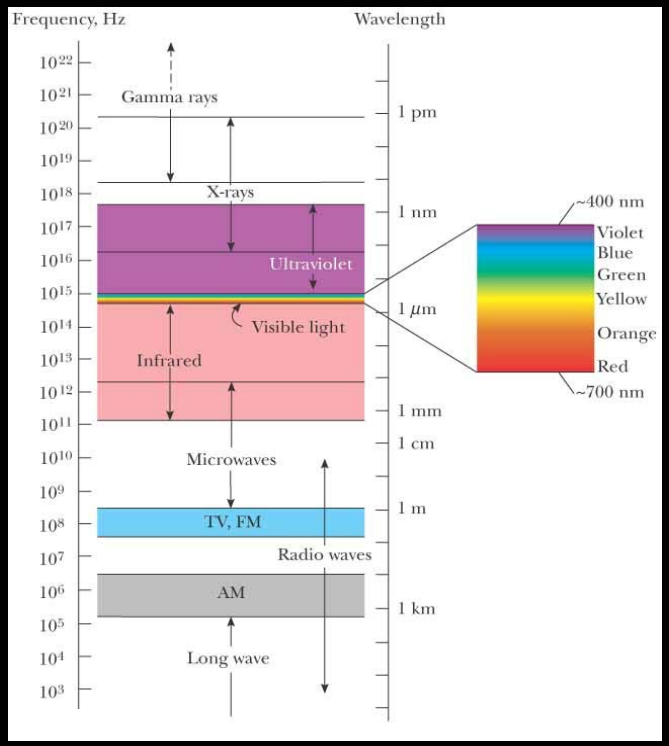
Chapter 35 Nature of Light and Laws of Geometric Optics

35.3 Geometric optics



Electromagnetic spectrum :

Optics :

The study of visible light.

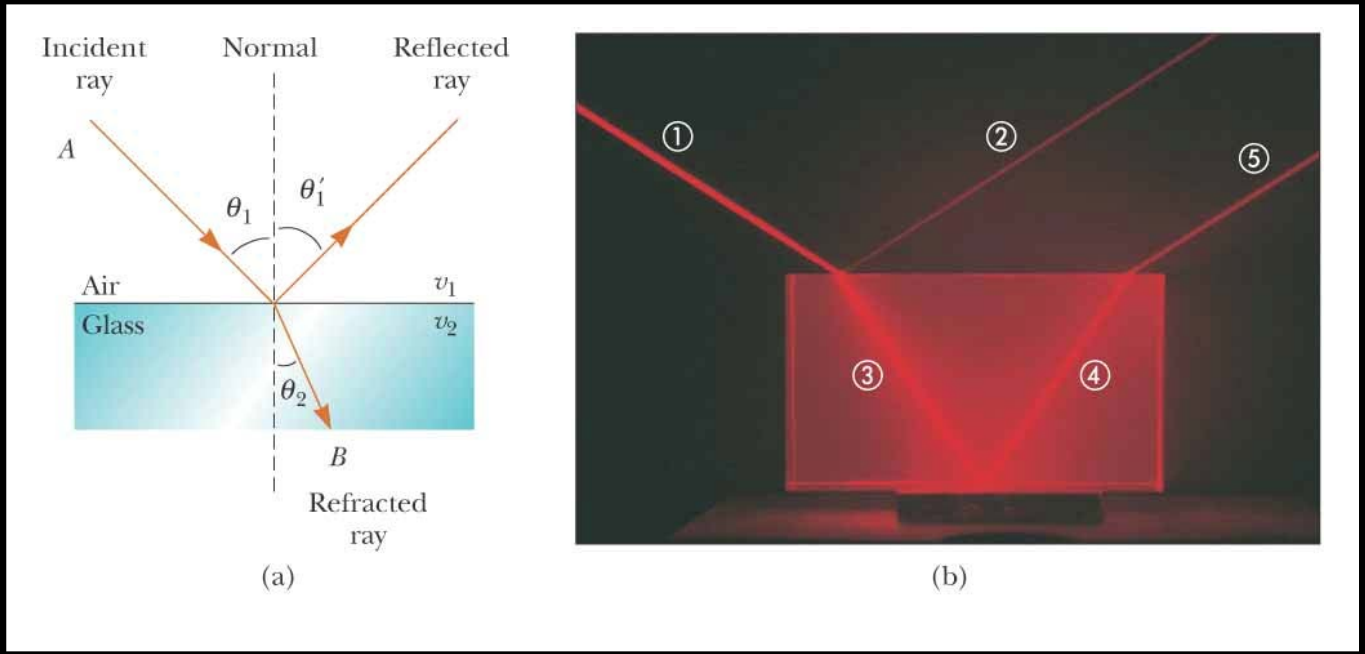
Geometric optics :

Light travels in a fixed direction in a straight line through a uniform medium and changes its direction when it meets the surface of a different medium.

