Electromagnetic Fields and Waves

$\vec{E}_B = \vec{v}_{BA} \times \vec{B}_A$

Speed of light: $v_{em} = c = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$

Field Transformations

Fields measured in frame A to be $\vec{E}_A$ and $\vec{B}_A$ are found in frame B to be

$\vec{E}_B = \vec{E}_A + \vec{v}_{BA} \times \vec{B}_A$

$\vec{B} = \vec{B}_A - \frac{1}{c^2}\vec{v}_{BA} \times \vec{E}_A$

Maxwell's Equations

$$\int_{surface} \vec{E} \cdot d\vec{A} = \frac{Q_{in}}{\epsilon_0} \text{ Gauss's law}$$
$$\int_{surface} \vec{B} \cdot d\vec{A} = 0 \text{ Gauss's law for magnetism}$$
$$\int_{surface} \vec{E} \cdot d\vec{s} = -\frac{d\Phi_m}{dt} \text{ Faraday's law}$$
$$\int_{surface} \vec{B} \cdot d\vec{s} = \mu_0 I_{through} + \epsilon_0 \mu_0 \frac{d\Phi_e}{dt} \text{ Ampère-Maxwell law}$$

Other Equations

Lorentz force law: $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$

Wave equation: $\frac{\partial^2 E_y}{\partial t^2} = \frac{1}{\epsilon_0 \mu_0}\frac{\partial^2 E_y}{\partial x^2}$

Poynting vector: $\vec{S} = \frac{1}{\mu_0}\vec{E} \times \vec{B}$

Wave intensity: $I = \frac{c\epsilon_0}{2}E_0^2$

Classical intensity spread: $E = \frac{P_{source}}{4\pi r^2}$

Radiation Pressure $\Delta p = \frac{\text{energy absorbed}}{c} = \frac{I}{c}$

Single Slit

Intensity as a function of y:

$I = I_0 \frac{\sin^2(\frac{\pi a y}{\lambda D})}{(\frac{\pi a y}{\lambda D})^2}$

$I_{slit} = I_0 (\frac{\sin(\pi a \sin(\theta/\lambda))}{\pi a \sin(\theta/\lambda)})^2$

Dark fringes: $\theta_p = p\frac{\lambda}{a} \;\; p = 1, 2, 3, \ldots$

Positions of dark fringes: $y_p = \frac{p\lambda L}{a} \;\; p = 1, 2, 3, \ldots$

Width of central maximum: $w = \frac{2\lambda L}{a}$

Ray Optics

$\text{Angle of incidence} = \text{Angle of reflection}$

Pinhole Camera Relationship

$\frac{h_i}{h_0} = \frac{d_i}{d_0}$

Where i is image or box dimensions.

Snell's law of refraction

$n_1 \sin(\theta_1) = n_2 sin(\theta_2)$

Where θ is angle from normal and $n = \frac{c}{v_{medium}}$.

Critical angle for total internal reflection: $\theta_c = \sin^{-1}(\frac{n_2}{n_1})$

Incident light polarized: $I_{transmitted} = I_0 \cos^2(\theta)$

Unpolarized light transmitted: $I_{transmitted} = \frac{1}{2} I_0 \cos^2(\theta)$

Constants

Elementary Charge: $e = 1.602 \times 10^{-19} C$

Mass of Electron: $m = 9.109 \times 10^{-31} kg$

Mass of Proton: $m = 1.672 \times 10^{-27}$

Vacuum Permittivity: $\epsilon_0 = 8.854 \times 10^{-12}$

Coulomb Constant $k = 9.0 \times 10^9 \frac{Nm^2}{C^2}$

Vacuum Permittivity Magnetism: $\mu_0 = 4\pi \times 10^{-7}$

Thin Lens

$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$

s is the

Focal length equation

$\frac{1}{f} = (n-1)(\frac{1}{R_1} - \frac{1}{R_2})$

Magnification

$m = -\frac{s'}{s}$

(m is + for upright)

Interference

Double Slit

Angles of bright fringes: $\theta_m = m\frac{\lambda}{d} \quad m = 0, 1, 2, 3, \ldots$

Position of fringes: $y_m = \frac{m\lambda L}{d} \quad m = 0, 1, 2, 3, \ldots$

Ideal double slit pattern: $I_{double} = 4I_1 \cos^2(\frac{\pi d}{\lambda L} y)$

Complete intensity: $I_{double} = I_0 (\frac{\sin(\pi a y/\lambda L)}{\pi a y/\lambda L})^2 \cos^2(\pi d y/\lambda L)$

Diffraction Grating

Bright and narrow fringes are at:

$d \sin(\theta)_m = m\lambda$

$y_m = L \tan(\theta)_m$