Basic Geometrical Optics

Module 1-4

of

Course 1, *Fundamentals of Light and Lasers*

OP-TEC

National Center for Optics and Photonics Education

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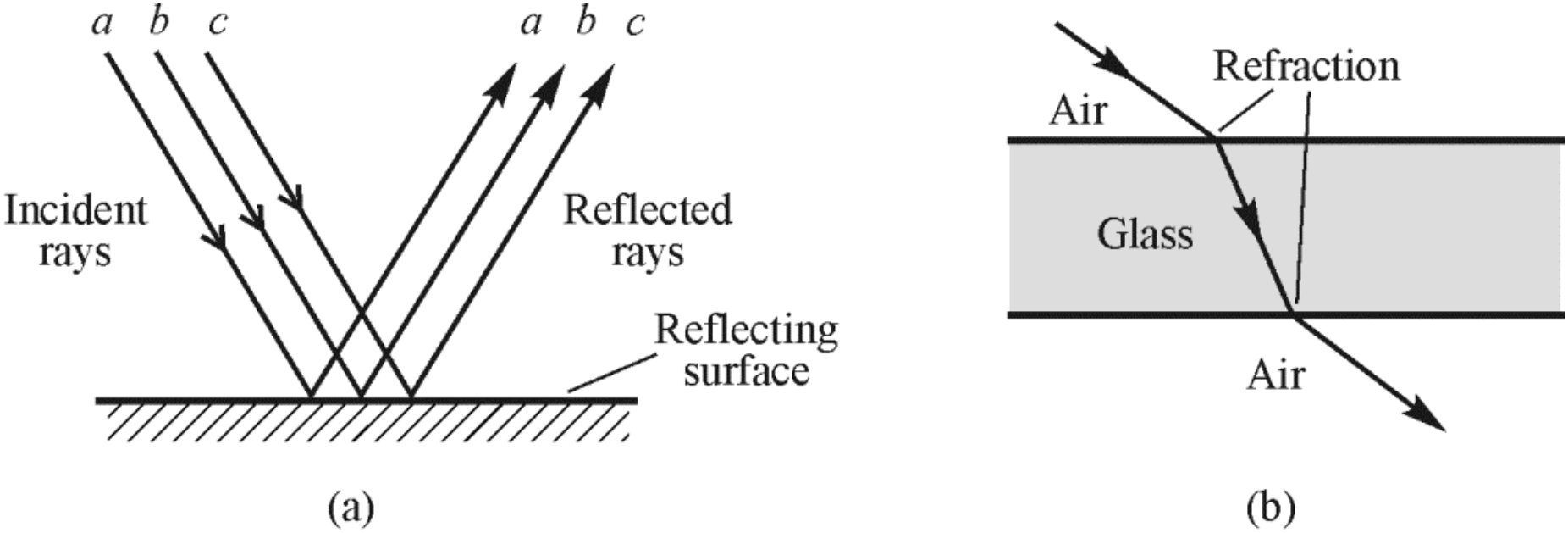
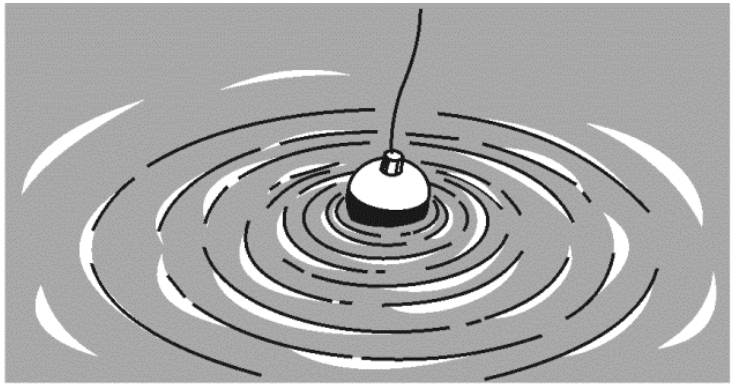
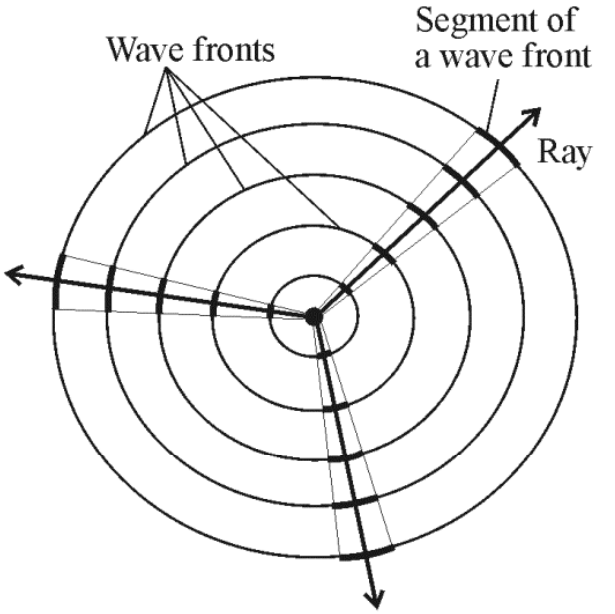


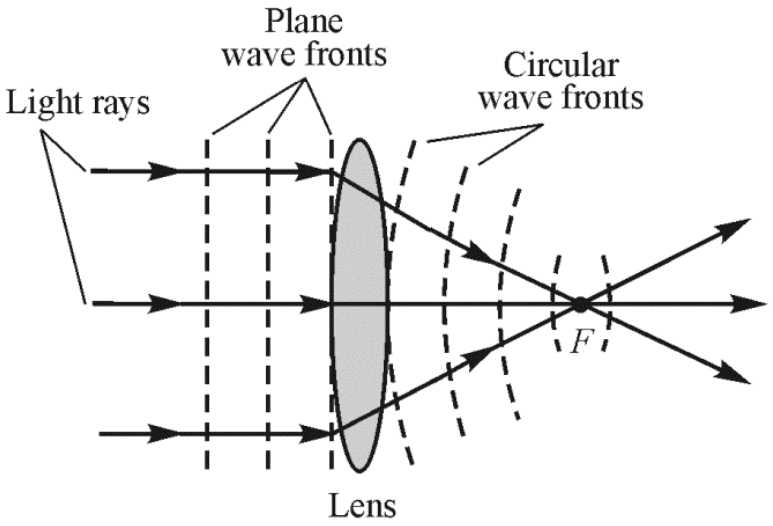
Figure 4-1 *Light rays undergoing reflection and refraction at plane surfaces*



(a) Radiating circular waves from a bobbing cork

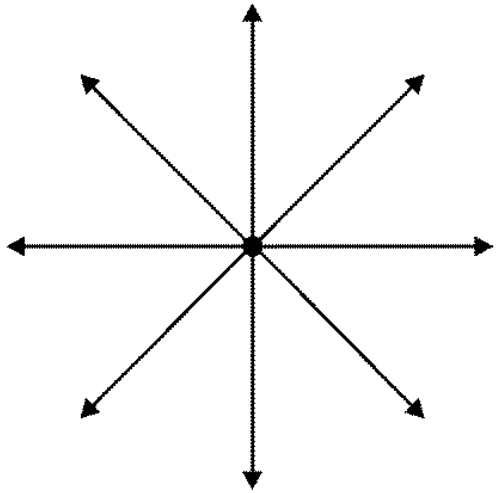


(b) Light rays and circular wave fronts

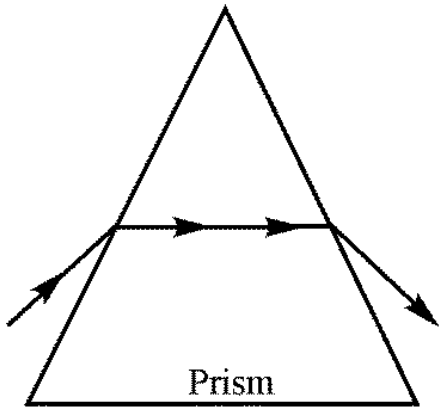


(c) Bending of light rays and changing shapes of wave fronts by a thin lens

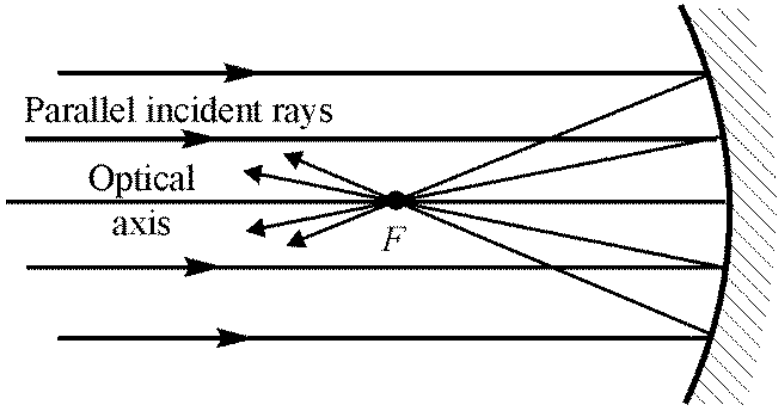
Figure 4-2 *Waves and rays*



(a) Radiating light energy



(c) Bending of light ray by a prism



(b) Light rays reflected by a curved mirror surface

Figure 4-3 *Typical light rays in (a) propagation, (b) reflection, and (c) refraction*

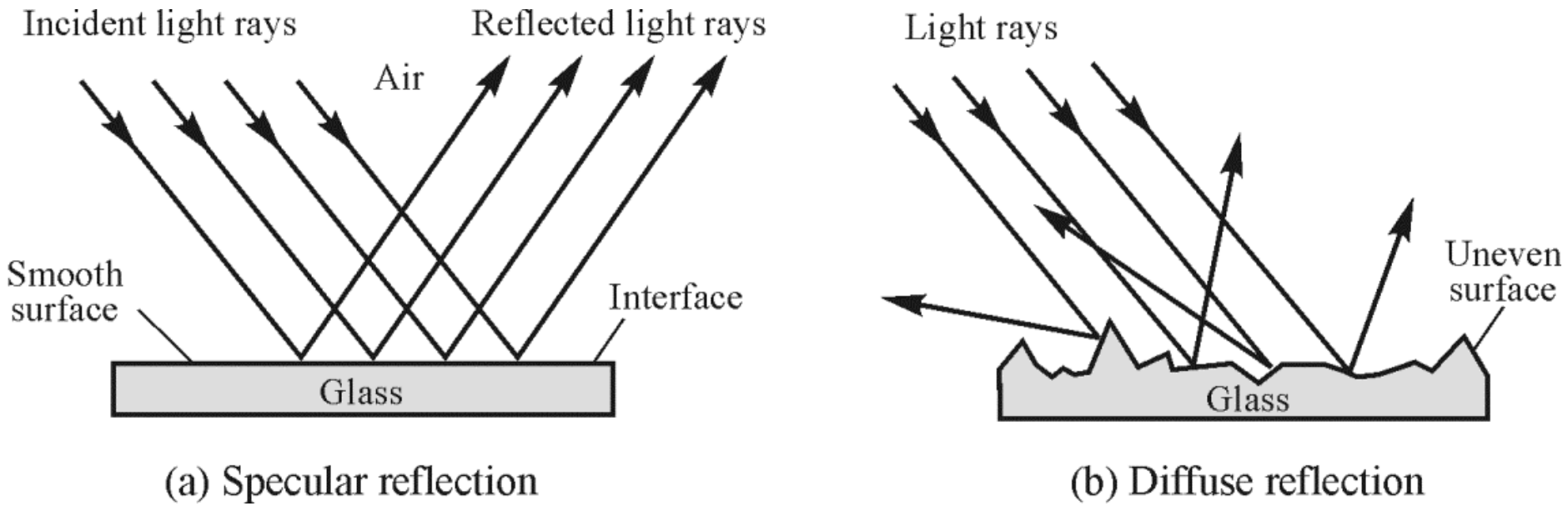
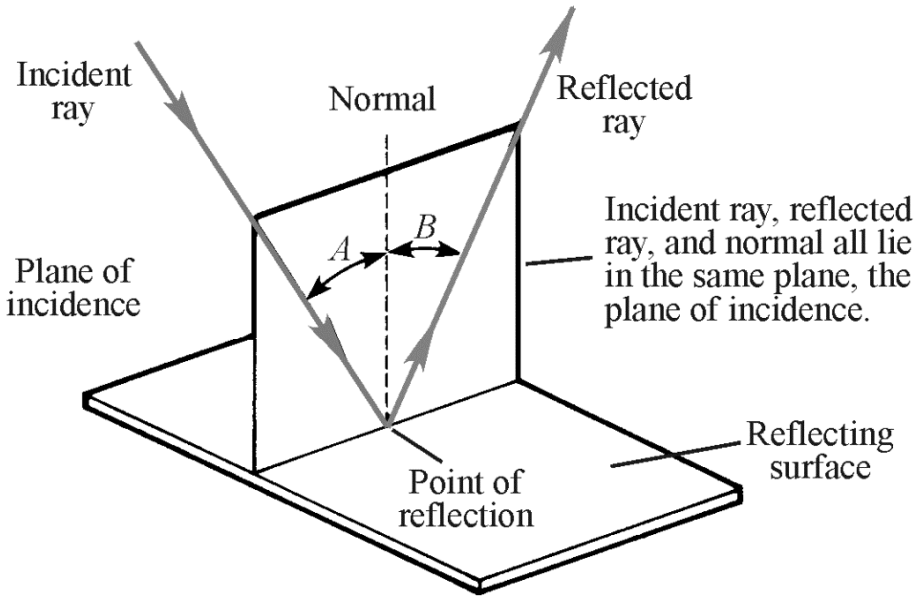
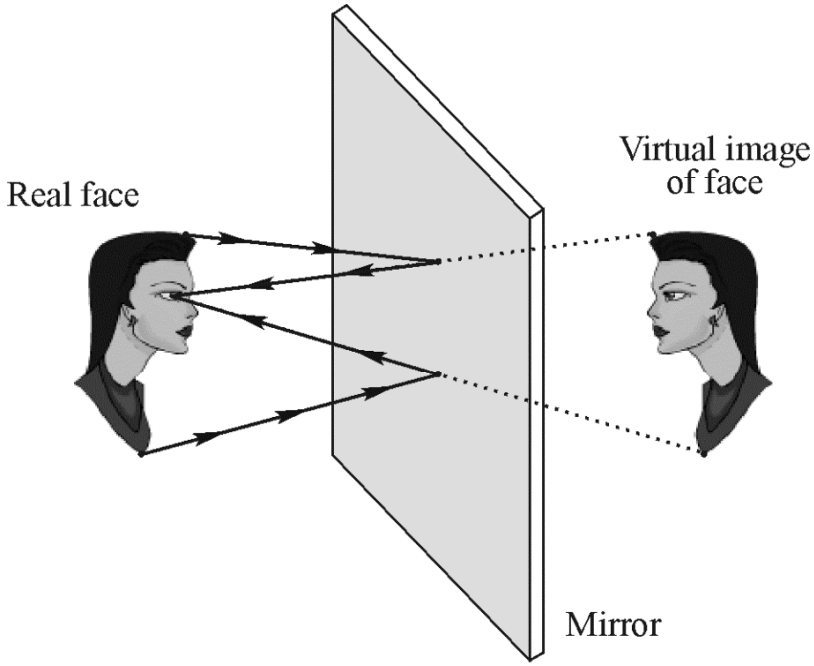


