Inquiry Investigation 12-A

Skill Check

✓ Initiating and Planning
✓ Performing and Recording
✓ Analyzing and Interpreting
✓ Communicating

Safety Precautions

- If a candle is used as the light source, handle it with care. Keep flammable materials, such as paper, well away from the candle, and tie back long hair.

Materials

- screen in a holder
- metric ruler
- support stands
- light source in a holder
- converging lens in a holder

Science Skills
Go to **Science Skills Toolkit 2** to learn more about making predictions in an inquiry investigation.

Image Characteristics of a Converging Lens

In this investigation, you will predict the position and characteristics of an image produced by a converging lens. You will then test your predictions.

Question

How can the thin lens equation be used to predict the characteristics of the image formed by a converging lens?

Predictions

Draw ray diagrams to make predictions comparing the image size (magnified or smaller), orientation (upright or inverted), and type (real or virtual) formed by a converging lens when the distance between the object and the lens is

a. more than twice the focal length of the lens ($2.5f$)

b. twice the focal length of the lens ($2.0f$)

c. one and a half times farther than the focal length of the lens ($1.5f$)

d. equal to the focal length of the lens (f)

e. less than the focal length of the lens ($0.5f$)

Procedure

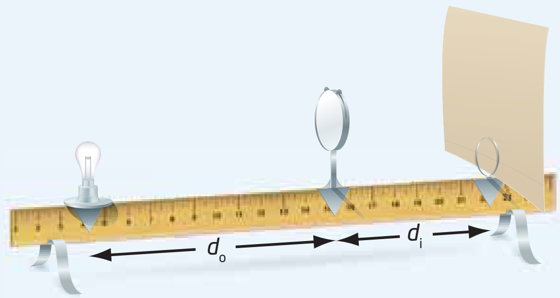
1. Copy the following tables into your notebook or into a spreadsheet program.

Data for Converging Lens Investigation

Focal Length, f (cm)		
(i) _______ cm	(ii) _______ cm	(iii) average _______ cm

Observation Data						
Object Distance (d_o) (cm)	$\frac{1}{d_o}$ (1 cm)	Image Distance (d_i) (cm)	$\frac{1}{d_i}$ (1 cm)	$\frac{1}{f}=\frac{1}{d_i}+\frac{1}{d_o}$ (1 cm)	Focal Length (f) (cm)	Image Characteristics
$2.5f$ =						
$2.0f$ =						
$1.5f$ =						
f =						
$0.5f$ =						

2. Set up the screen, ruler, light source, and converging lens as shown in the diagram below.



Set up the light source, lens, and paper as shown here.

3. Move the lens back and forth to form a focussed image of the light source (the object) on the screen. The image distance, d_i, is equal to the focal length of the lens. Record this value in (i) in your first table.

4. Turn the lens around and repeat step 3. Record this value in (ii) in your table. (**Note:** The two measurements of the focal length of the lens should not differ by more than 0.5 cm.) Calculate the average focal length of the lens, and record this value in (iii) in your table.

5. Use the average focal length to calculate the following object-to-lens distances (d_o): 2.5f, 2.0f, 1.5f, f, and 0.5f. Record these distances in your second table.

6. Place your object (the light source) so that $d_o = 2.5f$. Move the screen back and forth until you see a sharp, focussed image. Record d_i in your table. Describe the image characteristics: Is the image upright or inverted? Is the image magnified or smaller than the object?

7. Repeat step 6 using $d_o = 2.0f$ and $d_o = 1.5f$.

8. Place the light source at positions corresponding to $d_o = f$ and $d_o = 0.5f$. Record the image characteristics, but do not measure the image distance, d_i.

Analyze and Interpret

1. The thin lens equation is $\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$.
   a. What happens to the value of $\frac{1}{d_o}$ when the value of d_o is very large?
   b. When d_o is very large, what does the thin lens equation predict for the value of $\frac{1}{f}$?
2. The thin lens equation is given in question 1.
   a. Use the thin lens equation and data for d_o and d_i from the first two rows in your table to calculate the focal length of the lens.
   b. Compare these values with the average value of the focal length you determined in steps 3 and 4.
3. Which position of the object resulted in a very magnified image?
4. Which position of the object resulted in a virtual image?
5. Is there a difference between your experimental results and your predictions? Why or why not?

Conclude and Communicate

6. As the object moves toward the lens, from far away to a position just farther from the lens than its focal length,
   a. How does the position of the image change?
   b. What change occurs in the size of the image?
7. In the images you produced,
   a. In which position(s) was the image upright?
   b. In which position(s) was the image inverted?
8. Which of the object positions that you studied (2.5f, 2f, 1.5f, f, 0.5f) matches the way you use a magnifying glass? Explain.

Extend Your Inquiry and Research Skills

9. **Inquiry** Predict the effect on the image if you cover part of the lens. Test your prediction, and explain your observations.
10. **Research** Research and report history of eyeglasses.

Inquiry Investigation 12-B

Skill Check

Initiating and Planning

✓ Performing and Recording

✓ Analyzing and Interpreting

✓ Communicating

Safety Precautions

- Do not allow anything to touch your eyes.

