PHYS 121 March 25, 2024

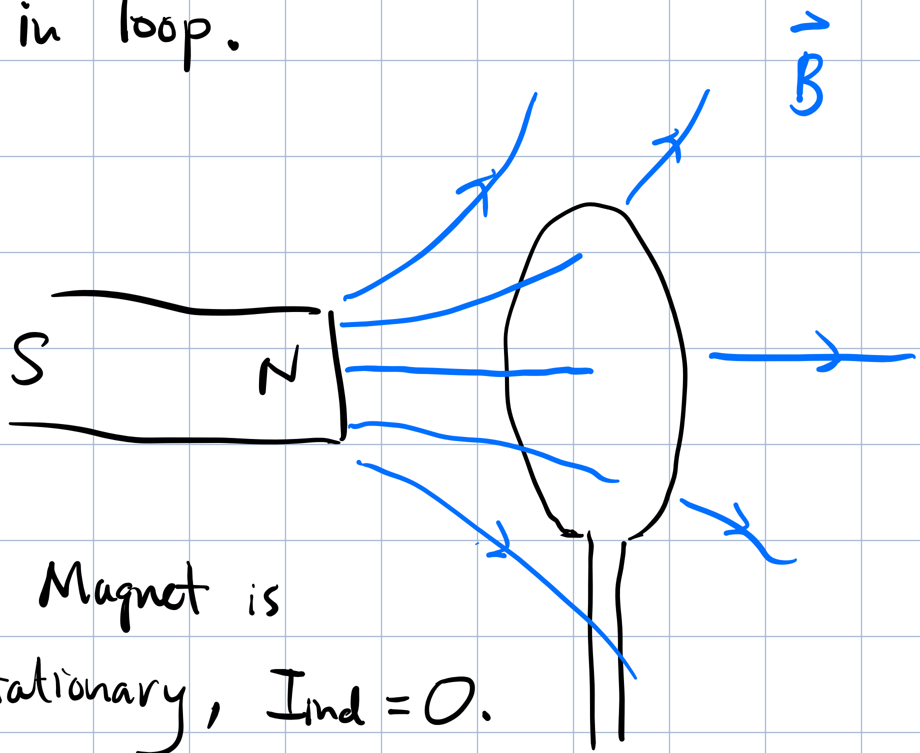
- The next PrairieLearn HW is due Fri., Mar. 29
- Complete Pre-Lab #8 before the start of Lab #8
- If completing the Hands-On bonus project, send me the link to your YouTube video by Monday, Apr. 8 @ 23:59.
- No office hours today. Extended office hours tomorrow (12:00 - 14:00)

Start by discussing/motivating Lab #8

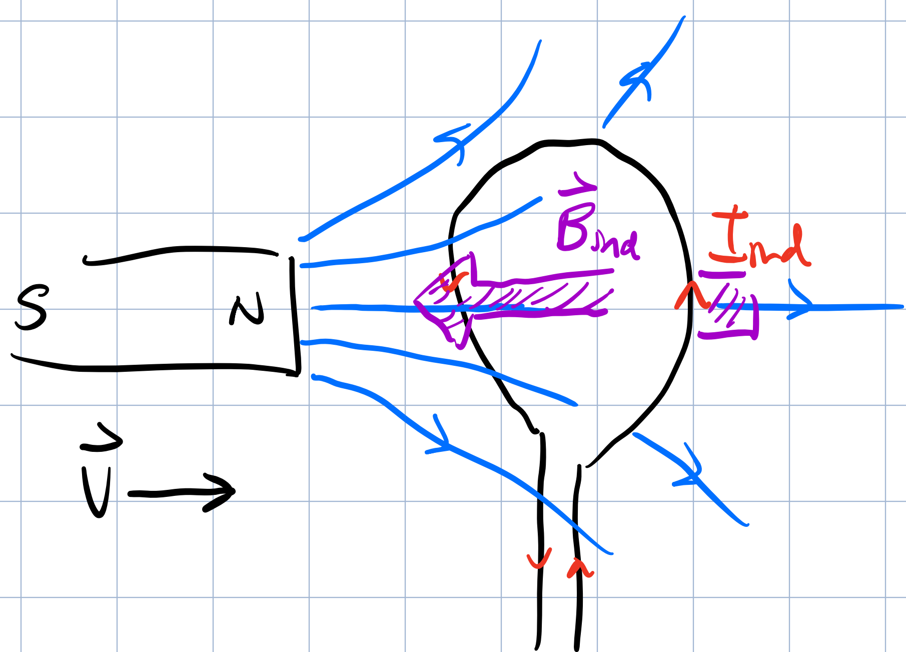
- changing dist'n of charge (currents) creates magnetic fields

