5.3 Using Lenses to Form Images

A lens is a piece of transparent material that can bend, or refract, light rays in useful ways to help form a well-focussed image. Concave lenses are thinner in the middle than at the edge. They are used to diverge light rays. Convex lenses are thicker in the middle than at the edge. They are used to converge light rays.

Key Terms

concave lens
convex lens
focal length
lens

Light rays refract through a piece of glass in a predictable way. Recall from Section 5.1 that when a light ray passes from air into a denser material, such as glass, it bends *toward* the normal. When the light ray passes out of the glass, back into the air, it bends *away from* the normal. Using these facts about light it is possible to design and construct lenses. A **lens** is a curved piece of transparent material, such as glass or plastic, that refracts light in such a way as to converge or diverge parallel light rays. The image that a lens forms depends on the shape of the lens. Like curved mirrors, a lens can be convex or concave.

5-8 Observing Light Rays — Find Out ACTIVITY

In this activity, you will observe how light rays refract as they pass through lenses.

Materials

- ray box
- concave lens
- convex lens
- printed page

What to Do

1. Shine the ray box at a concave lens. Observe how the rays are affected. Draw your observations.
2. Look through the concave lens at some printed text. Observe the appearance of the print. Draw your observations.
3. Shine the ray box at the convex lens. Observe how the rays are affected. Draw your observations.
4. Look through the convex lens at some printed text. Observe the appearance of the print. Draw your observations.

What Did You Find Out?

1. Compare what you observed about the appearance of the text with each of the two lenses.
2. Which type of lens would be best used as a magnifying glass? Why?
3. What might the other kind of lens be used for?

Concave Lenses

Concave lenses are lenses that are thinner in the middle than at the edge. As shown in Figure 5.22, light rays that pass through a concave lens diverge. The rays are refracted outward, and never meet at a focal point. The image formed is always upright and smaller than the actual object (see Figure 5.23 and Table 5.1). Concave lenses are used in some types of eyeglasses and some telescopes, and are often used in combination with other lenses.

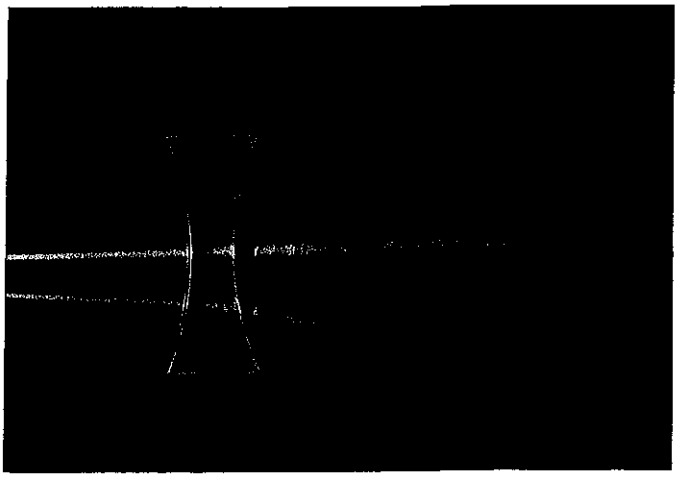

Figure 5.22 Light rays diverge when they pass through a concave lens.