Materials

- soft measuring tape
- piece of paper

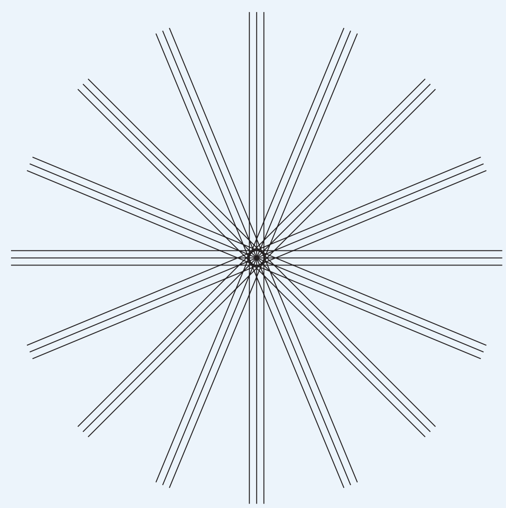
I "Speye"

In this investigation, you will test your vision for astigmatism, measure the near point of your vision, and estimate the size of the blind spot in your eye. The vision near point is the closest point at which you can view something clearly. The blind spot is a spot on the retina, at the point where the optic nerve exits the eye. The blind spot has no light-sensitive cells, so you cannot see a small object that is in the field of vision of the blind spot. If you wear glasses or contact lenses, remove them before you test your vision.

Procedure

Part 1 Checking for Astigmatism

1. Close one eye and look at the diagram below. If some of the lines appear blurred or darker than the others, you may have astigmatism in that eye.



Use this diagram to test for astigmatism.

2. Close the other eye and repeat step 1.

Part 2 Measuring Your Near Point

3. Look at the text on this page. Get your eyes as close to the page as you can, while still seeing the text *clearly*. Your partner can estimate the distance between your eyes and the page by holding a soft measuring tape against the page and well to one side of your eyes. In your notebook, record this value as your near point.

Part 3 Estimating the Size of Your Blind Spot

4. Close one eye and look at the X in the diagram below.
5. Hold the page close to your eye. Then slowly increase the distance between your eye and the page. Stop when you can no longer see the spot.

In the following steps, you will map out a blind spot region for one eye on a piece of paper.

6. Mark a small X in the centre of a sheet of paper. Have your partner help you hold your head so that your eye is 40 cm from the X you marked.
7. Close one eye and stare at the X. Slowly move the tip of your pencil away from the X until the pencil tip disappears from view. Mark the paper with a dot at this point.
8. Repeat step 7, moving your pencil in a different direction to map out an area for your blind spot.
9. The blind spot is typically higher than it is wide. At a distance of 40 cm from your eye, the image on your retina is about 0.044 times the length of an image you can see or, in this case, the blind spot you cannot see.
   a. Measure the maximum height and width of the blind spot you mapped out.
   b. Multiply these values by 0.044 to estimate the dimensions of your blind spot.

Analyze and Interpret

1. What value did you measure for the near point?
2. What are the dimensions of your blind spot? Show your calculations.

Conclude and Communicate

3. Why does a non-spherical cornea or lens result in the blurred vision of astigmatism?
4. Muscles in the eye change the curvature of the lens. At the near point, is the lens relatively thick or relatively thin? Explain your answer.

Extend Your Inquiry and Research Skills

5. **Inquiry** Examine a pair of bifocal lenses. Infer why people who wear bifocals have to move their eyes up and down to see properly.
6. **Research** Research astigmatism.
   a. What forms of treatment are available to correct astigmatism?
   b. Assess the risks and benefits of each treatment to decide which course of treatment you would choose if you were diagnosed with astigmatism.

For step 4

Inquiry Investigation 12-C

Skill Check

Initiating and Planning

✓ Performing and Recording

✓ Analyzing and Interpreting

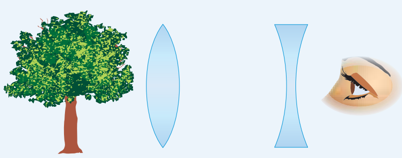
✓ Communicating

Safety Precautions

- Do not point the lenses at the Sun.

Materials

- converging lens, large, with a long focal length
- diverging lens, small, with a short focal length
- converging lens, small, with a short focal length



The arrangement of lenses in a Galilean telescope. (This illustration is not to scale.)

Make a Simple Telescope

In this investigation, you will use the same principles used by Galileo and Kepler to build two simple telescopes.

Question

How are the Galileo and Kepler telescopes similar, and how are they different?

Procedure

1. Use a distant bright window or a well-lit building as your object. Hold the small diverging lens very close to your eye. This is the eyepiece of your telescope.
2. The large converging lens is the objective. Hold the objective lens close to the eyepiece, so that light from the object passes through the objective, then the eyepiece.
3. Slowly move the objective lens away from the eyepiece, in the direction of the object. Looking through both lenses, adjust the position of the objective until you can see an image. Describe the characteristics of the image formed by the "Galileo telescope."
4. Now use the small converging lens for the eyepiece and the large converging lens as the objective.
5. Repeat steps 2 and 3, and describe the characteristics of the image formed by the "Kepler telescope."

Analyze and Interpret

1. Compare the image formed by the Galileo telescope with that formed by the Kepler telescope.
2. How does the sharpness of the image change as the magnification increases?

Conclude and Communicate

3. Using a graphic organizer of your choice, compare Galileo's and Kepler's telescopes.

Extend Your Inquiry and Research Skills

4. **Inquiry** Investigate the effects of eyepiece lenses with different focal lengths on the magnifying power of a telescope.