Physics 30
Electromagnetic Radiation - Optics

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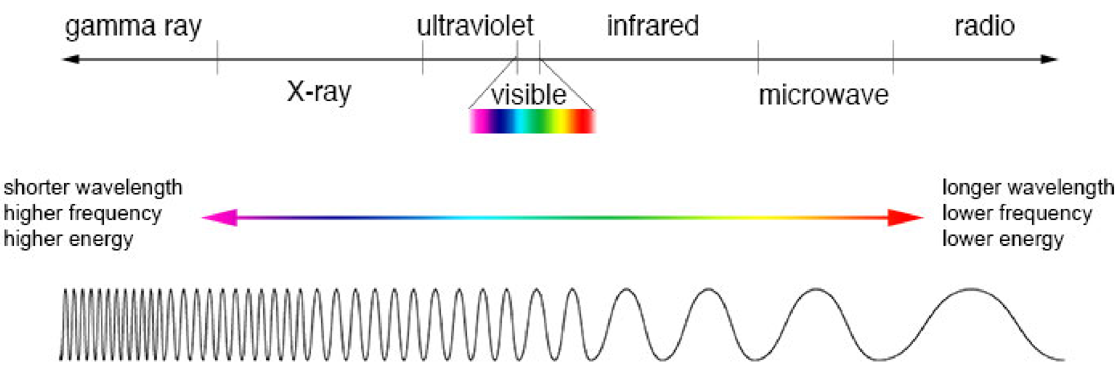
Unfinished!

Contents

Electromagnetic Spectrum

Figure 1: "Cosmic" rays on the left of gamma



- ALL EMR travels at the speed of light. ($c = 3.00 \times 10^8\,\frac{\text{m}}{\text{s}}$)
- Memorize the visible spectrum wavelength range
  - 400 nm to 750 nm
  - 400×10^{-9} m to 750×10^{-9} m

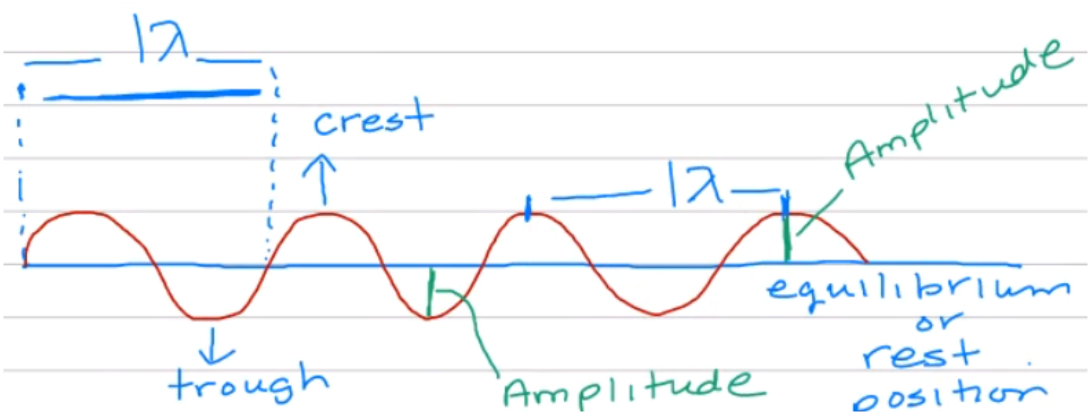
Universal Wave Equation

$$v = f\lambda$$

- v = speed ($\frac{\text{m}}{\text{s}}$)
- f = frequency (Hz)
- λ = wavelength (m) (often given in nanometers, $100\,\text{nm} = 100 \times 10^{-9}\,\text{m}$)

Speed of light: $c = f\lambda$

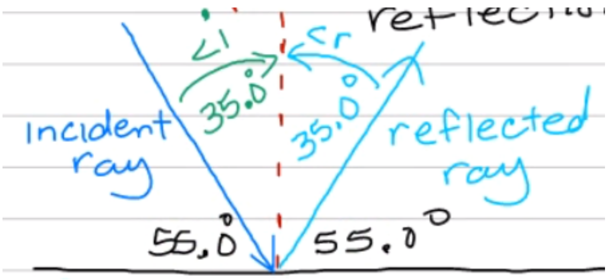
Transverse Wave



- **Crest**: peak of wave
- **Trough**: depression of wave
- **Amplitude**: the maximum displacement from the equilibrium position

