# Rotational EMF (REMF)

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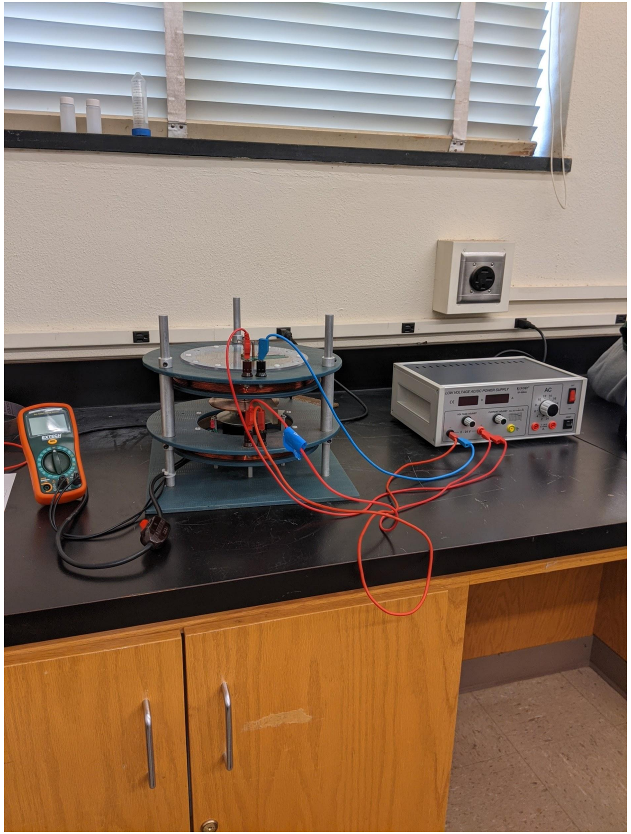
# What is REMF?

- Rotational electromotive force is produced by a change in magnetic flux running through a closed circuit (per Faraday)
    - Not a force, but a potential difference
    - Alessandro Volta used the term “electromotive force” in the 1800s
- This is stated by Faraday’s law of induction
    - Developed in 1831 by Michael Faraday
    - A change in magnetic flux through a closed circuit induces electromotive force
    - Usually achieved using closed loop moving in and out of magnetic field
    - Lends to Faraday Paradox

$$\epsilon = -\frac{d\phi}{dt}$$

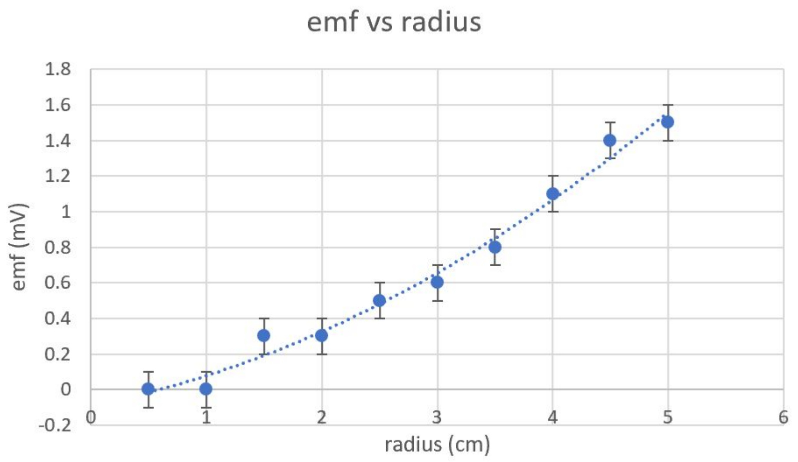
# Apparatus

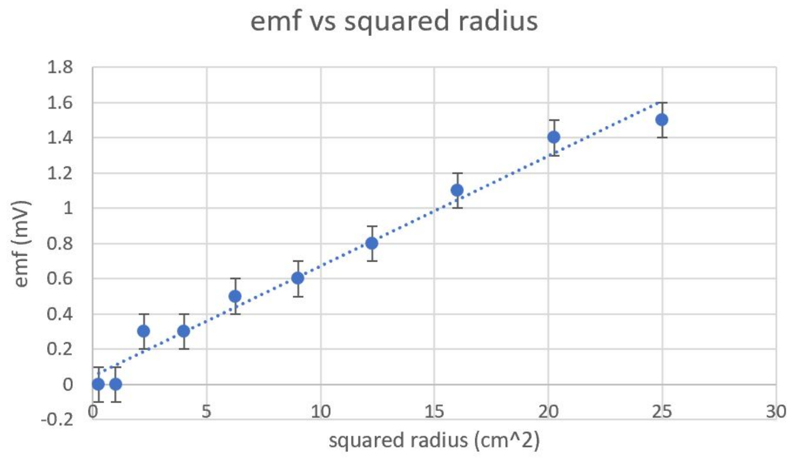
- Copper disk R = 5 cm which rotates ~50-60 rps inside Helmholtz coil with N=294 turns
- Two probes on either side which touch disk for closed circuit
- Current powers coil
- Multimeter to measure emf
- Issues
    - No stroboscope
    - It didn't spin for r > 3.5 cm
    - Power supply was not consistent, adjusting current caused fluctuation
    - Multimeter measurements fluctuated as well



