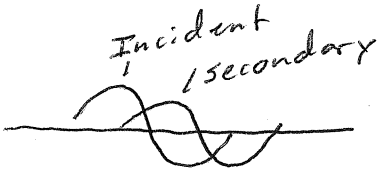
Refraction

- light passing into a medium from a different medium or vacuum.

- Atomic resonant frequencies determines the speed of refracted light.

* Incident Frequency < Resonant Frequency

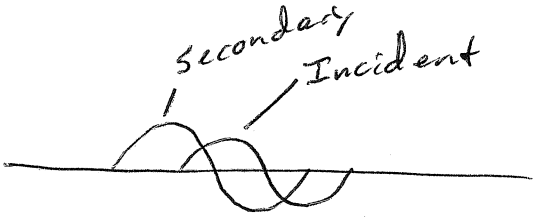
Secondary wave lags incident



Note: f is constant

* Incident Frequency > Resonant Frequency

Secondary wave leads



Note: f is constant

Refracted Wave is the Superposition of secondary and incident wave.

Refracted Wave has a different λ as a result of the superposition of incident and secondary waves.

Index of Refraction (n)

- measure of optical density of a medium

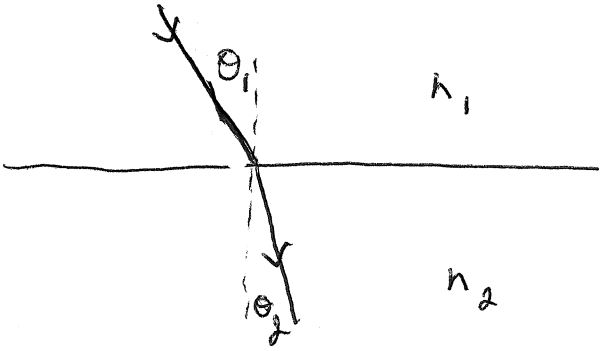
$$n = \frac{c}{v}$$

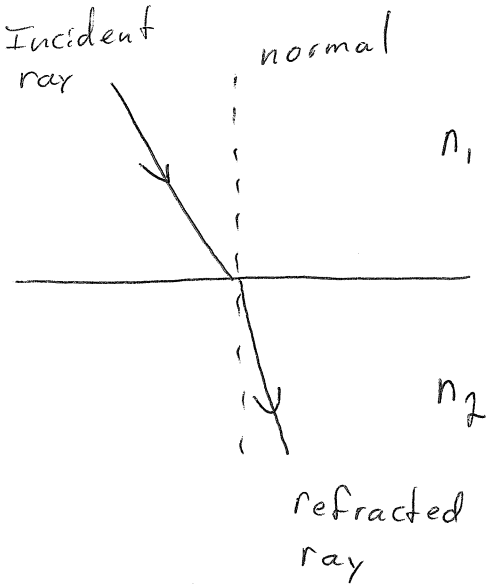
v = velocity in medium

c = velocity in vacuum

Snell's Law

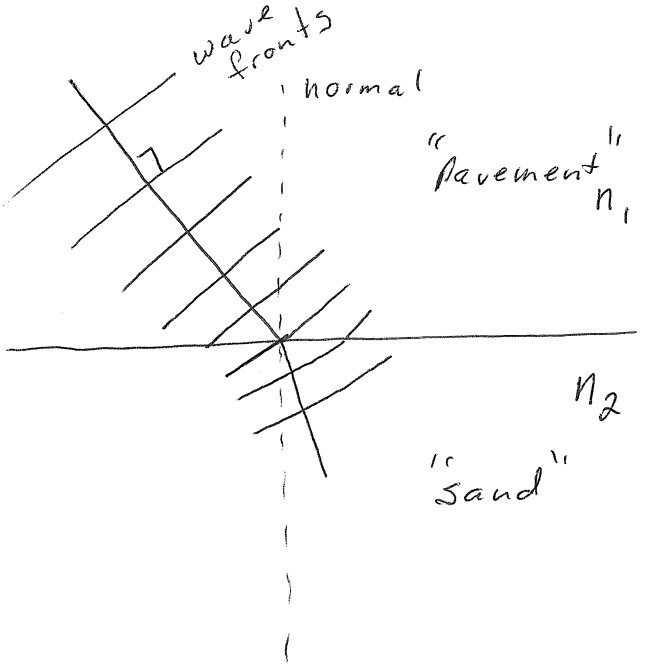
$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} \quad \text{or} \quad n_1 \sin\theta_1 = n_2 \sin\theta_2$$