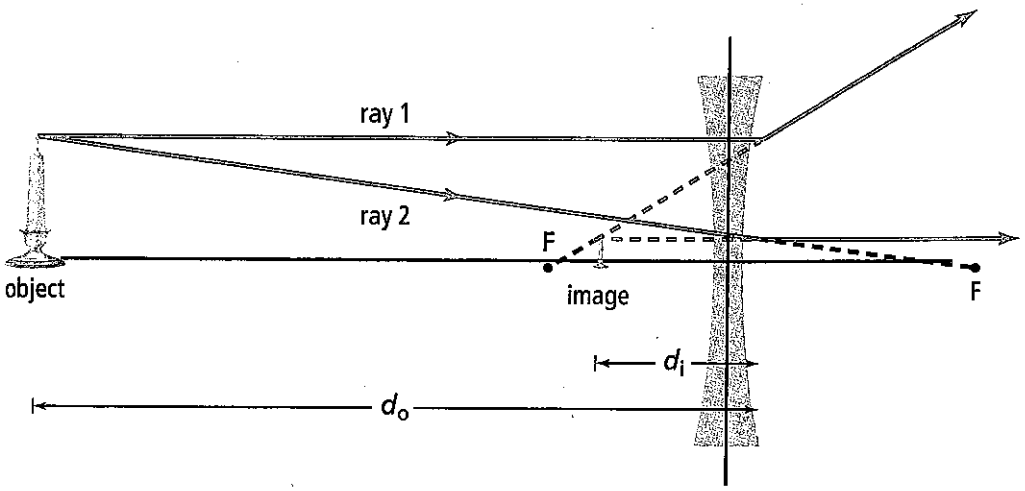

Figure 5.23 Concave lenses produce images that are upright and smaller compared to their objects.

Table 5.1 Images Formed by Concave Lenses

Distance of Object from Lens	Type of Image Formed
Any location	Smaller, upright

Did You Know?

Lenses have been made and used for hundreds of years. In 1303, French physician Bernard of Gordon wrote of the use of lenses to correct eyesight. Around 1610, Galileo used two convex lenses to make a telescope, with which he discovered the moons of Jupiter.

Convex Lenses

Convex lenses are lenses that are thicker in the middle than at the edge. As shown in Figure 5.24, light rays that pass through a convex lens come together, or converge. When parallel rays strike a convex lens from one side, they will all come together at the focal point of the lens. Light passing through the thicker, more curved areas of the lens will bend more than light passing through the flatter areas. A light ray that passes straight through the centre of the lens is not refracted. The image formed by a convex lens depends on the positions of the lens and the object (see Figure 5.25).

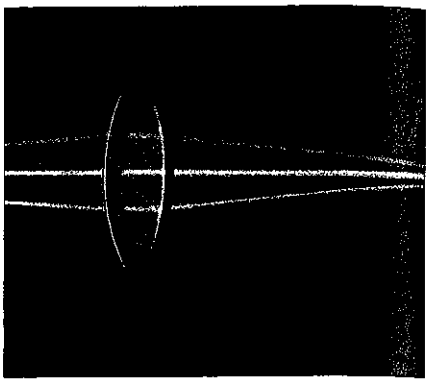

Figure 5.24 Light rays converge when they pass through a convex lens.

Internet

Raindrops take on a spherical shape as they fall, which gives them the shape of a convex lens. A drop of water sitting on a glass slide has a nearly spherical shape. Investigate whether a water droplet or a glass bead of the same size would make a good magnifying lens. Start your search at **www.bcscience8.ca.**