Figure 4-4 *Specular and diffuse reflection*



(a) Law of reflection: Angle B equals angle A



(b) Image formation in a plane mirror

Figure 4-5 *Reflection from a plane surface and a mirror*

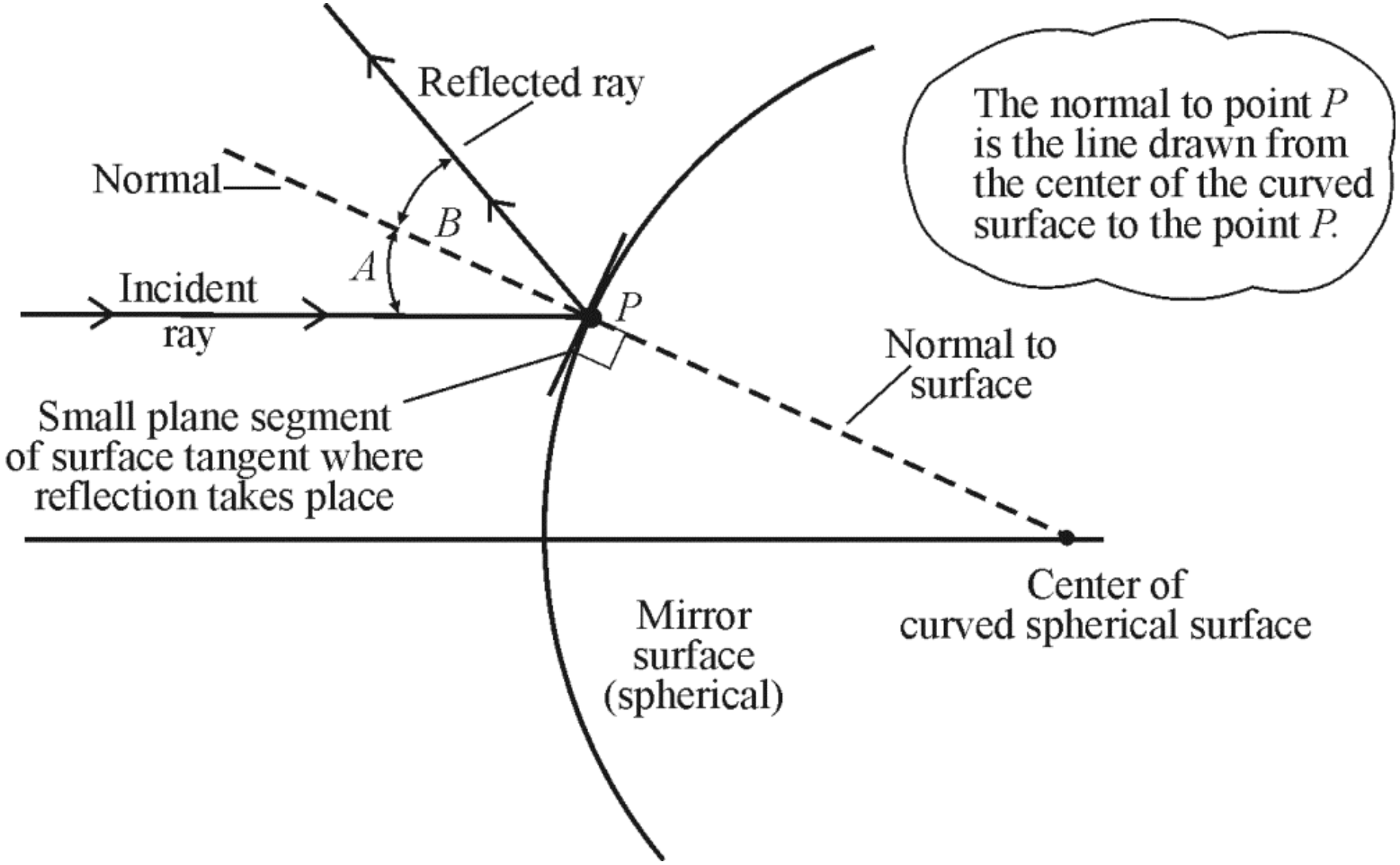


Figure 4-6 *Reflection at a curved spherical surface: Angle B equals angle A.*

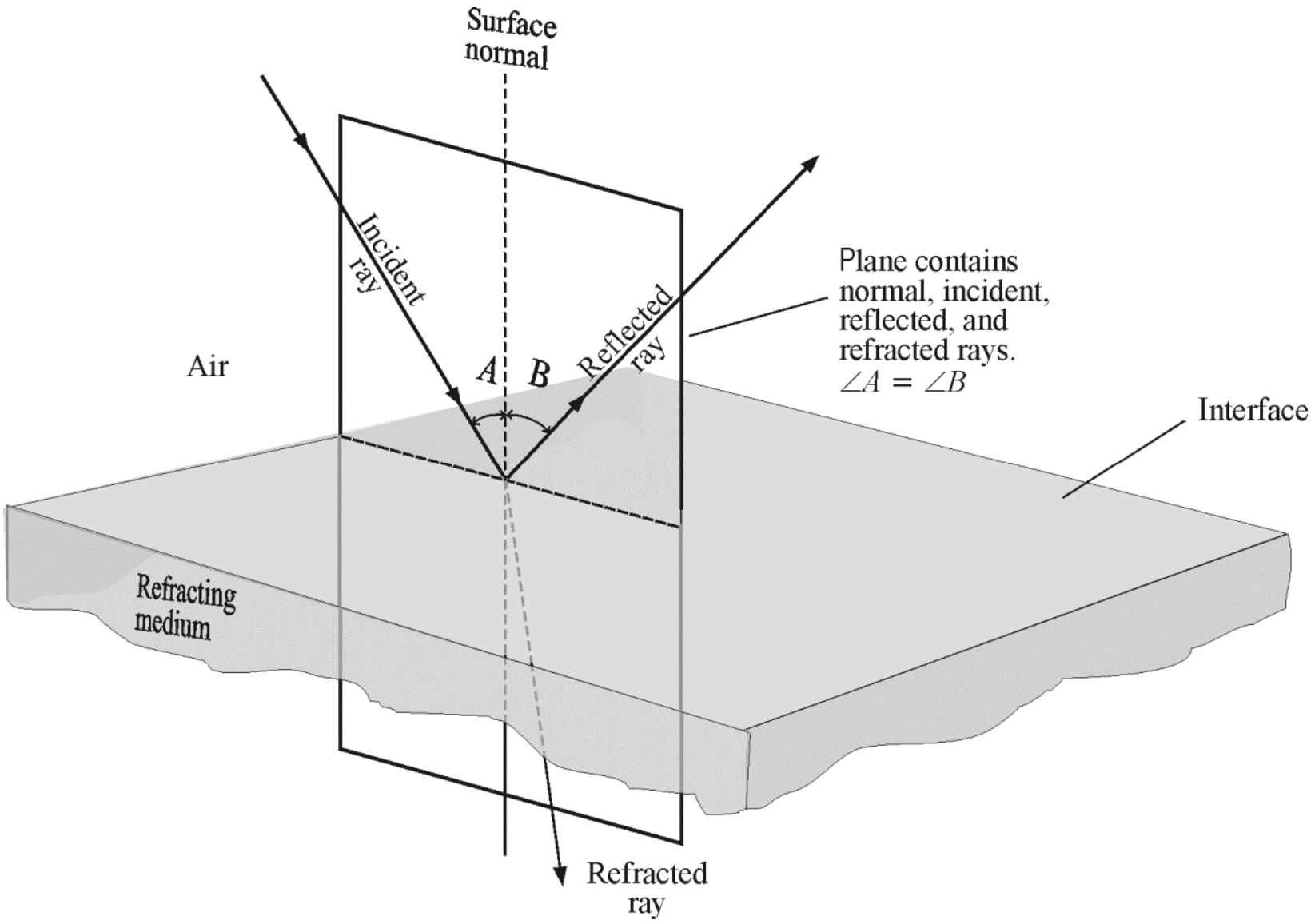
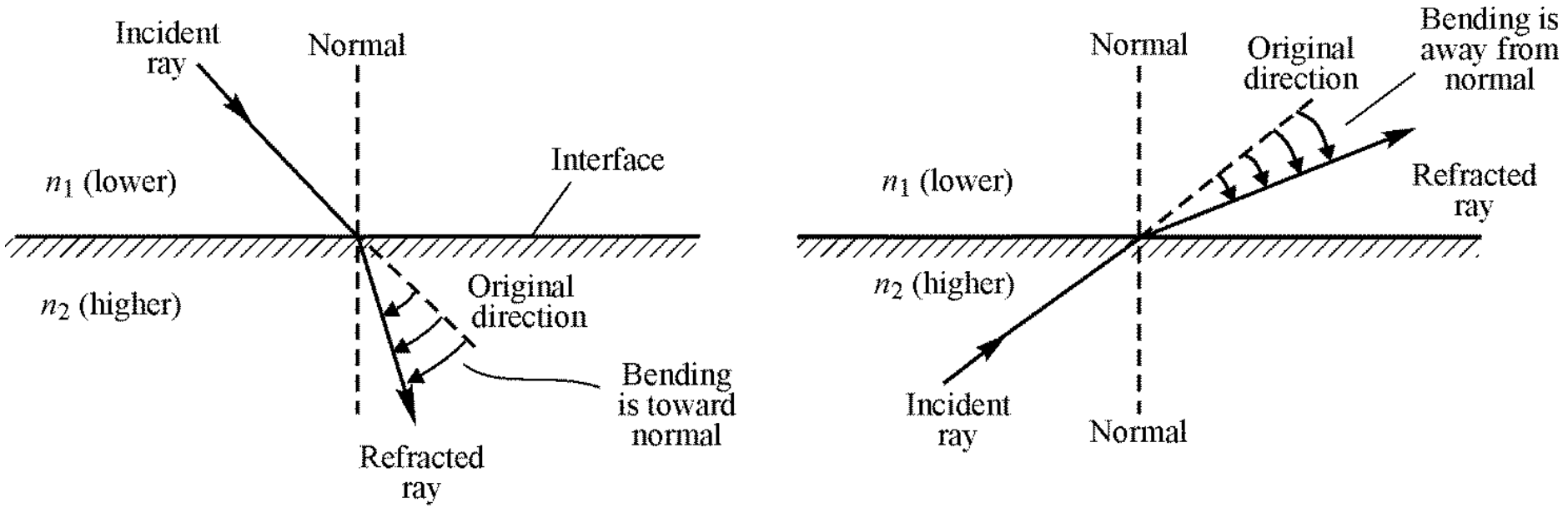


Figure 4-7 *Reflection and refraction at an interface between air and a different optical medium*



(a) Lower to higher: refracted ray bends *toward* the normal.

(b) Higher to lower: refracted ray bends *away from* the normal.

Figure 4-8 *Refraction at an interface between media of different refractive indexes n_1 and n_2*

