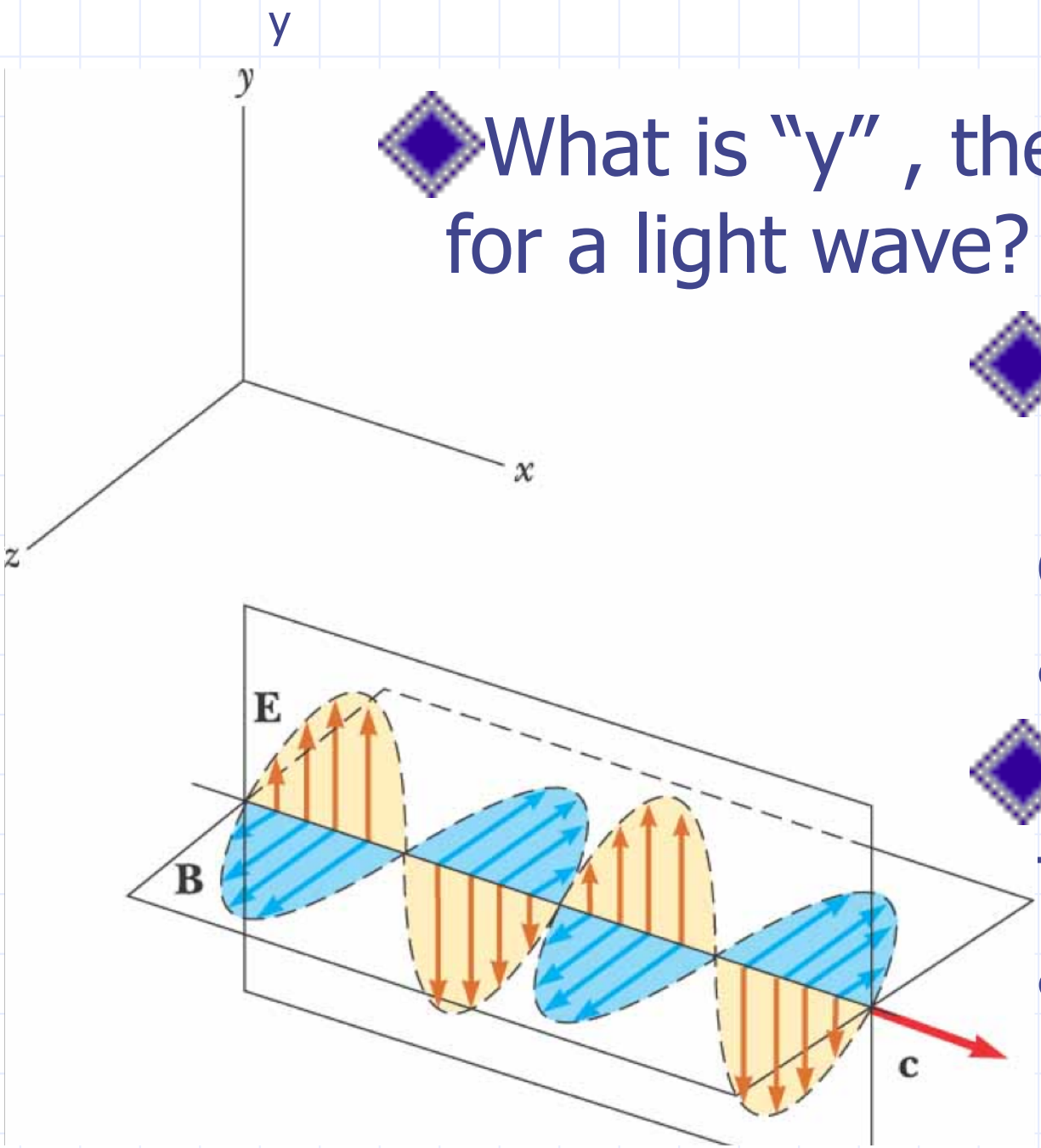
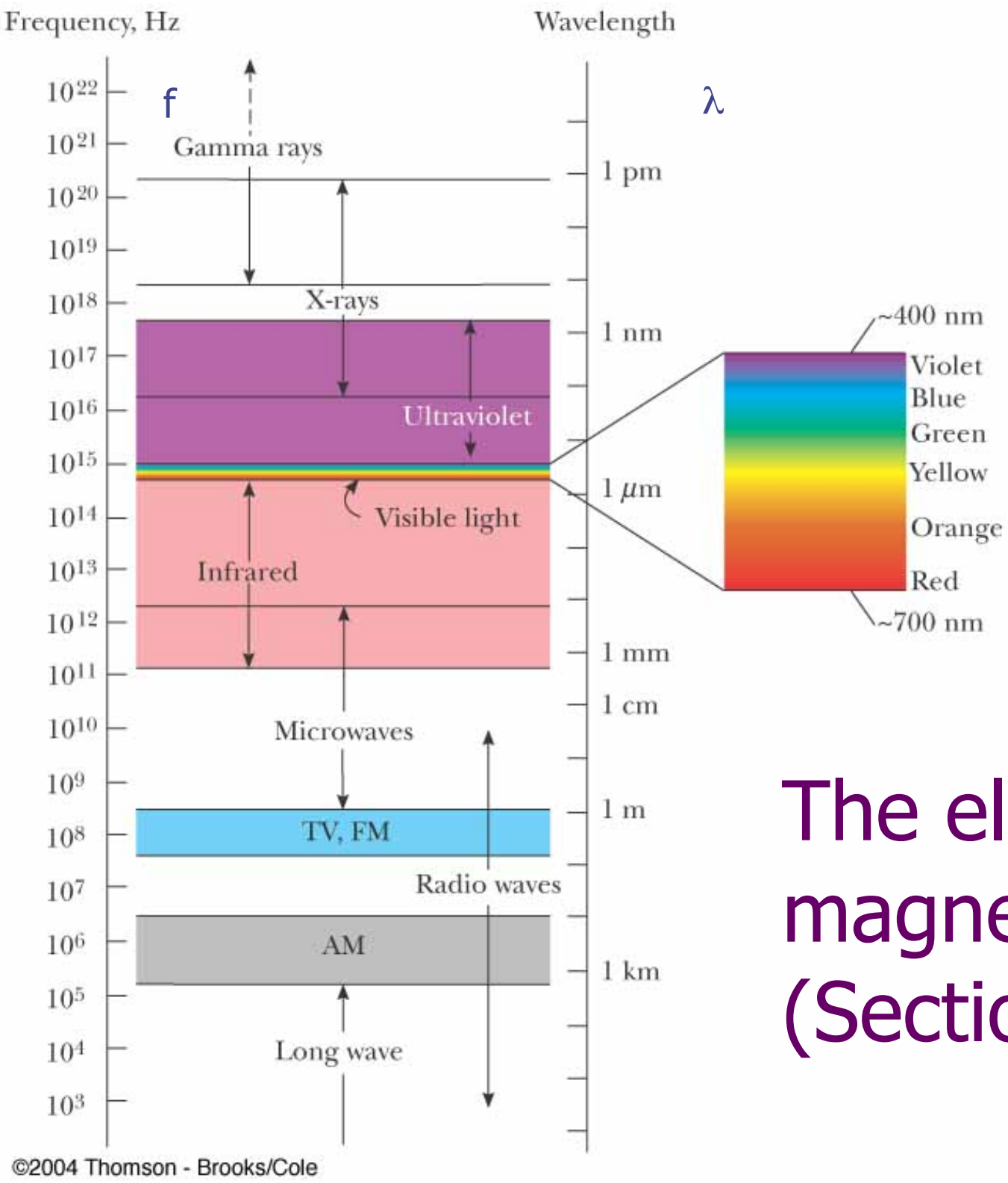
Chapter 23. Geometric Optics

