Laboratory #9

# A Simple Lens

In this laboratory we find the relationship between an object and an image in a simple lens.

Measure a convenient distance across the filament of the small lamp to determine the size, $h_o$, of the object. We will be checking if this measurement is correct using the size of the image. Place the lamp at one end of the meter stick so that the filament is at the 0 cm mark — this makes measuring distances a little easier.

Put the lens and screen in the little holders on the meter stick as shown in the diagram on the board. Before taking any data, play around with the lamp, lens and screen and practice focusing the image on the screen. This develops intuition about the relationships between the distances involved.

The basic lens equations are:

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}\,,$$

and

$$\frac{h_i}{h_o} = \frac{d_i}{d_o}\,,$$

Here $d_o$ is the distance from the object (lamp) and the lens; $d_i$ is the distance between the lens and the image (screen). We need to take a lot of data. So make a big table in your lab book headed with $d_o$, $d_i$, $h_i$, $f_{\text{est}}$, $h_{\text{est}}$, where the estimated values are those calculated for each value of $d_o$, $d_i$ and $h_i$.

Start with the lens 15 cm away from the object, so $d_o = 15\,\text{cm}$. Move the screen around until the image is well focused. Now, measure $d_i$ and $h_i$, and put all of the data in your table (remember to include units).

Repeat the measurements with $d_o = 20$, 25, 30, 35, 40 and 45 cm, and put the data in the table.

From the basic equations above, it is easy to see that

$$f = \frac{d_o d_i}{d_o + d_i}$$

and

$$h_o = h_i \, \frac{d_o}{d_i}\,.$$

Use these formulae to estimate $f$ and $h_o$ for each of your measurements. If the basic equations are correct, then all your estimates should agree pretty well. Do your data support the basic lens equations?

Now use the lens to focus an image on a distant wall, and measure $d_o$. In this case, $d_i$ and $h_i$ are huge and you don't need to measure them, but enter $\infty$ for $d_i$ in the table. Estimate $f$ from your data. Does $d_o$ match your expectations when $d_i$ is huge?

Move the lens and screen far away from your lamp. Focus a small image on the screen, and measure $d_i$. Enter $\infty$ for $d_o$ in the table and estimate $f$. Does $d_i$ match your expectations when $d_o$ is huge?