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

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

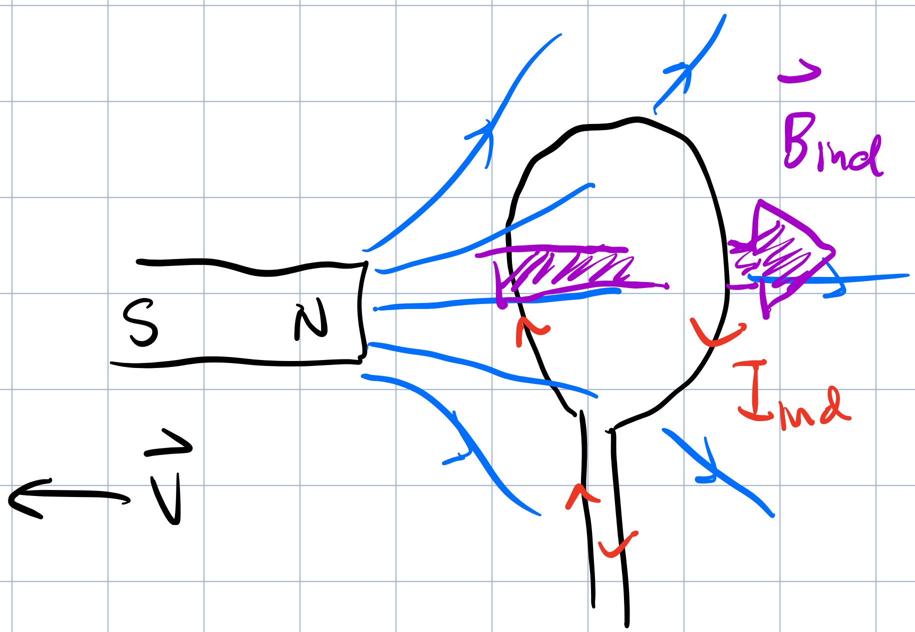


If Magnet is stationary, $I_{ind} = 0$.



If we push magnet towards loop, $\vec{B}$ increases through loop & we get $I_{ind} \neq 0$.

