University Physics 2

Alvin Lin

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Optics

Maxwell's Equations

Gauss's Law:

$$\oint \vec{E} \cdot \,\mathrm{d}\vec{A} = \frac{Q_{enc}}{\epsilon_\circ}$$

Magnetic Flux:

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

Faraday's Law:

$$\oint \vec{E} \cdot \,\mathrm{d}\vec{l} = -\frac{\mathrm{d}\Phi_B}{\mathrm{d}t}$$

Ampere's Law:

$$\oint \vec{B} \cdot \,\mathrm{d}\vec{l} = \mu_\circ(I_{enc} + \epsilon_\circ\frac{\mathrm{d}\Phi_E}{\mathrm{d}t})$$

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:

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

When solve the wave equation, we find that:

$$v_\circ = \frac{1}{\sqrt{\epsilon_\circ\mu_\circ}} = 3 \times 10^8 \frac{m}{s} = c$$

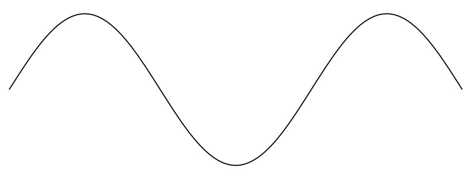
Light is an electromagnetic wave. Key properties:

- Electromagnetic waves are transverse. $\vec{s} = \frac{1}{\mu_\circ}\vec{E} \times \vec{B}$
- $E_{max} = cB_{max}$
- 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:

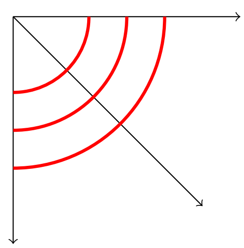
$$\begin{aligned}
\epsilon_\circ &\to \epsilon \\
\mu_\circ &\to \mu \\
v &= \frac{1}{\sqrt{\epsilon\mu}} \\
&= \frac{1}{\sqrt{\kappa\epsilon_\circ \cdot \kappa_\mu \mu_\circ}} \\
&= \frac{1}{\sqrt{\epsilon_\circ\mu_\circ}}\frac{1}{\sqrt{\kappa\kappa_\mu}} \\
&= \frac{c}{n}
\end{aligned}$$

where n is the index of refraction.

Properties of Waves

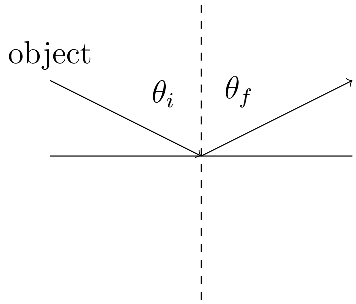


Waves in Optics



The direction of the arrows determine the direction of propagation.

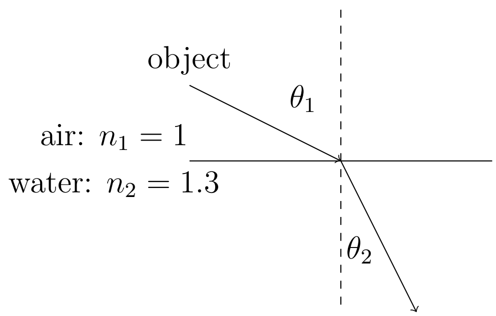
Reflection



$$\theta_i = \theta_f$$

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

Refraction

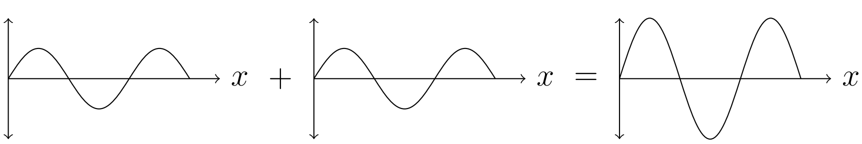


Snell's Law:

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

Interference

Interference is the interaction of multiple waves.



Interference works if the two waves have the same λ and have a constant phase relationship. For constructive interference:

$$\Delta r = r_A - r_B = m\lambda$$

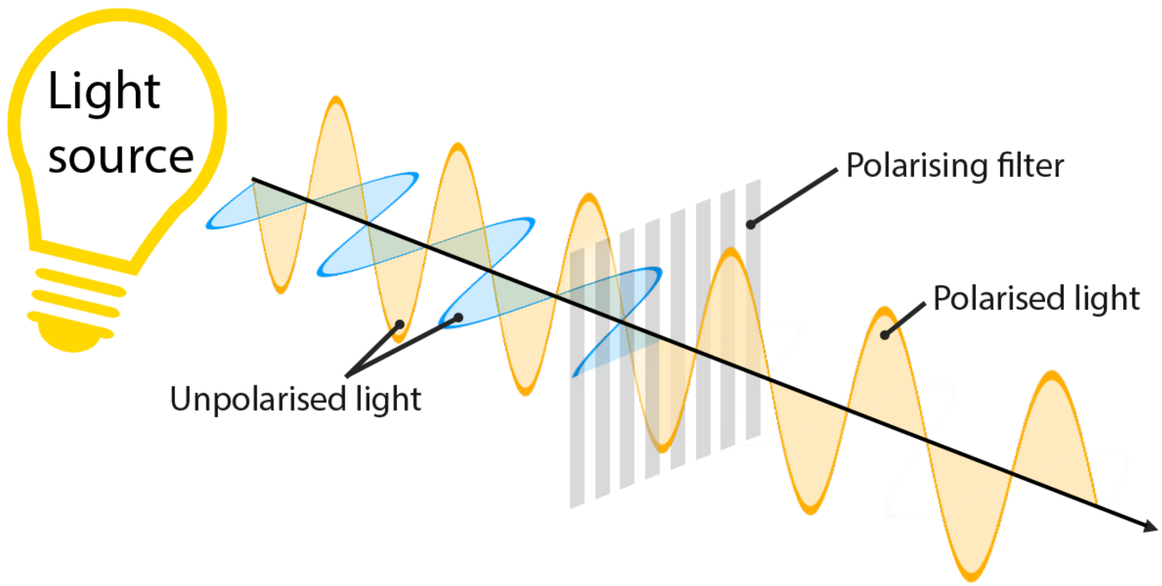
For destructive interference:

$$\Delta r = r_A - r_B = (m + \frac{1}{2})\lambda$$

With light, it is hard to get two coherent sources. Instead, we use a single light source and split it up using a thin film or partially reflective mirror.

Polarization

Polarization is the axis on which a wave oscillates.



We define the polarization of light as the polarization of light as the polarization of the electric field, without regard to the perpendicular magnetic field. Polarizers only let through light which is oriented according to the polarizer's angle of polarization. Polarized light will have an intensity relative to the unpolarized light according to the following equation:

$$I = \frac{I_\circ}{2}$$

When you have polarized light passing through a polarized filter:

$$I = I_\circ \cos^2(\phi)$$

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