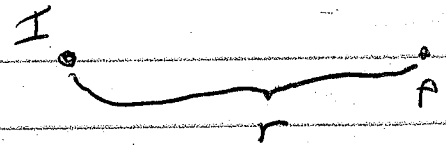
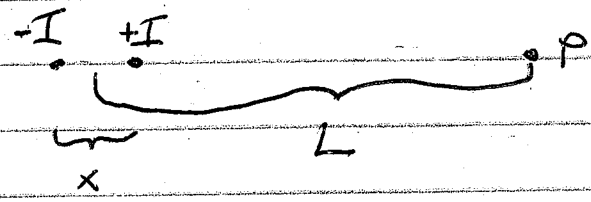
Phys 2426 2016-10-11 Lec 14

B of a single wire




$$B = \frac{\mu_0 I}{2\pi} \frac{1}{r}$$

B of a pair of wires




$$B = \frac{\mu_0 I}{2\pi(L+\frac{x}{2})} - \frac{\mu_0 I}{2\pi(L-\frac{x}{2})}$$

- Known L – just plug in values
- Known B – L is unknown; must solve

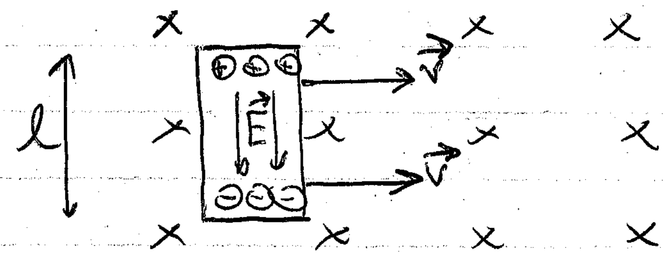
$$B = \left(\frac{\mu_0 I}{2\pi}\right)\left[\frac{1}{L+\frac{x}{2}} - \frac{1}{L-\frac{x}{2}}\right]$$

# # #

| Distance | B |
|---|---|
| 37 cm | 17.5 nT |
| 117 cm | 1.75 nT |
| 3.2 times more | 10 times less |
| $\sqrt{10}$ times more | |

(2)

## Motional EMF




$\vec{B} = B_0$ (in)

Thought process:

① $\vec{F}_B = qvB$ (up)

② Charges cause $\vec{E} = E_0$ (down)

③ Charges feel no force when

$$F_E = F_B \quad \text{(magnitudes)}$$

$$qE_0 = qvB_0$$

$$E_0 = vB_0$$

④ Electric field is negative gradient of voltage
(gradient └ slope or derivative)

$$\Delta V = \text{"EMF"} = \mathcal{E} = E\ell$$

$$\mathcal{E} = vB\ell$$

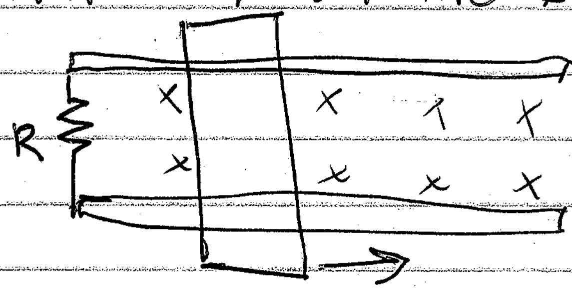
③

How can we use this voltage in a circuit?

Method 1: Hook wires to it, Attach Load to the moving metal.

Problem: The wires generate the opposite voltage. Can't even measure w/ voltmeter on plane.

Method 2: Mount the bar on rails



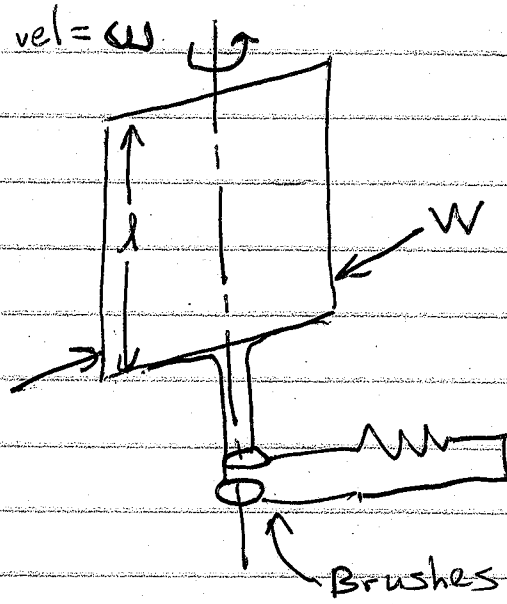

Bar moves, circuit doesn't.
Used in the shake light.
Inconvenient, but straightforward.

