

Lab 08: Geometric Optics

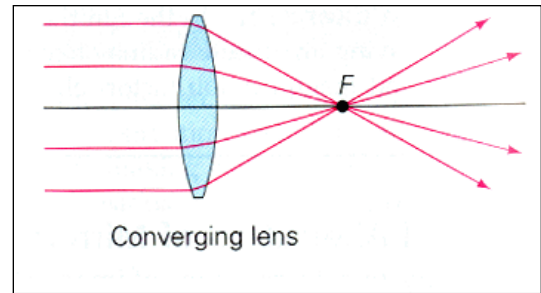


INTRODUCTION

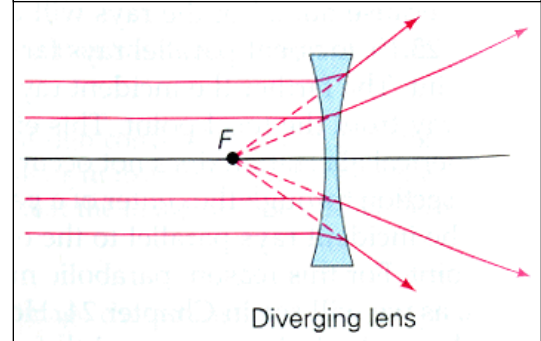
If you (or your cat) wear glasses or contact lenses, you are already familiar with the science of optics. Whether you realize it or not, you understand the idea of a focal point. You are very aware when an image is out of focus (no glasses) or in focus (put your glasses back on). You even know the difference between a real and a virtual image, although you have probably never said to yourself, "I wish that the real image formed by the lens in my eye was better focused on my retina!" Or maybe you have (or maybe your cat has).

OBJECTIVES

- Identify the differences between concave and convex lenses
- Use the lens equation to determine the focal length of a convex lens
- Construct ray diagrams to accurately show how an image is formed



Convex lenses are converging lenses.
Concave lenses are diverging lenses.



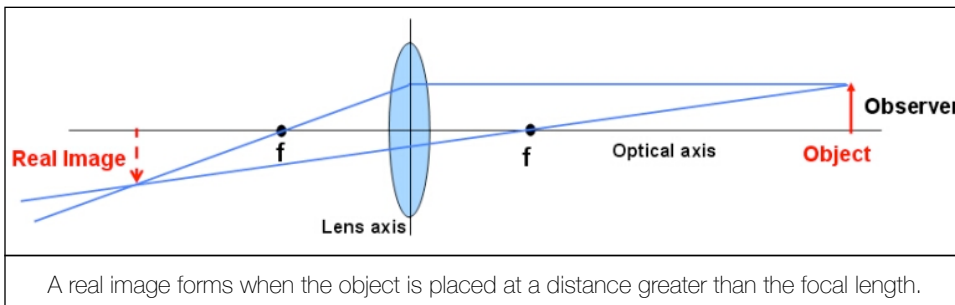
- Demonstrate the difference between a near- and far-sighted eye, and show how each vision problem can be corrected

ACTIVITY 1: CONVERGING AND DIVERGING LENSES

- Use the loose lenses, both converging and diverging, to observe objects around the room.
- Try to use both as magnifying glasses to enlarge text.
- While observing a single object, move the lens toward and away from your eye. Do this for both types of lens.
- Try observing objects using various combinations of lenses: two converging, two diverging, one of each.

QUESTIONS

1. Which type of lens can you use to magnify text? What happens to the magnified image as you draw the lens farther from the text?
2. Can you position a diverging lens in any way to create an upside down image?
3. Describe the results of using two lenses at once (try using two converging lenses). Do any kind of useful optical instruments use multiple lenses (name some)?



ACTIVITY 2: IMAGE FORMATION

- Create and observe images using a converging lens. Place the Crossed Arrow Target on the front of the light source. The arrow will be the object that will be used to form the image.
- Place one of the converging lenses in front of the light source. Make sure that the distance is greater than the focal length marked on the front of the lens.

- Adjust the position of the screen to find the image.
- Measure and record the distance from the light source to the lens. This is the object distance d_o .
- Measure and record the distance from the lens to the screen. This is the image distance d_i .
- Measure and record both the object height h_o and the image height h_i . If the image is upside down, h_i is **negative**.
- Repeat twice more, using different object distances.

