Refraction

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What is Refraction?

- The bending of light as it passes at an angle from one medium to another.
- Occurs because the speed of light changes in different mediums.
- The amount of bend is related to the wavelength of the light, therefore different colors will be bent different amounts.
- Violet bends the most. Red the least.

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Optical Density

- A property of a transparent medium that describes the speed at which light travels through it.
- The larger the optical density, or the more optically dense a material is, the slower light travels through the material

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Index of Refraction (n)

- Based on the speed of light in the medium.
- Ratio of the speed of light in a vacuum (c) to the speed of light in a medium (v).

$$n = \frac{c}{v}$$

- As the index of refraction increases the speed of light decreases
- n_{air}= 1.0003 n_{water}= 1.33

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Example Problem

- **A ray of light passes through a boundary between air and an unknown substance. The ray slows down to a speed of 1.24×10^8 m/s. What is the index of refraction of the unknown substance? What is the substance? (Table 17-1 on p.397)**

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Example Problem (cont.)

$$n = \frac{c}{v}$$

$$n = \frac{3 \times 10^8 \text{ m/s}}{1.24 \times 10^8 \text{ m/s}}$$

$$n = 2.42$$

Answer: 2.42, Diamond

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Example Problem

- **What is the speed of light in a sapphire? (n = 1.77)**

$n = \frac{c}{v}$

$1.77 = \frac{3 \times 10^8 \text{ m/s}}{v}$

$\frac{1.77v}{1.77} = \frac{3 \times 10^8 \text{ m/s}}{1.77}$

$v = 1.69 \times 10^8 \text{ m/s}$

Answer: 1.69 x 10^8 m/s

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Laws of Refraction

- **1st Law**
  - **All rays and normal line lie in the same geometric plane**
- **2nd Law**
  - **The index of refraction in a homogeneous medium (medium is the same throughout) is constant**
- **3rd Law**
  - **Lower to higher optical density => bends towards normal**
  - **Higher to lower optical density => bends away from normal**

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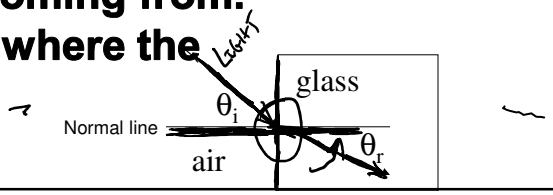
Snell's Law

- **When light travels from one medium to another, the indices of refraction are related in the following equation**

$$n_i \sin\theta_i = n_r \sin\theta_r$$

- **The "i" side of the equation refers to where the light is coming from. The "r" side refers to where the light is going to.**



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Sample Problem

- **Light is incident on water at an angle of 32^0. What is the angle of refraction as the light travels into the water?**

$n_i = 1.0003$ $\quad n_r = 1.33$

$\theta_i = 32^0$ $\quad \theta_r =$

$n_i \sin\theta_i = n_r \sin\theta_r$

$\frac{1.0003 \sin 32^0}{1.33} = \frac{1.33 \sin\theta_r}{1.33}$

$.399 = \sin\theta_r$

$\sin^{-1}(.399) = \theta_r = 23.5$

Answer: 23.5^0

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Sample Problem 2

- **Light passes through a 2 inch thick piece of glass (n = 1.55) into water. The angle in the water is 47^0. What is the angle of incidence in the glass?**

$n_i = 1.55$ $\quad n_r = 1.33$

$\theta_i =$ $\quad \theta_r = 47^\circ$

$$\frac{1.55 \sin\theta_i}{1.55} = \frac{1.33 \sin 47^\circ}{1.55}$$

$$\sin\theta_i = .628$$

$$\theta_i = \sin^{-1}(.628) = 38.9^\circ$$

Answer: 38.9^0

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