

University Physics 2

Alvin Lin

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Optics

Maxwell's Equations

Gauss's Law:

$$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{enc}}{\epsilon_0}$$

Magnetic Flux:

$$\oint \vec{B} \cdot d\vec{A} = 0$$

Faraday's Law:

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

Ampere's Law:

$$\oint \vec{B} \cdot d\vec{l} = \mu_0(I_{enc} + \epsilon_0 \frac{d\Phi_E}{dt})$$

Electric fields can be created by a time varying magnetic field and vice versa. This is usually created by accelerating charge, which is usually oscillatory or circular. We can find that Maxwell's equations satisfy the wave equation:

$$\frac{d^2 f(x, t)}{dx^2} = \frac{1}{v^2} \frac{d^2 f(x, t)}{dt^2}$$

When solve the wave equation, we find that:

$$v_o = \frac{1}{\sqrt{\epsilon_0 \mu_0}} = 3 \times 10^8 \frac{m}{s} = c$$

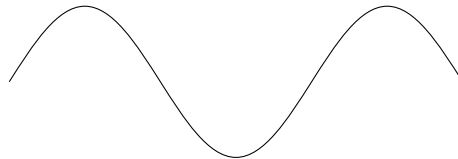
Light is an electromagnetic wave. Key properties:

- Electromagnetic waves are transverse. $\vec{s} = \frac{1}{\mu_0} \vec{E} \times \vec{B}$
- $E_{max} = cB_{max}$
- The speed of light is constant (within a material).
- No transmission medium is required for electromagnetic waves. When it is not traveling in a vacuum:

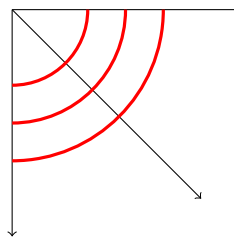
$$\begin{aligned}
 \epsilon_0 &\rightarrow \epsilon \\
 \mu_0 &\rightarrow \mu \\
 v &= \frac{1}{\sqrt{\epsilon\mu}} \\
 &= \frac{1}{\sqrt{\kappa\epsilon_0 \cdot \kappa\mu_0}} \\
 &= \frac{1}{\sqrt{\epsilon_0\mu_0}} \frac{1}{\sqrt{\kappa\kappa\mu}} \\
 &= \frac{c}{n}
 \end{aligned}$$

where n is the index of refraction.

Properties of Waves

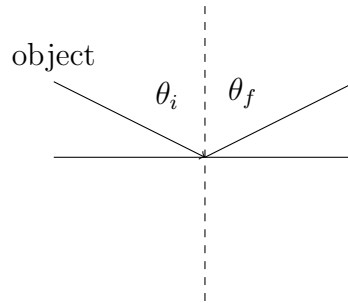


Waves in Optics



The direction of the arrows determine the direction of propagation.

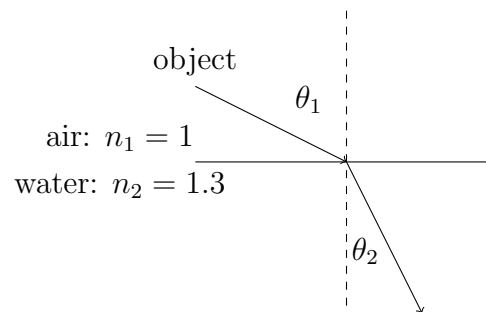
Reflection



$$\theta_i = \theta_f$$

You always see objects as if your line of sight never deviated.

Refraction



Snell's Law:

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

You can find all my notes at <http://omgimanerd.tech/notes>. If you have any questions, comments, or concerns, please contact me at alvin@omgimanerd.tech