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Reflection and Refraction

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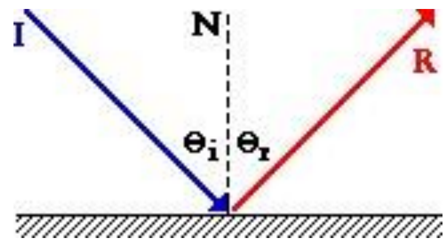
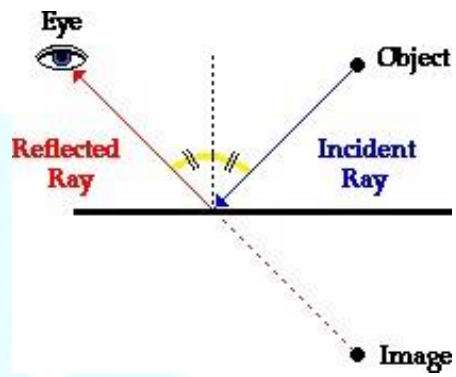
Reflection

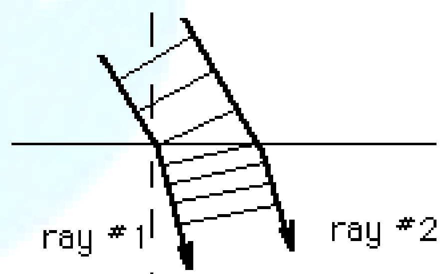




When a ray of light strikes a plane mirror, the light ray reflects off the mirror. Reflection involves a change in direction of the light ray. The convention used to express the direction of a light ray is to indicate the angle which the light ray makes with a normal drawn to the surface of the mirror (a line that is perpendicular to the surface). The angle of incidence is the angle between this normal and the incident ray; the angle of reflection is the angle between this normal and the reflected ray. According to the law of reflection, the angle of incidence equals the angle of reflection.

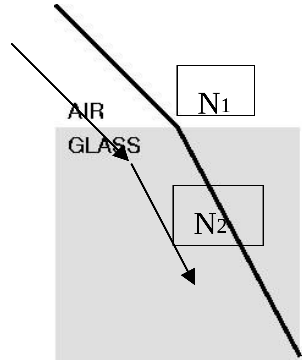
To view an image of an object in a mirror, you must sight along a line at the image location. As you sight at the image, light travels to your eye along the path shown in the diagram. The diagram shows that the light reflects off the mirror in such a manner that the angle of incidence is equal to the angle of reflection.

Refraction



The most common example of refraction is the bending of light on passing from air to a liquid, which causes submerged objects to appear displaced from their actual positions. Refraction is also the reason that prisms separate white light into its constituent colors. Refraction is commonly explained in terms of the wave theory of light and is based on the fact that light travels with greater velocity in some media than it does in others. When, for example, a ray of light traveling through air strikes the surface of a piece of glass at an angle, one side of the wave front enters the glass before the

other and is retarded (since light travels more slowly in glass than in air), while the other side continues to move at its original speed until it too reaches the glass.



As a result, the ray bends inside the glass, i.e., the refracted ray lies in a direction closer to the normal (the perpendicular to the boundary of the media) than does the incident ray. A light ray entering a different medium is called the incident ray. After bending, the ray is called the refracted ray. The speed at which a given transparent medium transmits light waves is related to its optical density (not to be confused with mass or weight density). In general, a ray is refracted toward the normal when it passes into a denser medium, and away from the normal when it passes into a less dense medium. The law of refraction relates the angle of incidence (angle between the incident ray and the normal) to the angle of refraction (angle between the refracted ray and the normal). This law, credited to Willebrord Snell, states that the ratio of the sine of the angle of incidence, θ_i, to the sine of the angle of refraction, θ_r, is equal to the ratio of the speed of light in the original medium, v_i, to the speed of light in the refracting medium, v_r. Snell's law is often stated in terms of the indexes of refraction of the two media rather than the speeds of light in the media. The index of refraction, n, of a transparent medium is the ratio of the speed of light in a vacuum, c, to the speed of light in the medium: $n = c/v$.

Using indexes of refraction, Snell's Law (also known as the Law of Refraction) takes the form $\sin \theta_i/\sin \theta_r = n_r/n_i$, or $n_i \sin \theta_i = n_r \sin \theta_r$.

Snell's law has two special cases: critical angle and total internal reflection. When the angle of incidence makes a 90° angle of refraction, total internal reflection occurs. When there is total internal reflection, then you can obtain the critical angle. The critical angle is measured with respect to the normal at the refractive boundary and is equivalent to

$$\theta \qquad 90^\circ \rightarrow \theta\ \theta\ \arcsin \frac{n}{n}.$$

The critical angle only takes place when the light is traveling from a medium with a higher index of refraction to a medium with lower index of refraction. This is to say, we find the critical angle when the value of the incident theta is equal to 90° and thus $\sin(\theta_i)$ is equal to 1. The resulting value of the refracted theta will then be equal to the critical angle. For total internal reflection to occur, n_r must be greater than n_i.