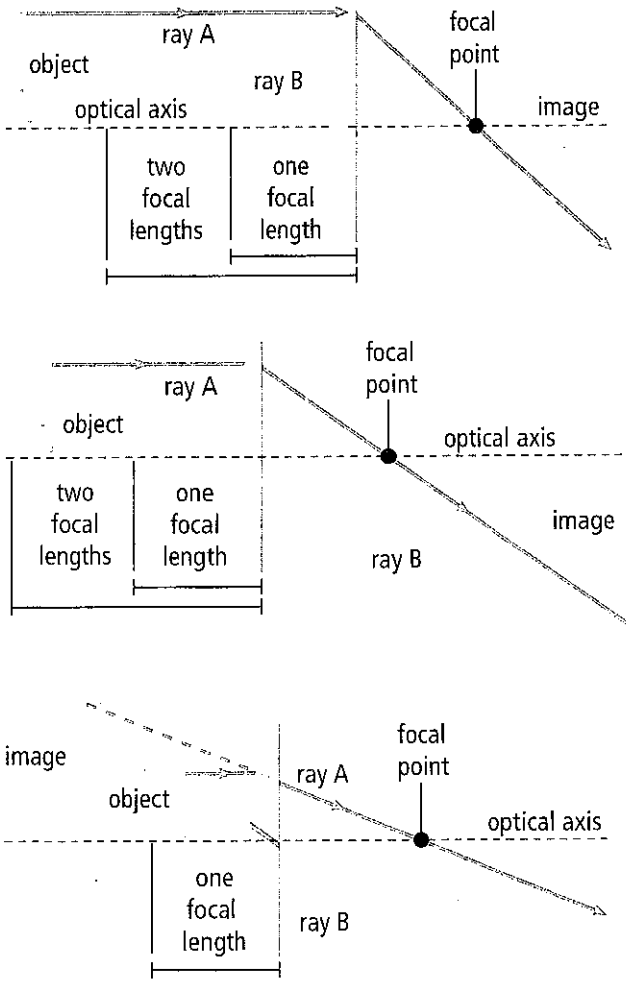

Figure 5.25 An image formed by a convex lens may be inverted, or flipped upside down.

Focal Length in Convex Lenses

Convex lenses and concave mirrors share a similar property in that the light rays converge at the focal point. The distance from the centre of the lens or mirror to the focal point is called the **focal length**. There is a mathematical relationship linking the distance of the object in front of the lens to the distance of the image formed by the lens.

- If the object is more than two focal lengths in front of the lens, the image is smaller than the object and inverted.
- If the object is moved closer to the lens so that it is one to two focal lengths away, the image is larger than the object and still inverted.
- If the object is very close, less than one focal length away, the image appears to be located on the other side of the lens and is both upright and larger than the object.

As summarized in Table 5.2 and shown in Figure 5.26, the type of image a convex lens forms depends on where the object is relative to the focal point.

Suggested Activities

Find Out Activity 5-9 on page 194
Find Out Activity 5-10 on page 195

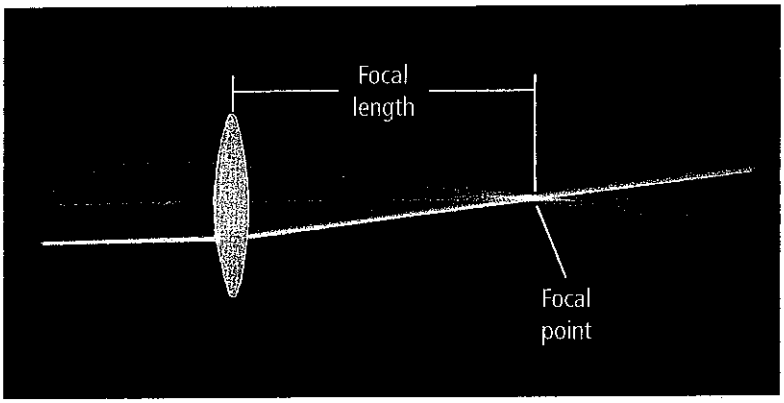

Figure 5.26 The image formed by a convex lens depends on the positions of the lens and the object.

Table 5.2 Images Formed by Convex Lenses

Distance of Object from Lens	Type of Image Formed
More than two focal lengths	Smaller, inverted
Between one and two focal lengths	Larger, inverted
Object at focal point	No image
Less than one focal length	Larger upright

Reading Check

1. What happens to parallel light rays that strike a concave lens?
2. What happens to parallel light rays that strike a convex lens?
3. What type of image is formed by a concave lens?
4. What determines the type of image that is formed by a concave lens?

Explore More

Eyeglasses would more correctly be called "eyeplastics" these days. Glass refracts well but is heavy and can shatter. The highest quality of plastic in widespread use for glasses is polycarbonate plastic. Find out what properties it has that makes it so useful in lenses. Start your search at **www.bcscience8.ca.**