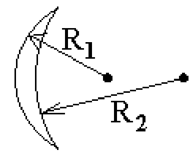
Experiment 1: Lenses and Mirrors

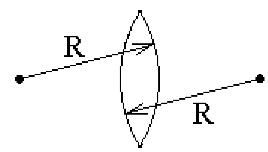
Part One: Focal length.

The focal length of a thin lens in air is determined by the curvature of its surfaces and its index of refraction, n, according to the lensmaker's equation.



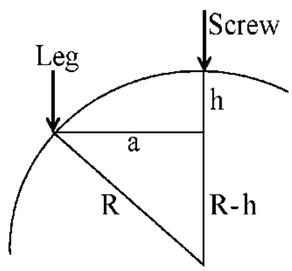
$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

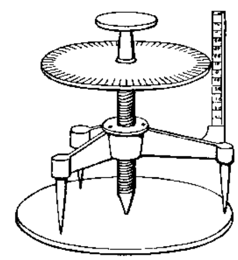
For the lens you have, $R_1 = R_2$. Also, measuring the radii from different sides instead of the same side of the lens changes the minus to a plus.



$$\frac{1}{f} = (n-1)\frac{2}{R} \Rightarrow \boxed{f = \frac{R}{2(n-1)}}$$

To measure the radius of curvature, you have a spherometer. This is a little tripod with a micrometer screw in the middle. You adjust the screw so that it touches the lens while all three legs also touch the lens. The spherometer then tells you h, in the diagram on the left. If you also measure a, you can get R from the Pythagorean theorem.





1. Become familiar with the spherometer and check its zero. Run the screw up a little, then hold the spherometer against the table. Run the screw down, touching it lightly so you will notice any increase in resistance. As soon as you feel it touch the table, stop. If it does not read 0.00 mm, notice how much you should add or subtract from later readings. Recheck elsewhere on the table.

2. Use a ruler to measure a, the distance from any leg to the center screw. Estimate tenths of a mm.

3. Back the spherometer off by two turns, 2.00 mm. Hold the lens in your hand. You can remove the lens from its holder if you want. Turn the screw downward to measure h. Try to watch from the side for when the screw first touches the glass. If the spherometer rocks around, you went too far.

4. Calculate R from a and h. Calculate f from R and n = 1.50.

You will now use this lens to produce an image of a lamp with an arrow painted on it.

Part Two, Real Image.

1. Set things up: Mount the meter stick on its feet. Clamp the light you will use for an object to a ring stand, about the same height above the counter as the lens. Place the lens on the meter stick so that the object is about 5 or 10 cm beyond the focal point.

Measure s_o and h_o. (Note that h_o is the length of the arrow, not its height above the counter.)

2. Calculate the distance of the image from the lens s_i, and calculate the height of the image h_i. Also, decide whether the image should be erect or inverted.

3. Solve the problem again, this time by measurement on a ray diagram instead of using equations.

4. Move the card along the meterstick to locate the actual image. Record its position, size, and character.

In your conclusion,

a. State whether the calculated position, size and character agrees with what you observed.

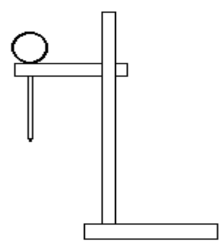
b. State whether the position, size and character you predicted with the ray diagram agrees with what you observed.

Consider all numbers to have 10% uncertainties.

Part Three, Virtual Image.

1. Unplug the lamp. The pointy metal thing holding the screen makes a more convenient object, so take the cardboard off and place that on the meterstick. Arrange things so you can comfortably look through the lens at the object, which should be roughly halfway between the lens and its focal point, give or take a centimeter or so. Measure $s_{o.}$ Be sure the object and lens are vertical, not leaning.

2. Calculate the distance of the image from the lens, s_i,. Skip h_i. Should a virtual image be erect or inverted? To save time, do not do a ray diagram.



3. Use parallax to experimentally locate the image. Parallax is the apparent movement of something due to the motion of the observer. Mount a thermometer so that it hangs from a ring stand. Don't turn it on, you will just use it as a pin. Notice that as you move your head back and forth, the thermometer seems to move back and forth along the wall behind it. Also notice that the amount of parallax depends on your distance; the closer you are to the thermometer, the larger the parallax. Position the thermometer with its tip just above the lens. While looking through the lens and moving your head, move the ring stand until the parallax of the thermometer, seen over the top of the lens, is the same as that of the image, seen through the lens. When the parallax is the same, the distances are the same. Measure $s_{i.}$

In your conclusion, state whether the position you calculated for the image agrees with what you observed, and whether it was oriented as you expected. 20% uncertainty this time.

Part four, Concave Mirror.

Plug the lamp back in and place the object 10 to 20 cm from the mirror. Measure the object and image distances. The screen goes in front of the mirror, so you will have to use a very narrow screen so it does not block all of the light.

Compute the focal length of the mirror, and its radius of curvature. No comparison in this part.

Phy 133 Report on Experiment 1: Lenses and Mirrors

Part 1.

a = ________________ h = ________________

Calculate R:

Calculate f:

Part 2, Real Image:

s_o = ________________ h_o = ________________

Calculate s_i:

Calculate h_i:

Should it be erect or inverted?

From ray diagram s_i = ________________ h_i = _________________
(attach diagram)

Should it be erect or inverted?

experimental: s_i = ________________ h_i = _________________

Is it erect or inverted?

Part 3, Virtual Image:

s_o = ________________ Calculate s_i:

Should it be erect or inverted?

experimental: s_i = ________________ Is it erect or inverted?

Part 4, Converging mirror:

s_o = ________________ s_i = _________________

compute f:

R =