Snell's Law

$$\frac{\sin i}{\sin r} = \frac{n_r}{n_i}$$, where

i is the angle of incidence

r is the angle of refraction

n_i is the refractive index in the incident medium

n_r is the refractive index in the refracting medium

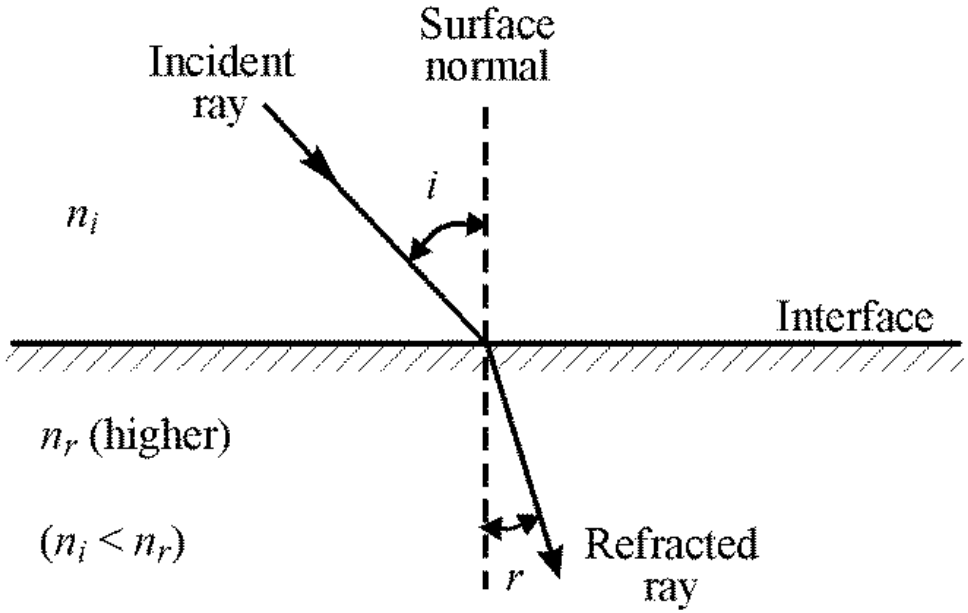


Figure 4-9 *Snell's law: formula and geometry*

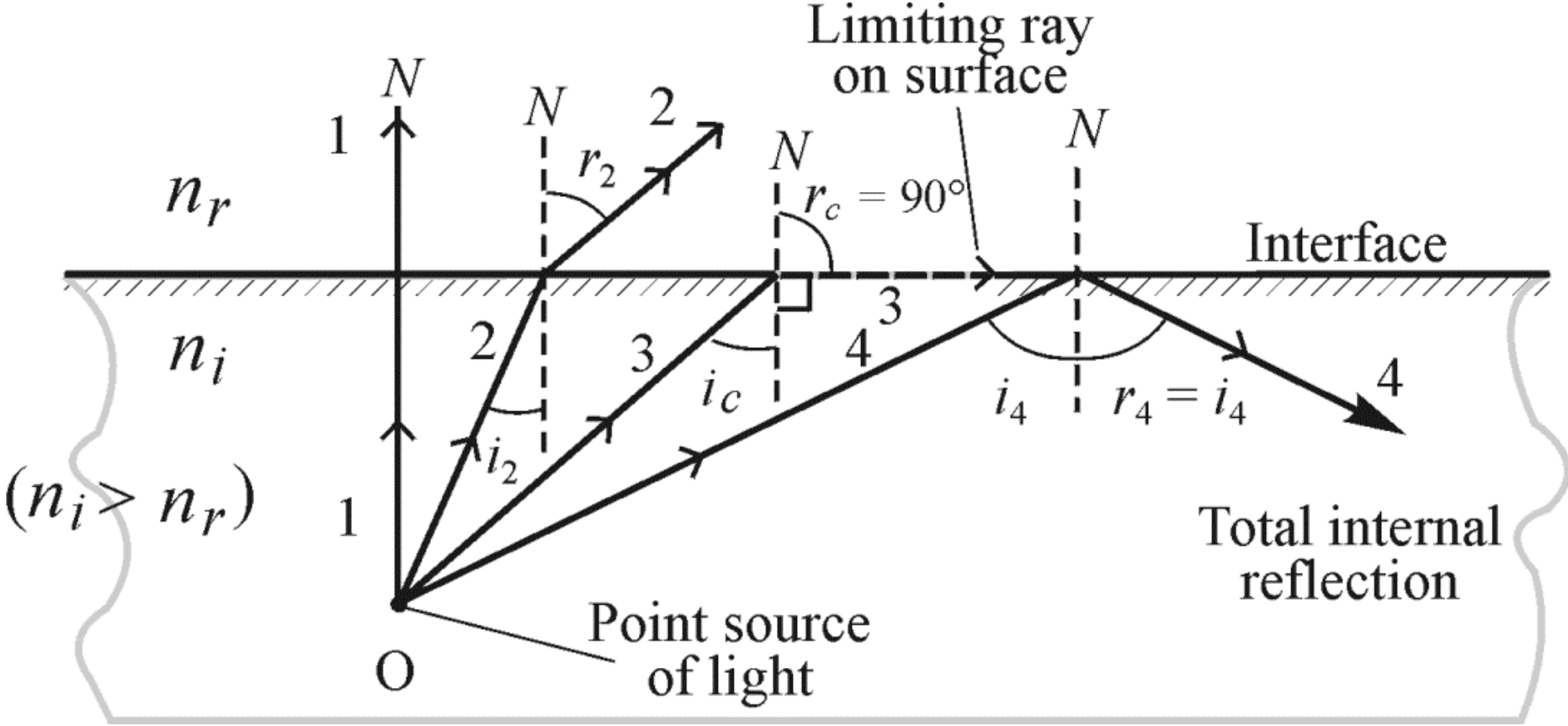


Figure 4-10 *Critical angle* i_c *and total internal reflection*

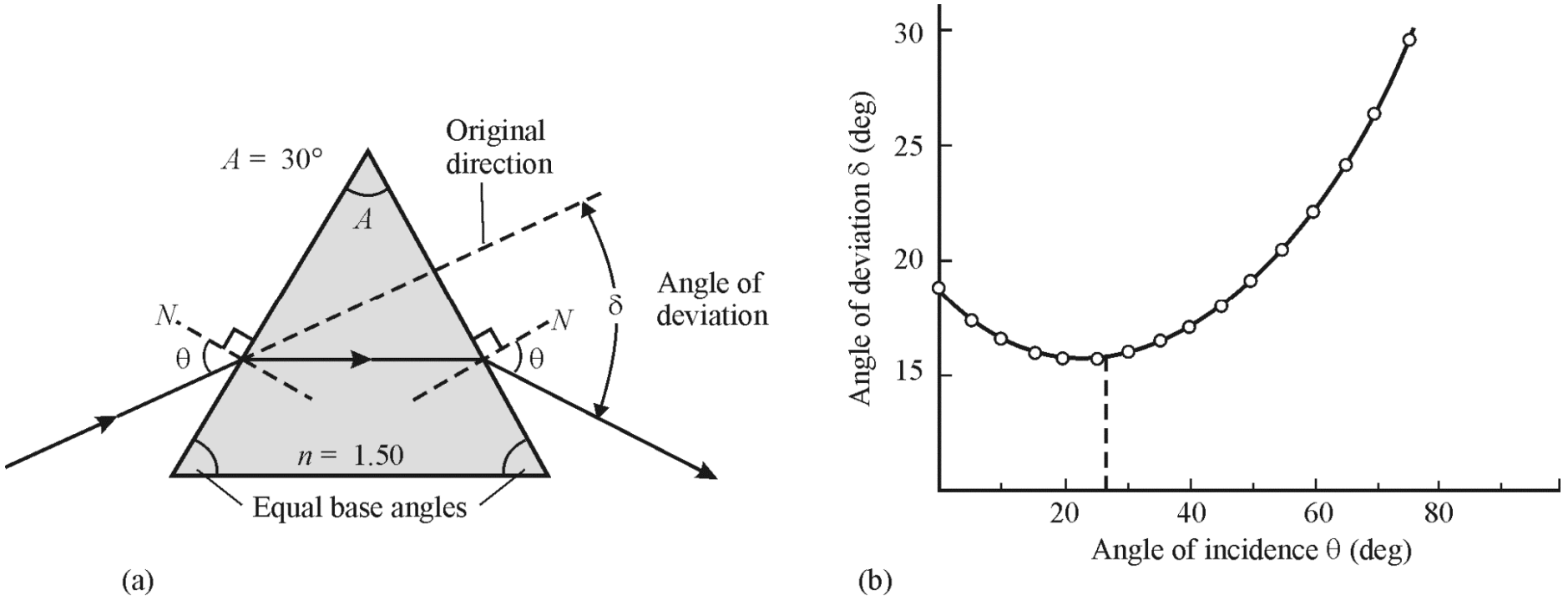
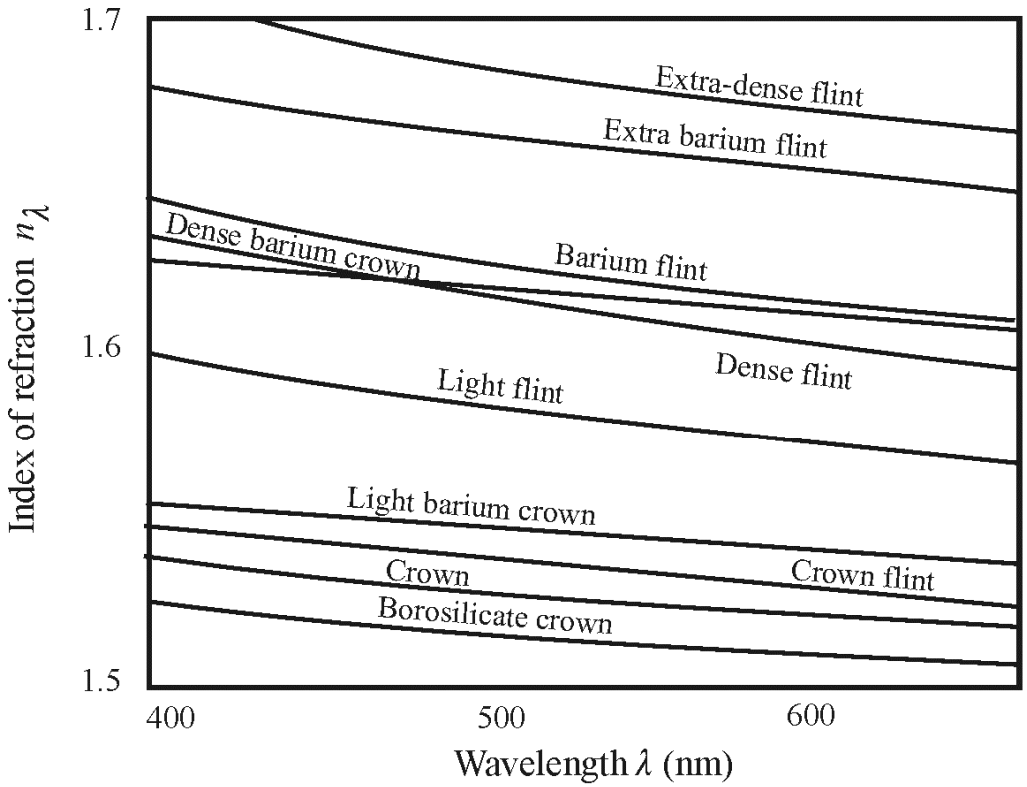
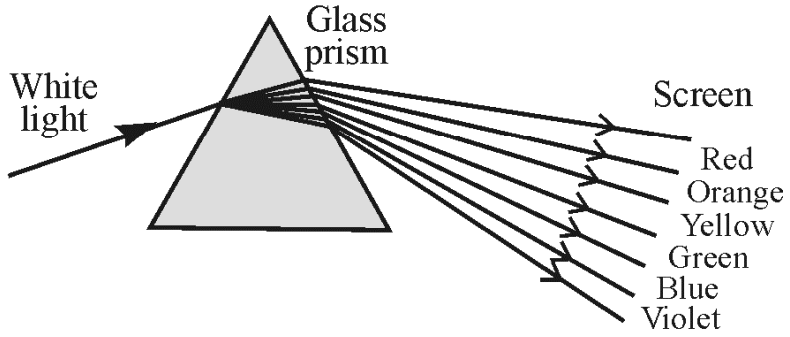


Figure 4-11 *Refraction of light through a prism*



(a) Optical glass dispersion curves



(b) Refraction by a prism

Figure 4-12 *Typical dispersion curves and separation of white light after refraction by a prism*

