Electromagnetic waves

A. Karle
Physics 202
Nov. 2007

Note: These slides are not a complete representation of the lecture. Details are presented on whiteboard.

- Maxwell's equations, review
- Wave equation
- Electromagnetic waves
- Speed of em waves (light)
- Antenna, radio waves
- Electromagnetic spectrum

Demonstrations

- Radio emission from dipole transmitter,
  - Receiver with small light bulb
  - Length of antenna
  - Orientation and distance of receiving antenna
  - Magnetic loop antenna (with LC circuit)
- Microwave transmitter
  - Polarized waves get absorbed or reflected by grid when grid is oriented in direction of dipole.

Maxwell's Equations

$$\oint_S \vec{E} \cdot \vec{dA} = \frac{q}{\varepsilon_0}$$

- Gauss's law (electric)

$$\oint_S \vec{B} \cdot \vec{dA} = 0$$

- Gauss's law in Magnetism

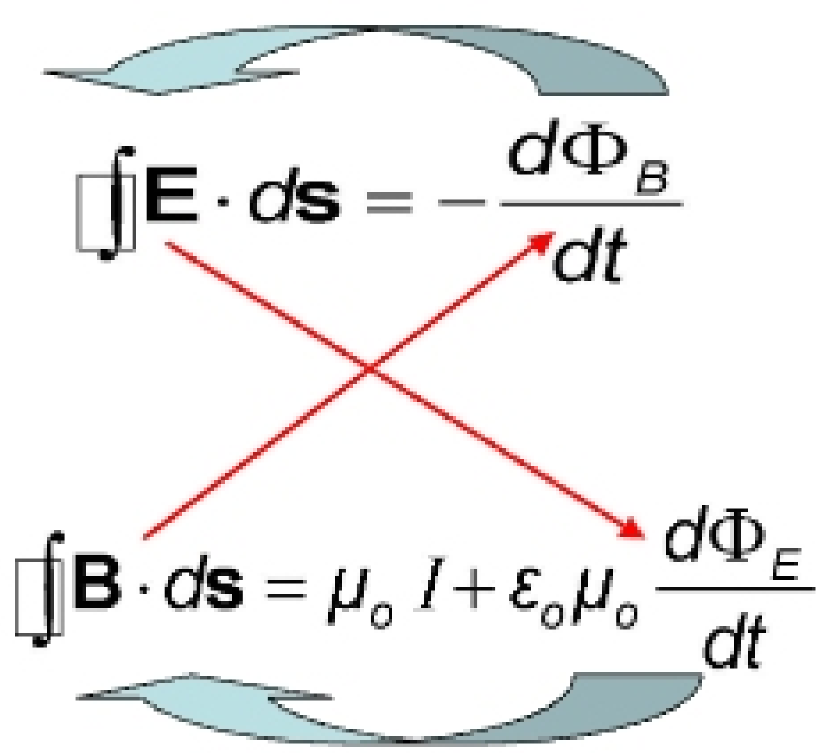
$$\oint \vec{E} \cdot \vec{ds} = -\frac{d\Phi_B}{dt}$$

- Faraday's Law

$$\oint \vec{B} \cdot \vec{ds} = \mu_0 I + \varepsilon_0 \mu_0 \frac{d\Phi_E}{dt}$$

- Ampere-Maxwell Law

Connections between Maxwell's equations:



Derivation of Speed – Some Details

- From Maxwell's equations applied to empty space, the following partial derivatives can be found:

$$\frac{\partial^2 E}{\partial x^2} = \mu_o \varepsilon_o \frac{\partial^2 E}{\partial t^2} \quad and \quad \frac{\partial^2 B}{\partial x^2} = \mu_o \varepsilon_o \frac{\partial^2 B}{\partial t^2}$$

- These are in the form of a general wave equation, with

$$v = c = \frac{1}{\sqrt{\mu_o \varepsilon_o}}$$

- Substituting the values for μ_o and ε_o gives c = 2.99792 x 10^8 m/s

E to B Ratio – Some Details

- The simplest solution to the partial differential equations is a sinusoidal wave:
  - $E = E_{max} \cos (kx - \omega t)$
  - $B = B_{max} \cos (kx - \omega t)$
- The angular wave number is $k = 2\pi/\lambda$
  - λ is the wavelength
- The angular frequency is $\omega = 2\pi f$
  - f is the wave frequency