Chapter 35 Light: Reflection and Refraction

35.1 Ray Optics

It is natural to treat the propagation of light in terms of **rays**.

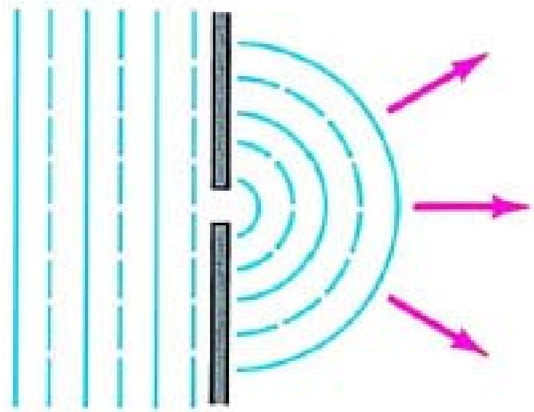
A ray is equivalent to a very narrow beam of light, and it indicates the path along which the energy of the wave travels.

Geometrical optics is the study of the behavior of straight-line rays at the interference between two media by the use of simple geometrical constructions.

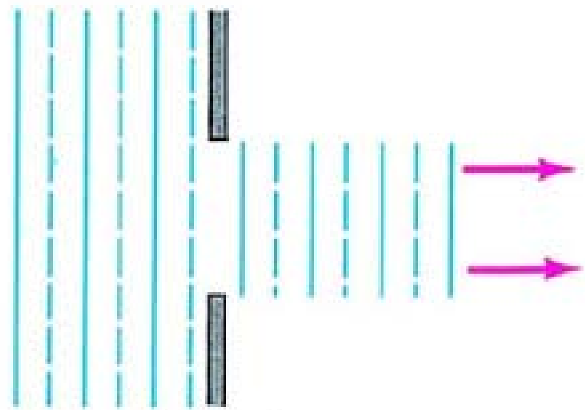
Diffraction

Water waves passing through a small opening in a barrier, as in the figure below, spread into the region behind the barrier.

This phenomena, call **diffraction**, is significant when the size of the aperture, d, is comparable to the wave.



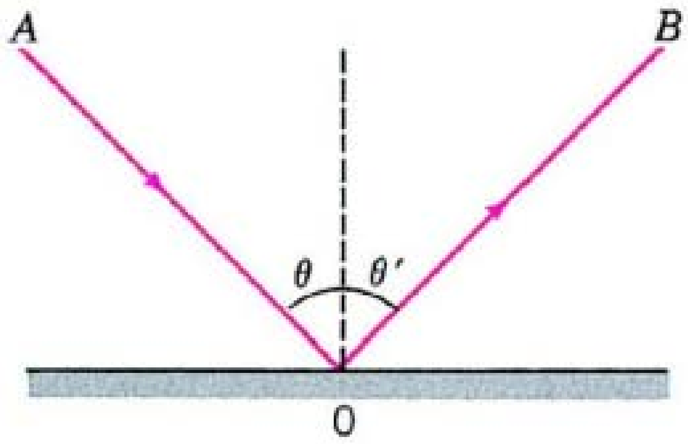
$d = \lambda$



$d >> \lambda$

35.2 Reflection: The law of reflection

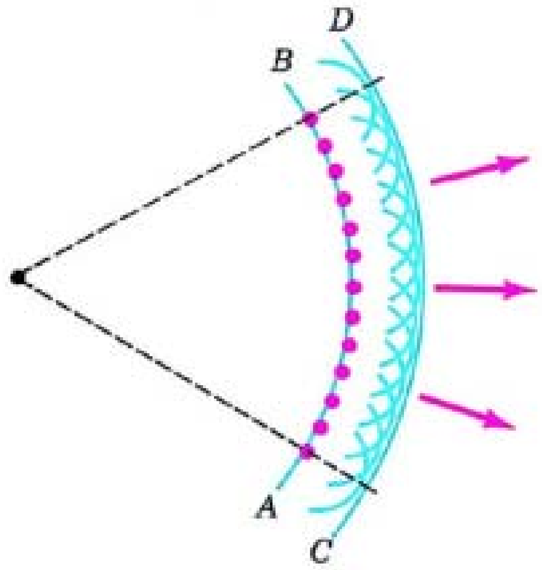
The **law of reflection** states: the angle of the incidence, θ, is equal to the angle of reflection, θ'.

