Experiment: Converging Lens – Image and Object Relationships

**EQUIPMENT NEEDED:**
- Optics Bench
- 75 mm Focal Length Convex Lens
- Component Holders (3)
- Light Source
- Crossed Arrow Target
- Viewing Screen.

**Introduction**
Given a lens of any shape and index of refraction, you could determine the shape and location of the images it forms based only on the Law of Refraction. You need only apply the law along with some of the ray tracing techniques you have already used. 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 Fundamental Lens equation:

\[
\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}
\]

where \( f \) is the focal length of the lens, and \( d_o \) and \( d_i \) are the distance from the mirror to the image and object respectively (see Figure 7.1). The magnification of the image is given by the equation:

\[
m = -\frac{d_i}{d_o}
\]

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

**Procedure**
Set up the equipment as shown in Figure 7.1. Turn on the Light Source and slide the lens toward or away from the Crossed Arrow Target, as needed to focus the image of the Target onto the Viewing Screen.

1. Is the image magnified or reduced?
2. Is the image inverted?
3. Based on the Fundamental Lens Equation, what would happen to \( d_i \) if you increased \( d_o \) even further?
Table 7.1: Data and Calculations

<table>
<thead>
<tr>
<th>Data</th>
<th>Calculations</th>
</tr>
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<tbody>
<tr>
<td>Data (mm)</td>
<td>( d )</td>
</tr>
<tr>
<td>500</td>
<td></td>
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<tr>
<td>450</td>
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<tr>
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<tr>
<td>75</td>
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<td>50</td>
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</tbody>
</table>

4. What would happen to \( d \), if \( d_o \) were very, very large?  

6. Using your answer to question 4, measure the focal length of the lens.  
   Focal Length = ________________
   
   Now set \( d_o \) to the values (in millimeters) listed in the table above. At each setting, locate the image and measure \( d_i \). Also measure \( h_i \), the height of the image. (\( h_o \) is the height of the arrow on the crossed arrow target.)
   
   Using the data you have collected, perform the calculations shown in the table.

6. Are your results in complete agreement with the Fundamental Lens Equation? If not, to what do you attribute the discrepancies?

7. For what values of \( d_o \) were you unable to focus an image onto the screen? Use the Fundamental Lens Equation to explain why.

Additional Questions

1. For a lens of focal length \( f \), what value of \( d_o \) would give an image with a magnification of one?

2. Is it possible to obtain a non-inverted image with a converging spherical lens? Explain.

3. For a converging lens of focal length \( f \), where would you place the object to obtain an image as far away from the lens as possible? How large would the image be?