Physics
Chapter 14: Refraction

Section 14.2
Thin Lenses

Lenses

--Lenses make use of the refraction of light to form images of objects.

--Depending upon the kind of lens used and the location of the object, the image may be:

1) real or virtual,

2) right-side up or inverted, and

3) smaller or larger than the object.

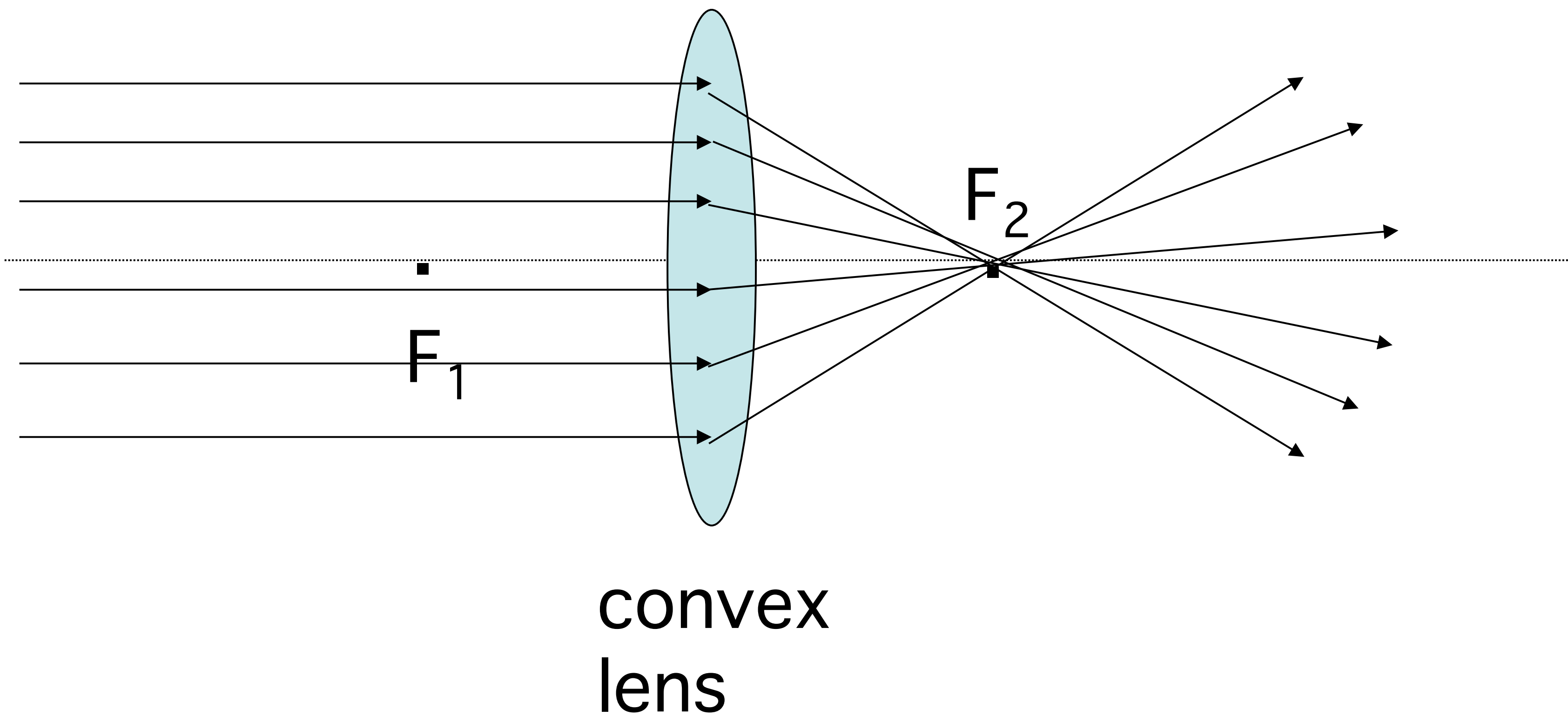
--Lenses are used in eyeglasses, magnifying lenses, and in optical instruments such as cameras, projectors, microscopes, and telescopes.