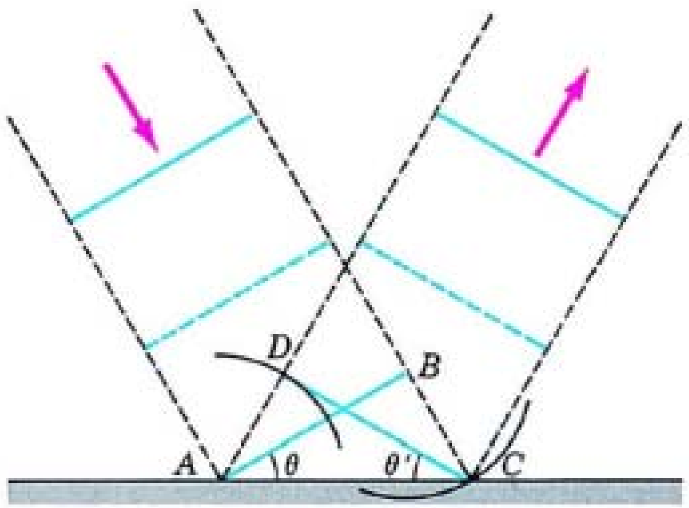


The incident ray and the reflected ray all lie in the same plane, which we call the **plane of incidence**.

Huygens' Principle

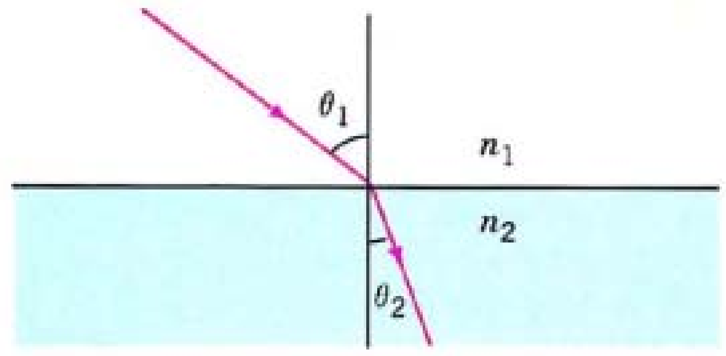
Each point on a wavefront acts as a source of secondary wavelets. At a later time, the envelop of the leading edges of the wavelets forms the new front.

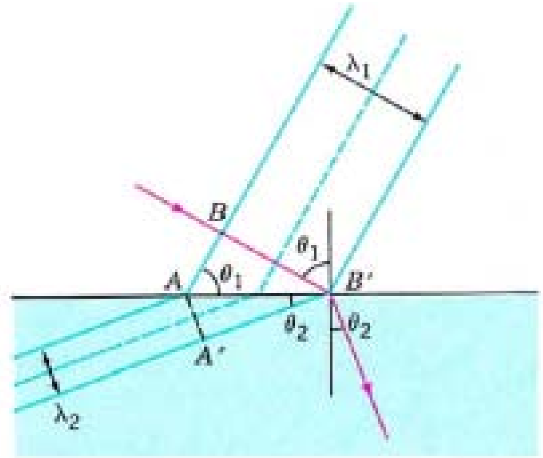




35.3 Refraction

Snell's law: $n_1 \sin\theta_1 = n_2 \sin\theta_2$.