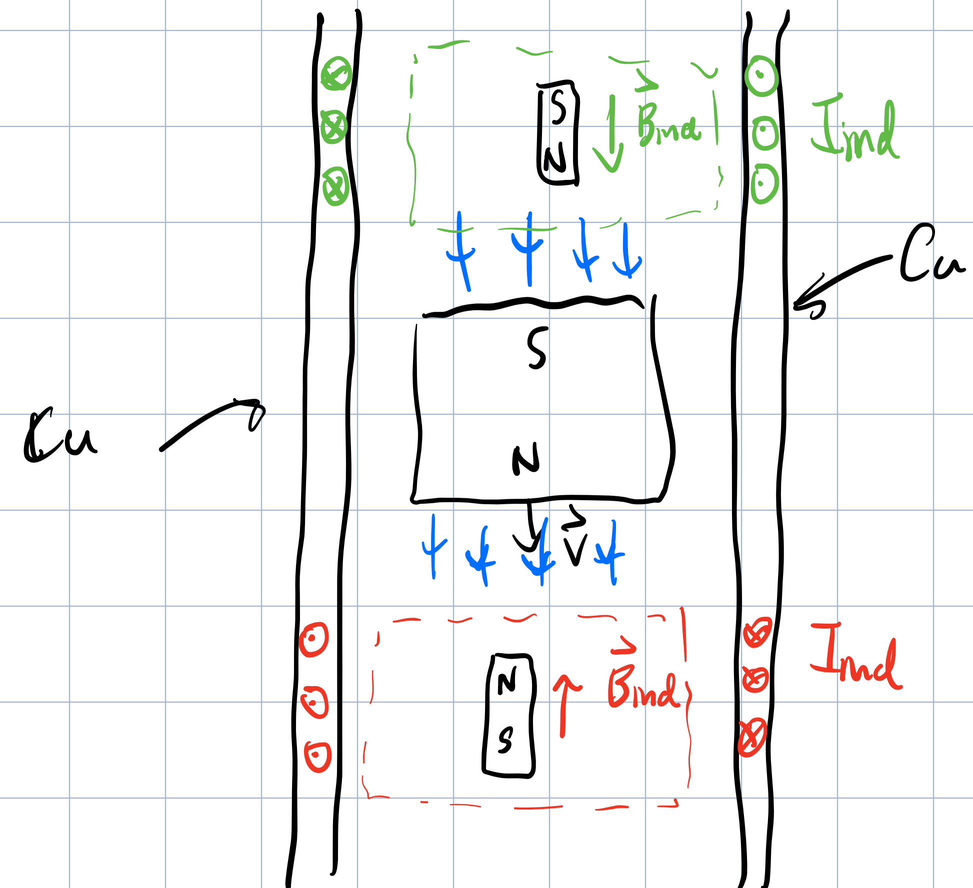
The induced current creates its own magnetic field $\vec{B}_{ind}$ that opposes in change in $\vec{B}$ through the loop.



When we pull the magnet away, get an I_{ind} that creates a $\vec{B}_{ind}$ that tends to maintain the original magnetic field that was in the loop.

For a magnet falling through a copper tube

Cross-section



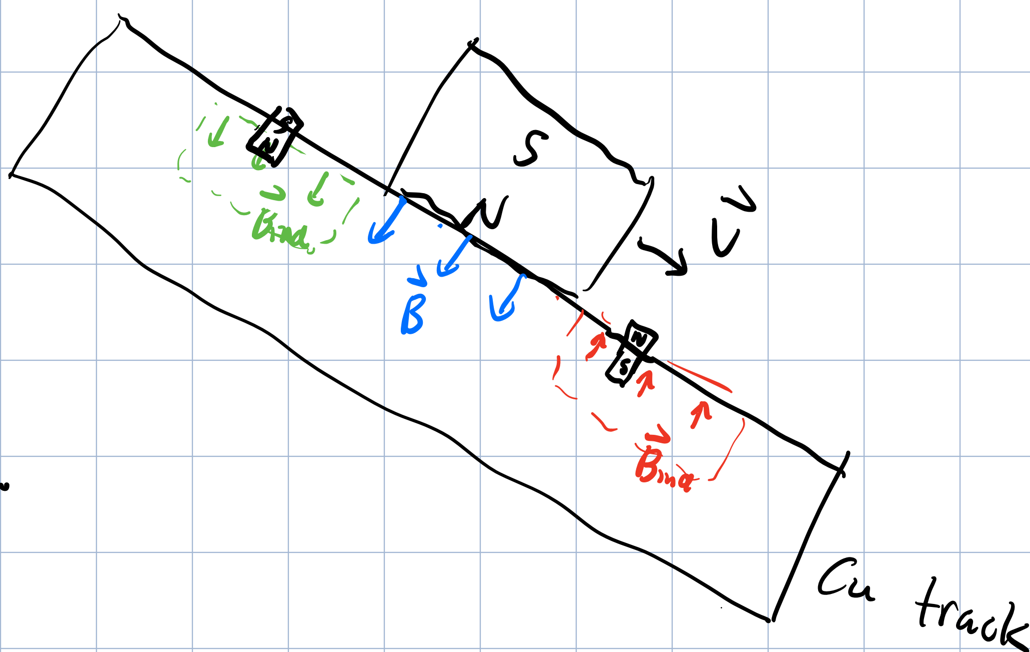
As magnet falls into red region, get I_{ind} that creates an upwards $\vec{B}_{ind}$ to oppose changing field due to falling magnet

