85 Bifocals

Purpose

To investigate the nature, position, and size of images formed by a converging lens.

Required Equipment/Supplies

converging lens
small amount of modeling clay
cardboard
meterstick
night-light with clear, 7-watt bulb

Optional Equipment/Supplies

data plotting software
computer

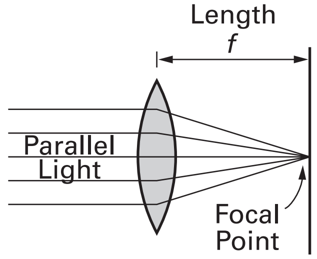
Discussion

The use of lenses to aid vision may have occurred as early as the tenth century in China. Eyeglasses came into more common use in Europe in the fifteenth century. Have you ever wondered how they work? In Experiment 80, Funland, you learned that the size and location of an image formed by a concave mirror is determined by the size and location of the object. In this experiment, you will investigate these relationships for a converging glass lens.

Procedure

Step 1: A converging lens focuses parallel light rays to a *focal point*. The distance from the center of a lens to the focal point is called the *focal length*, *f*. Measure the focal length of the lens by having it convert a parallel beam of light into a converging beam that comes to a small spot on a screen. Use the filament of a lit, clear, 7-watt bulb as a source of approximately parallel light and a piece of cardboard as a small screen. Record your measurement below to the nearest 0.1 cm. Also, record the number of your lens.

Measure focal length.



focal length = __________ cm

lens number = __________

Step 2: The rays of light striking the lens may not be parallel. What effect, if any, would this have on your measured value for the focal length? What effect would moving the light source farther away have? Move it farther away and record the focal length to the nearest 0.1 cm. (If a better source of parallel light is available, use it to find the focal length of your lens.)

focal length f = ________ cm

Find inverted image with lens.

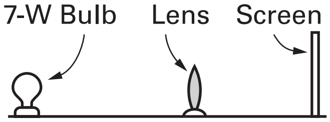


Fig. A

Step 3: Use a small amount of modeling clay at the bottom of the lens as a lens holder. Arrange a screen and a light source as shown in Figure A. Observe the image of the filament on the screen, and move the screen until the image of the filament is as sharp as possible. Where, in relation to one focal length from the lens, is the object when the image appears upside down (inverted)? What is the relative size of the image (magnified or reduced) and the object (the filament)? Is the image real or virtual? Record your findings in Data Table A.

Data Table A

Position of Object	Nature of Image		
	Real or Virtual?	Magnified?	Inverted or Erect?
Beyond f			
At f			
Within f			

Find erect image with lens.

Step 4: Where, in relation to one focal length from the lens, is the object when the image appears right-side up (erect)? What is the relative size of the image compared with the object? Is the image real or virtual? Record your findings in Data Table A.

Step 5: Is there a distance of the object from the lens for which no image appears at all? If so, what is this distance relative to the focal length? Record this position in Data Table A.

Measure d_i and d_o.

d_o (cm)	d_i (cm)

Data Table B

Step 6: Position the lens two focal lengths away from the light source to form an image on the screen on the other side of the lens as in Figure A. The distance between the object and the *focal point* closest to it is the distance d_o, and the distance between the other focal point and the image is the image distance d_i. Record the distances d_o and d_i in Data Table B. Move the lens 5 cm farther away from the light source, and reposition the screen until the image comes back into focus. Repeat these 5-cm movements five more times, recording d_o and d_i each time.

Step 7: Plot d_i (vertical axis) vs. d_o (horizontal axis), then different powers of each, to discover the mathematical relation between d_i and d_o. Does any combination give a linear graph through the origin and, thus, a direct proportion? If available, use data plotting software to plot your data.

1. What mathematical relationship exists between d_i and d_o?

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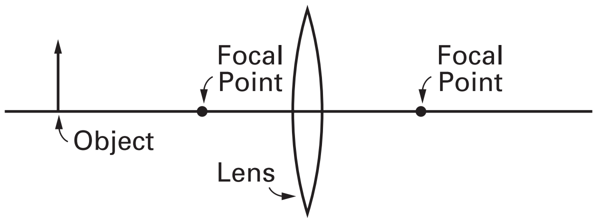
Step 8: You can locate the position of the image in Figure B using the ray-diagram method. Draw the path of the light ray that leaves the tip of the arrow parallel to the principal axis.

Fig. B



2. Where does this ray go after it is refracted?

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____

Draw the light ray that leaves the tip of the arrow and passes through the focal point.

3. Where does this light ray go after it is refracted?

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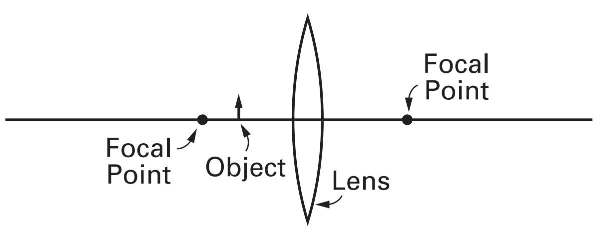
Now, draw the paths of these two light rays after they are refracted. At the point where they cross, an image of the tip of the arrow is formed.

Step 9: Use the ray-diagram method to locate the image of the object in Figure C. Draw the path of the ray that leaves the tip of the arrow parallel to the principal axis and is refracted by the lens. Trace another ray that heads toward the lens in the same direction as if it *originated* from the focal point and is refracted by the lens.

Fig. C



4. Do the refracted rays *actually* cross?

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5. Where do they *appear* to cross?

6. Could the image be projected onto a screen?

Going Further

Step 10: Use two converging lenses to see if you can create a magnified image of a distant object. Sketch your arrangement of lenses with their relative positions and focal lengths. (Had you been the *first* person to have discovered, 400 years ago, that two converging lenses can make a telescope, your name would be the answer to questions in science classes today!)