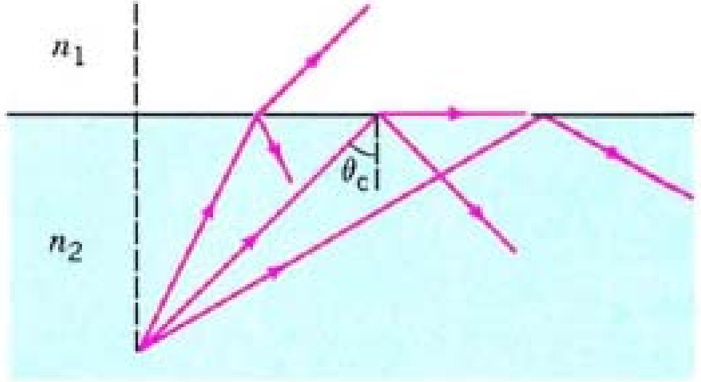


The **refractive index**, n, of a medium is defined as the ratio of the speed of light in vacuum, c, to the speed v in the medium,

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

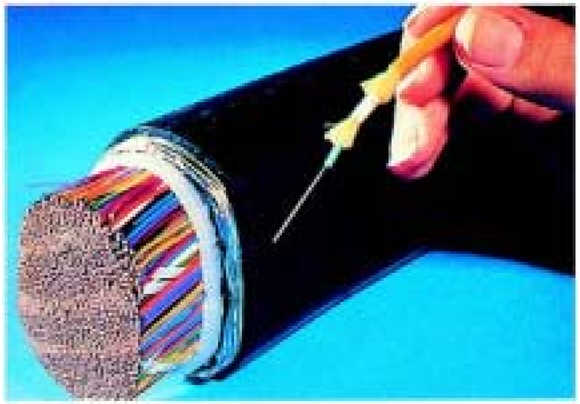
35.4 Total Internal Reflection

At some critical angle of incidence, θc, the light is totally reflected back into the medium of higher refractive index. This is called the **total internal reflection** and was first noted by Kepler in 1604.



