

Light

**Transverse
electromagnetic waves
that have a constant
speed in space**

Light

- Transverse electromagnetic waves
- Electric field component and magnetic field component are in phase at perpendicular to each other.
- No medium required.
- Light can travel through space.
- Speed of light = 3.0×10^8 m/s
- Light slows down in denser media

Sources of Light

- Black Body Radiation = hot objects glow
 - Example: the sun
- Accelerating Electrons
 - Example: radio wave transmits have accelerating electrons in the antenna
- Excited Electrons
 - Example: energetic electrons are in higher energy levels and eventually fall back down emitting light

Electromagnetic Spectrum

- Gamma rays: $10^{20} - 10^{21}$ Hertz
- X-rays: $10^{17} - 10^{20}$ Hertz
- Ultraviolet rays: $10^{15} - 10^{18}$ Hertz
- Visible Light: $3.84 \times 10^{14} - 7.7 \times 10^{14}$ Hertz
- Infrared Light: $10^{12} - 10^{14}$ Hertz
- Microwaves: $10^9 - 10^{12}$ Hertz
- FM: $10^8 - 10^9$ Hertz
- AM: 10^6 Hertz

Light is a Periodic Wave

- Reflection (incident angle = reflected angle)
- Diffraction (single slit experiment)
- Refraction (bent due to change in speed but frequency is constant)
- Interference (double slit experiment)
- Doppler Effect

Reflection

- The angle of incidence is equal to the angle of reflection.
- N.B.: the angle of incidence is between the incoming ray and the perpendicular to the surface; the angle of reflection is between the reflected ray and the perpendicular to the surface

Diffraction

- Light, as a wave, spread out.
- Given a barrier with a small opening, if the opening is approximately the same size as the wavelength of the incoming wave, the waves will “fan” out past the opening

Refraction

- Light is bent when it passes from one medium into another medium.
- Refractive index $n = c/v = (3 \times 10^8 \text{ m/s})/v$
- N.B. Light slows down in denser media.
- The Law of Refraction = Snell's Law
- $n_1 \sin(\text{incident angle}) = n_2 \sin(\text{refracted angle})$

Interference

- Young's Double slit Experiment (1801): Light from the sun falls on a barrier with two closely spaced slits. Young saw a series of bright lines. When light as a wave is in phase, its crests "superpose" ("add"). The place of maximum constructive interference is at the antinode. The place of maximum destructive interference is at the node.

Doppler Effect

- Light from sources moving away from us appears to have fewer waves and so its frequency is apparently less (red-shifted).
- Example: The Big Bang occurred 13.7 billion years ago. Galaxies from the expanding universe are traveling away from us and their light finally reaching us is red-shifted to lower frequencies.

Example of Snell's Law

- A ray of light is incident on a surface boundary between air and corn oil at an angle of 60 degrees to the normal. Calculate the refracted angle of the ray in the corn oil.
- $n_1 \sin(\text{incident angle}) = n_2 \sin(\text{refracted angle})$
- $1 \times \sin(60) = 1.47 \times \sin(\text{refracted angle})$
- $0.59 = \sin(\text{refracted angle})$
- Refracted angle = $\arcsin(0.59) = 36$ degrees.

Group Activity

- Determine the angle of refraction for a ray of light on a surface boundary between air and each of the following media at an angle of 60 degrees to the normal. Calculate the angle of refraction.
- 1. water ($n = 1.33$)
- 2. ethyl alcohol ($n = 1.36$)
- 3. glycerol ($n = 1.47$)
- 4. Lucite ($n = 1.50$)
- 5. diamond ($n = 2.42$)