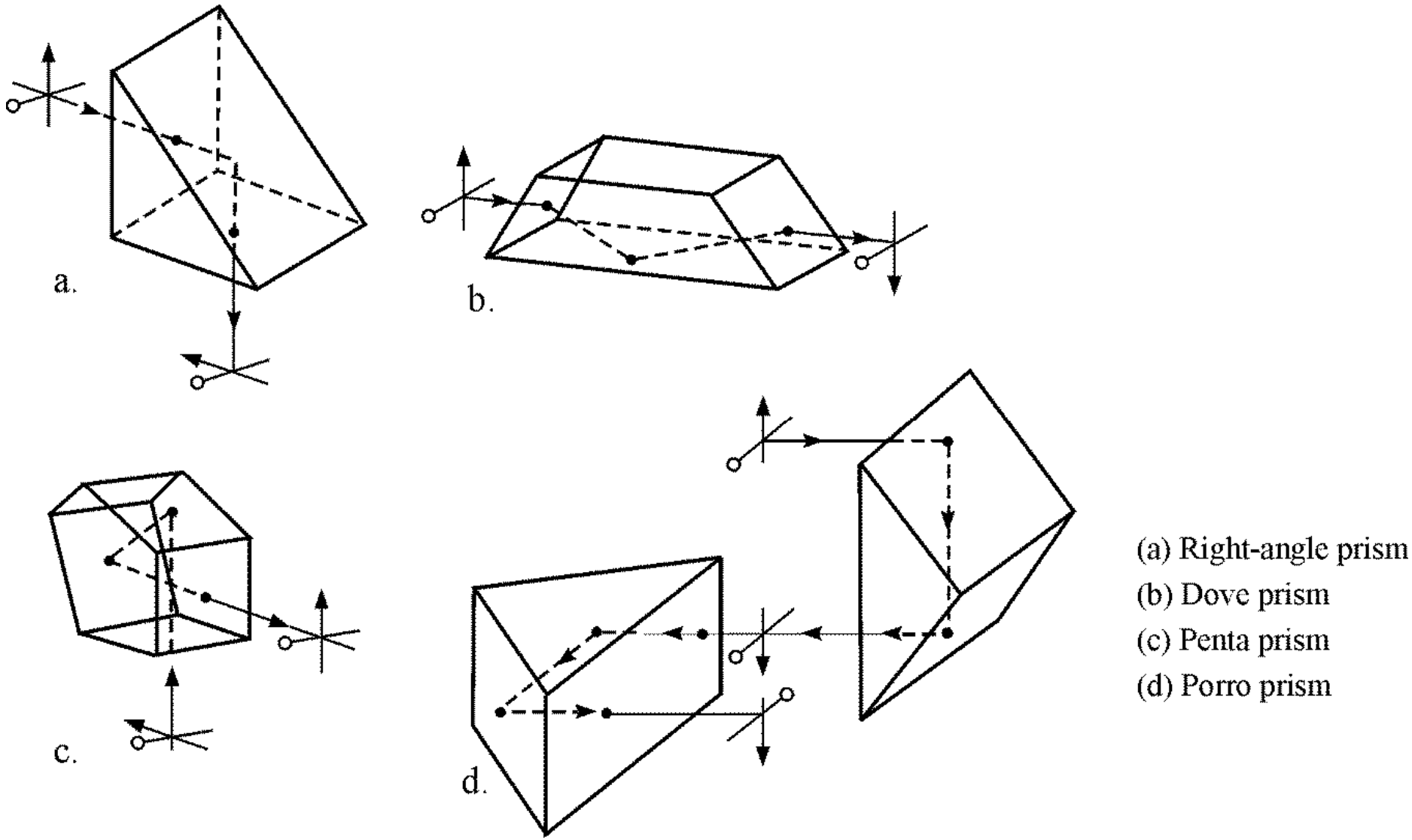


Figure 4-13 *Image manipulation with refracting prisms*

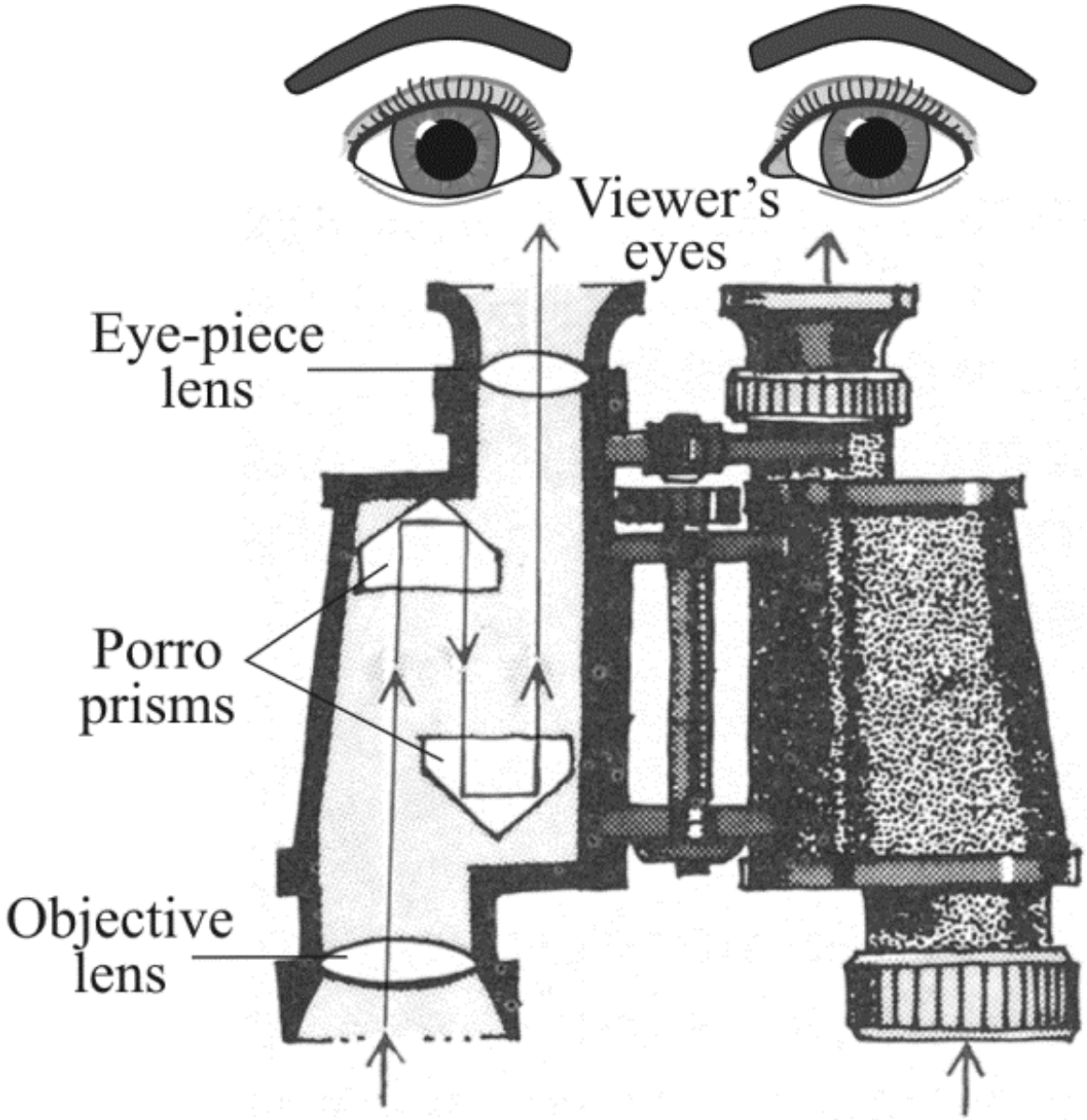


Figure 4-14 *The use of Porro prisms in ordinary binoculars*

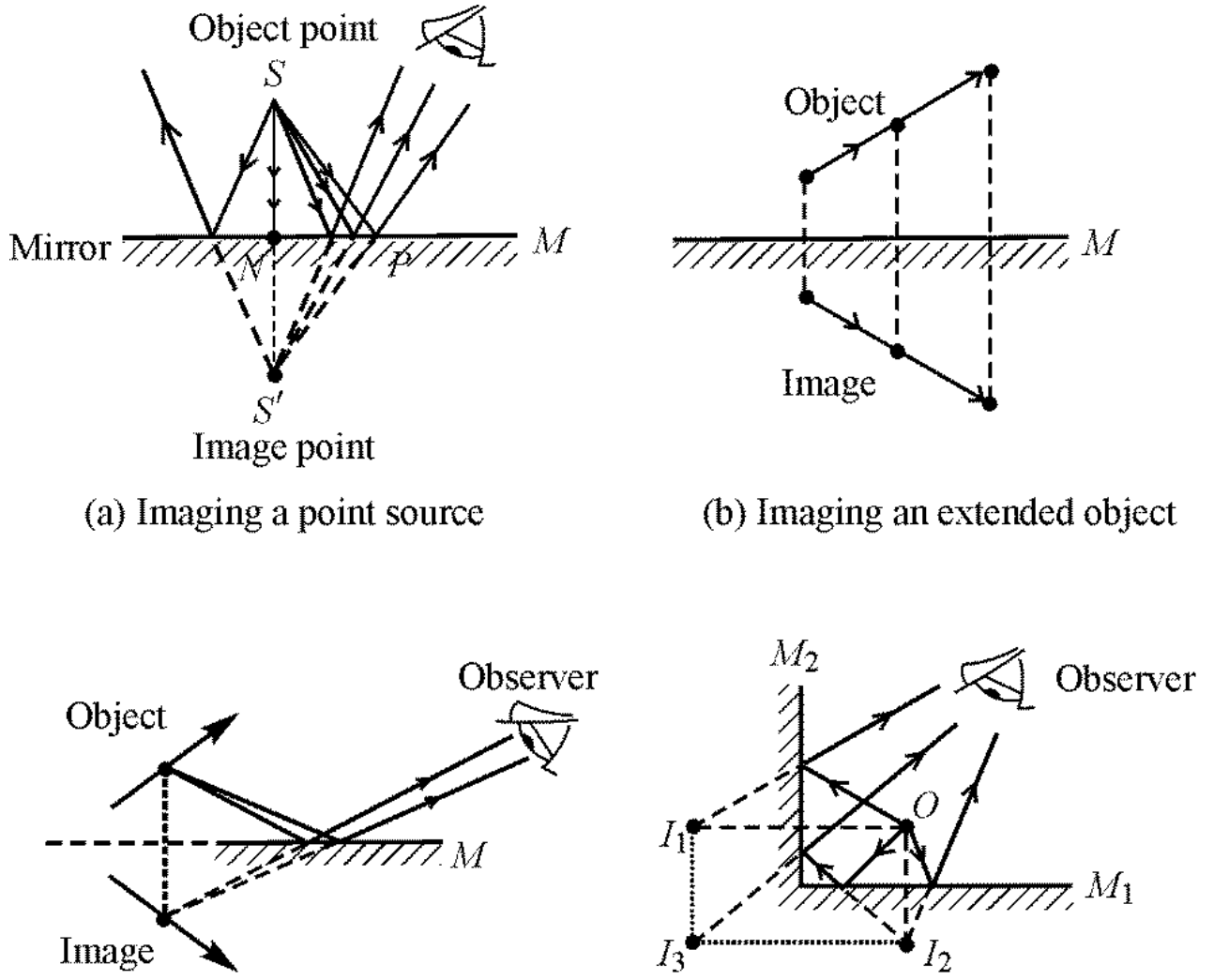


Figure 4-15 *Image formation in a plane mirror*

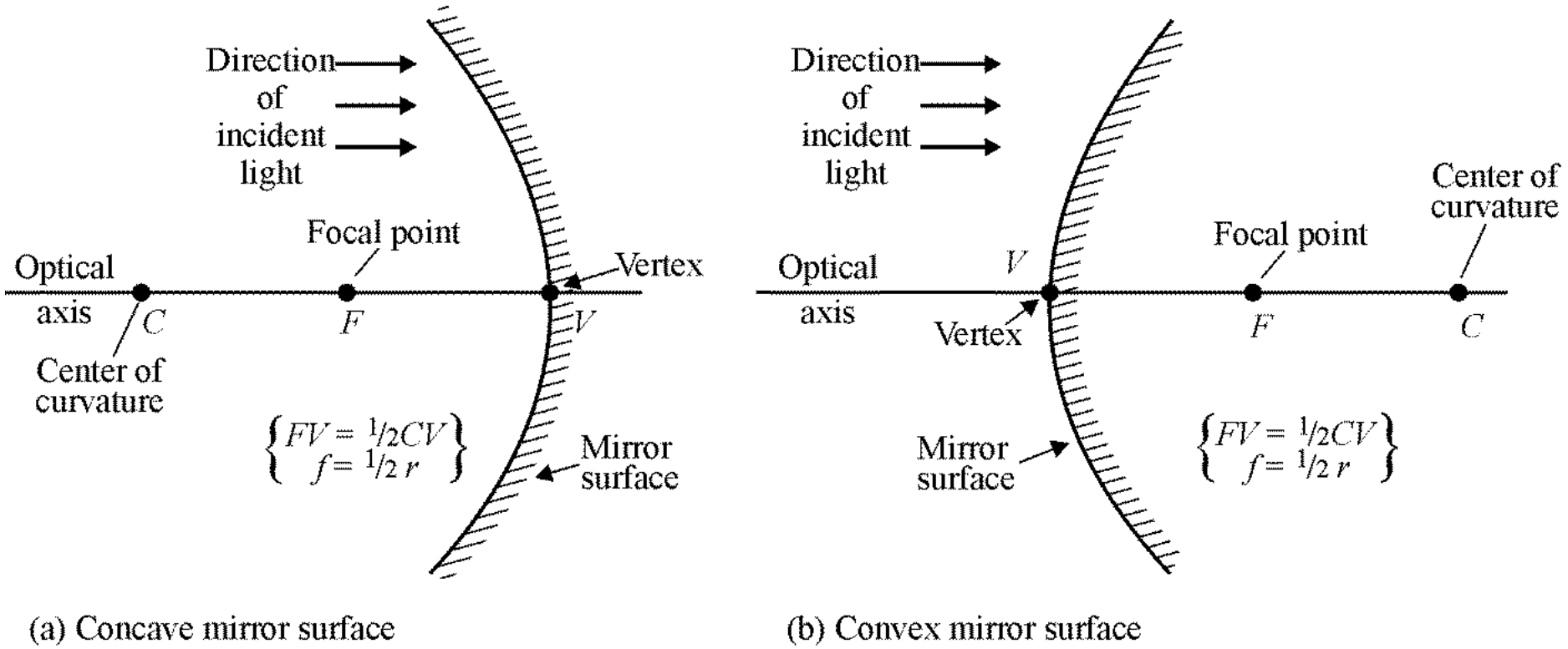


Figure 4-16 *Defining points for concave and convex mirrors*

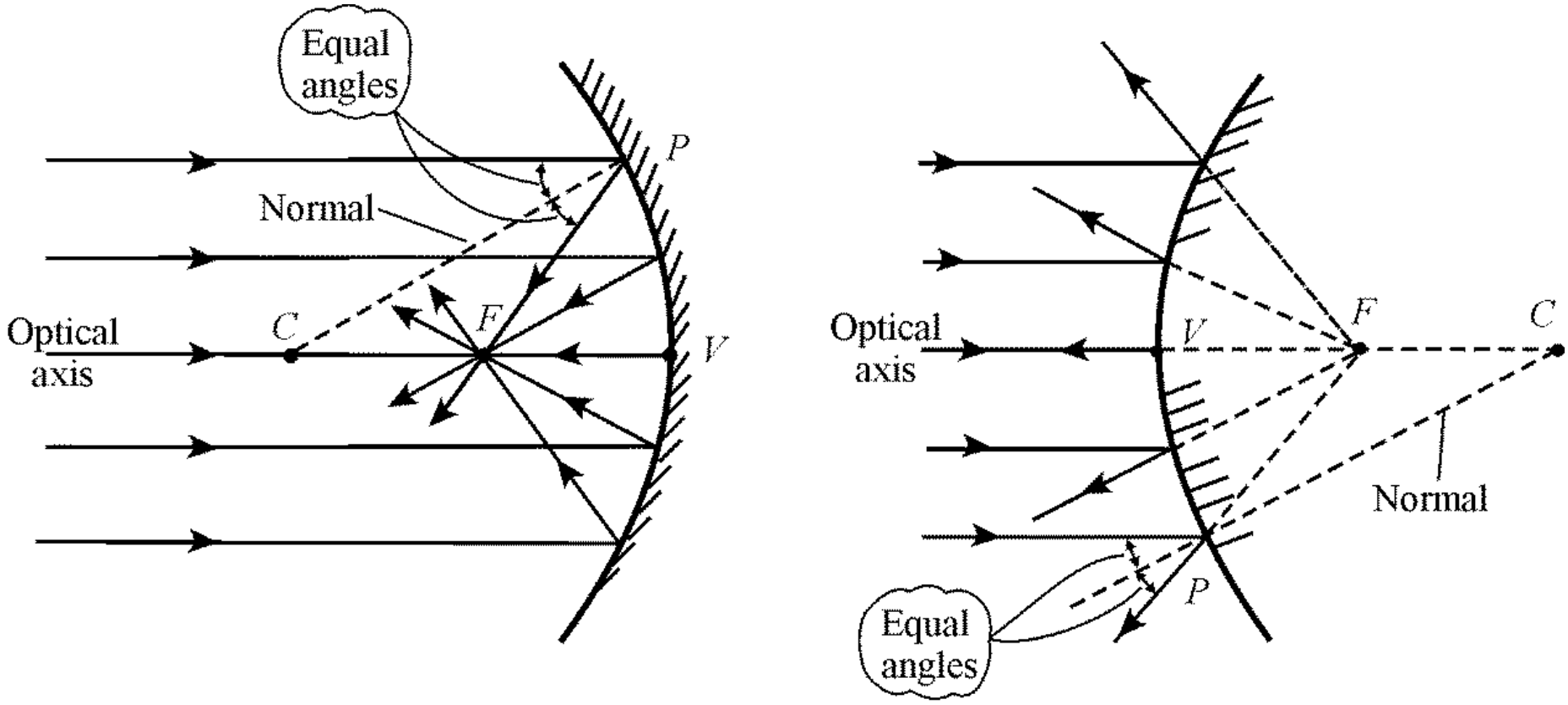
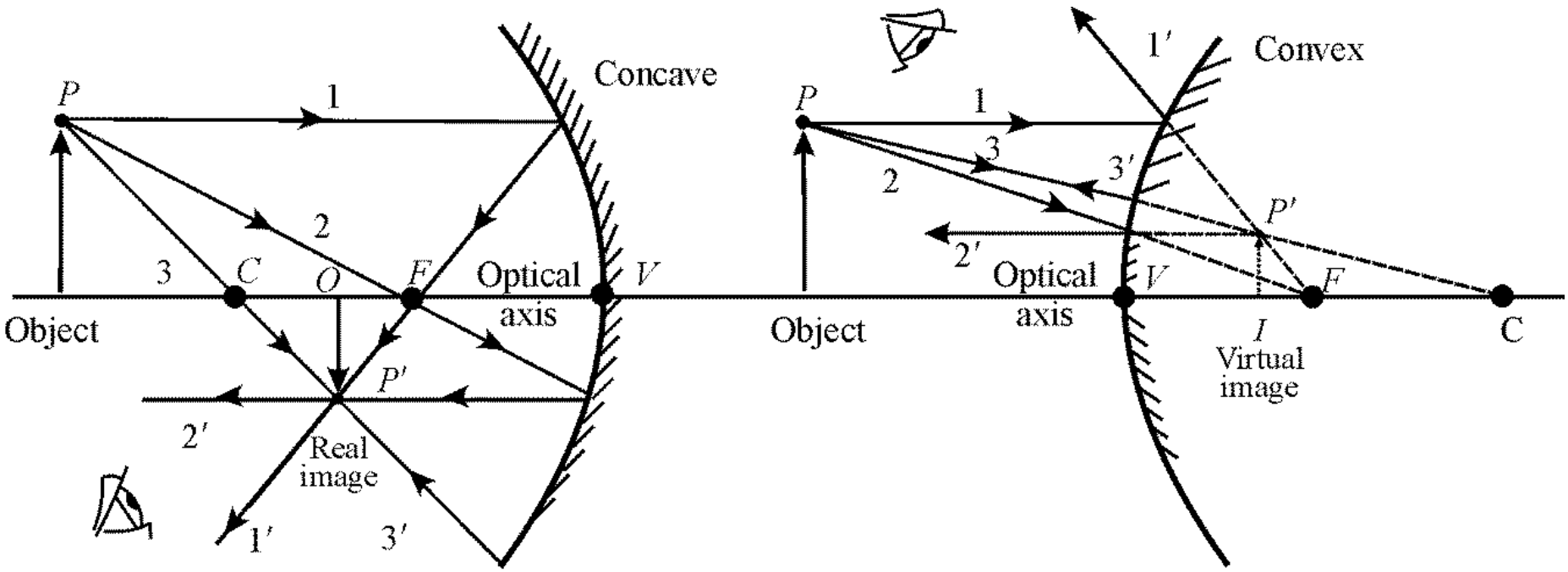