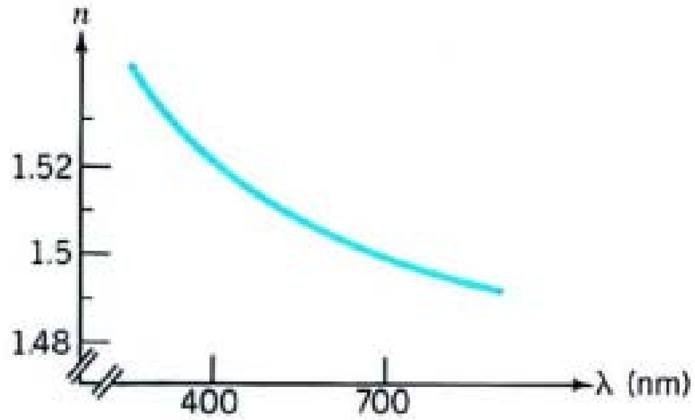
$$n_2 \sin \theta_c = n_1$$

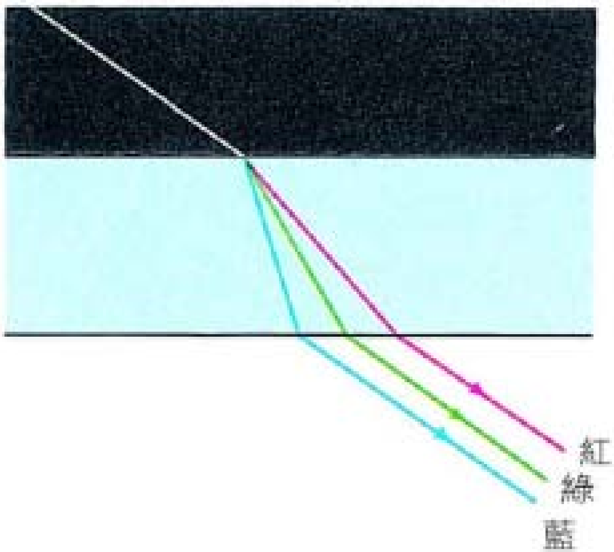
Applications: optical fibers

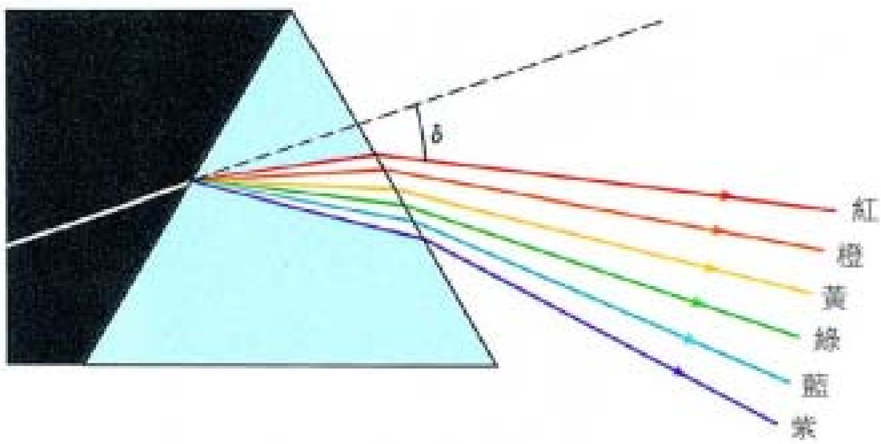


35.5 The Prism and dispersion

In general, the refractive index of any medium is a function of wavelength.

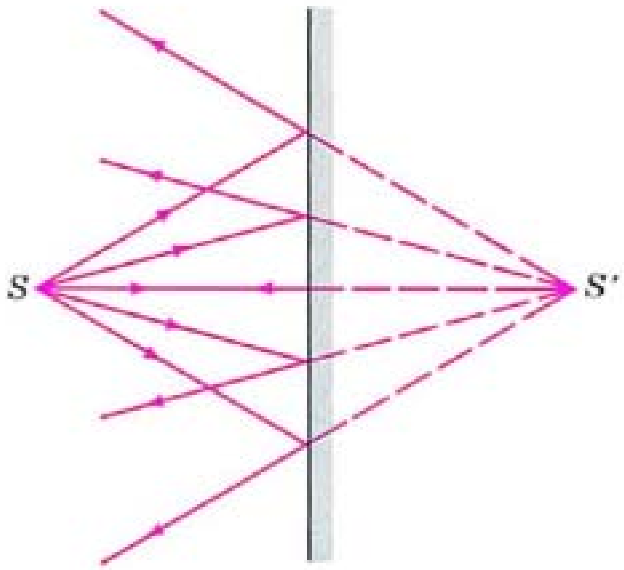






35.6 Images Formed by Plane Mirrors

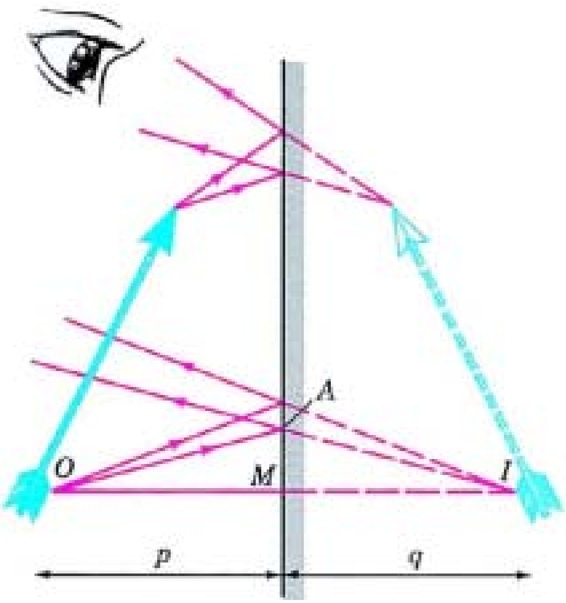
S is called a **real object** because the light rays actually emerge from it.