Ray approximation :

A wave moving through a medium travels in a straight line in the direction of its rays. (*i.e.*, no diffraction considered.)

- **<u>Law of Reflection and Refraction :</u> Two principal laws that allow a complete treatment of geometric optics.**

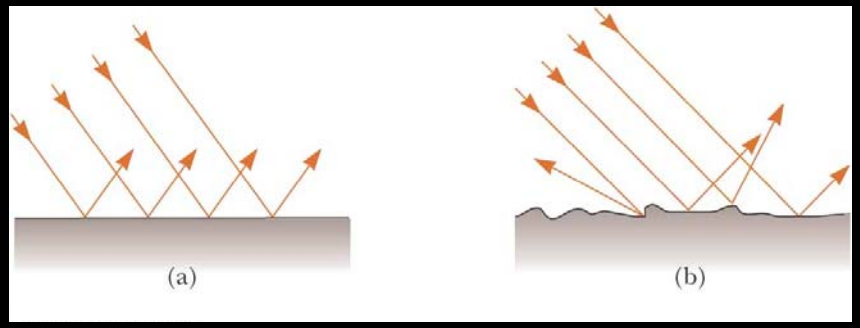


(a) A ray obliquely incident on an air–glass interface. The refracted ray is bent toward the normal. All rays and the normal lie in the same plane.

(b) Light incident on the Lucite block bends both when it enters the block and when it leaves the block.

35.4 Reflection

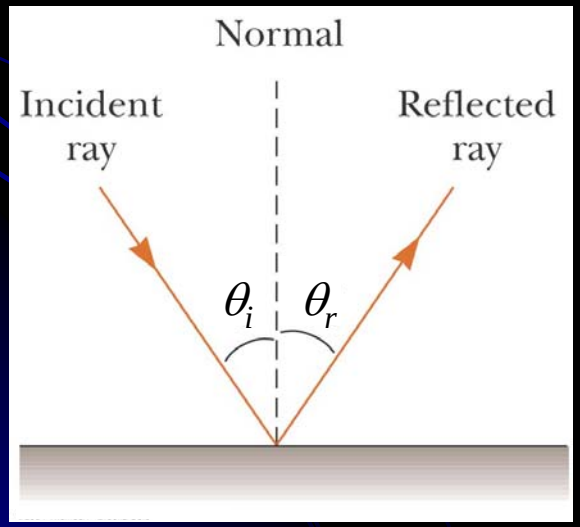
- Types of reflection : Specular reflection & Diffuse reflection.



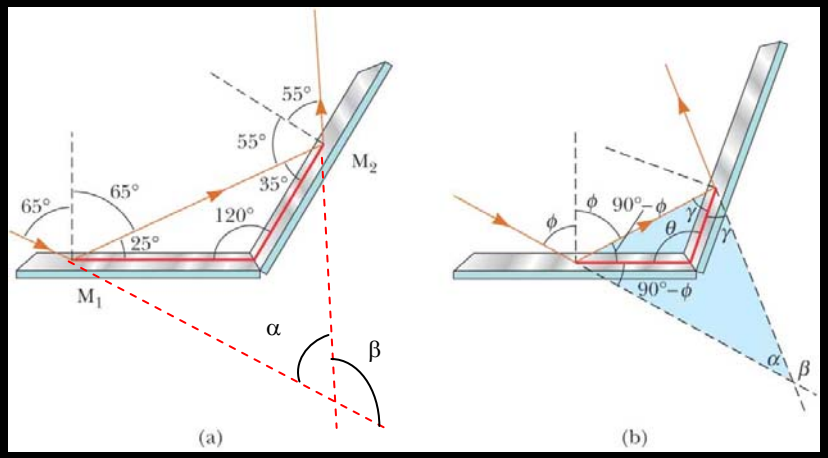
(a) Specular reflection, where the reflected rays are all parallel to each other,
(b) Diffuse reflection, where the reflected rays travel in random directions.