# Our Results (EMF vs r and EMF vs $r^2$)

- Linear relationship between EMF and $r^2$ within error

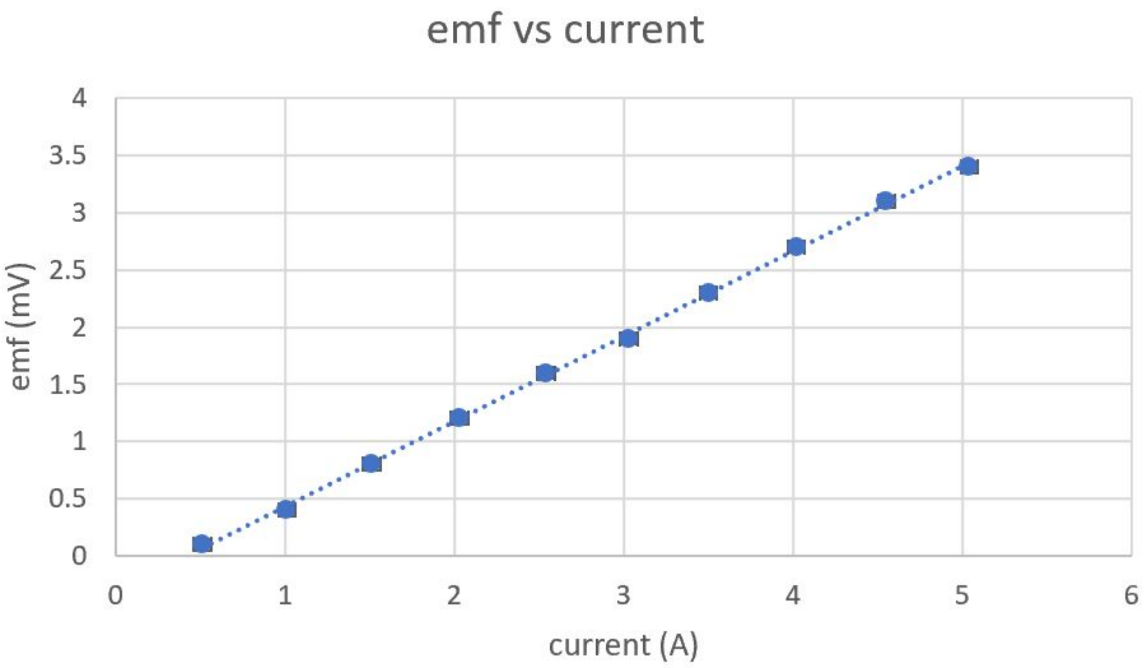


# Our Results (EMF vs Current)

- Linear relationship between EMF and current within error
- Basic Biot-Savart Law also implies linear relationship between magnetic field and EMF

$$B = \frac{\mu_0 N I}{2R}$$



# Rotational Frequency

- Using data points:
  - I = 3.50 A
  - EMF = 2.30 mV
  - r = .05 m
- Solve for B using Biot-Savart
- Rearrange Lorentz
- Solve for $\omega$: 142.30 Hz

# Some Derivations (Lorentz Force)

$$F = qv \times B$$

$$F = qr\omega B$$

$$F = qE = q\frac{dV}{dr}$$

$$qr\omega B = \frac{dV}{dr}$$

$$V(r) = B\omega\frac{r^2}{2}$$

# More Derivations (Biot-Savart)

$$d\vec{s} \times \hat{r} = cos A$$

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I d\vec{s} \times \hat{r}}{r^2}$$

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I ds \times cos A}{r^2}$$

$$B = \oint dB = \frac{\mu_0}{4\pi}\frac{cos A}{r^2}\oint ds$$

$$B = \frac{4\mu_0}{\sqrt{5}}\frac{I}{5R}$$

$$B = \frac{8\mu_0}{\sqrt{5}}\frac{I}{5R} = \frac{8\mu_0}{\sqrt{125}}\frac{I}{R}$$

# Conclusion

- Both graphs concur with our derivations
- yay