$\mathcal{E} = V$ $\quad \mathcal{E} = vBl$, $\; V = IR$

Method 3: Mount the bar on a rotating frame.

Angular vel $= \omega$

$v = \omega R$




$\mathcal{E} = Blw\omega$

$= BA\omega$ ← loop

$\mathcal{E} = NBA\,\omega$ ← coil

Recall: $\tau = NBAI$

Similar result for Watt Balance

The given EMF was the "peak" or amplitude of a varying $\mathcal{E}$.

$$\mathcal{E}(t) = \mathcal{E}_0 \cos(\omega t)$$

$\uparrow$ $NBA\omega$

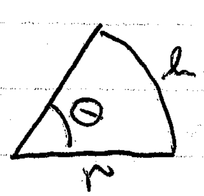
Angular Speed is measured in radians per second.

Ex: $$3600 \text{ RPM} = 3600\left(\frac{2\pi \text{ rad}}{60 \text{ s}}\right)$$

$$1 \text{ rotation} = 2\pi \text{ rad}$$

$$3600 \text{ RPM} = 377 \text{ rad/s} = 377 \text{ s}^{-1}$$

Note: radian is dimensionless




$$l = r\theta$$

$$\frac{l}{r} = \theta$$

Ex: Full circumference

$$\theta = \frac{2\pi r}{r} = 2\pi$$

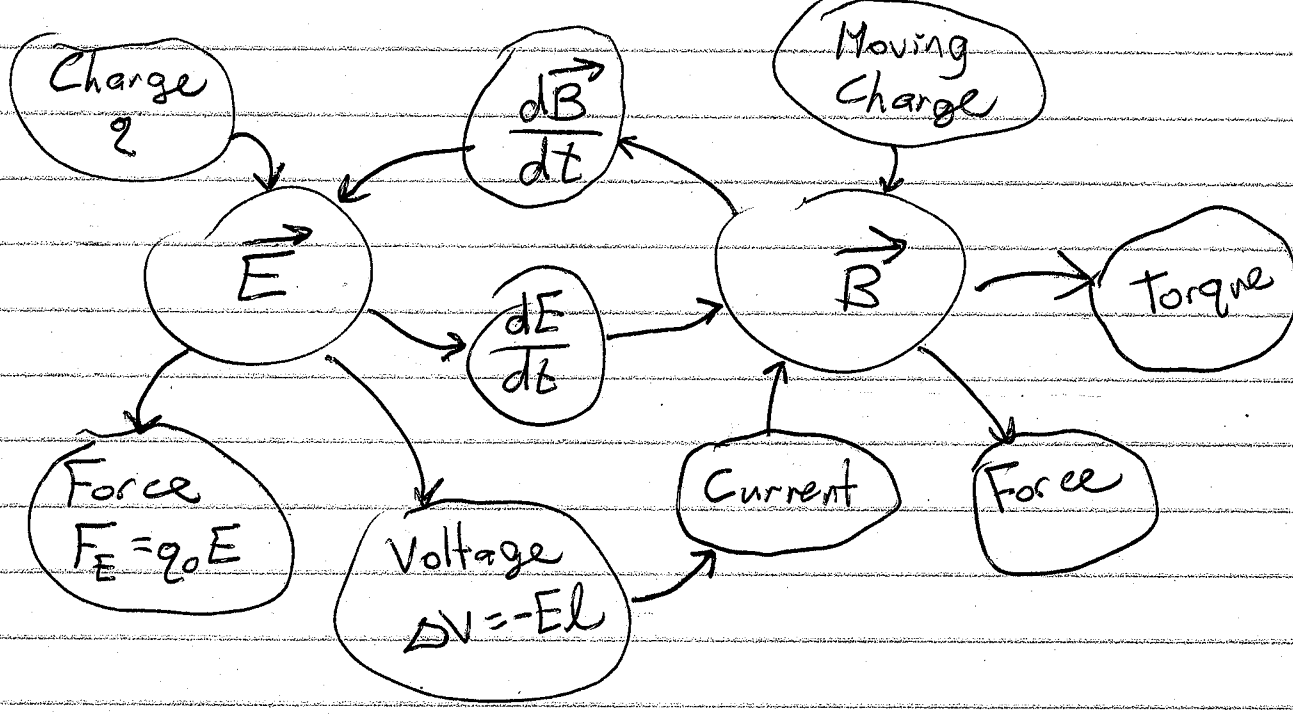
$$= 2\pi \text{ radians}$$

(5)

It doesn't matter if the coil or the magnet moves.

Moving Coil ⇒ Motional EMF ⇒ Voltage

Moving Magnet ⇒ ? ⇒ Voltage




Faraday's Law

$$\mathcal{E} = -\frac{d\Phi_B}{dt}$$

Magnetic Flux

$$\Phi_B = NBA\cos\theta$$