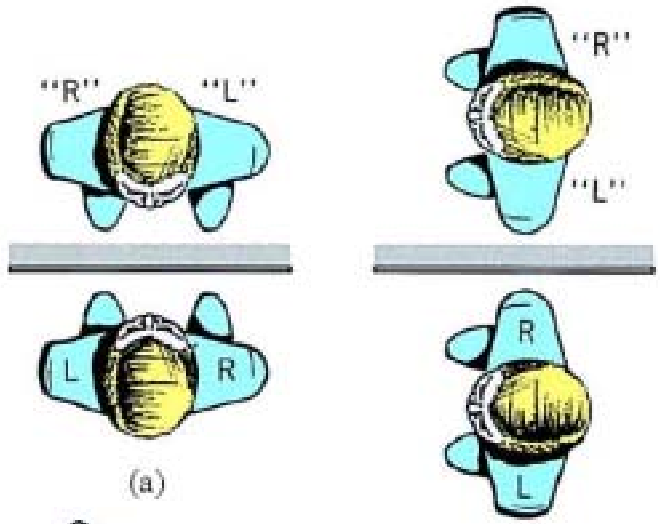


S′ is called the image of *S* in the mirror.

The light does not really come from *S′*, but only appears to do so, it is called a **virtual image**.

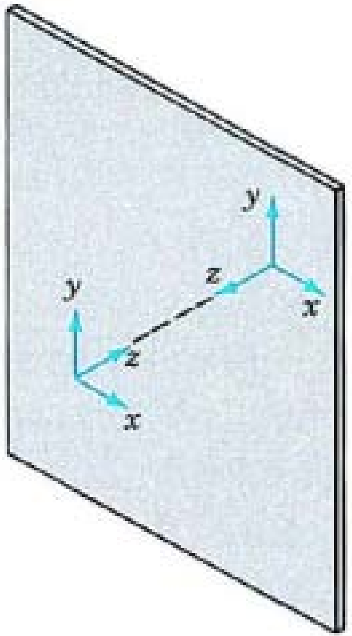
Images Formed by Plane Mirrors





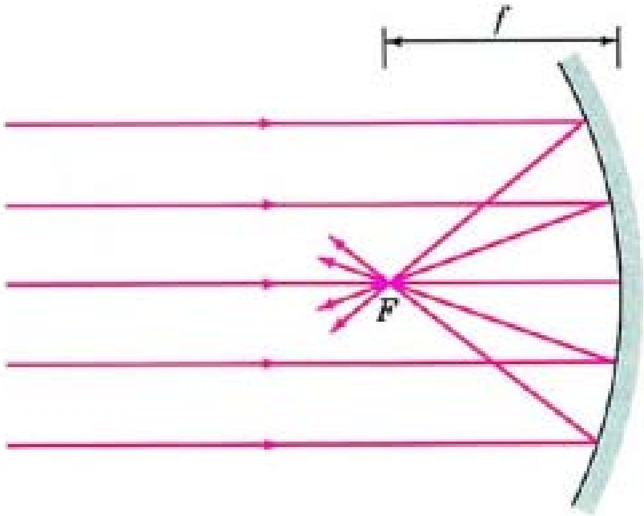
(a)

(b)



35.7 Spherical Mirrors

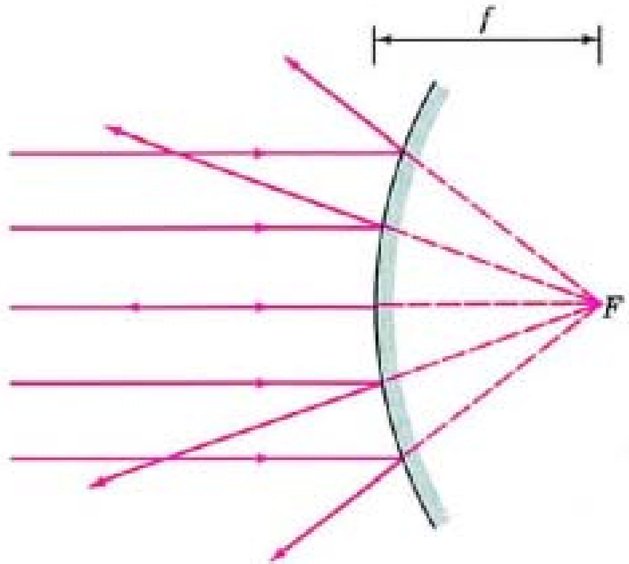
Concave



(a)凹面鏡

Parallel rays reflected by a concave mirror converge toward, and pass through a **real focal point**, F.