Figure 4-17 *Parallel rays and focal points*



(a) Ray tracing from P to P' for a concave mirror

(b) Ray tracing from P to P' for a convex mirror

Figure 4-18 *Key rays for graphical ray tracing with spherical mirrors*

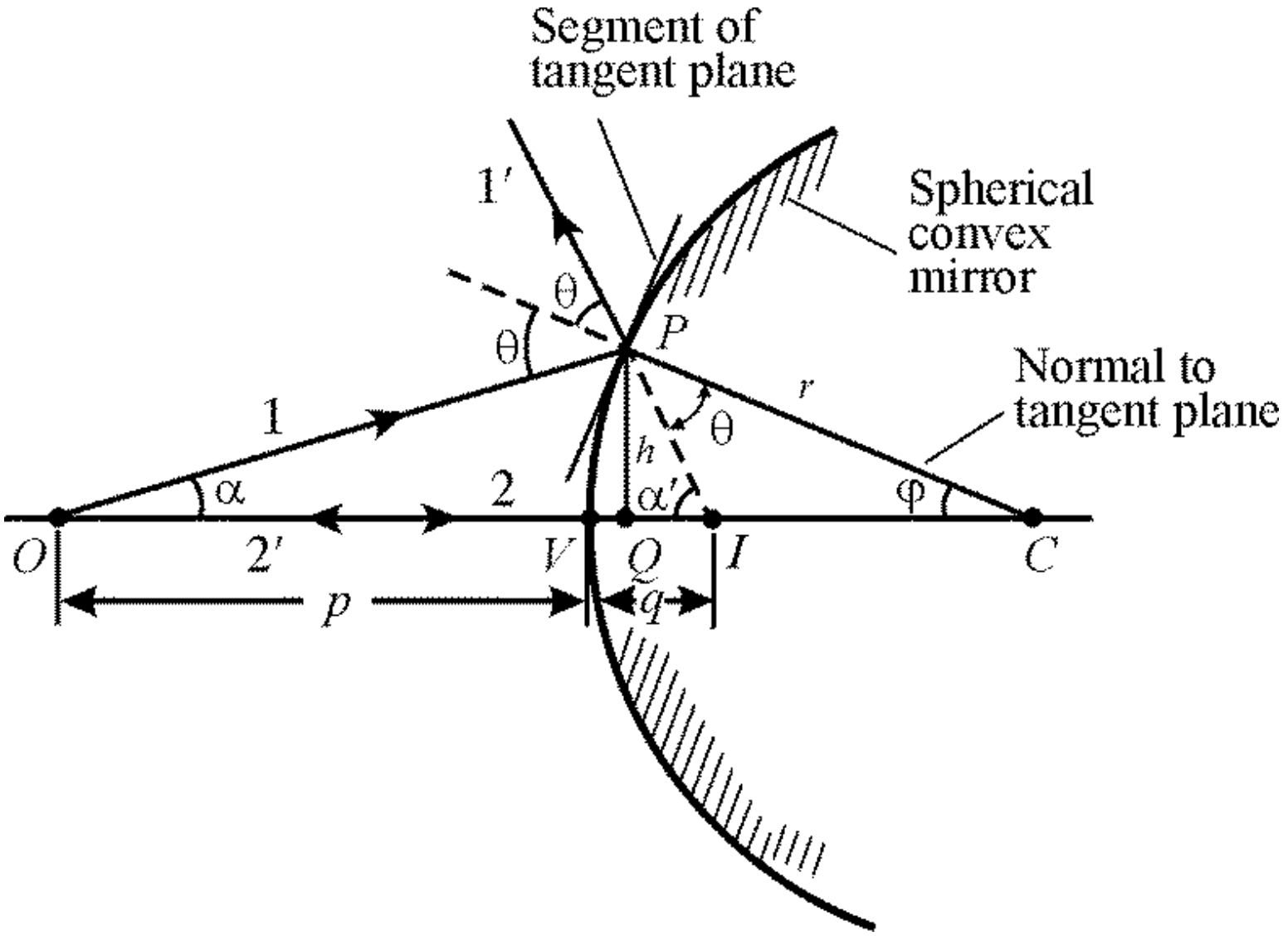


Figure 4-19 *Basic drawing for deriving the mirror formula*

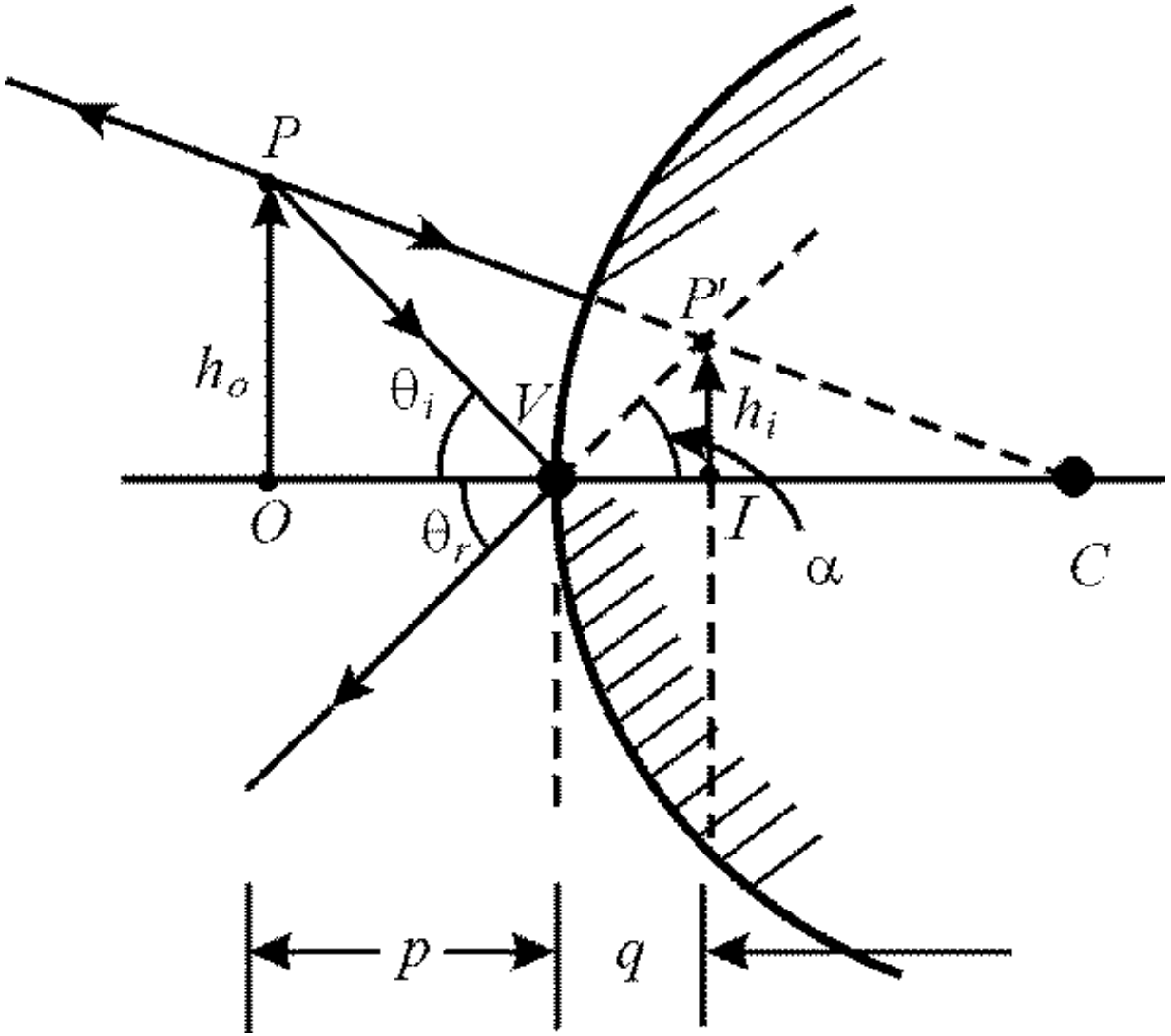
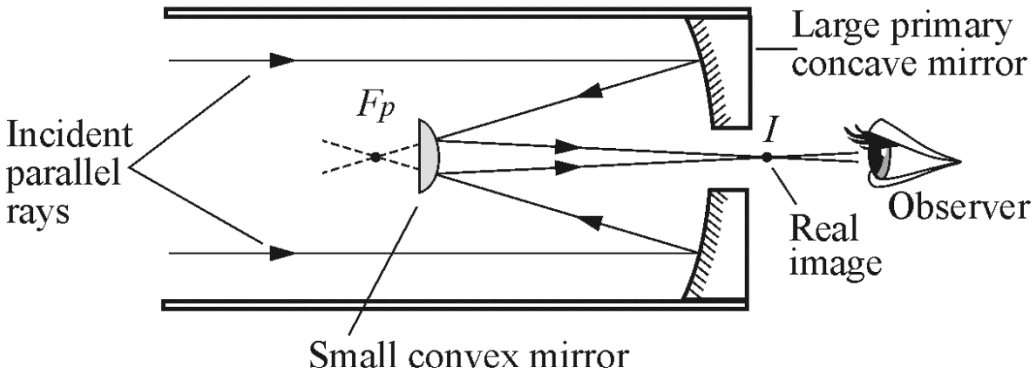
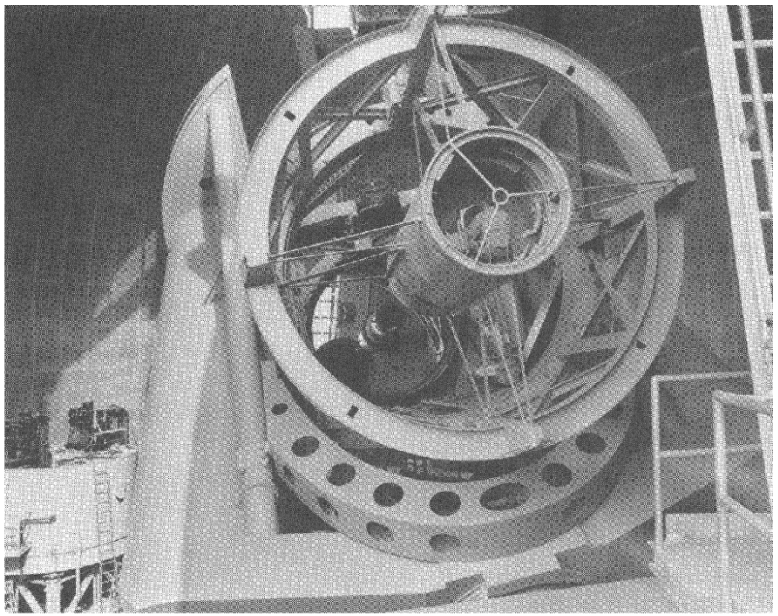


Figure 4-20 *Construction for derivation of mirror magnification formula*



(a) Ray optics for a Cassegrain telescope



(b) Hale telescope (200-in.) showing observer in prime-focus cage and reflecting surface of 200-in. mirror (California Institute of Technology.)