- **Law of reflection :**

$$\theta_i = \theta_r$$

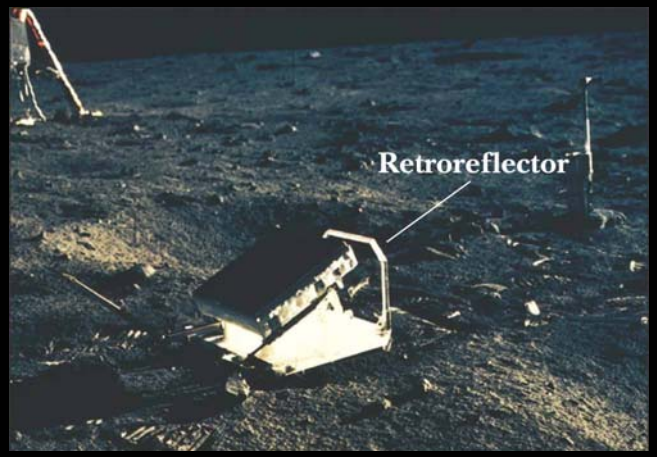


- **Double-reflected light**



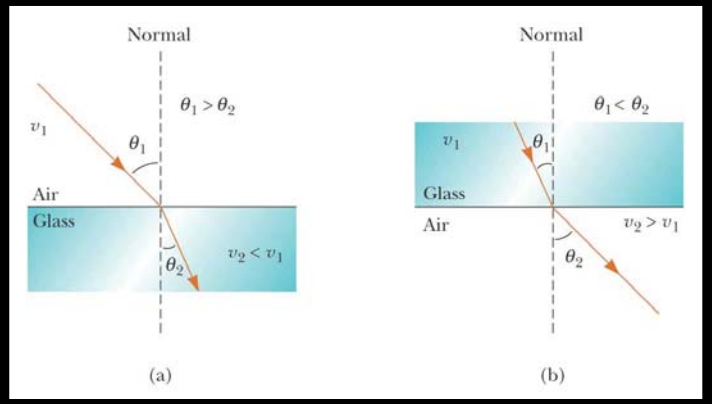
(a) Mirrors M_1 and M_2 make an angle of 120° with each other.
(b) The geometry for an arbitrary mirror angle.

- Applications of ***Retroreflection*** :



This panel on the Moon reflects a laser beam directly back to its source on the Earth.

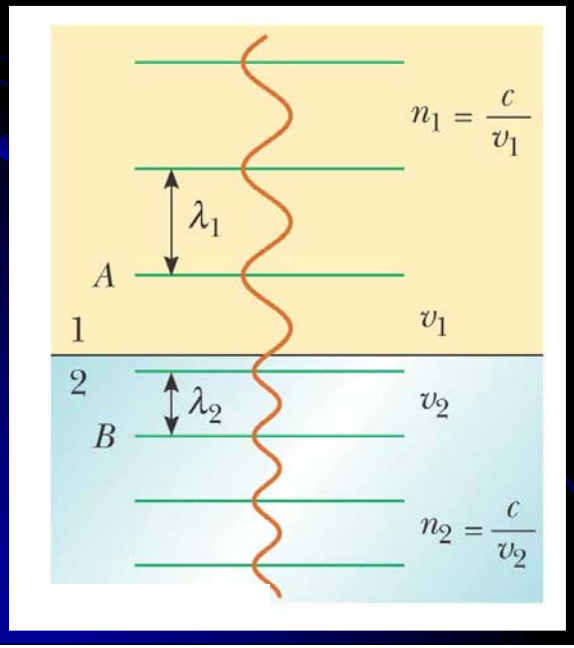
35.5 Refraction → The ray is bent at the boundary.



