E. Exploring Convex and Concave Lenses

Purpose: In this experiment, you will study convex and concave lenses.

Introduction: Lenses are different from mirrors in that they transmit light rather than reflect it. Some of the first lenses invented were used as magnifying glasses (1238) and eyeglasses (1284), followed by combinations of lenses for microscopes in the 1590's and telescopes in the early 1600's.

Lenses can be made of either glass or plastic and are classified into two basic shapes (convex or concave). The convex lens is thicker in the middle than at its edges. As light rays pass through a convex lens, they are refracted so that all converge and intersect at a given point on the opposite side. This point represents the focal point of the lens; and the distance from the focal point to the lens is the focal length. The focal length of the lens determines the type of image formed. The convex lens produces a real image when an object is located at a distance (more than twice the focal length). When an object is located within the focal length of a convex lens; the lens acts as a magnifier, forming an upright, enlarged and virtual image. Real images can be projected onto a screen; virtual images cannot.

The concave lens is thicker in the middle than at its edges. The concave lens functions differently than did the convex lens. As light rays pass through a concave lens, they are refracted so that they all diverge (except for the one traveling through the center) on the opposite side. The image formed by a concave lens is a virtual image. Diverging rays cannot project an image on a screen.

Both convex and concave lenses bend, or refract, light as it passes through them. Like a triangular-shaped prism, the light is always refracted toward the thicker portion of the lens.

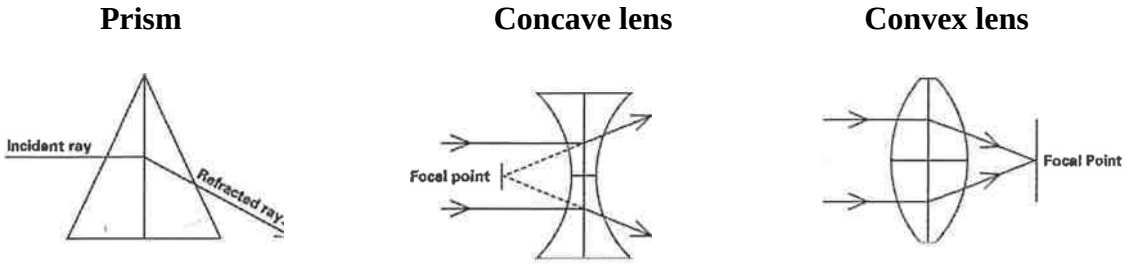


Figure 1. Light refraction in a prism and concave and convex lenses

Caution: The convex and concave lenses are made of glass. Handle with care. They can crack or shatter if dropped, and cause injury to the user.

Procedure:

Exploring Convex Lenses

Part A. Light Rays Through a Convex Lens (Convergence or Divergence)

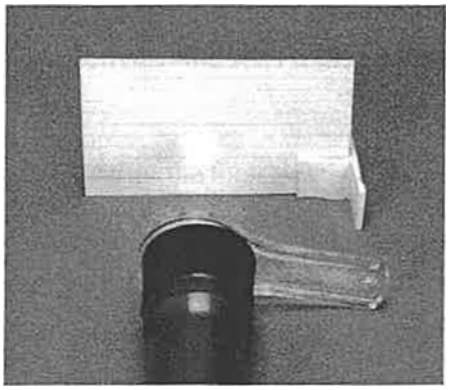
1. Turn a mirror support down so that the clamps are parallel with the lab counter.

2. Insert a short side of an index card into the clamp.

3. Turn on a flashlight, align it so that the circle of light is projected onto the card about 6 inches away.

4. Place the large lens of the convex lens (dual hand lens) over the flashlight lens and move this assembly toward the card. See setup below. Record in the data sheet what happens to the image of the light as you move the assembly closer to the card.

5. Move the flashlight/hand lens assembly until you have the image in focus (smallest image of light possible) on the card. Think about the parallel light rays as they enter the convex lens from the flashlight. In order for the rays to form a focused smaller image on the card, do they converge or diverge to form the image? Record on the data sheet. Record the distance from the middle of the lens to the image on the card. This is the focal length.



Part B. Determine Whether a Convex Lens Refracts Light to Produce Real or Virtual Images

1. While standing near a window or under an overhead light, look through the convex lens (dual hand lens) at a printed page or object located at a distance (more than twice the focal length) and answer the following questions on your data sheet:

1. What is the orientation of the image (right side up or upside down)?

2. What is the size of the image compared to the object (reduced or enlarged)

3. Is the image real or virtual?
(Remember a real image has light reflected from it and can be projected on a screen. A virtual image has no light coming from the image location and cannot be projected on a screen.)

2. Look through the convex lens at a printed page or object located within the focal length and answer the following questions on your data sheet:

1. What is the orientation of the image (right side up or upside down)?

2. What is the size of the image compared to the object (reduced or enlarged)?

3. Is the image real or virtual?
(Remember a real image has light reflected from it and can be projected on a screen. A virtual image has no light coming from the image location and cannot be projected on a screen.)

Exploring Concave Lenses

Part C. Light Rays Through a Concave Lens (Convergence or Divergence)
1. Place a clean sheet of white copier paper on a flat surface.