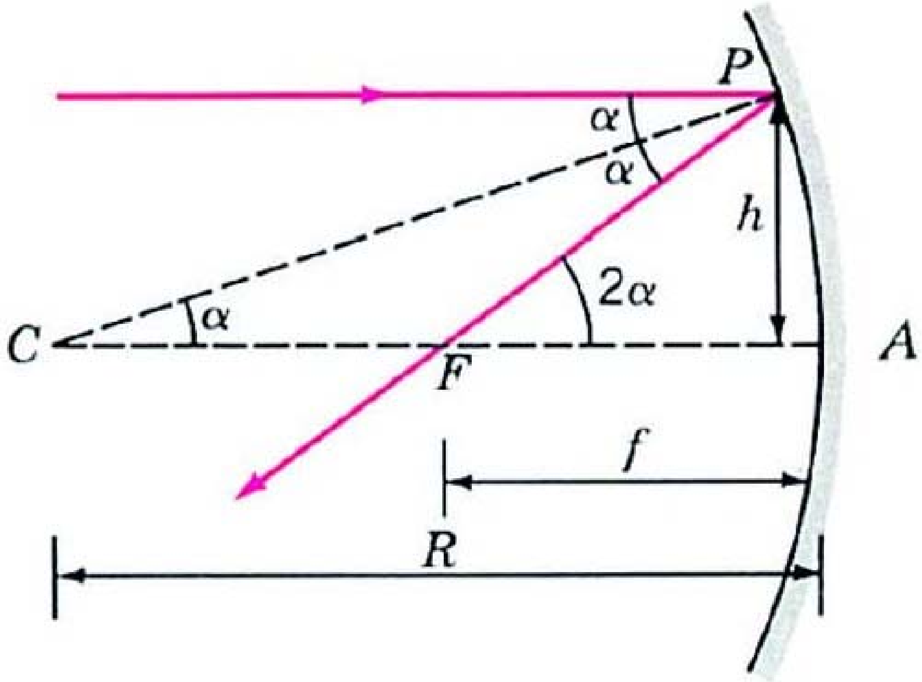
Convex



(b)凸面鏡

Parallel rays reflected by a convex mirror do not actually pass through this **virtual focal point**.

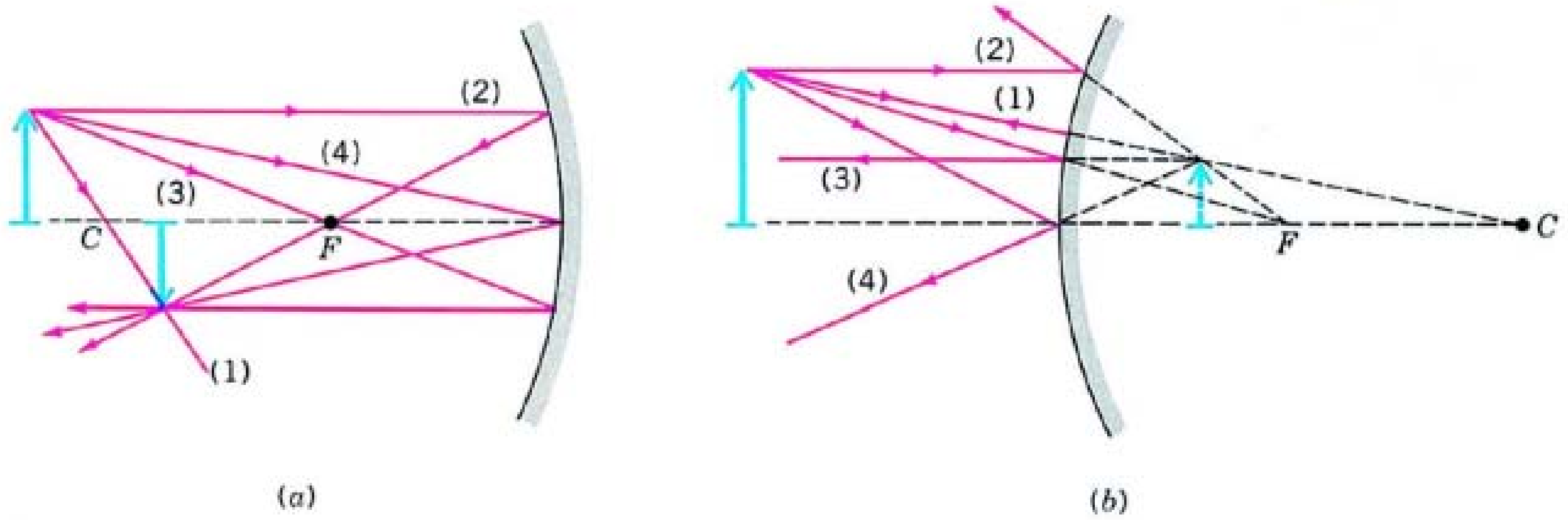
Simple relationship between the focal length and the radius of curvature of a spherical mirror.