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

- **Def. of <u>Index of refraction</u> :** $n = c / v$ $(n > 1)$

- **Behavior of *f* and λ during traveling in medium :**



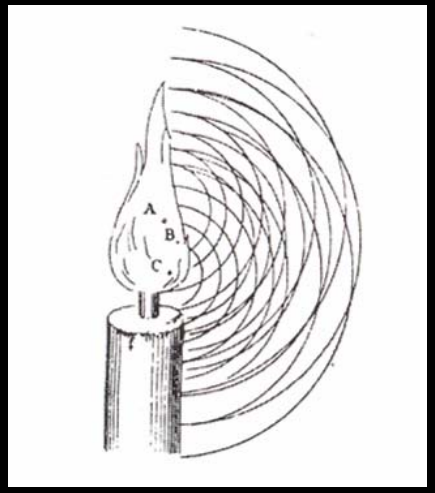
As a wave moves from *medium 1* to *medium 2*, its *wavelength* changes but its *frequency* remains constant.

- **<u>Snell's law of refraction</u>** (1621):

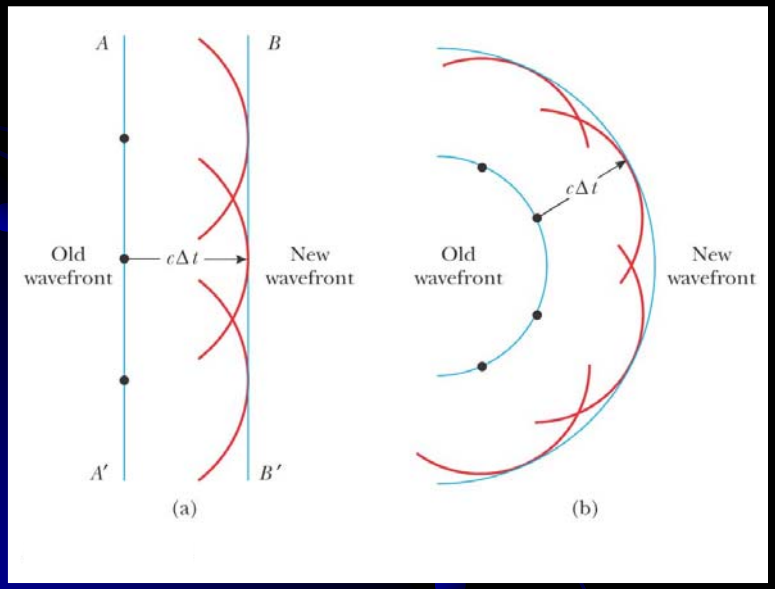
$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

35.6 Huygens's principle

Every point on a wave front can be considered as a source of tiny wavelets that spread out in the forward direction at the speed of the wave itself. The new wave front is the envelope of all the wavelets – that is, the tangent to all of them.

