PHYS-1120 Chapter 27
Faraday's Law

Dawson Beatty

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Faraday showed that there's another way to make a magnetic field: A *changing* electric field makes a magnetic field.

EMF ε

Defined as a voltage difference, $\Delta V = Ed$. Think of it as a battery voltage.

$$\boxed{\varepsilon = \oint_{\mathcal{L}} \vec{E} \cdot \mathrm{d}\vec{l}}$$

Magnetic Flux $\Phi_{\mathbf{B}}$

$$\Phi_{\mathrm{B}} = \int_{\mathrm{S}} \vec{B} \cdot \mathrm{d}\vec{A} = \vec{B} \cdot \vec{A} = BA\cos\theta$$

The right two terms above are *only* true if B is constant, and A is flat.
Units: $[\Phi] = I \cdot m^2 =$ weber (Wb)

0.1 Faraday's Law

An induced emf (ε) is created by changing magnetic flux

$$\boxed{\varepsilon_{\mathrm{N\ loops}} = -N\frac{\mathrm{d}\Phi_{\mathrm{M}}}{\mathrm{dt}}}$$

B = constant $\Rightarrow \varepsilon = 0$ B is changing with time $\Rightarrow |\varepsilon| = \left|\frac{\mathrm{d}\Phi}{\mathrm{dt}}\right|$

Changing the Magnetic Flux

- Change B (increase or decrease magnitude of B-field)
- Change A (altering the shape of the loop)
- Change the angle θ between B and the vector A, (by rotating the loop)

Lenz's Law

States that the induced emf induces a current that flows in the direction which creates an induced B-field that *opposed the change* in flux. Lenz's law doesn't like change, wants to keep the status quo.

Eddy Currents

If a piece of metal and a B-field are in relative motion such that Φ changes through some loop within the metal, the changing Φ creates an emf which drives a current I. This is called an *Eddy current.* This current and the B-field will always cause a magnetic force to slow the motion of the metal.

$$\vec{F} = I\vec{L} \times \vec{B}$$