Convex or Converging Lenses

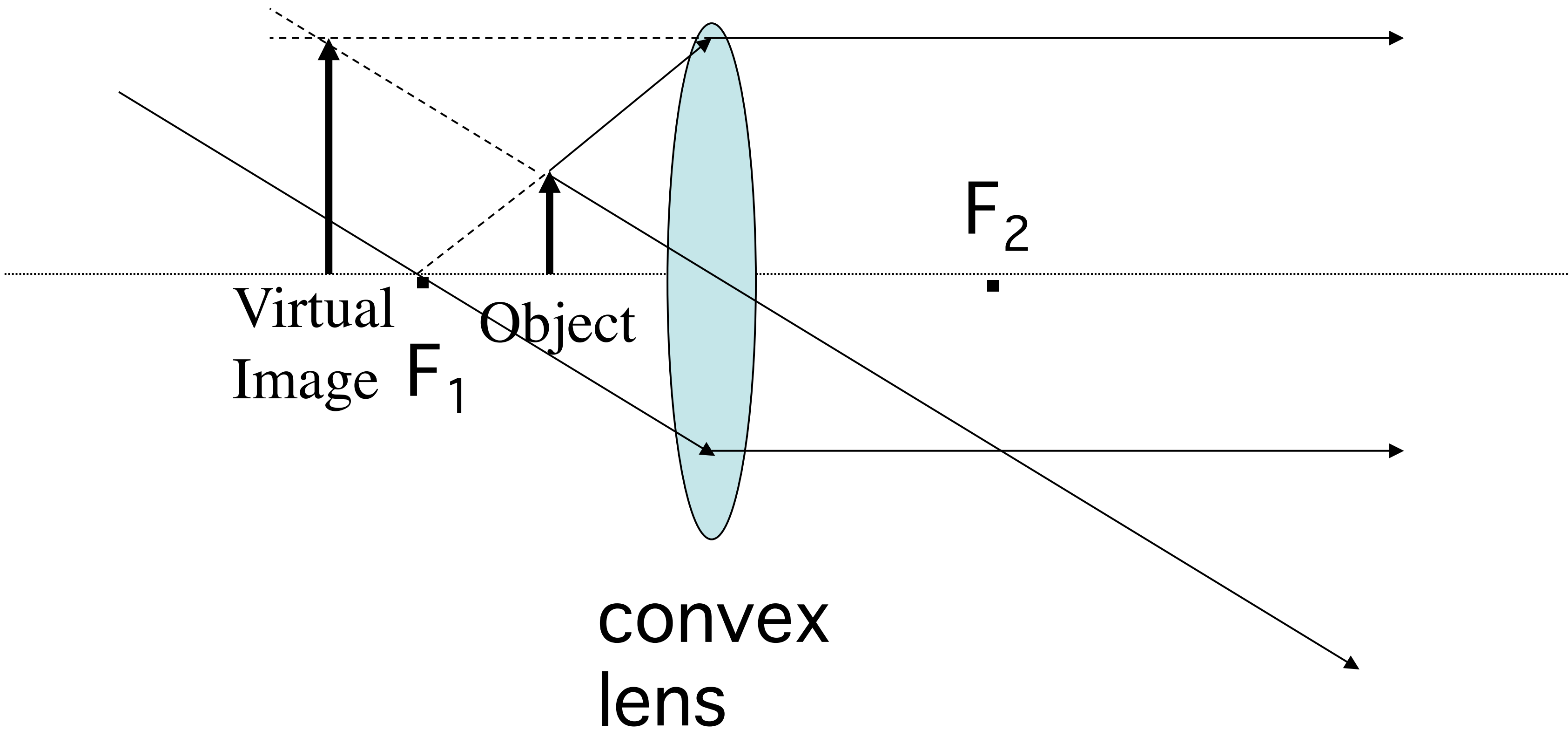
--A lens that is <u>thicker</u> at the center than at the edges is called a <u>convex lens</u>.

-- A convex lens causes rays of light to meet at a <u>focal point</u> and are therefore also called <u>converging lenses</u>.