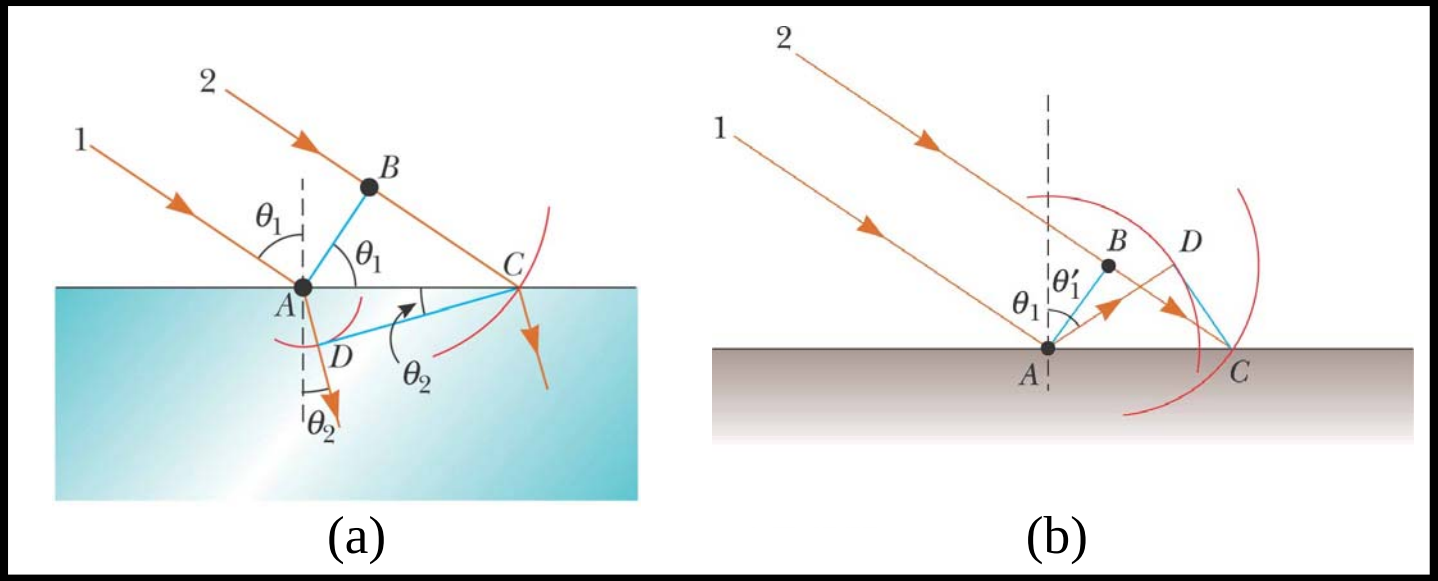


Huygens's illustration of wavelets, here for a candle frame, from his book (1885)



Huygens's construction for (a) a plane wave propagating to the right (b) a spherical wave propagating to the right.

- **Huygens's principle applied to refraction and reflection**

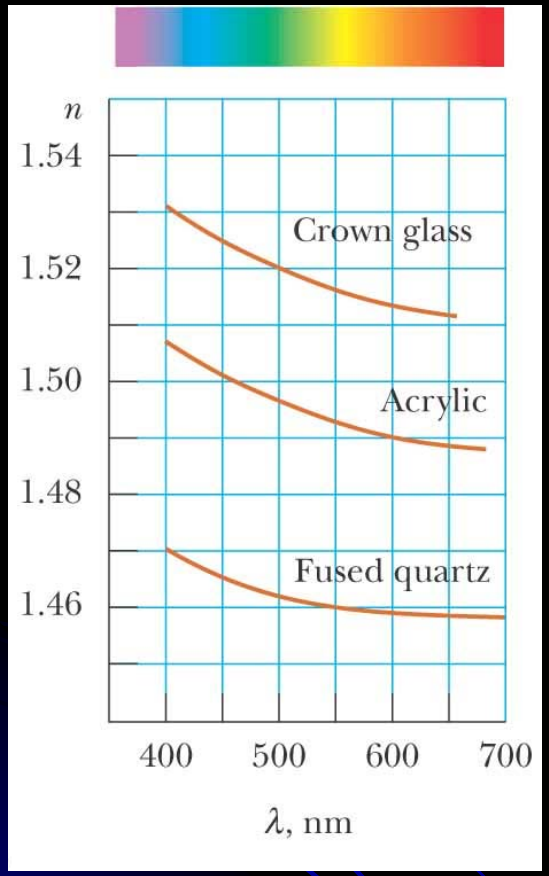


(a) Huygens's construction for proving Snell's law of refraction. At the instant that ray 1 strikes the surface, it sends out a Huygens wavelet from *A* and ray 2 sends out a Huygens wavelet from *B*. The two wavelets have different radii because they travel in different media.

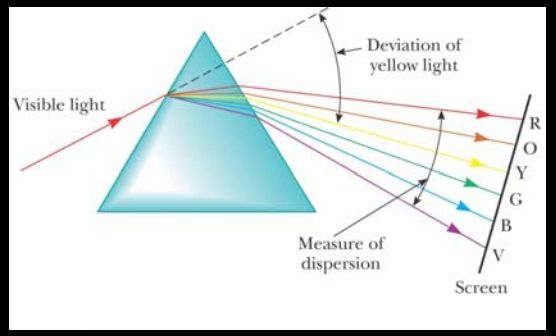
(b) Huygens's construction for proving the law of reflection. At the instant that ray 1 strikes the surface, it sends out a Huygens wavelet from *A* and ray 2 sends out a Huygens wavelet from *B*. We choose a radius of the wavelet to be $c\Delta t$, where Δt is the time interval for ray 2 to travel from *B* to *C*.

35.7 Dispersion

The spreading of light by the refraction due to the dependence of n on wavelength. → $n(\lambda)$



(1) Visible spectrum :



Dispersion separates the colors in white light.

(2) Rainbow :