Electromagnetism

Electromagnetic Induction

Applications

Moving rod

$$BI\ell v = \varepsilon I \Rightarrow \varepsilon = B\ell v$$

A.C. Generator

$$\varepsilon_i = -\frac{d}{dt}(NBA\cos\omega t) = NBA\omega\sin\omega t = \varepsilon_0 \sin\omega t$$

D.C. Generator

$$\varepsilon_i = |-\frac{d}{dt}(NBA\cos\omega t)| = |NBA\omega\sin\omega t| = |\varepsilon_0 \sin\omega t|$$

Transformer

$$\frac{\varepsilon_s}{\varepsilon_p} = \frac{N_s}{N_p} = \frac{I_s}{I_p}$$

$$\eta = \frac{P_{out}}{P_{in}} \times 100\% = \frac{\varepsilon_s I_s}{\varepsilon_p I_p} \times 100\%$$

Faraday's Law

- Current is induces when a conductor meets a changing magnetic flux
- $I_i = \frac{\varepsilon_i}{R}$
- $\varepsilon_i = -\frac{d\Phi}{dt}$
- $\oint_{Closed\ Loop} \vec{E} \cdot \vec{d\ell} = -\frac{d}{dt}\int \vec{B} \cdot \vec{dA}$
- Kirchoff's Rule is when $\int \vec{B} \cdot \vec{dA} = 0$

Lenz's law

- Direction of induced emf is opposed to the change causing it
- Direction of induced current opposes the change producing it

Magnetic Field

Electromagnet

- Straight conductor
- Narrow coil
- Solenoid

Magnetic Field Strength

- A vector, S.I. unit: Tesla (T)
- $B = \frac{F_m}{I\ell}$

Narrow coil

$B = \frac{\mu_0 NI}{2r}$

Straight Conductor

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

Solenoid

$B = \mu_0 nI$

Magnetic Forces

Ampere Force

- $F_m = BI\ell sin\theta$
- Direction: $I \times B$

Lorentz Force

- $F_m = q(\vec{v} \times \vec{B}) = Bqvsin\theta$
- $r = \frac{mv}{Bq}$
- $T = \frac{2\pi m}{Bq}$ is independent of v
- For helix: $R = \frac{mvsin\theta}{Bq}$

Applications

- Mass Spectrometer
- Cyclotron

Magnetic flux

$$\phi = \int_{open\ surface} \vec{B} \cdot \vec{dA} = \vec{B} \cdot \vec{A}$$

Ampere's Law

$$\oint_{Closed\ Loop} \vec{B} \cdot \vec{d\ell} = \mu_0 (I_p + \varepsilon_0 \kappa \frac{d}{dt}\int_{Open\ Surface} \vec{E} \cdot \vec{dA})$$

Hall Effect

$$Bqv = qE_H = q(\frac{V_H}{d}) \Rightarrow V_H = Bvd$$