Converging Lens

Purpose: To use a converging lens to make measurements to test the Thin Lens and Magnification Equations.

Equipment: Optics Bench, Light Source, 75 mm Focal Length Convex Lens, Crossed Arrow Target Component Holders (3), Viewing Screen.

Introduction: Given a lens of any shape and index of refraction, you could determine the size and location of the image it forms based only on Snell's Law and ray tracing techniques. However, for spherical lenses (and for spherical mirrors as well), there is a more general equation that can be used to determine the location and magnification of an image. This equation is called the Thin Lens Equation: $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$ ***Eq.*1**, where f is the focal length of the lens, and d_o and d_i are the distances from the lens to the object and from the lens to the image, respectively (see Figure 1). The magnification, m, of the image is given by the Magnification Equation: $m = \frac{\textit{image height}}{\textit{object height}} = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$ ***Eq.*2**

In this experiment, you will have an opportunity to test and apply these equations.

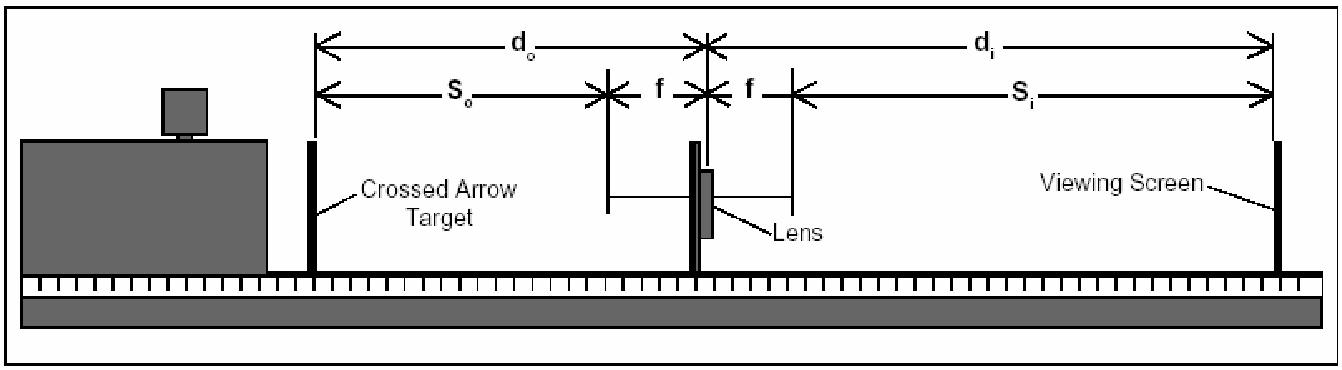

Figure 1 Experimental set-up for converging lens experiment.

Procedure:

1. Set up the equipment as shown in Figure 1. Turn on the Light Source and slide the Lens toward or away from the Crossed Arrow Target (the object), as needed to focus the image of the Target onto the Viewing Screen. Is the image magnified, reduced or identical to the object? Is the image inverted or upright?
2. Based on ***Eq.* 1**, what would happen to d_i if you increased d_o even further? What would happen to d_i if d_o was very, *very* large? Try to form a clear image of your object when it is several meters away. Using your answer to the question above, measure the focal length of the lens, and record it in your lab journal.
3. In your lab journal, make a table similar to Table 1. Now set d_o to the values (in millimeters) listed in the table. At each setting, locate the image (by moving the Viewing Screen until a clear image comes into focus) and measure and record d_i. Also measure and record h_i, the height of the image, and h_o, where h_o is the height of the arrow on the crossed arrow target. Be sure to include the units for each measurement.

Data			Calculations			
d_o (mm)	d_i	h_i	$1/d_i + 1/d_o$	$1/f$	h_i/h_o	$-d_i/d_o$
500						
450						
400						
350						
300						
250						
200						
150						
100						
75						
50						

Table 1 Sample data table, with calculations.

4. Using the data you have collected, perform the calculations shown in the table.
5. Are your results in complete agreement with $\boldsymbol{Eq.1}$? Do they agree with $\boldsymbol{Eq.2}$? If not, to what do you attribute the discrepancies in each case?
6. For what values of $\boldsymbol{d_o}$ were you unable to focus an image onto the screen? Use $\boldsymbol{Eq.1}$ to explain why an image could not be focused on the screen for each of the appropriate object distances.
7. Is it possible to obtain a non-inverted image with a converging spherical lens? Explain.
8. For a converging lens of focal length $\boldsymbol{f}$, where would you place the object to obtain an image as far away from the lens as possible? How large would the image be?