Figure 4-21 *Cassegrain telescope*

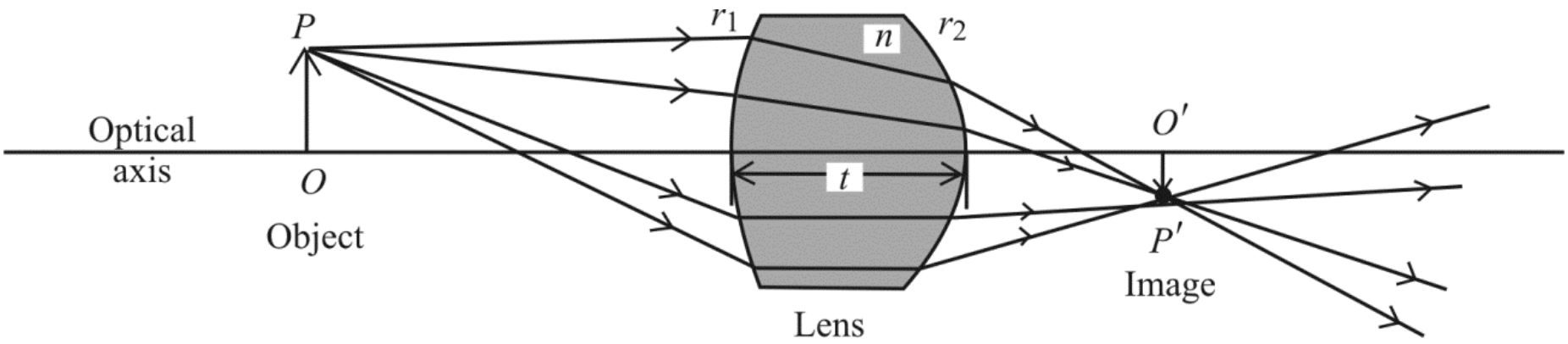


Figure 4-22 *Refraction of light rays by a lens*

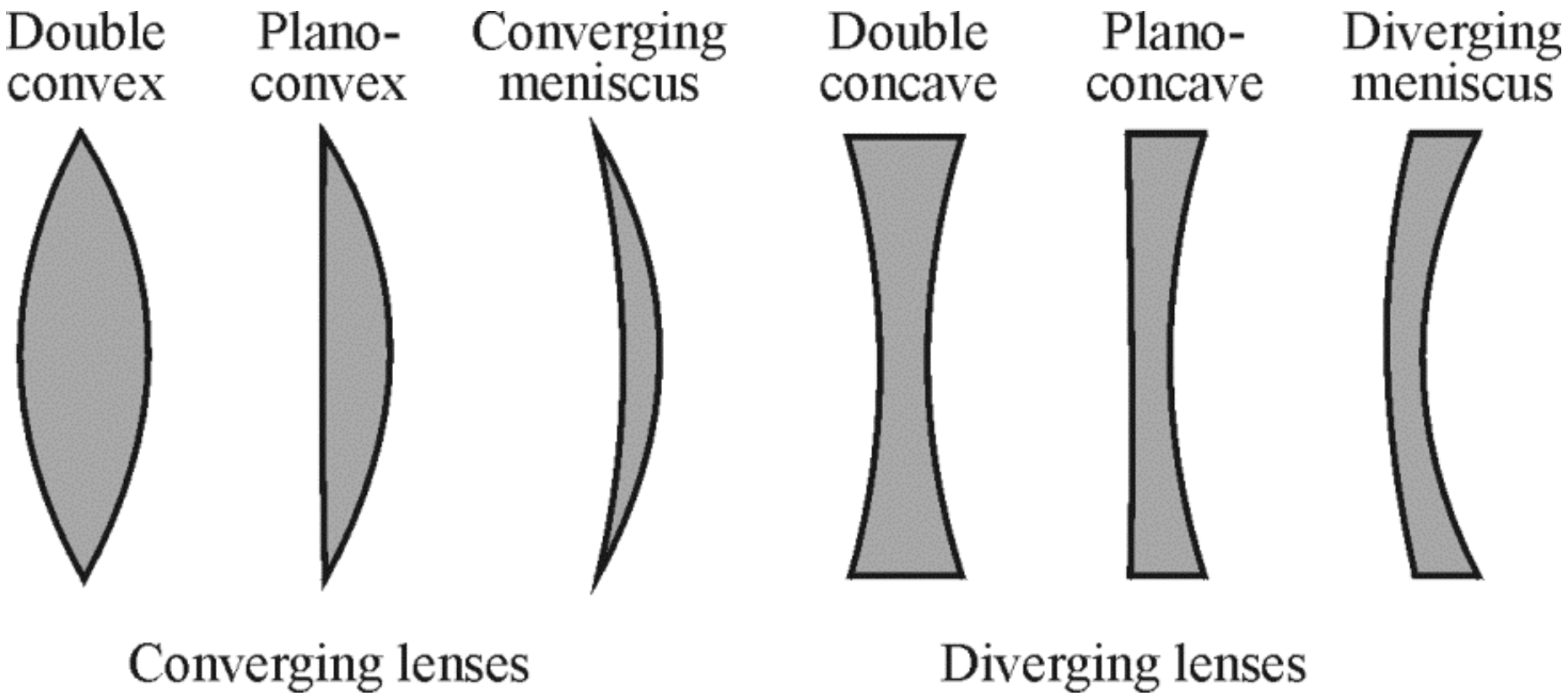


Figure 4-23 *Shapes of common thin lenses*

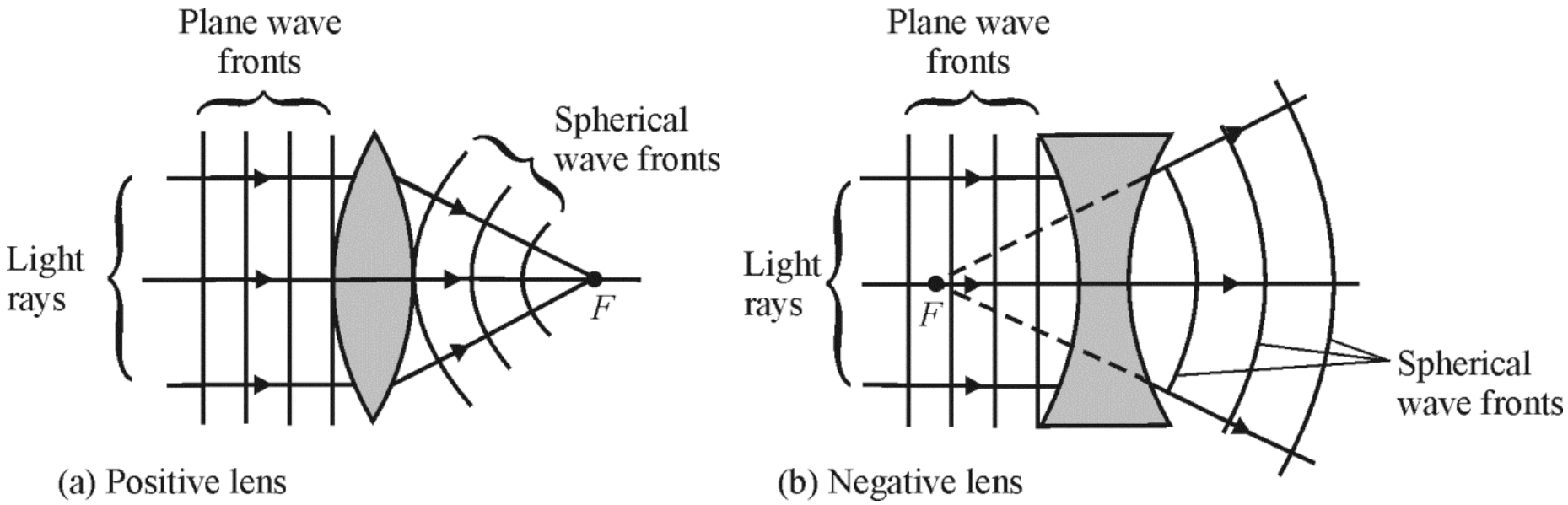


Figure 4-24 *Focal points for positive and negative lenses*

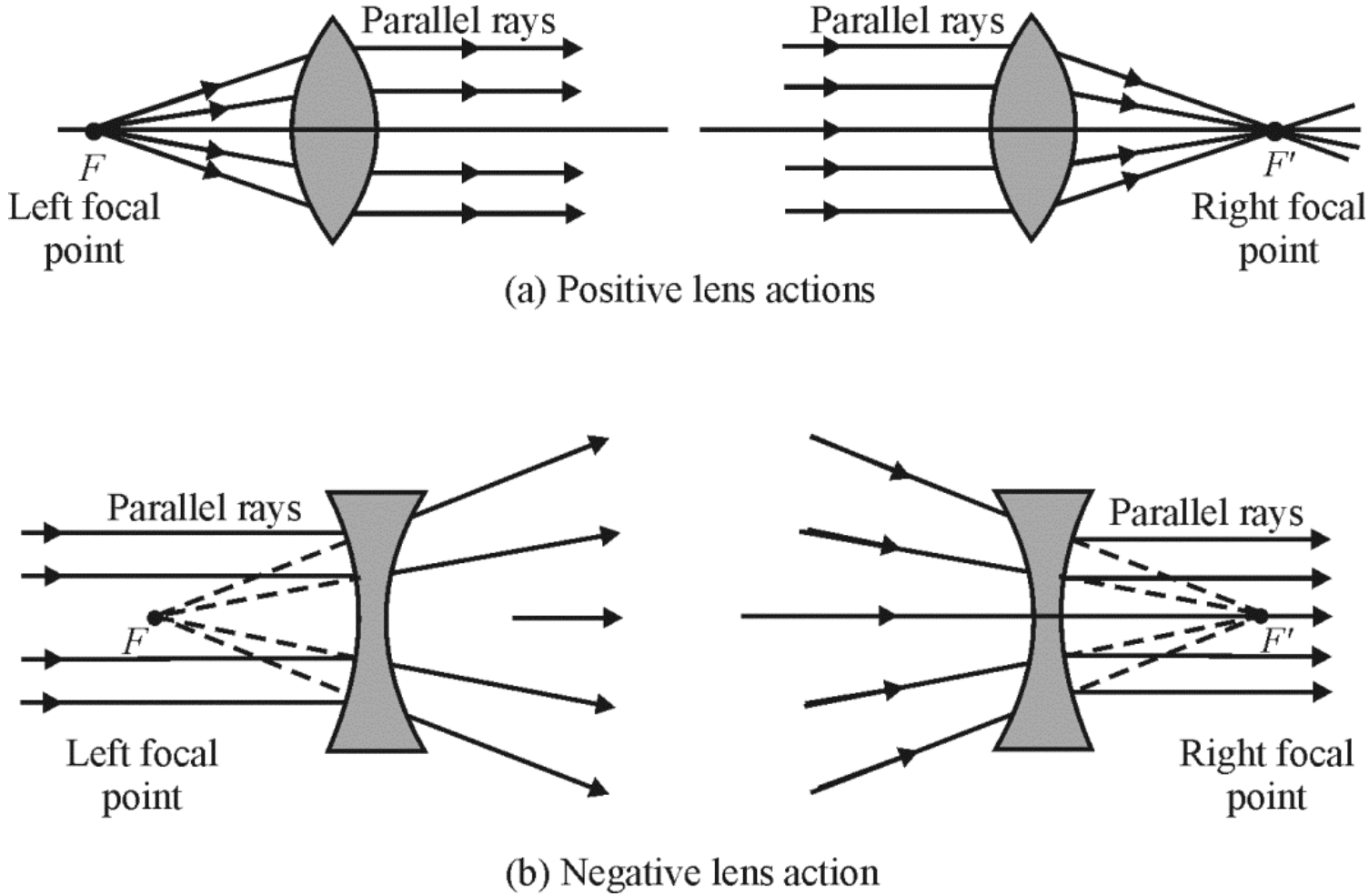


Figure 4-25 *Relationship of parallel light rays to right and left focal points in thin lenses*

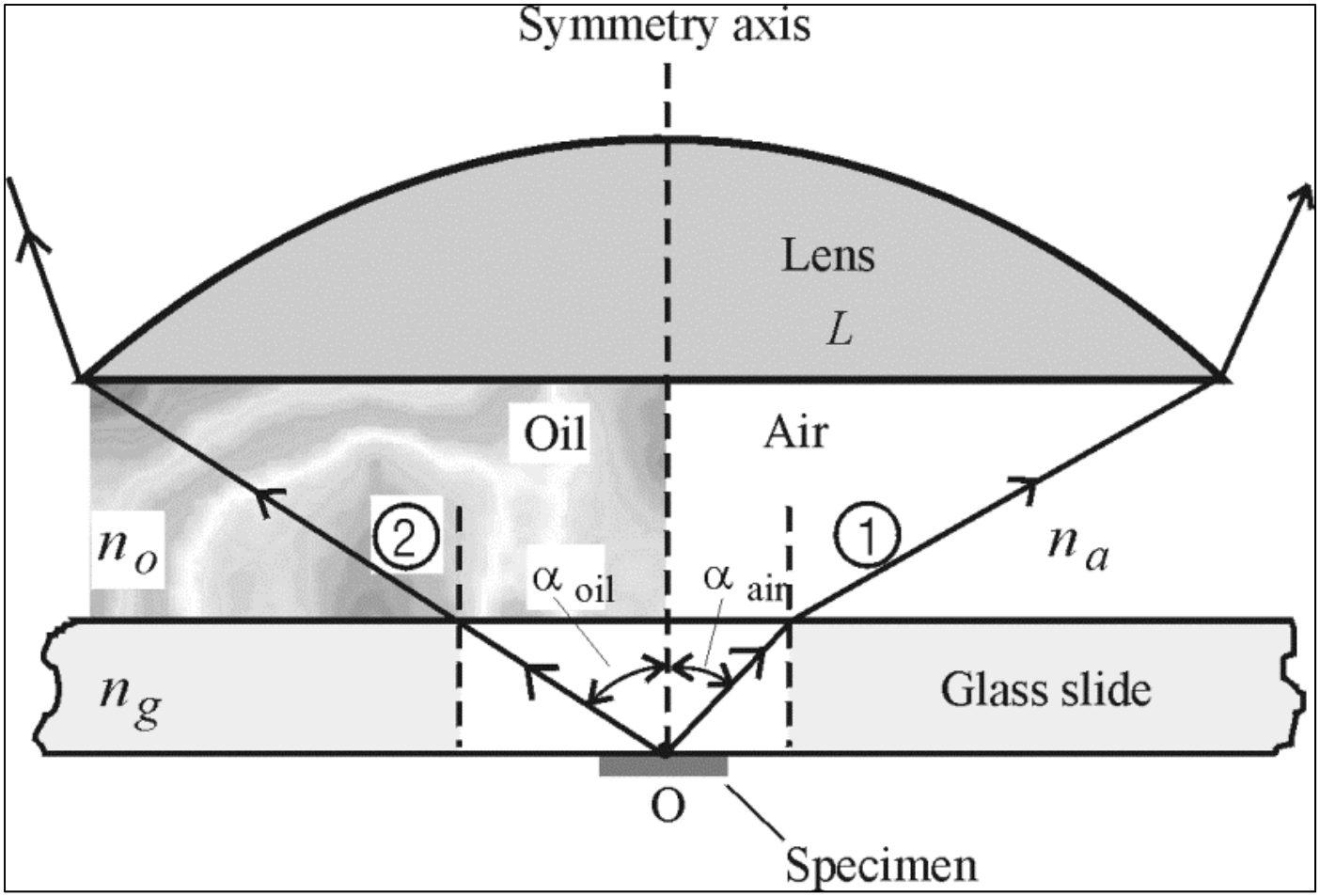


Figure 4-*26* *Comparison of light-gathering power of an oil-immersion lens system and an air-immersion lens system, showing that the oil-immersion lens system is superior*

