

### Introduction

In this lab you will have the opportunity to use a variety of lenses and mirrors to form images. The equipment you will use includes a light bulb as a source (object); cards and screens (and your eyes) to view images; several lenses, mirrors, and baffles to create images; and a ruler to measure lengths. The theory behind these experiments is covered in Hecht 2<sup>nd</sup> Ed., Chapter 24. Each group will have a setup for Experiments A and B. There is only one set of equipment for Experiment C: the miscellaneous optical elements. Take time to look at these anytime during the lab whenever they are not in use by another group. Your light source (often referred to as “the object”) is a Maglite<sup>®</sup> flashlight, with its top focussing mechanism removed. This provides a comfortably bright and small light source. You should perform this lab with the main lab lights off. Use the desk lamps for reading.

### Experiment A: Positive and Negative Lenses

#### Pre-Lab Homework:

1.
  - (a) Write down the Gaussian lens equation
  - (b) Draw a ray diagram *to scale* to show the meaning of the terms used, subject to the following guidelines: For your figure, choose a lens with  $f = +2$  cm and make the object distance 8 cm. Show an object that is 1 cm high and draw at least 3 rays from each end of the object to the image. Label the object, the lens, the image and the focal points of the lens. Use a ruler to make the rays straight.
  - (c) Calculate the magnification you expect and compare it to the magnification from your figure.
2. Using the lens equation, show that if the object is at a very large distance from the lens (compared to the lens's focal length) the resulting image is at the focal point. Draw a ray diagram, including the distant object and image formed, to demonstrate this.
3. Converging lenses are often referred to as “positive lenses” since their focal lengths are positive. Similarly, diverging lenses are known as “negative lenses.” However, a lens shape can be complicated. (e.g., A lens may be described as positive *and* concavo-convex.)
  - (a) Draw a concavo-convex lens.
  - (b) Is it thinner or thicker in the middle than at the edge?
  - (c) What easily measured shape characteristics distinguish a positive from a negative lens?
  - (d) Find someone who wears spectacles. Describe the shape of their eyeglass lenses. What type of eye problem do their lenses correct? Try to do this for both an older person (usually farsighted person such as your parents or grandparents), and a nearsighted (younger) person.

**Experiment A (continued):***Procedure and Questions:*

- A1. Your TA has many different lenses available. Find 6 different lenses, labeled L1 to L6. Use your fingers and eyes to determine which are positive lenses and which are negative.
- (a) Describe how you can tell the difference between the lenses.
- Clean the lens with a tissue after handling it, but realize that in any professional optics lab handling an optical element like this would harm it and might cost you your job.*
- (b) Based on Homework #2, measure the approximate focal lengths of the positive lenses. Use a light source (“object”) at a large distance from the lens (such as the desk light from the lab table across the room, or light from the open lab door).
- (c) What is the orientation of the image?
- (d) Give a few applications of both positive and negative lenses.
- A2. Which of the lenses could be used as a magnifying glass? Try them all to see which work and which do not. Which lens works best? Which lenses “minify”?
- A3. Mount the L2 lens on a holder and put it on the optical bench. The Maglite<sup>®</sup> is the light source, but its *filament* (about 1 cm long) is the “object.” Place one of the white plastic squares with the ruler markings on a holder to use as a screen. Adjust the distance between the light and the lens to form an image on the screen that is twice the size of the object. Make sure the image is sharp.
- (a) Is the image upright or inverted?
- (b) Measure the image and object distances, and, using the lens equation, determine the focal length of L2 again.
- (c) Does it agree with the measurement you made before in A1?
- (d) Is the magnification positive or negative?
- (e) Draw the object, lens, and image with a few rays in your lab notebook.
- A4. Now use a card as a baffle to block some of the light from source to image. Put the card close to the Maglite<sup>®</sup> so it partly obscures the light going to the lens. Look at the image and describe what you see. Next, put the card next to the lens and cover the top half of the lens. Again, describe what happens to the image.

**Pre-Lab Homework:**

4. For the procedure in A4, predict what image on the screen will look like when you have the baffle obscuring the top half of the source. Predict what the image will look like when you move the baffle to cover the top half of the lens.
- A5. Slowly slide the same card into the beam at several points between the source and the lens and also between the lens and the image. Describe how the image is affected as you slide the card into the beam. Note the shape of the beam on the card at each point. Can you explain what you see?

**Experiment B: Mirrors***Procedure and Questions:*

- B1. There are 4 different mirrors at each lab station. Ask your TA if you think you are missing any equipment.
- (a) Which of these are convex and which concave?
  - (b) Which ones have a small radius of curvature and which a large radius of curvature?
  - (c) Can you use the same method of measuring focal lengths that you used for the positive lenses? Why or why not?
  - (d) What is one method of measuring the focal length of a concave mirror? Check with your TA to verify your method is legitimate.
  - (e) Measure the approximate focal length of one of the concave mirrors.

*Pre-Lab Homework:*

5. Find a shiny spoon and look at your reflection. Describe the size and orientation of your image from each side of the spoon. Do you eat from the concave or convex side? Estimate the radii of curvature and focal lengths of each side of your spoon. Try the experiments in "Exploring Physics On Your Own" (Hecht, 2<sup>nd</sup> Ed., pg. 979).

**Experiment C: Other Mirrors and Lenses***Procedure and Questions:*

You should find a selection of optical elements.

- C1. View the large convex and concave mirrors. Estimate their focal lengths and suggest uses for them.
- C2. Look at the Fresnel (pronounced, *fray-NELL*) lens. What differences are there between this and a regular lens? How is it made? What is its approximate focal length? What was it originally used for? What possible advantages would there be in making a lens this way?
- C3. Examine the cylindrical lenses. Hold them on the top and bottom, *not* on the sides that you look through. Look through them. Can you make an image with a cylindrical lens? Note that the water bottle (full of water) is a cylindrical lens. What is its focal length? If the water bottle were empty would it still act as a lens? What is a possible use for cylindrical lenses?
- C4. Examine the eyeglasses provided. Which pair should be used for reading? What is the approximate focal length of the lenses? Which pair should be used for correction of nearsightedness? Are these positive or negative lenses? How can you tell?
- C5. Identify the type of each of the lenses labeled A, B, C, D, and E in the box: Are they positive or negative? Describe the shapes of each surface? Which types would be most comfortable as eyeglasses?
- C6. Can you pick up the pig?