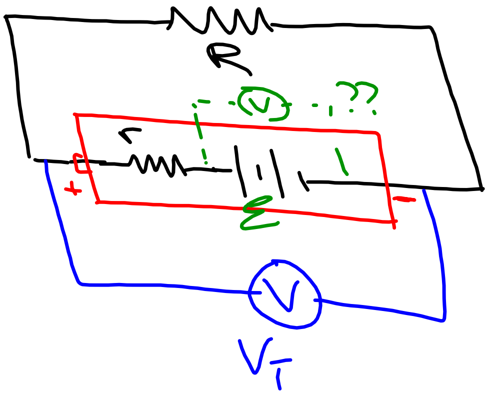
Electromagnetic Induction

Induced EMF, Faraday's Law and Lenz's Law

Sections 21-1 and 21-2

EMF - Electromotive Force ($\mathcal{E}$)

Not a force - a potential difference (voltage)



Voltmeter measures the terminal voltage, V_T of the battery

$R = r$

$R_T = r + R = 2r$

$I_T = \frac{\mathcal{E}}{R_T} = \frac{\mathcal{E}}{2r}$

$V_T = I_T R = \frac{\mathcal{E}}{2r} \cdot r = \frac{\mathcal{E}}{2}$

$R = 1000\,r$

$I_T = \frac{\mathcal{E}}{1001\,r}$

$V_T = I_T R = 1000\, I_T r = \frac{1000}{1001}\mathcal{E}$

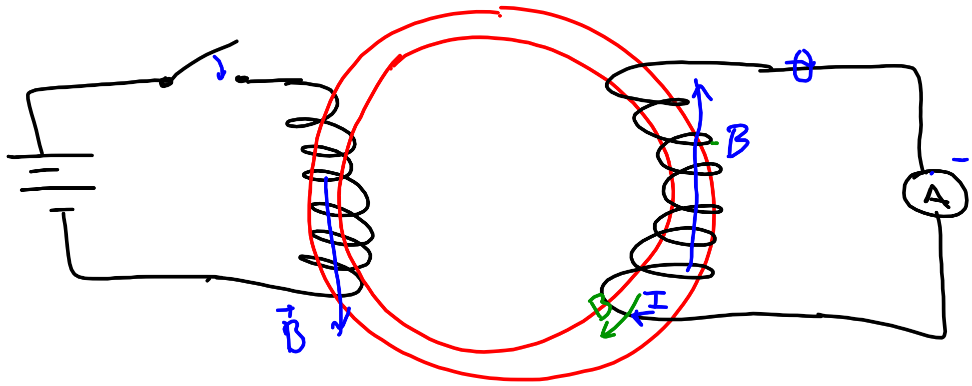
Generally $R \gg r$
so $V_T \approx \mathcal{E}$

$\mathcal{E} = I(R_T + r)$

R_T = resistance outside the battery

$V_T = I R_T$

Faraday's Experiment



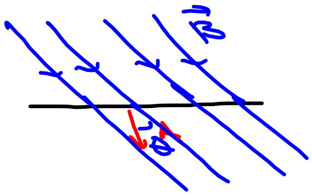
capital Φ (phi)

Magnetic Flux (Φ_B)

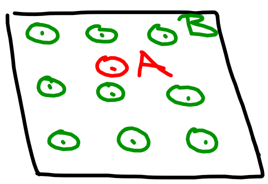
Def'n

$$\Phi_B = \vec{B} \cdot \vec{A} = B_{\parallel} A = BA\cos\theta$$

↑ angle between $\vec{B}$ and $\vec{A}$.



$\Phi = BA\cos\theta$



$\Phi = BA$

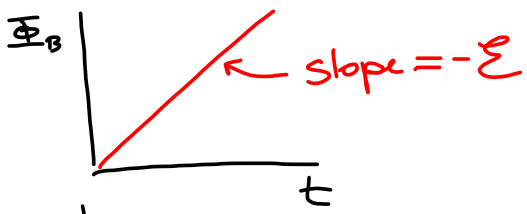
A measure of the # of field lines passing through a surface.

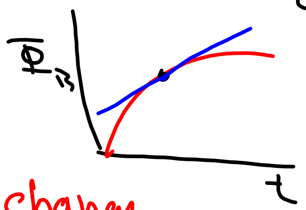
Faraday's Law and Lenz's Law

$\mathcal{E}$ must be induced to induce a current.

Lenz

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





The induced current must create a magnetic field that opposes the initial change.

(otherwise we get a continuously increasing current and a cons. of energy problem)