QUESTIONS

4. For each trial, find the focal length of the lens using the lens equation on the right. Then calculate the average focal length of the lens.
5. Compare the average focal length with the focal length printed on the lens. Is your value comparable? Why might your value be slightly too large or too small?
6. Calculate the magnification of the images using:

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

$$M = -\frac{d_i}{d_o}$$

7. Calculate the magnification of the images using:

$$M = \frac{h_i}{h_o}$$

8. The magnification of an image can be expressed two ways, as you have just calculated. Are your results comparable? Which method do you think might be

more accurate? Why?

9. Construct a careful ray diagram (use a ruler!) to show the formation of the real image created by a converging lens. Is the image real or virtual?
10. If the object is placed exactly at the focal point of the lens, will an image be formed? Use the lens equation to determine your answer.
11. What kind of image is formed when the object is placed inside the focal length of a converging lens? Show this using a ray diagram.

ACTIVITY 3: CHROMATIC ABERRATION

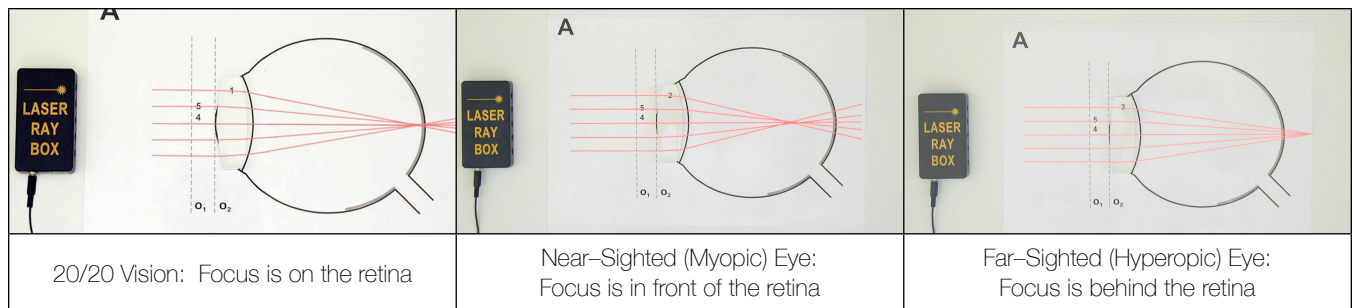
- Using the 150 mm converging lens, test the color filters.
- With the red filter placed in front of the light source, focus the image on the screen.
- Measure the object and image distances, and use them to determine the focal length of the lens. Repeat for two additional object distances, and calculate an average focal length.
- Repeat for each of the remaining blue and green color filters.

QUESTIONS

12. Compare the focal lengths for the different colors of light. Is there a noticeable difference? Is there a trend that you can correlate to wavelength?

ACTIVITY 4: VISION CORRECTION

In a near-sighted eye, the focal plane of the image lies in front of the retina. Corrective lenses are required to "push" the image back onto the retina. A nearsighted person cannot see distant objects clearly; if you are near-sighted, you have probably pulled a book in closer to your face in order to read the words. A far-sighted eye focuses images on a plane behind the retina, so corrective lenses are necessary to "pull" the image forward onto the retina. As people age, they tend to become more far-sighted. Many middle-aged people who never needed glasses before find that they need reading glasses—that, or they simply hold the magazine they are trying to read farther and farther away!



- On the optics bench, place the 75mm converging lens in front of the light source. The lens simulates the converging lens inside your eye.
- Adjust the screen (which represents your retina) to focus the image. An image focused on the retina represents a normal eye.
- To simulate near-sightedness, move the screen away from the lens by a small amount. Prescribe some glasses for your defective eye. Remember that the corrective lens must be placed between the object and the lens of the eye (not between the lens and the screen).
- Make your eye more near-sighted, and compare the lens required to correct this with the previous eye.
- Simulate far-sightedness by moving the "retina" closer to the lens, and again prescribe corrective lenses.

QUESTIONS

13. What kind of lens must be used to correct near-sightedness? Can this lens correct far-sightedness?
14. What kind of lens is used to correct far-sightedness? Can this lens correct near-sightedness?
15. In *The Lord of the Flies*, Piggy's glasses are used to focus the sun's rays and start a fire (what type of lens do you need for this?). Sometime later in the novel, the spectacles are broken, and poor Piggy has a hard time getting around because he is so nearsighted (what type of lenses are in his glasses?). What is the problem here?

