Geometric Optics

Purpose (Write the purposes at the beginning of each problem.)

Problem 1: find the focal length of a concave mirror to verify the mirror equation;
Problem 2: find the focal length of a converging lens to verify the thin lens equation;

Introduction and Theory

Two types of images can be formed by a lens or mirror. A real image can be seen on a screen placed at the image position, whereas a virtual image cannot. Whether or not the image is real or virtual, the following relationship exists:

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

where: f is the focal length of the mirror or the lens
d_o is the object distance, which is the distance from the object to the mirror (or the lens).
d_i is the image distance, which is the distance from the image to the mirror (or the lens).

This equation is known as the *mirror equation* or the *thin lens equation*, depending on the setup.

Problem 1 The Focal Length of a Small Concave Mirror

Apparatus Draw a labelled diagram of the apparatus (See Figure 1) and list all other apparatus required.

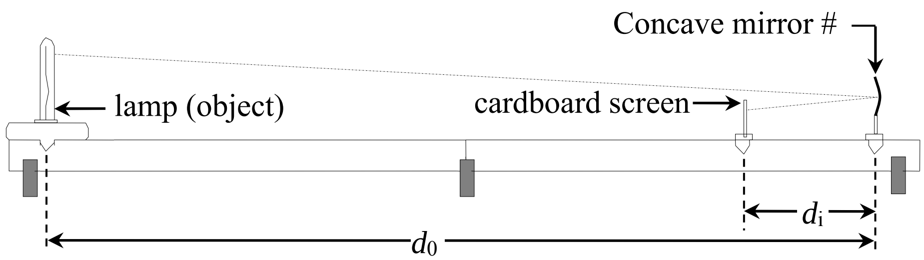

Figure 1

Data (All data must be recorded in proper table format)

1. If the object distance in the mirror equation is infinite, the focal length is equal to the image distance. This suggests a method of measuring the focal length. In practice, an infinite object distance will be approximated as the distance from the front of the classroom to an object (eg. a tree) outside the windows. Place the concave mirror in its holder on the metrestick. Place the screen in front of the mirror. Go to the front of the classroom and obtain an image of the tree on the screen. Focus a clear image by adjusting the position of the screen. Record the positions of the mirror and the screen, together with their uncertainties. Calculate the image distance, in this case it is approximately equal to the focal length of the mirror. We will call it the *reference focal length*.

2. Go back to your desk and set up the optical bench as shown in Figure 1.

3. Set the object distance d_o to 60.0 cm, and adjust the position of the cardboard screen until you see a clear image of the lamp filament.

4. Record the positions of the mirror, the object and the screen. The uncertainty for the image position may be large, as it may be hard to decide where the image is clearest. Calculate the object distance and the image distance, and put them in the data table as well.

5. Record the image type (real/virtual), orientation (upright/inverted), and magnification (is the image larger/smaller than the apparent size of the object) in your table.

6. Repeat steps (3) to (5) with an object distance of 150.0 cm.

Calculations

Calculate a focal length for both object distances using the mirror equation. These two focal lengths should be approximately the same. Calculate the average focal length: this is our final result.

Conclusions

State the final result of the concave mirror's focal length in a sentence.

Calculate the percentage discrepancy between the final focal length and the reference value measured earlier. Are they in agreement considering the uncertainty?

Problem 2 The Focal Length of a Converging Lens

Apparatus Draw a labelled diagram of the apparatus (see Figure 2) and list all other apparatus required.

Data (All data must be recorded in table format)

1. Measure the reference focal length for the lens. (Repeat step 1 from Problem 1, with the screen placed behind the lens.)

2. At your desk, set up the optical bench as shown in Figure 2.

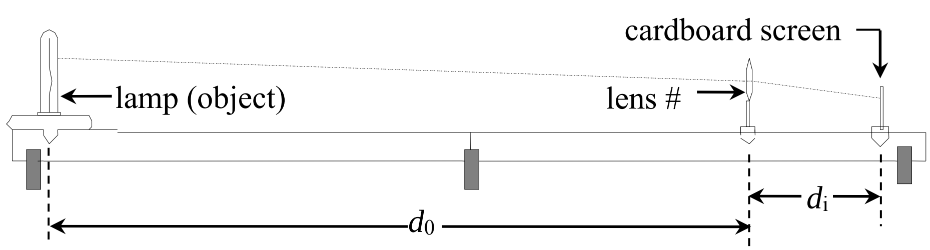

Figure 2

3. Repeat steps (3) to (6) from Problem 1, using the lens this time.

Calculations and Conclusions

Repeat the Calculations and Conclusions from Problem 1, using the thin lens equation.