$$f = \frac{R}{2}$$

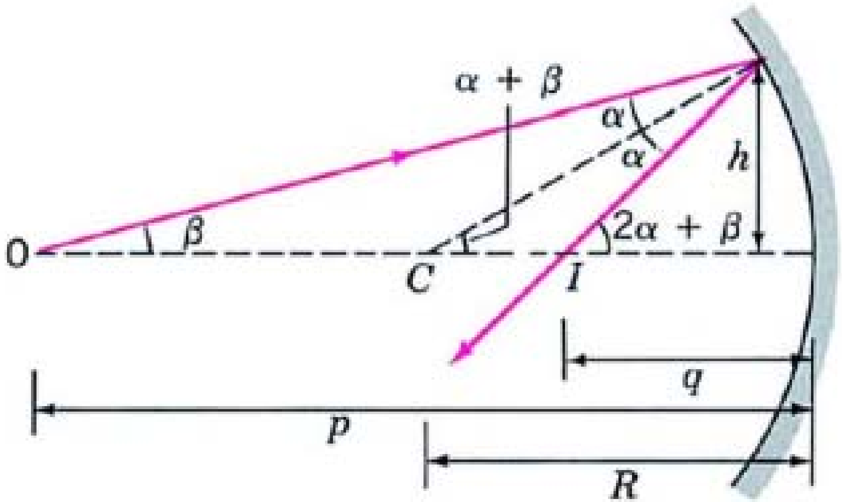
Ray Diagrams

A simple way of locating the image of an object at an arbitrary position was devised by Smith in 1735. It is called a ray diagram.



The Mirror Formula

Instead of using a ray diagram to locate the image, we can develop an equation that relates the object distance, p, and the image distance, q, to the focal length, f.



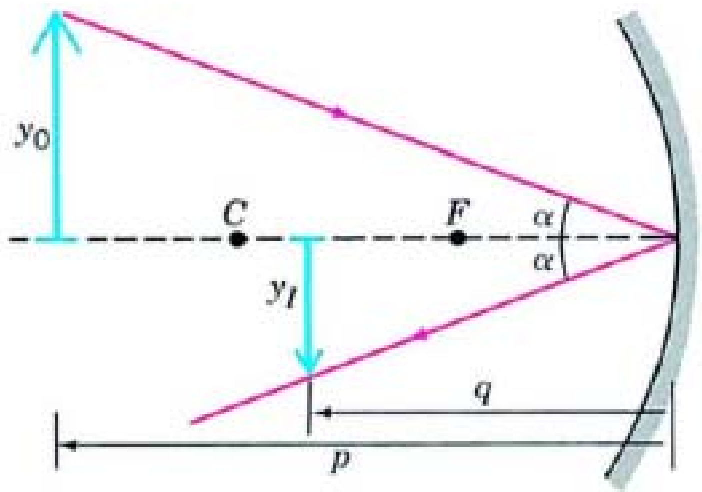
$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

Sign convention: p, q, and f are positive (real) on the left and negative (virtual) on the right.

Linear Magnification

In general, the size of the image is not the same as that of the object.

The **transverse** (or **linear**) **magnification**, m, is defined as



$$m = \frac{y_I}{y_O} = -\frac{q}{p}$$

Exercises and Problems

Ch.35:

Ex.

Prob.