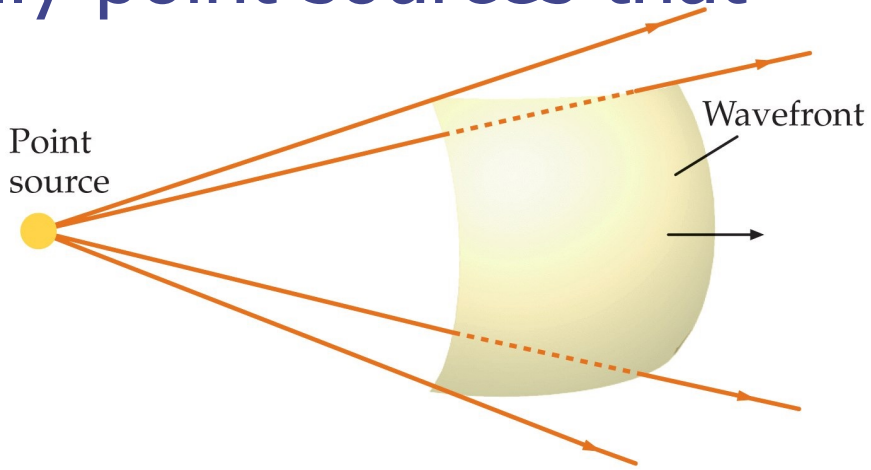


- What is "y" , the magnitude, for a light wave?
  - The wave magnitude is the oscillating electric and magnetic field
  - We take the wave to move at speed c along the x-axis

