1 – The Refraction of Light

- When a ray of light traveling through a transparent medium encounters a boundary leading into another transparent medium, part of the light is reflected and part enters the second medium.
- The ray that enters the second medium is bent at the boundary. It is said to be *refracted.*
- The angle of refraction, θ_2, is related to the incident angle, θ_1, as follows

$$\frac{\sin\theta_2}{\sin\theta_1} = \frac{v_2}{v_1} \tag{1}$$

where v_1 is the speed of light in medium 1, and v_2 is the speed of light in medium 2 (**Snell's law**).

The Refraction of Light

- It is convenient to define the **index of refraction** of a medium:

$$n = \frac{c}{v} \tag{2}$$

where c is the speed of light in vacuum and v is the speed of light in the medium. $n > 1$, since the speed of light in a medium is always *less* than that in vacuum (vacuum: $n = 1$).

- When light travels from one medium to another *its frequency does not change*, but the wavelength does ($\lambda = v/f$):

$$\frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2} = \frac{c/n_1}{c/n_2} = \frac{n_2}{n_1}$$

This allows us to write Snell's law in the following form:

$$n_1 \sin\theta_1 = n_2 \sin\theta_2 \tag{3}$$

Application: apparent depth, d', of an object in a medium with n_1 viewed from directly above in a medium with n_2 ($n_1 > n_2$): $d' = d\, n_2/n_1$

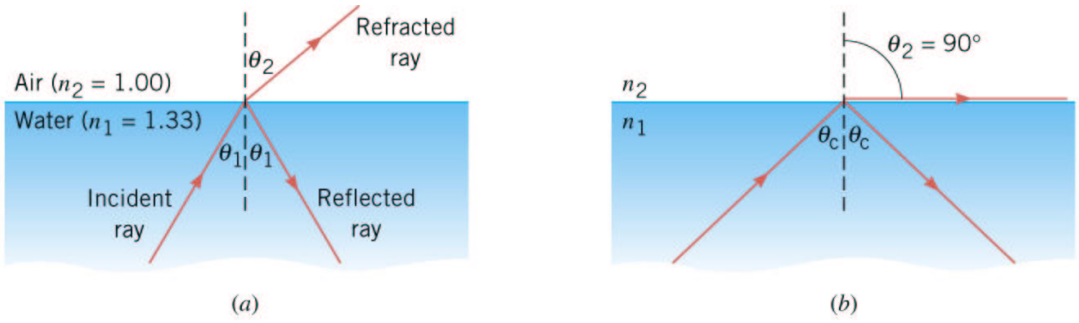
2 – Total Internal Reflection

- When light attempts to move from a medium with a *high* index of refraction to one with a *lower* index of refraction, *total internal reflection* can occur.
- At the so-called **critical angle**, θ_c, the refracted light ray moves parallel to the boundary between the two media, *ie.* $\theta_2 = 90°$. *For angles of incidence larger than* θ_c the beam is entirely reflected at the boundary.
  From Snell's law:

$$n_1 \sin\theta_c = n_2 \sin 90° = n_2$$

  or

$$\boxed{\sin\theta_c = \frac{n_2}{n_1}} \qquad (4)$$



- **example:** diamond: $n = 2.42$ and $\theta_c = 24°$. A small critical angle, together with proper faceting, causes diamonds to sparkle brilliantly.
- **application:** one can alter the direction of travel of a light beam.
- **application: fiber optics** total internal reflection is also used to guide light through "light pipes". This has medical applications and is also used in high speed transmission of large data quantities between computers.