Law of Reflection

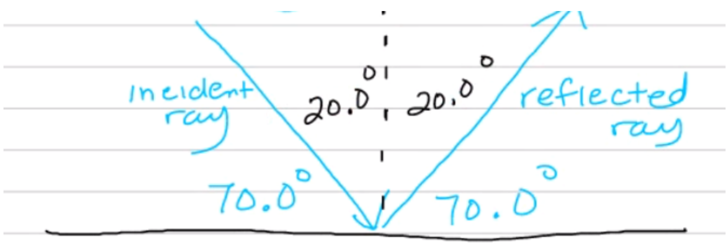
$$\angle I = \angle R$$



- $\angle I$: **Angle of Incidence**
  Measured from the light ray to the normal
- $\angle R$: **Angle of Reflection**
  Measured from reflected ray to normal
- **Normal**
  - Perpendicular to the surface
  - Broken/dotted line
  - Drawn from where the incident ray contacts the mirror surface

Example

A light ray strikes a flat mirror at an angle of 70.0° to the mirror surface. What is the angle of reflection? What is the angle between the incident ray and the reflected ray?



$\angle r = 20.0°$

40.0° = the angle between the incident ray and the refected ray.

Refraction

The bending of a wave when entering a new medium at an angle.

- n: Index of Refraction (air is $n = 1.00$)
- When a light ray travels from a lower n-value medium to a greater n-value medium, the light ray will bend toward the normal

Snell's Law

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

Use to calculate the new angle in a different medium/n value.

$$\frac{n_2}{n_1} = \frac{\sin \theta_1}{\sin \theta_2} = \frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2}$$

Frequency

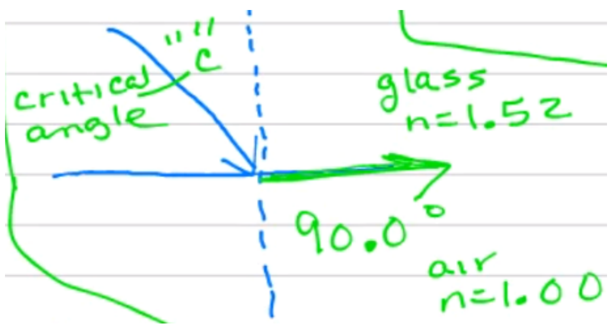
Frequency is unaffected by medium.

Frequency can only be changed at the source.

Critical Angle

Two conditions must be met for a critical angle.

- The light must travel from a greater n-value to a lesser n-value
- The angle of refraction must be 90.0°



