

Lens Optics Spring 2010

Introduction

In this experiment, you will examine the optical properties of *converging* (convex or positive) and *diverging* (concave, or negative) lenses.

I. Images of distant objects.

1. *Converging lens observations:*

- Remove all of the lenses from the optical bench. Take the +200 mm converging (convex) lens, hold it at arms length, and look at a distant object outside the window. Now, hold this lens about 8 to 10 cm from your hand or your text (*not* your eye!). Briefly sketch what you see in each case, noting the difference in the magnification and orientation of the images.
- Place the +200 mm lens at the 50 cm mark of the optical bench, between the light source and plastic screen. Remove the light source and aim the front of the optical bench at the window. Move the screen back and forth until you get a sharply focused (*real*) image of a distant object (e.g. a tree) through the window.
- Remove the screen, and look through the lens at the image from the window, keeping your eye at the end of the optical bench. Briefly describe the image that you see.
- Now take the -150 mm diverging (concave) lens, and place it in the bench about 10 cm from the converging lens. Look through the diverging lens, and *decrease* the distance between the two lenses until the image is focused. Briefly sketch the appearance of a distant object through the window as viewed through your simple telescope, again noting the orientation and magnification.

2. *Measurement of focal length:*

- Remove the diverging lens from the bench, leaving the converging lens in place. Place the screen back on the bench, on the side of the lens opposite the window.
- Again move the screen until you see a sharp image of a distant object; at this point the screen is located at the *focal point* of the lens. Measure the distance between the lens and the screen; note that there is a pointer on the lens holder to measure from. Compare this distance to the actual focal length of the lens by calculate the % difference.
- Repeat this procedure to measure the focal length of the other two converging lenses, and compare the measured value to the actual value.

3. *Diverging lens observations:*

- Repeat step (1a) using the -150 mm diverging (concave) lens. Sketch the appearance of a distant and close object, and compare these images to those seen using the converging lens.
- Repeat step (1b). Explain what the difference is when using the diverging lens to perform this step.

II. Comparison of image distances determined by measurement and by calculation.

1. *Measurement of the image location:*

- Set up a table like the one at the end of these instructions.
- Put the object/light source on the 10 cm mark of the optical bench. Place the +200 mm lens a distance o from the object as indicated in the table below (note that you will measure to the front

edge of the object/light source). Adjust the screen until you have a sharp image, and measure i , the image distance, for each case.

- c. *Interesting* things happen to the image with the last two object distances. Briefly describe what happened when you tried to find the image at $o = 20.0 \text{ cm}$. Why do you think this happened? The last object distance is less than the focal length of the lens. What kind of image will this create?
- d. Since a virtual image cannot be projected on the screen, we will have to use a second lens to determine where the virtual image is located. For the last object distance in the table, position the object/light source at the 20 cm mark of the optical bench; place the $+200 \text{ mm}$ converging lens 10 cm from the object, and note its position on the optical bench.
- e. Move the screen back and forth. Is any image formed?
- f. Look through the lens at the object/light source. Briefly describe the appearance of this virtual image.
- g. Place the $+250 \text{ mm}$ converging lens at the 70 cm mark of the optical bench (don't move the other lens or the light source). Adjust the screen until a sharp image is formed
The *real image* you now see on the screen is created by the $+250 \text{ mm}$ lens looking at the *virtual image* created by the $+200 \text{ mm}$ lens! Now you need to find the location of the virtual image.
- h. Remove the $+200 \text{ mm}$ lens, leaving the other lens, light source and screen in position. What happens to the image on the screen?
- i. Now adjust the position of the *light source* until you again get a sharp image on the screen. The object/light source will now be located at the position of the virtual image created by the $+200 \text{ mm}$ lens. Calculate the image distance for the virtual image, recalling that it is a negative value, and the previous position of the $+200 \text{ mm}$ lens.

2. Theoretical location of an image:

- a. Now calculate i for each o value using the Thin Lens equation: $\frac{1}{f} = \frac{1}{o} + \frac{1}{i}$.
- b. You may note that there seems to be a problem with your calculations when the object is 20 cm away. What do you suppose your calculations are telling you about the image in this case? What did you notice when you tried this object distance on the optical bench?
- c. Find the % difference between the expected and measured values for i .

3. Calculation of focal length:

- a. Use KaleidaGraph to plot $1/o$ (the *actual* object distance on the optical bench) vs. $1/i$ (the *measured* image distance). Calculate the focal length (and its uncertainty) of the lens from the parameters of the best-fit line. How does your measured value compare to the actual value?

Object distance, o (cm)	Measured image distance, i (cm)	Calculated image distance, i (cm)	% Difference
60.0			
40.0			
30.0			
20.0			
10.0			

Discussion:

- Summarize what you have learned about the difference between converging and diverging lenses.
- Where is the image created when the object is placed at the focal point of a converging lens?