Lensmaker's Equation

Required Equipment from Basic Optics System (OS-8515C)

Light Source

Concave Lens from Ray Optics Kit

Other Required Equipment

Metric ruler

Purpose

In this experiment you will determine the focal length of a concave lens in two ways: *a)* by direct measurement using ray tracing and *b)* by measuring the radius of curvature and using the lensmaker's equation.

Theory

The lensmaker's equation is used to calculate the focal length (in air or a vacuum), *f*, of a lens based on the radii of curvature of its surfaces (R_1 and R_2) and the index of refraction (*n*) of the lens material:

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

In this notation, *R* is positive for a convex surface (as viewed from outside the lens) and *R* is negative for a concave surface (as in Figure 1).

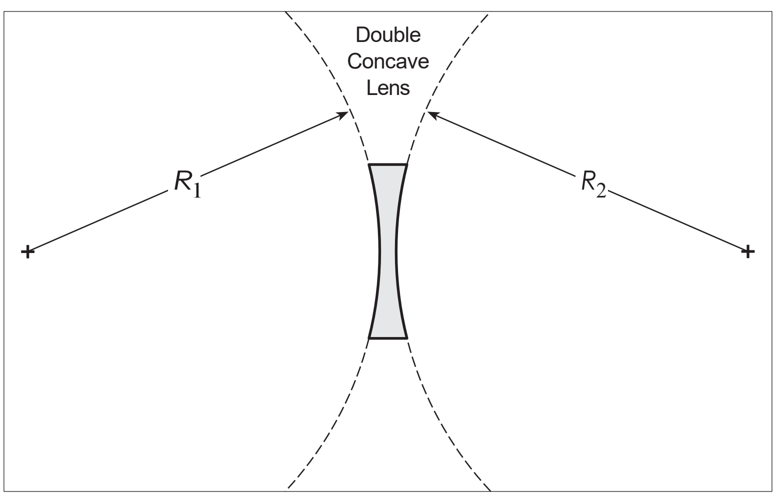

Figure 1

Procedure

1. Place the light source in ray-box mode on a white sheet of paper. Turn the wheel to select three parallel rays. Shine the rays straight into the convex lens (see Figure 2).

   Note: The lens has one flat edge. Place the flat edge on the paper so the lens stands stably without rocking.

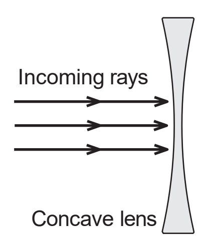

Figure 2

2. Trace around the surface of the lens and trace the incident and transmitted rays. Indicate the incoming and the outgoing rays with arrows in the appropriate directions.

3. Remove the lens. To measure the focal length, use a ruler to extend the outgoing diverging rays straight back through the lens. The focal point is where these extended rays cross. Measure the distance from the center of the lens to the focal point. Record the result as a negative value:
f = ________________(measured directly)

4. To determine the radius of curvature, put the concave lens back in the path of the rays and observe the faint reflected rays off the first surface of the lens. The front of the lens can be treated as a concave mirror having a radius of curvature equal to twice the focal length of the effective mirror (see Figure 3).

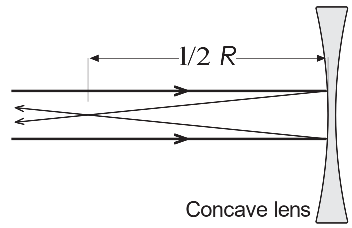

Figure 3: Reflected rays from the lens surface

Trace the surface of the lens and mark the point where the central ray hits the surface. Block the central ray and mark the point where the two outer rays cross. Measure the distance from the lens surface to the point where the reflected rays cross. The radius of curvature is *twice* this distance. Record the radius of curvature:

R = ________________

5. For this lens, it is not necessary to measure the curvature of both sides because they are equal ($R_1 = R_2 = R$). Calculate the focal length of the lens using the lensmaker’s equation (Equation 1). The index of refraction is 1.5 for the acrylic lens. Remember that a concave surface has a negative radius of curvature.
f = ________________(calculated)

6. Calculate the percent difference between the two values of f from step 3 and step 5:
% difference = ________________