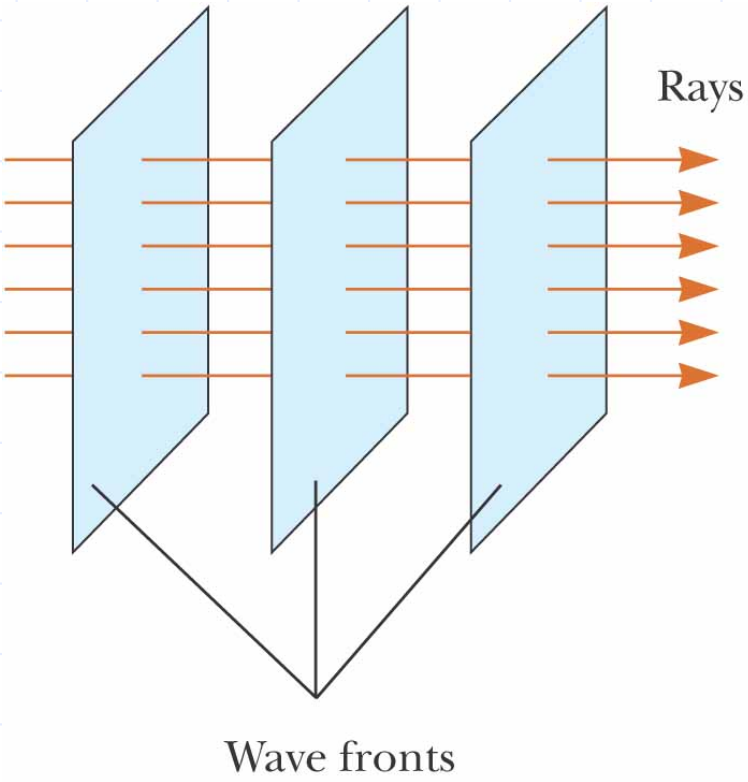


The electro-magnetic spectrum (Section 23.4)

- What is optics? The study of how light behaves as it encounters different media during its propagation
- Why study optics? We can understand how many things work: the eye, glasses, cameras, telescopes, …, the effects at Disney's Haunted Mansion, …
- Light sources are generally point sources that emit spherical waves

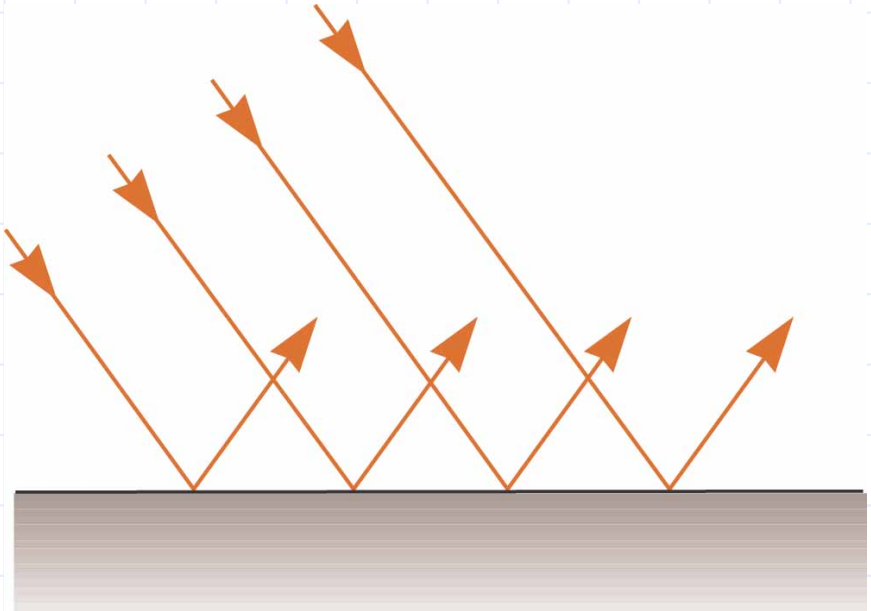


- A wave front is a point on the wave (peak or trough) that propagates at speed c with the wave
- A ray defines the direction of the wave and is perpendicular to the wave front
- We adopt the **ray approximation** which assumes that the wave moves through a medium in a straight line in the direction of the rays
- At a sufficiently far distance from the source, a spherical wave can be approximated as a plane wave