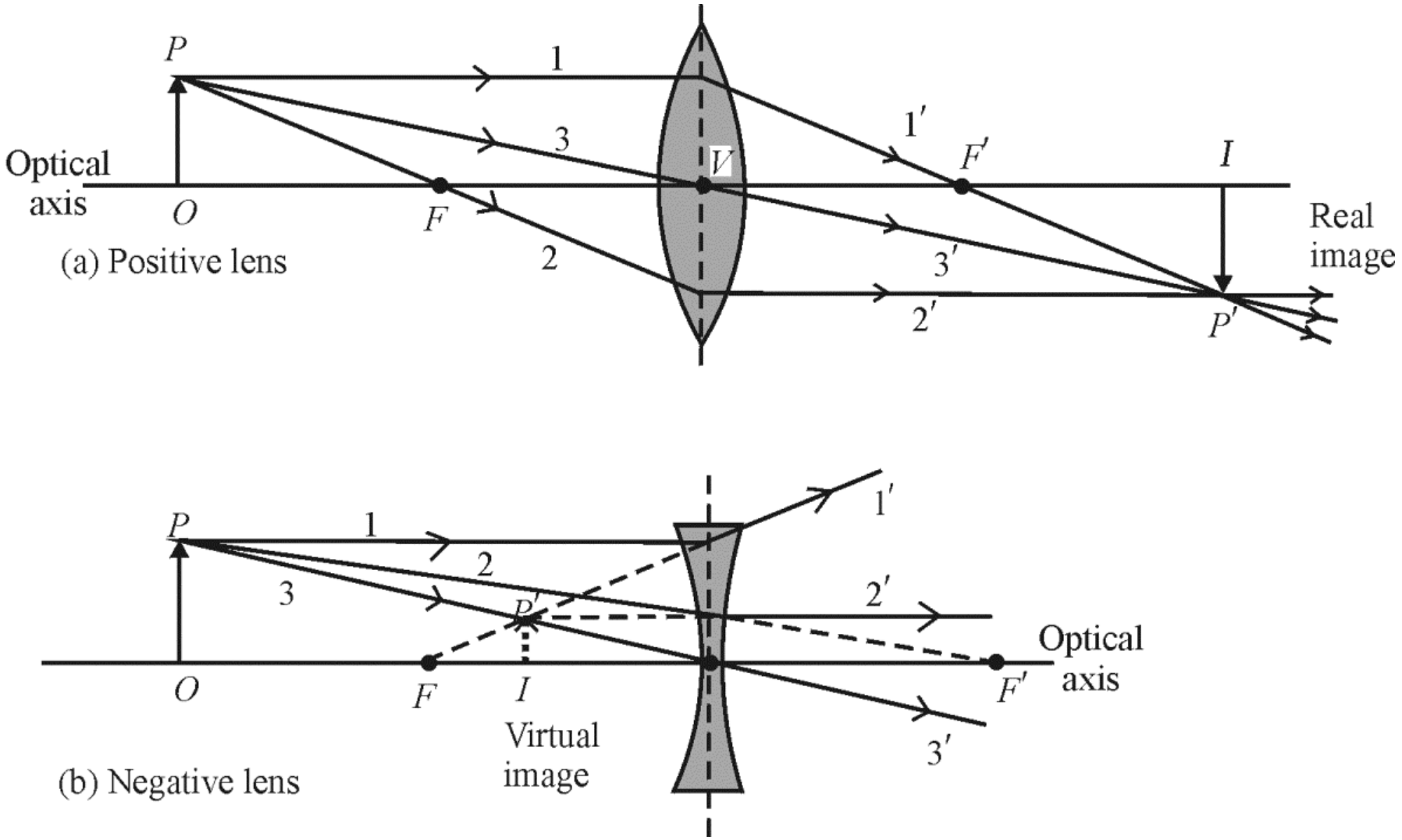


Figure 4-27 *Ray diagrams for image formation by positive and negative lenses*

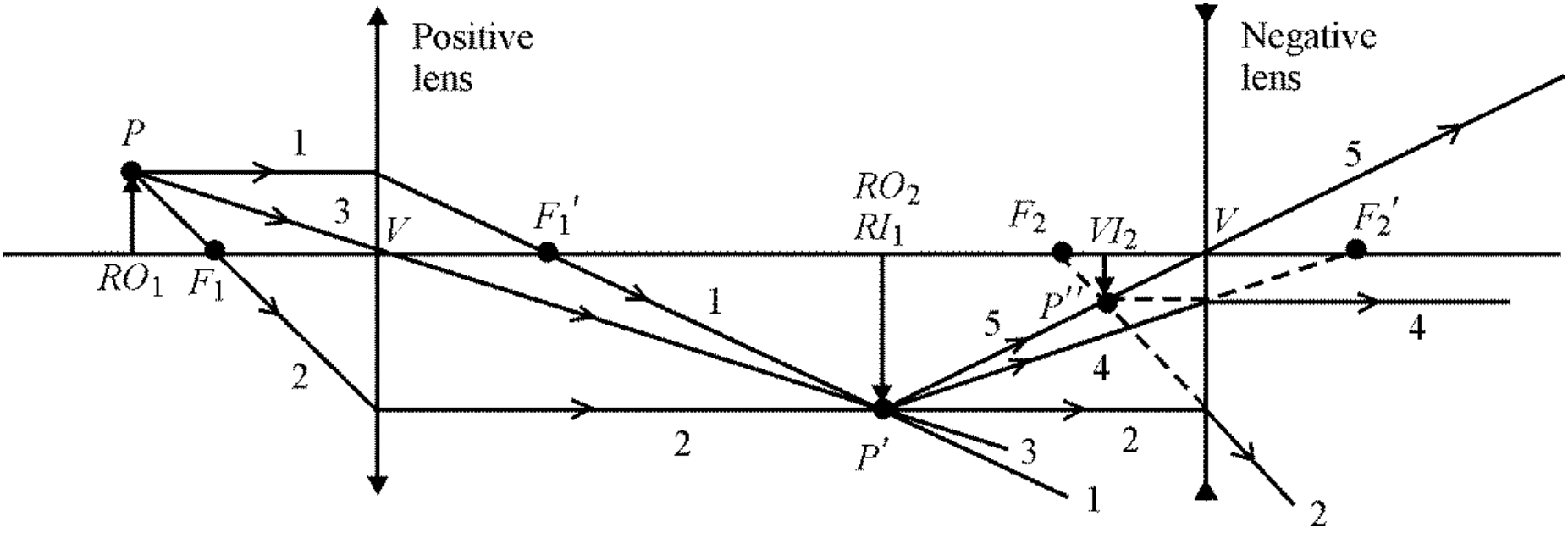


Figure 4-28 *Ray diagram for image formation through two lenses*

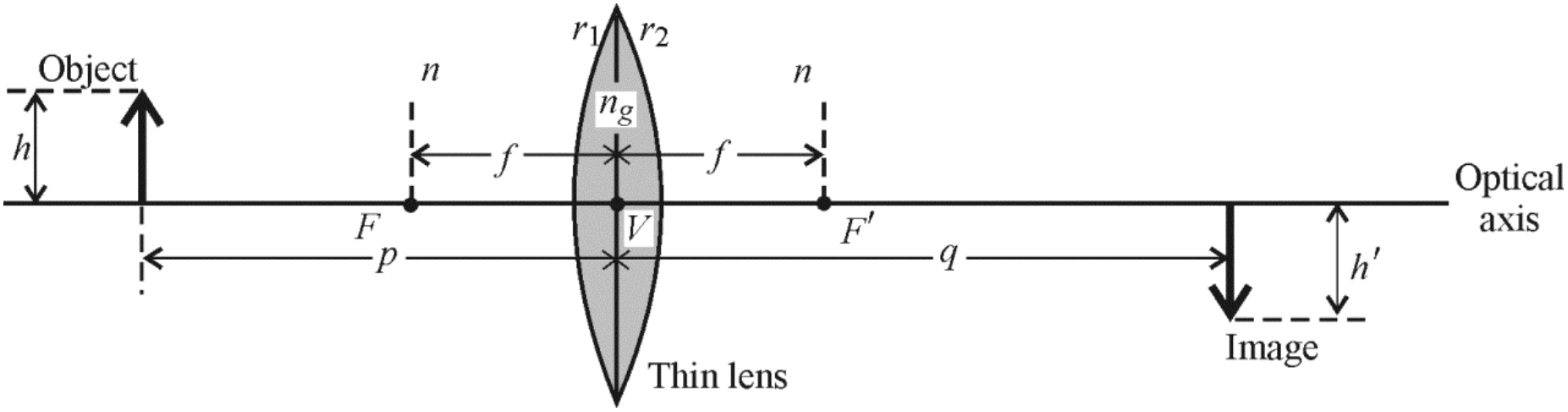


Figure 4-29 *Defining quantities for image formation with a thin lens*

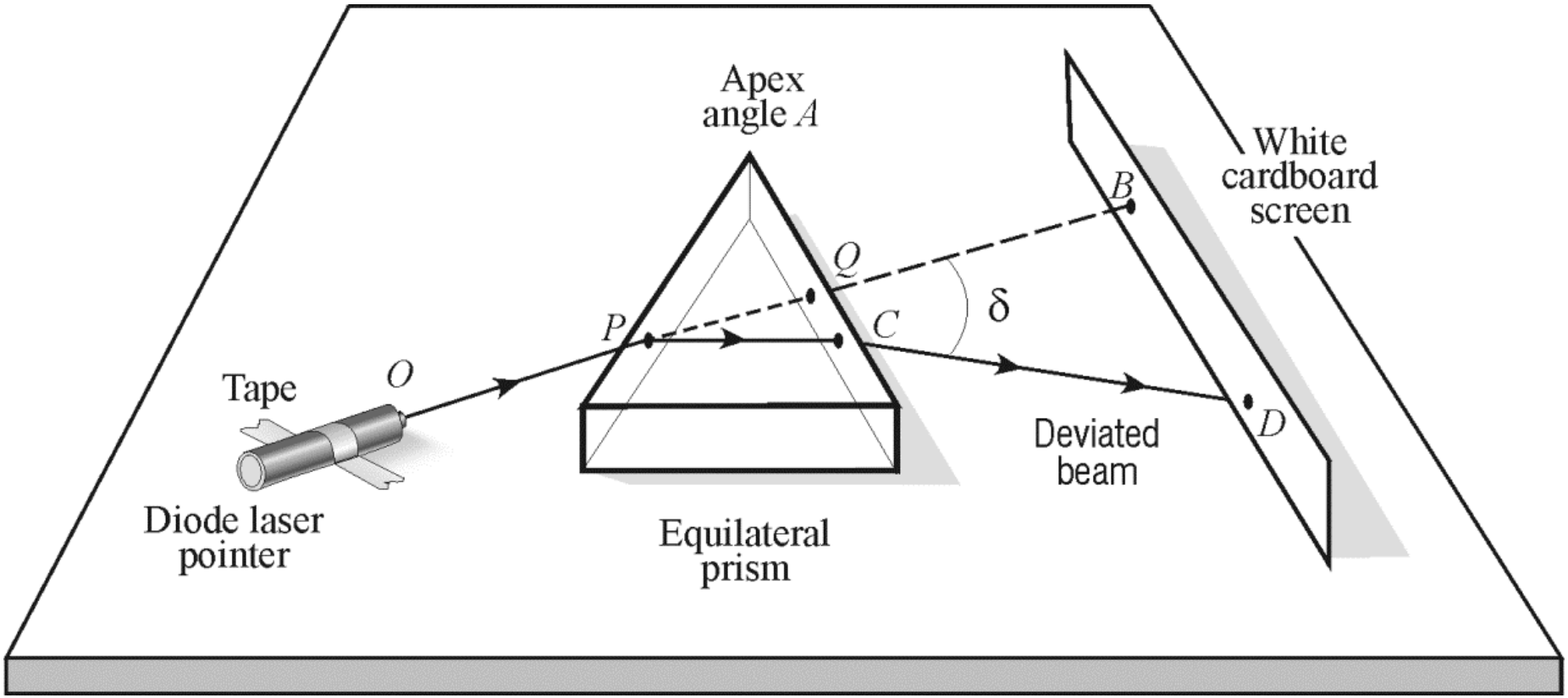


Figure 4-30 *Setup for measuring minimum angle of deviation*
(Laboratory 1-4A: Prisms and Lenses)