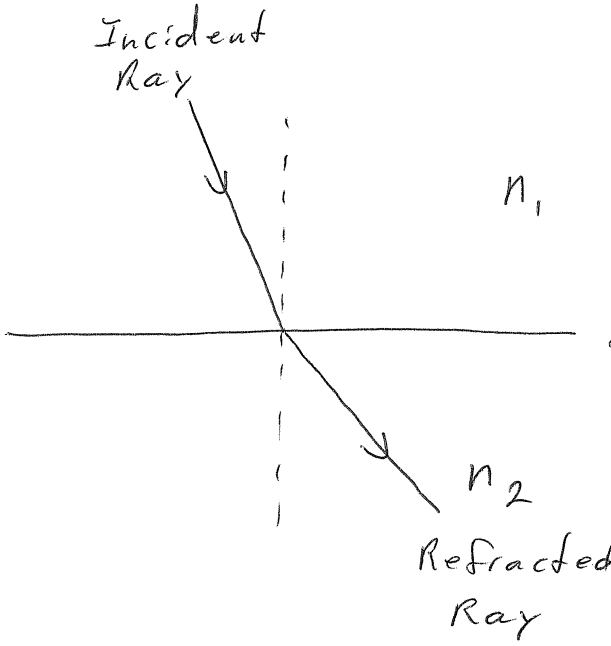


$n_1 < n_2$

* refracted ray bends toward normal

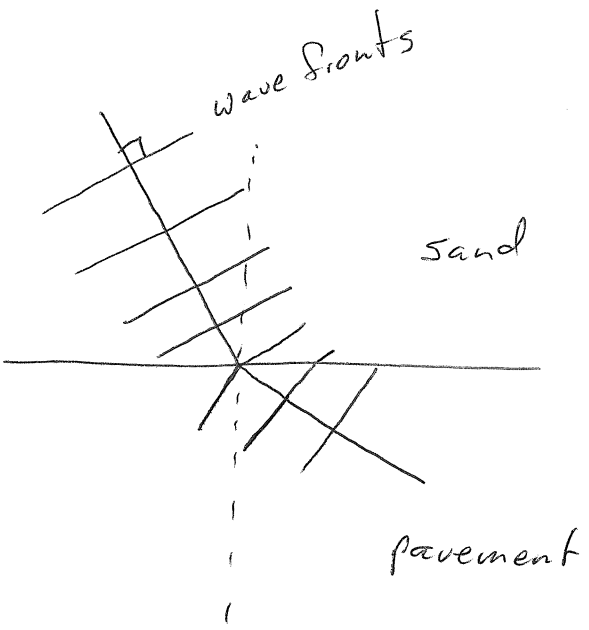


Think of successive wave fronts as lines in a marching band. The band can't move as easily in sand, so it slows down.



$n_1 > n_2$

* refracted ray bends away from normal



The band can speed up as it enters the pavement.

Since light is observed to travel slower in a medium, it must also change wavelength.

$$v = f\lambda$$

frequency is the defining characteristic of electromagnetic radiation.

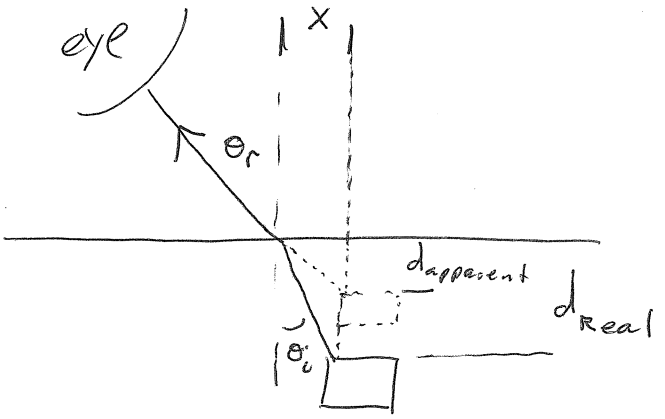
- determines color - (for visible light)
- determines classification and energy for all electromagnetic waves.

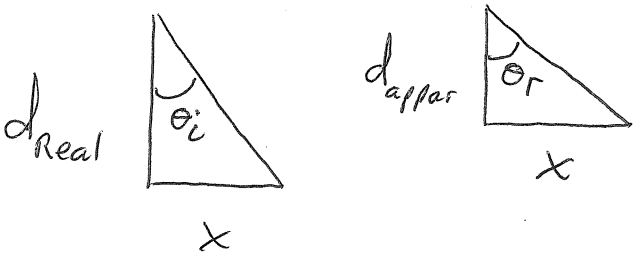
Special Case for Snell's Law

When the distance between observer and object is small,

$$\sin\theta_i \sim \tan\theta_i = \frac{x}{d_{Real}}$$

$$\sin\theta_r \sim \tan\theta_r = \frac{x}{d_{apparent}}$$





$$\text{Tan}\,\theta_i = \frac{x}{d_R} \qquad \text{Tan}\,\theta_r = \frac{x}{d_A}$$

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

$$n_i\left(\frac{x}{d_R}\right) = n_r\left(\frac{x}{d_A}\right)$$

$$\frac{n_i}{d_R} = \frac{n_r}{d_A}$$

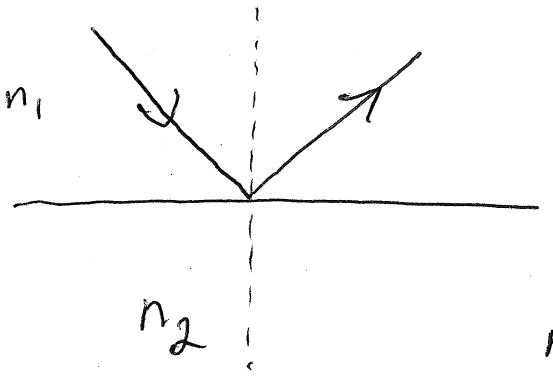
* Special case for small angles.

Total Internal Reflection

Total Internal Reflection

- occurs when light is reflected back into a medium at a boundary.

$n_1 > n_2$ must be satisfied



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

$$\theta_2 = 90^\circ$$

$$n_1 \sin\theta_1 = n_2$$

$$\theta_1 = \sin^{-1}\left(\frac{n_2}{n_1}\right)$$

↑
critical angle

As long as $\theta_1 > \theta_c$, light will be internally reflected.