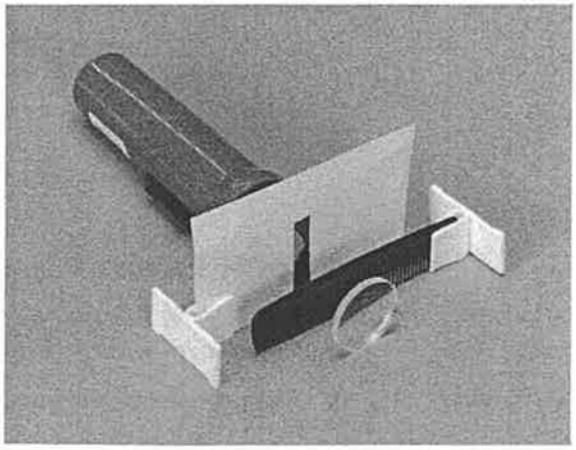
2. Turn one mirror support on its side with the jaw parallel with the paper and insert a short side of an index card that has a 10-mm (1.0 cm) slit.

3. Position a flashlight horizontally on a short side of the paper, pointing toward the opposite side of the paper.

4. Place the card so that its 10-mm (1.0 cm) slit is in front of the lens of the flashlight, then turn on the flashlight.

5. Position the fine teeth of a comb in front of the slit, forming multiple light rays.

6. Position the concave lens approximately 2 cm from the comb and trace on the white paper the rays entering and leaving the lens. See setup below.



7. How has the direction of the rays changed as the light travels through and exists the lens compared to the path of the rays before they entered the lens? Do they converge or diverge to form the image? Record on the data sheet.

Part D. Image for a Concave Lens

1. While standing near a window or under an overhead light, look through the concave lens at a printed page or object and answer the following questions on your data sheet:

1. What is the orientation of the image (right side up or upside down)?

2. What is the size of the image compared to the object (reduced or enlarged)?

3. Is the image real or virtual?

(Remember a real image has light reflected from it and can be projected on a screen. A virtual image has no light coming from the image location and cannot be projected on a screen.)

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Data and Results (Lenses)

Name(s) _____

Exploring Convex Lenses

Part A. Light Rays Through a Convex Lens (Convergence or Divergence)

What happens to the image of the light as you move the large lens of the convex lens (dual hand lens)/flashlight lens assembly closer to the card?

_____

_____

In order for the rays to form a focused smaller image on the card, do they converge or diverge to form the image?

_____

The distance from the middle of the lens to the image on the card (focal length) =

_____cm

Part B. Determine Whether a Convex Lens Refracts Light to Produce Real or Virtual Images

1. Look through the convex lens at a printed page or object located at a distance (more than twice the focal length):

1. What is the orientation of the image (right side up or upside down)? _____
2. What is the size of the image compared to the object (reduced or enlarged)? _____
3. Is the image real or virtual? _____

2. Look through the convex lens at a printed page or object located within the focal length:

1. What is the orientation of the image (right side up or upside down)? _____
2. What is the size of the image compared to the object (reduced or enlarged)? _____
3. Is the image real or virtual? _____

Exploring Concave Lenses

Part C. Light Rays Through a Concave Lens (Convergence or Divergence)

How has the direction of the rays changed as the light travels through and exists the lens compared to the path of the rays before they entered the lens?

_____

_____

Do the rays converge or diverge to form the image?

_____

Part D. Image for a Concave Lens

1. Look through the concave lens at a printed page or object:

1. What is the orientation of the image (right side up or upside down)? _____
2. What is the size of the image compared to the object (reduced or enlarged)? _____
3. Is the image real or virtual? _____

Instructor's Guide
(Lenses)

Time: 30-40 minutes

Equipment and Materials: Per group:

Items	Number	Comment
concave lens	1	
convex lens (dual hand lens)	1	
flashlight	1	
mirror support	2	
comb	1	
index card	1	
Index card with 10-mm (1.0 cm)-wide slit	1	With scissors, cut a 10-mm (1.0 cm)-wide slit 3.0 cm up the middle of the card, starting from the edge of one of the longer sides.
sheet of white copier paper	1	

Many of the materials listed above, including the concave and convex lenses, can be found in the Carolina Introduction to Light and Optics Kit (Item # 755019) by Carolina Biological Supply Company.

Exploring Convex Lenses

Part A. Light Rays Through a Convex Lens (Convergence or Divergence)

What happens to the image of the light as you move the large lens of the convex lens (dual hand lens)/flashlight lens assembly closer to the card?

As light rays pass through a convex lens, they are refracted so that they all converge and intersect at a given point on the opposite side

In order for the rays to form a focused smaller image on the card, do they converge or diverge to form the image?

___**converge**_____

The distance from the middle of the lens to the image on the card (focal length) =

_____cm

Part B. Determine Whether a Convex Lens Refracts Light to Produce Real or Virtual Images

1. Look through the convex lens at a printed page or object located at a distance (more than twice the focal length):

1. What is the orientation of the image (right side up or upside down)? __**upside down**__
2. What is the size of the image compared to the object (reduced or enlarged)? __**reduced**_
3. Is the image real or virtual? ___**real**_____

2. Look through the convex lens at a printed page or object located within the focal length:

1. What is the orientation of the image (right side up or upside down)? ___**right side up**__
2. What is the size of the image compared to the object (reduced or enlarged)? _**enlarged**_
3. Is the image real or virtual? ____**virtual**_____

Exploring Concave Lenses

Part C. Light Rays Through a Concave Lens (Convergence or Divergence)

How has the direction of the rays changed as the light travels through and exists the lens compared to the path of the rays before they entered the lens?

As light rays pass through a concave lens, they are refracted so that they all diverge (except for the one traveling through the center) on the opposite side.

Do the rays converge or diverge to form the image?

_____**diverge**_____

Part D. Image for a Concave Lens

1. Look through the concave lens at a printed page or object:

1. What is the orientation of the image (right side up or upside down)? ___**right side up**__
2. What is the size of the image compared to the object (reduced or enlarged)? _**reduced**__
3. Is the image real or virtual? ____**virtual**_____