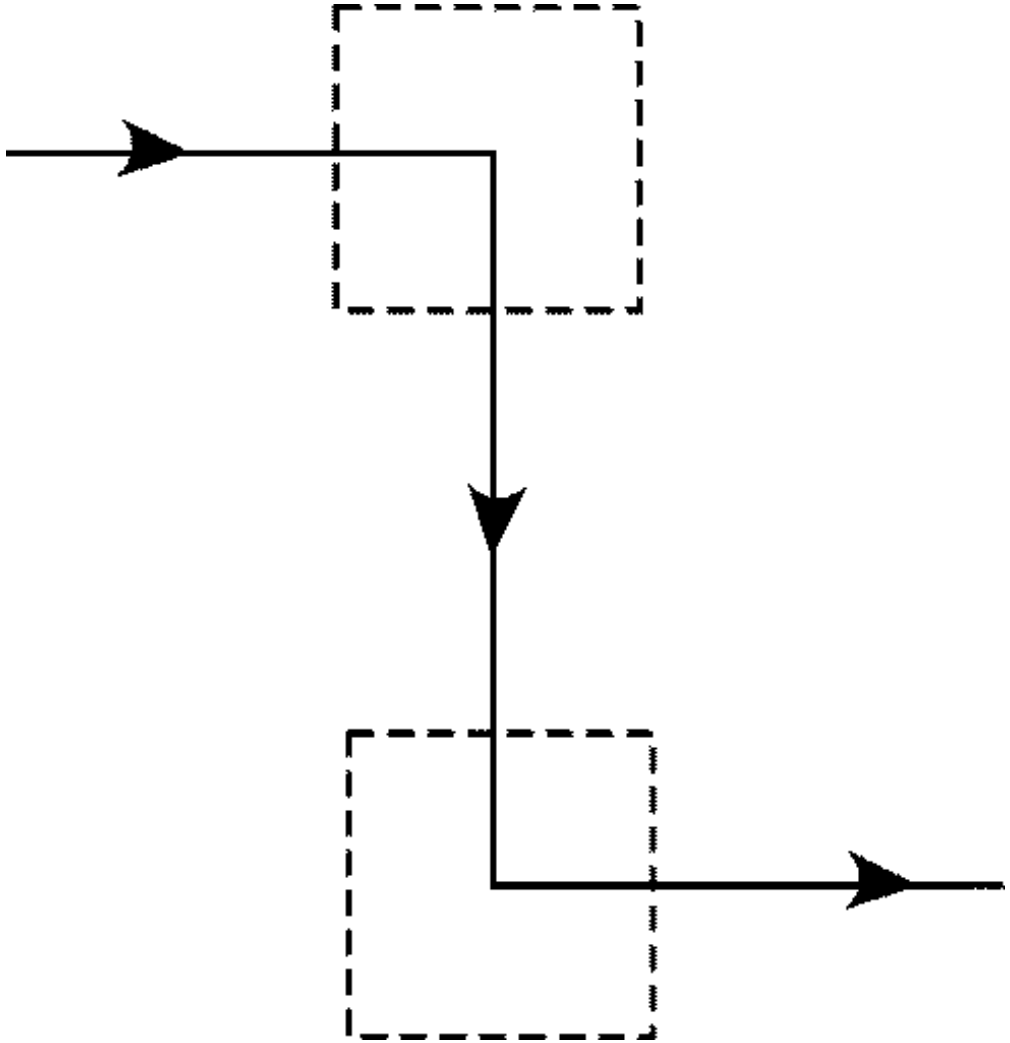


Figure 4-31
(Laboratory 1-4A: Prisms and Lenses)

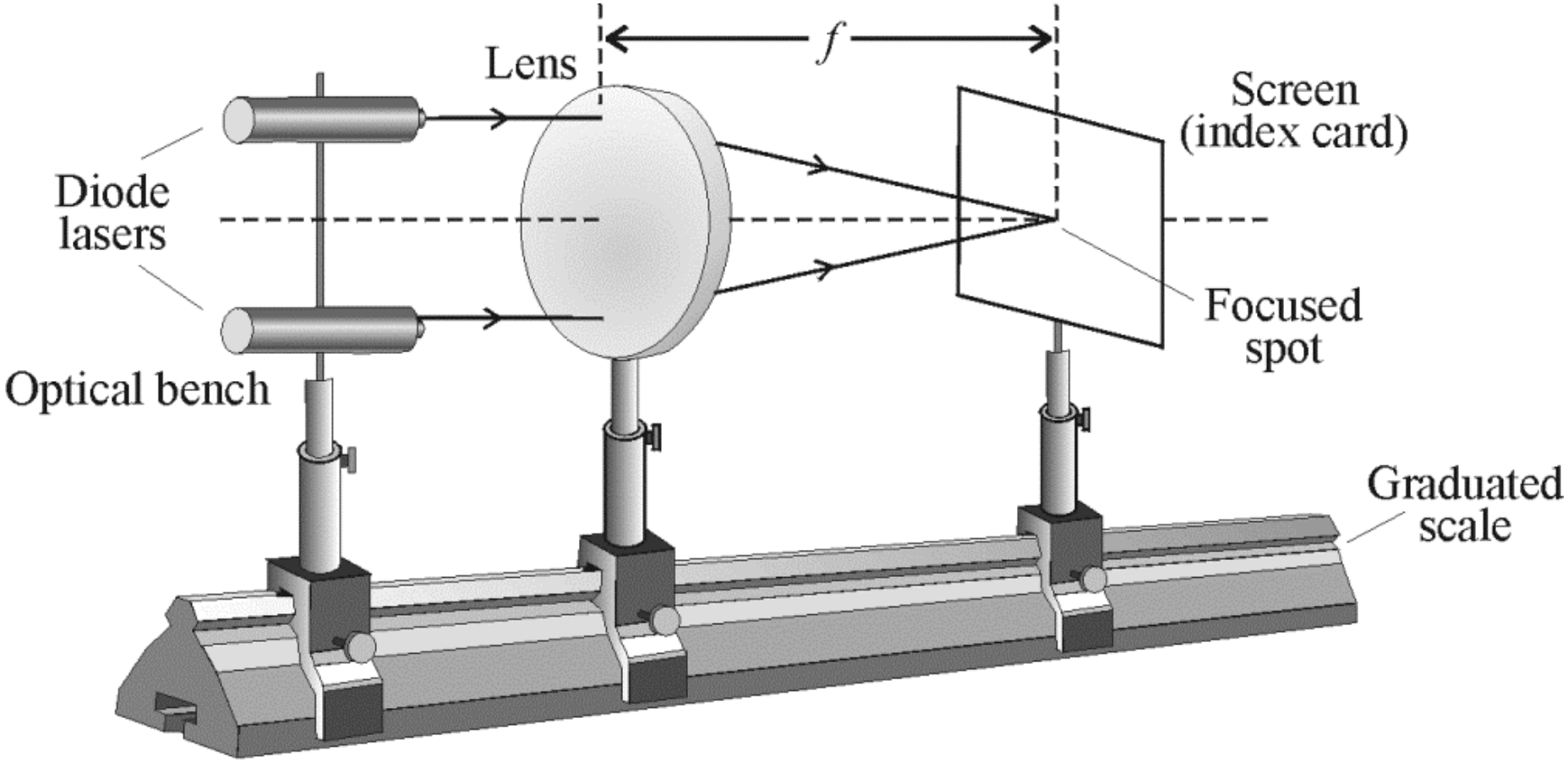


Figure 4-32 *Setup for determining focal length of a positive lens*
(Laboratory 1-4A: Prisms and Lenses)

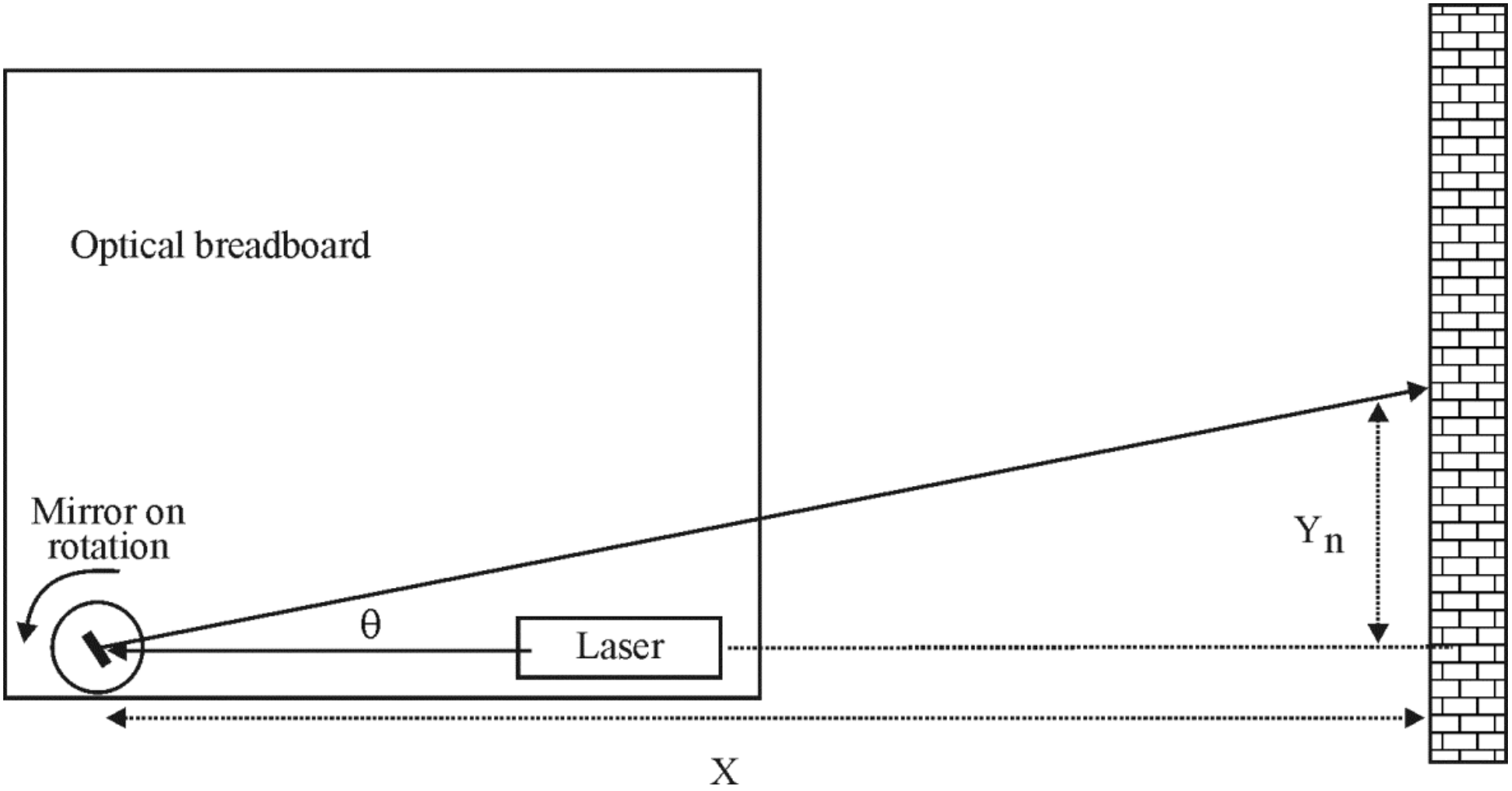


Figure 4-33 *From Laser Beam at Mirror to Point on Wall*
(Laboratory 1-4C: Law of Reflection)

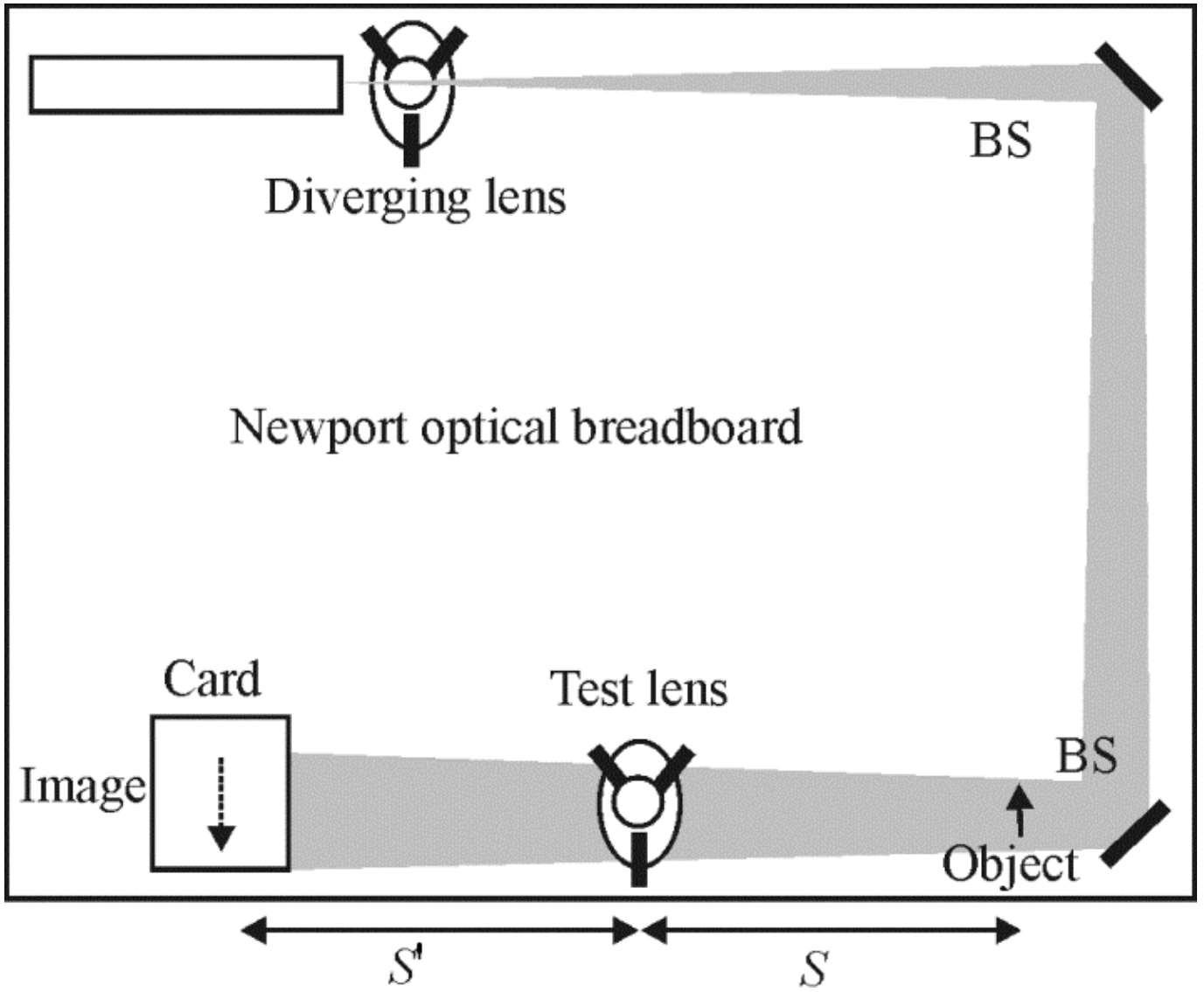


Figure 4-34
(Laboratory 1-4D: Lenses)