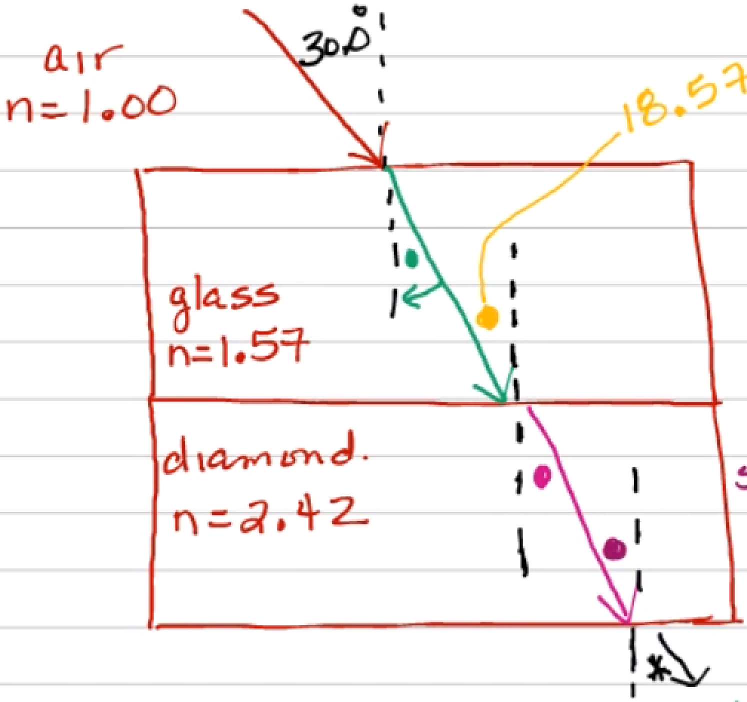
Total Internal Reflection

If the angle of incidence is greater than the critical value, then the ray will reflect instead of refract.

Trying to calculate this angle with Snell's Law will error.

Examples

Parallelogram



$\frac{n_2}{n_1} = \frac{\sin\theta_1}{\sin\theta_2}$

$\sin\theta_2 = \frac{n_1 \sin\theta_1}{n_2}$

$\sin\theta_2 = \frac{2.42 \times \sin 11.9°}{1.00}$

$\theta_2 = 30.0°$

n=1.00
air

Calculate the angle the light leaves the diamond with

$\frac{n_2}{n_1} = \frac{\sin\theta_1}{\sin\theta_2}$

$\sin\theta_2 = \frac{n_1 \sin\theta_1}{n_2}$

$\sin\theta_2 = \frac{1.00 \times \sin 30.0°}{1.57}$

$\theta_2 = \angle R = 18.57050303°$

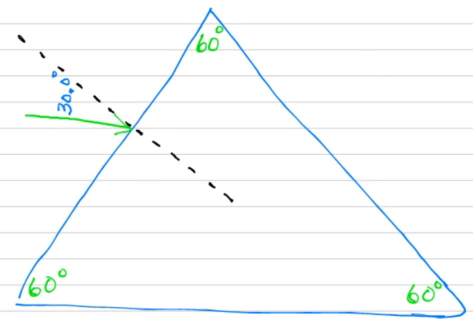
$\frac{n_2}{n_1} = \frac{\sin\theta_1}{\sin\theta_2}$

$\sin\theta_2 = \frac{n_1 \sin\theta_1}{n_2} = \frac{1.57 \times \sin 18.57}{2.42}$

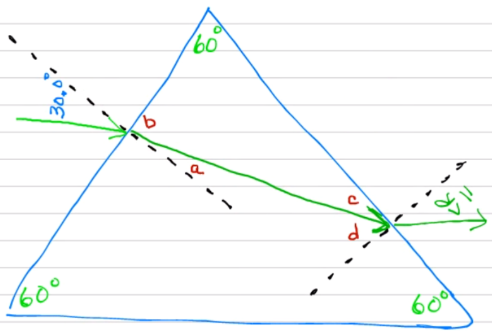
$\theta_2 = 11.92385513°$

Equilateral Triangle

Angle of incidence = 30.0°
$n_{glass} = 1.52$
Equilateral Triangle
Refraction in a Triangular Prism.



Calculate the angle the light ray leaves the PRISM with.



(a)

$$\frac{n_2}{n_1} = \frac{\sin\theta_1}{\sin\theta_2}$$

$$\sin\theta_2 = \frac{n_1 \sin\theta_1}{n_2}$$

$$\sin\theta_2 = \frac{1.00 \times 30.0^\circ}{1.52}$$

$$\theta_2 = 19.2048975^\circ$$

(b) We know the normal is ⊥ to the surface

$\therefore\ 90^\circ - 19.2048975^\circ = $ "b"

$b = 70.7951025^\circ$

(c) The sum of the angles of a $\Delta = 180^\circ$

$180^\circ - 70.7951025^\circ - 60^\circ = c$

$\angle c = 49.2048975^\circ$

(d) The normal is ⊥ to the surface.

$\therefore\ 90^\circ - c = d$

$90^\circ - 49.2048975^\circ = 40.7951025^\circ$

$\angle d = 40.7951025^\circ$

$$\theta = 83.3^\circ$$