As magnet falls away from green region, $\vec{B}_{ind}$ that is downwards to maintain original $\vec{B}$ that was in the region.

Both top & btm $\vec{B}_{ind}$ tend to slow falling magnet ⇒ Magnetic Braking.

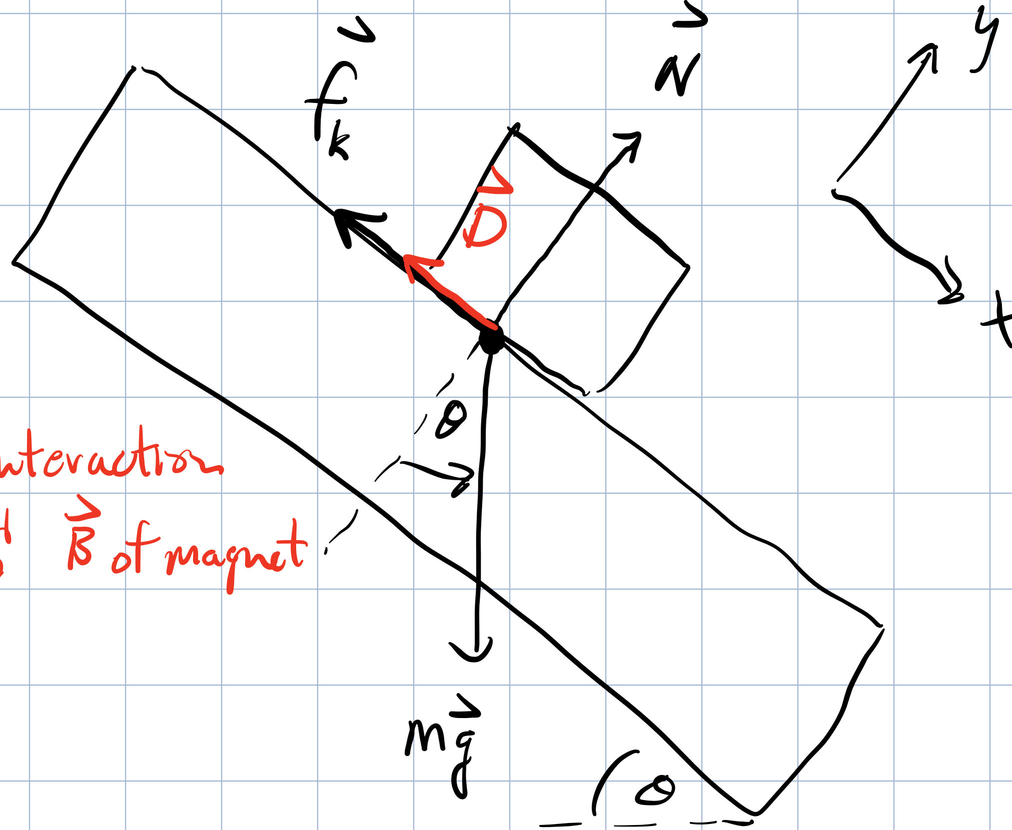
Lab # 8 Slide magnets down a conducting track.

Side:



The two induced magnetic fields slow the magnet.

