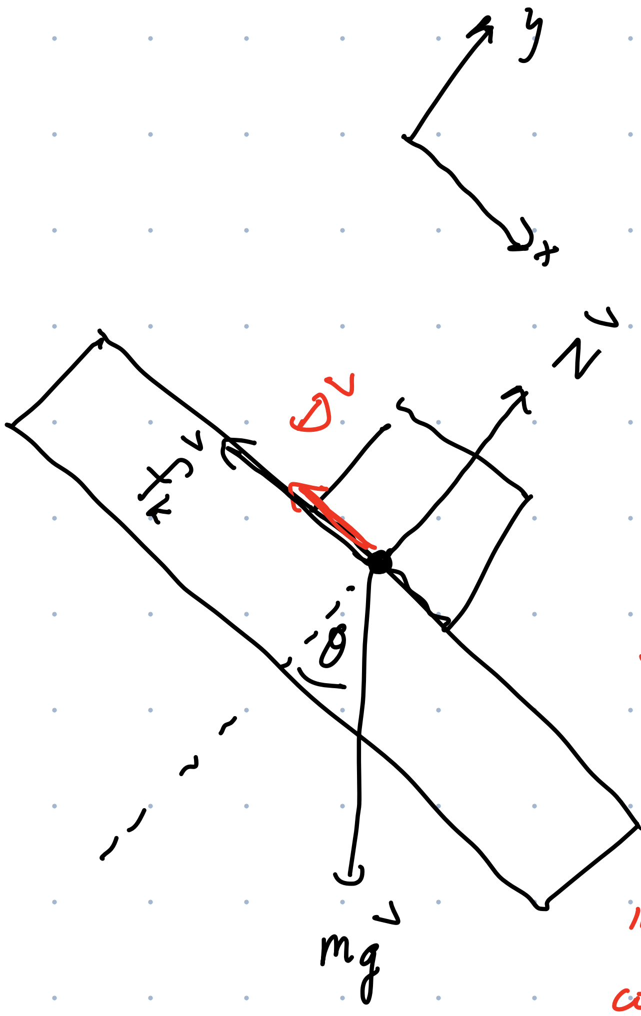
Lab # 8



Sliding magnet slows down

→ magnetic braking

FBD



$\vec{D}$: drag force due to the magnetic interaction w/ induced currents.

Model the drag force as

$$D = b\,v$$

"drag coefficient" (b), speed of magnet (v)

y-dir'n:

$$ma_y = 0 = N - mg\cos\theta$$

$$\Rightarrow N = mg\cos\theta$$

x-dir'n

$$ma_x = mg\sin\theta - \underbrace{\mu_k N}_{f_k} - \underbrace{bv}_{D}$$

$\therefore m a_x = mg\sin\theta - \mu_k mg\cos\theta - bv$

divide by m

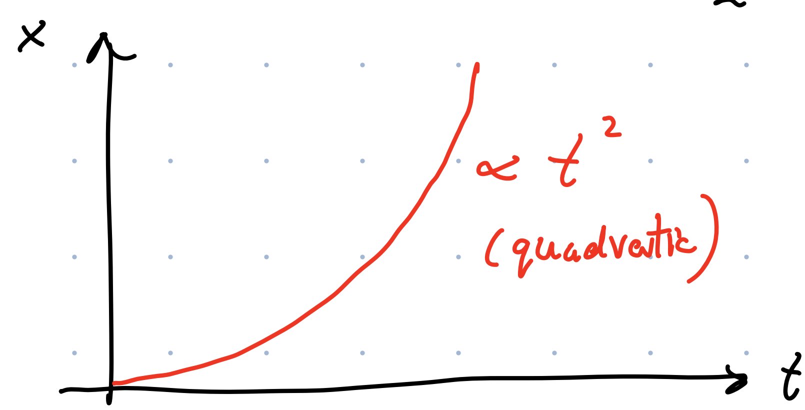
$$a_x = g(\sin\theta - \mu_k\cos\theta) - \frac{b}{m}v$$

acceleration of the magnet.

Case ①: If track is not conducting $\Rightarrow b = 0$

$$a_x = g(\sin\theta - \mu_k\cos\theta) = \text{const.}$$

Since a_x is const, $x = \frac{1}{2} a_x g t^2$

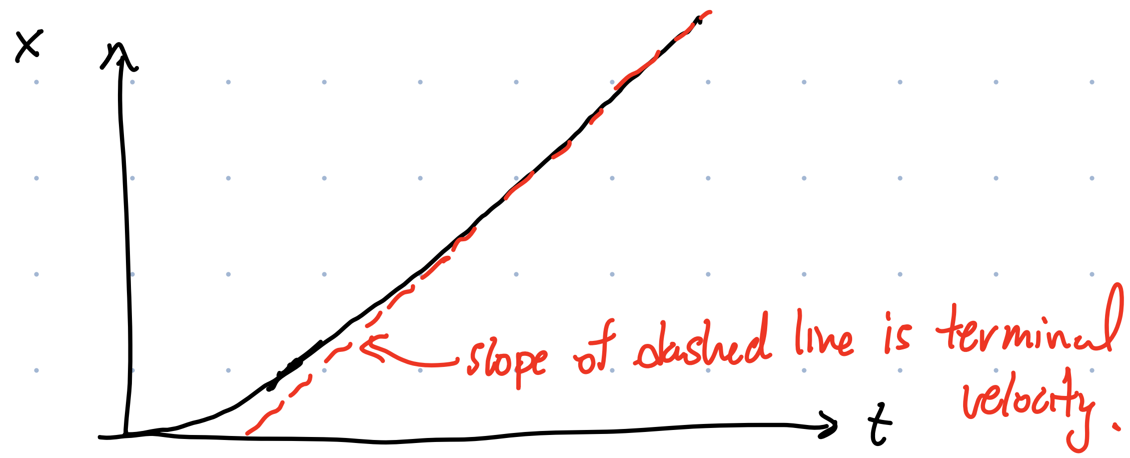


case ② $b \neq 0$ (Cu track)

$$a_x = g(\sin\theta - \mu_k\cos\theta) - \frac{b}{m}v$$

In this case, as magnet speeds up, the acceleration decreases. Eventually, reach a "terminal" velocity for which $a_x = 0$ and magnet slides at a const. speed.

(i) b is small, approach to terminal velocity is slow.



(ii) b is large, reach terminal velocity quickly