Lab 10. THIN LENSES

10.1. Equipment

Optics bench, lens and holder, flat "object" light source, ruler, screen

10.2. Background

The thin lens equation describes the mathematical relationship between the location of an object, the location of its image, and the focal length of a lens. It is given by

$$\frac{1}{d_0} + \frac{1}{d_i} = \frac{1}{f}$$

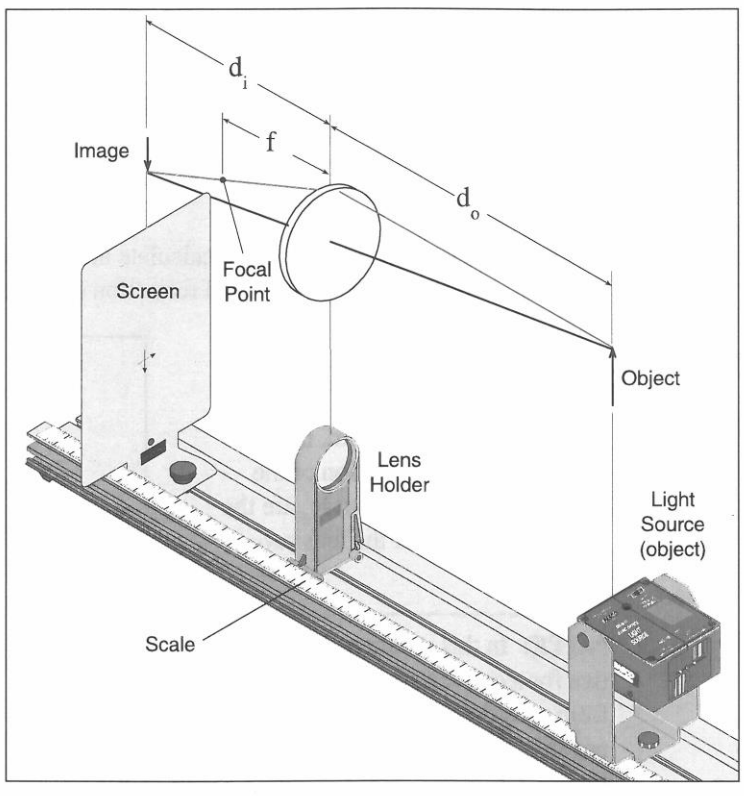

Figure 9.1

The magnification by a lens is defined as $M \equiv h_i/h_o$ and is approximated by $M \approx -d_i/d_o$. The absolute value of the magnification indicates whether the image is reduced ($|M| < 1.0$) or enlarged ($|M| > 1.0$), while the sign of the magnification specifies whether the image is upright ($M > 0$) or inverted ($M < 0$).

10.3. Activities

A. *Object at infinity*

Using a convex lens, focus a distant light source on a piece of paper taped to a wall by adjusting the location of the lens. Using a ruler, measure and record the image distance d_i from the lens to the paper.

Using the thin lens equation, take the limit as d_o goes to infinity, and solve for the focal length. Record the focal length.

B. *Between the ends*

Use the same lens as in the "object at infinity" activity. Place the object light source at one end of the optics bench, the screen at the other end, and the lens between them.

Measure and record h_o, the size of the object light source.

Position the lens so that a clear image of the light source appears on the screen. In the table, record L, the distance between the screen and the object; d_o, the distance between the lens abnd the object; and h_i, the size of the image. Recall that h_i is positive if the image is upright and negative if the image is inverted, and that d_i is positive if the image is on the opposite side of the lens from the object and negative if the image is on the same side of the lens as the object.

Keeping the screen and the light source in the same place, move the lens forward or backward until an image again is sharply focused on the screen. (If the lens previously was closer to the object than to the screen, move the lens closer to the screen, and vice versa.) Again, record L (which should be the same), d_o, and h_i.

Now find the smallest L that allows a sharp image on the screen. Do this by gradually moving the screen toward the light source while simultaneously adjusting the lens to give a sharp image. When you can't get a sharp image by moving the screen any closer, you are there. (The lens should be about midway between the light and the screen.) Record L, d_o, and h_i.

Repeat the measurements for four more values of L (the light-screen distance) that are between the largest and smallest values. For each L, find two object-lens distances d_o and measure h_i. Record all values in the table. (Don't forget the units!)

h_o: ________________

L	d_o	h_i	d_i	f	M	$-d_i/d_o$

Calculate the remaining columns in the table (or set up a spreadsheet). The lens-image distance is $d_i = L - d_o$; $1/f$ and f can be estimated by solving the thin lens equation; $M = h_i/h_o$.

10.4. Interpretation

Average the calculated values of the focal length f from the table: $\bar{f} = \sum f/N$. Also find the standard deviation $\sigma = \sqrt{\sum(f - \bar{f})^2/(N-1)}$.

$\bar{f}$: ________________ σ: ________________

How well does the formula $-d_i/d_o$ predict the magnification? Make a log-log plot by plotting a scatter plot of ln ($-M$) vs ln (d_i/d_o). On the same plot, draw a line of $y = x$. If the formula works, all the data points should fall near the line.

10.5. Lab report

Show me your data, the completed table, and the log-log plot for the magnification.