FBD



$\vec{D}$ is a "drag" force due to interaction between $\vec{B}_{ind}$ & $\vec{B}$ of magnet

$D = bv$

b: "drag" coefficient

v: speed of magnet

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

$$\therefore N = mg\cos\theta$$

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

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

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

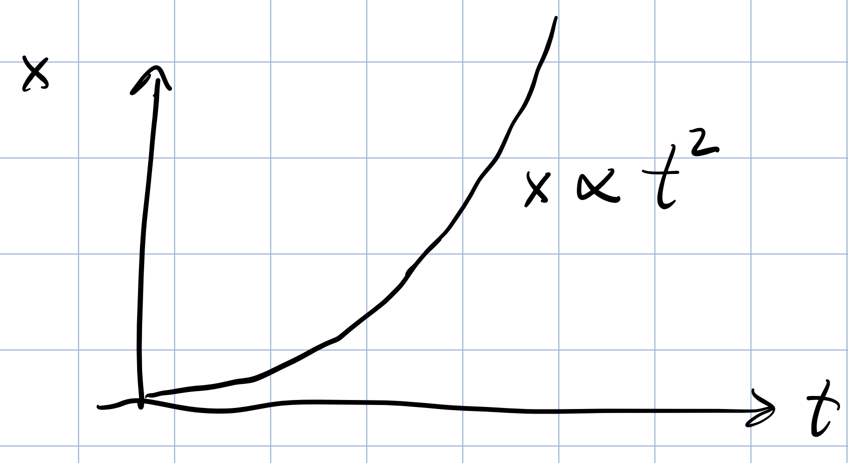
acceleration of magnet.

Case ①. If track is not conducting (plastic) then $b = 0$

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

Since a_x is const., use kinematics

$$x = \frac{1}{2}a_x t^2 \Rightarrow x \propto t^2$$

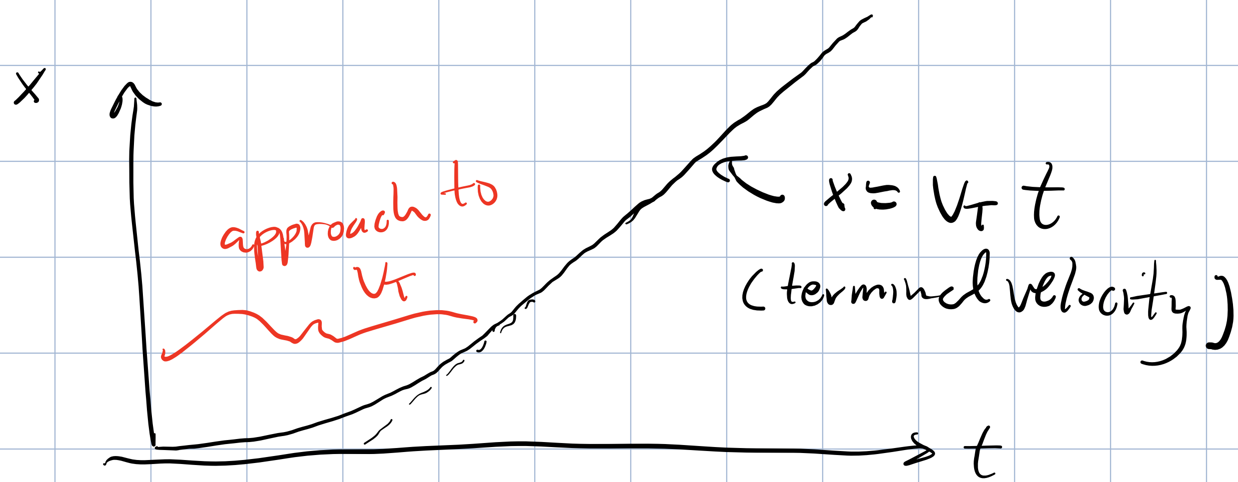


Case (2) Use Cu track $b \neq 0$

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

In This case, as magnet speeds, the acceleration approaches zero & magnet reaches a terminal velocity v_T. $\Rightarrow$ $x = v_T t$

(i) b is small → approach to v_T is slow



(ii) b is large → magnet reaches v_T almost instantly