Convex Lens



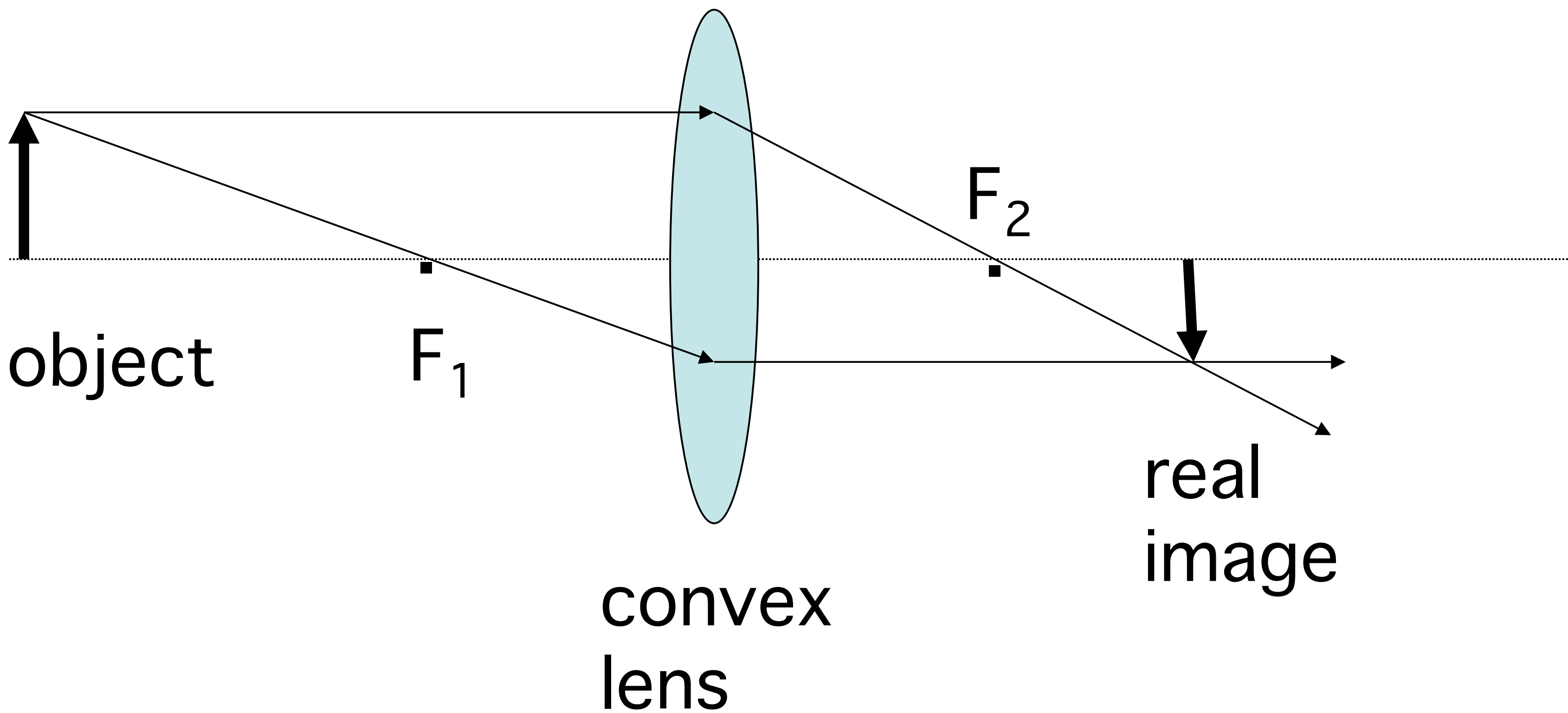
Convex Lens



--A convex lens forms a <u>real image</u> when the object is located outside the focal point of the lens.

--The real image is inverted with its size changing from smaller to larger than the object as the object approaches the focal point.

Convex Lens



--When the object is at the focal point, no image is seen because the refracted rays are parallel to each other.

--When the object is between the focal point and the lens, the image is virtual, right-side up, and larger than the object.

--Convex lenses are used as magnifying lenses when they are held close to an object, such as the printing in a book.