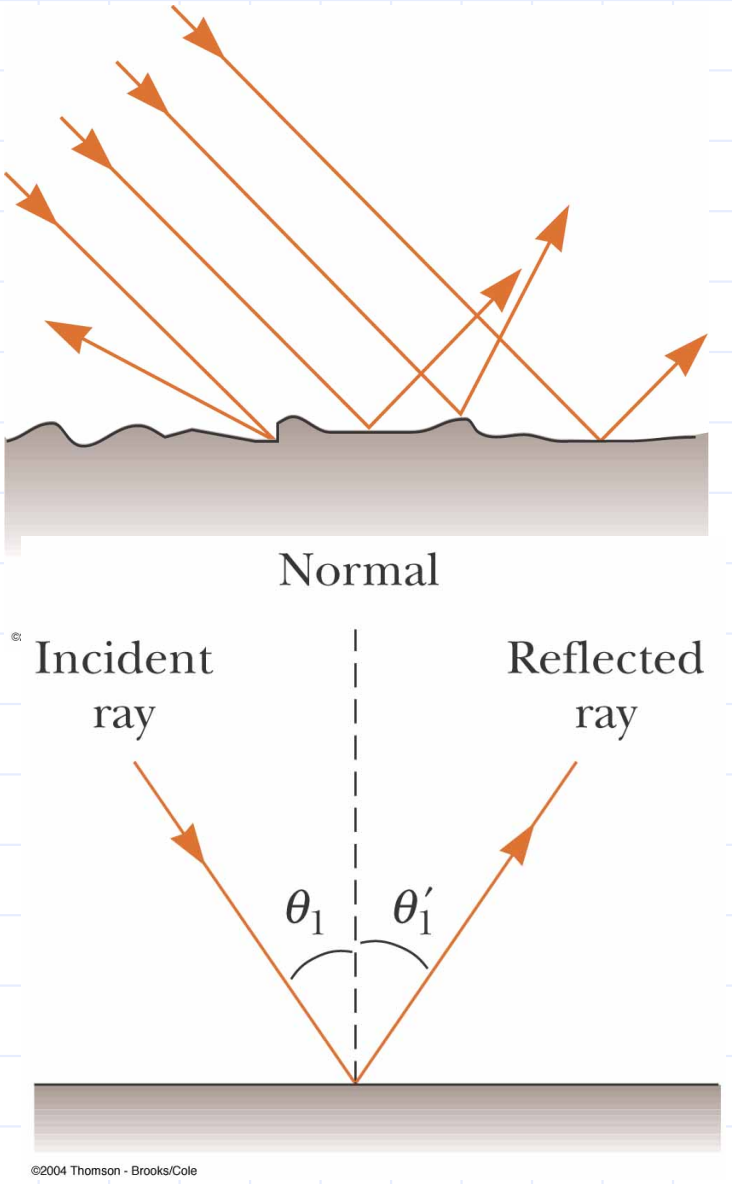
Law of Reflection

- Consider light (here a plane wave illustrated by a number of rays) striking a reflective surface
- If the surface is smooth, the rays will "bounce" off of the surface in a "orderly" manner
  - specular reflection

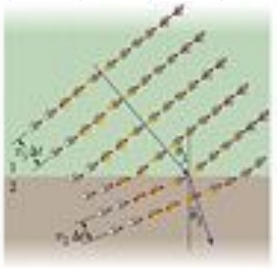


- If the surface is rough, the rays will reflect in random directions – diffuse reflection
  - We will mostly consider smooth surfaces
  - It turns out for smooth surfaces that the angle of reflection equals the angle of incidence – the law of reflection

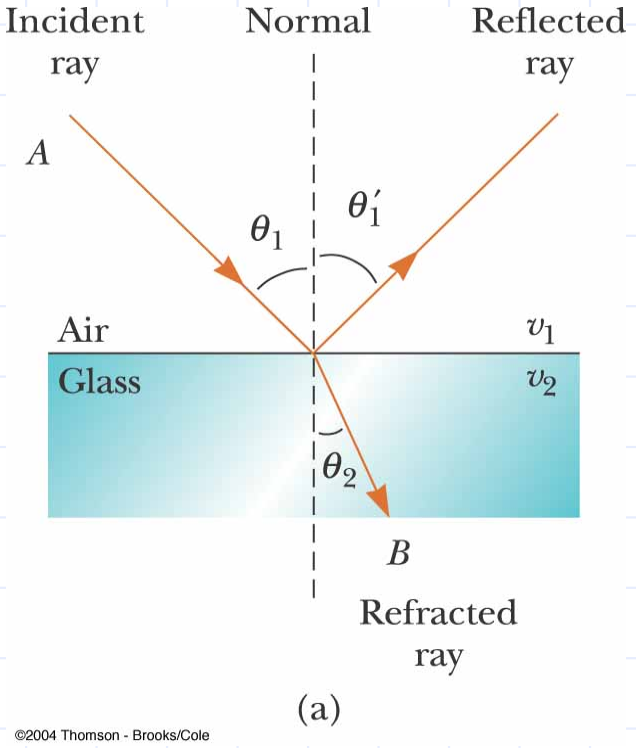
$$\theta_1' = \theta_1$$



Snell's Law of Refraction

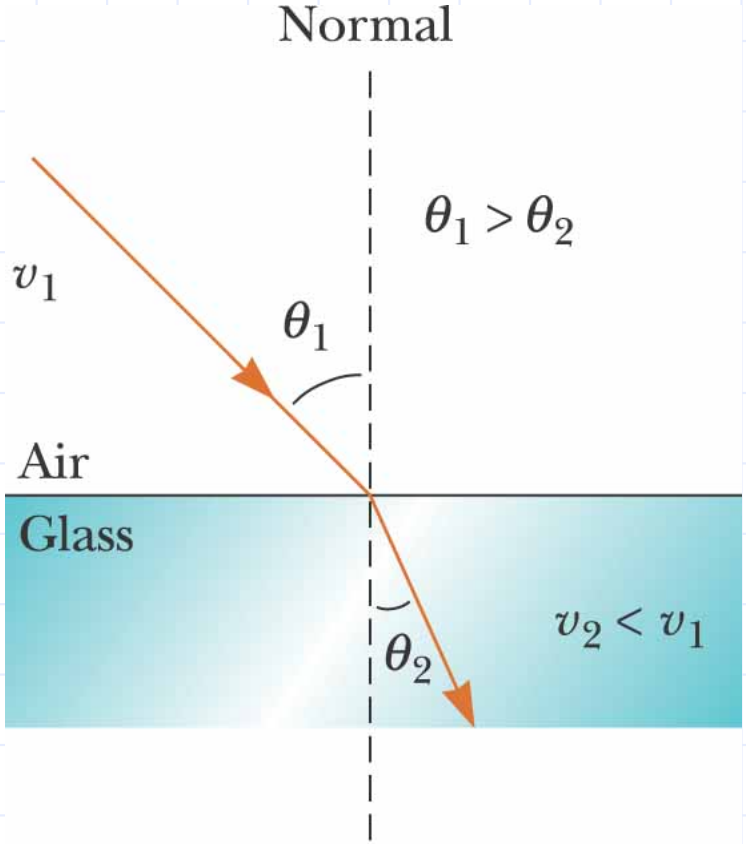


- Consider "light" propagating in one "transparent" medium (e.g. air). It encounters a boundary to another "transparent" medium.
- Some of the light is reflected, while some of the light travels into the second medium
- Note, we will not worry here about the intensities of the incident, reflection, and transmitted beams



- When light travels through any medium, its speed v < c, since c is the speed of light in a vacuum. However, the speed of light in air is ≈ $c=v_1$.
- After the light enters the new medium (e.g. glass), its speed v_2 decreases
- Since the speed changes, the ray is bent and propagates through the second medium at a new angle:

$$\frac{\sin\theta_2}{\sin\theta_1} = \frac{v_2}{v_1} = \text{constant}$$



- What is this constant? It is related to the two media that the light propagates through.
- For any medium, we can make the following definition from the ratio:
(speed of light in vacuum)/
(speed of light in the medium) or

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

- n is the index of refraction. n ≥ 1. p. 966 gives the index of refraction for some materials. Examples: air (1.0003), glass (1.52), diamond (2.42).

- Therefore, using the index of refraction in the previous relation gives

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

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

which is Snell's law of refraction.

- Note that

$$n_2 = \frac{c}{v_2} = \frac{f\lambda}{f_2\lambda_2} = \frac{\lambda}{\lambda_2}$$

since the frequency does not change.