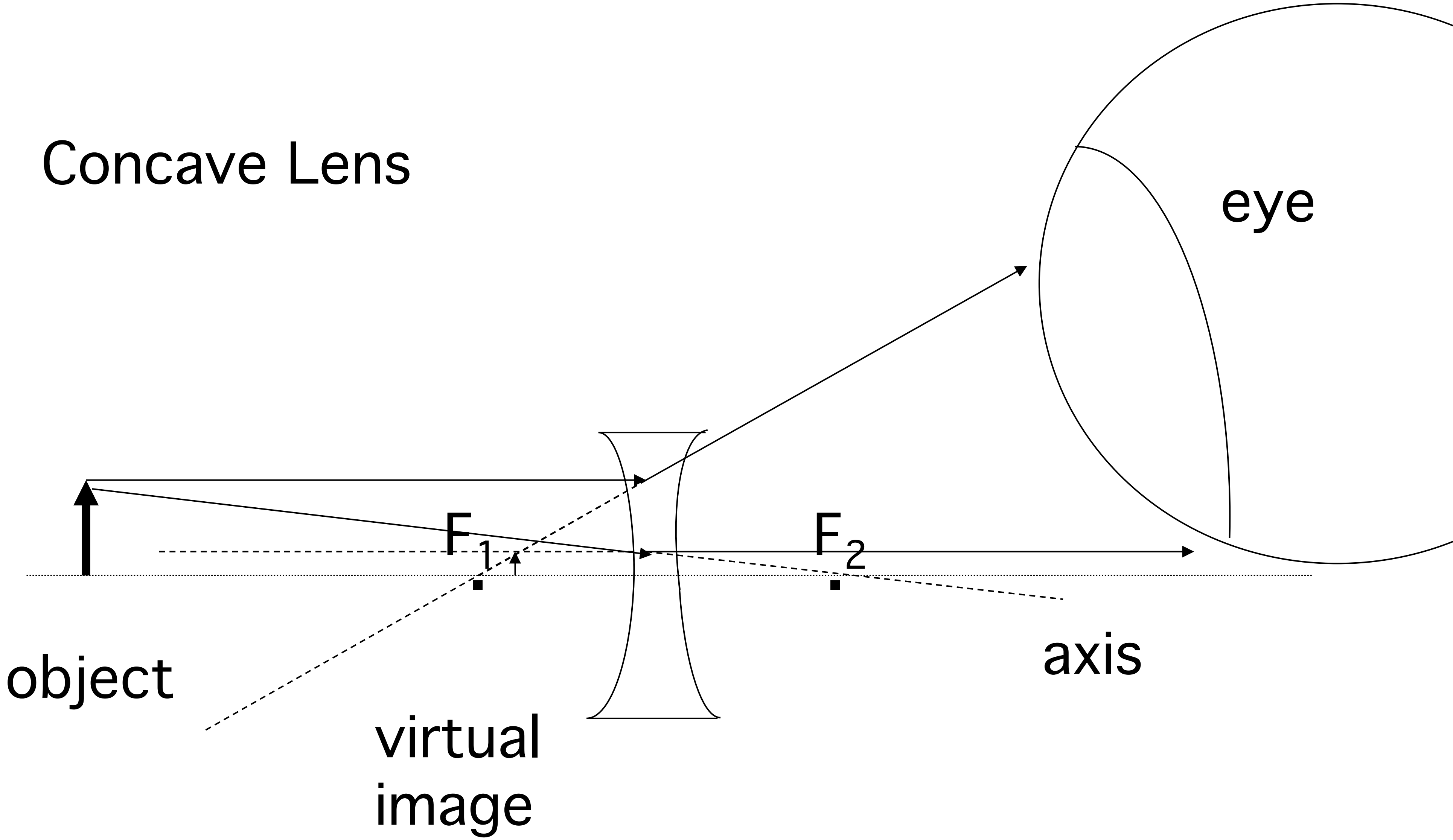
Concave or Diverging Lenses

--A lens that is <u>thinner</u> at the center than at the edges is called a <u>concave lens</u>.

--A concave lens causes rays of light to diverge (spread out) and are therefore also called <u>diverging lenses</u>.

--The image form by a concave lens is always a virtual image, smaller than the object, and right side up.

Concave Lens



Equations for Lenses

--Equations for the formation of real images by convex lenses can be derived using rays diagrams with the incident 1) parallel ray and 2) ray through the focal point and the similar triangles that are formed.

--The equations are:

$$\frac{H_i}{H_o} = \frac{f}{S_o} \qquad \frac{H_i}{H_o} = \frac{S_i}{f} \qquad \frac{f}{S_o} = \frac{S_i}{f} \text{ or}$$

$$S_i S_o = f^2$$

--As with mirrors, equations that work for both convex and concave lenses and for real and virtual images can be derived .

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f} \qquad\qquad M = \frac{h^{'}}{h} = -\frac{q}{p}$$

Where: p = object distance from lens
q = image distance from lens
f = focal length
M = magnification
h’ = image height
h = object height

--Sign conventions must be used with these equations to allow them to be used with either convex or concave lenses. (See Table 14-4, page 499)

--Once again note that the equations are the same as those for mirrors.

--These equations work for lenses that are thin compared to their focal length so that the distance from the focal point to the center of the lens and the distance from the focal point to the surface of the lens may be treated as being equal; these are called thin-lens equations.