

Chapter 1: Thin Lenses and Index of Refraction

Overview:

In this experiment we will examine the refraction of light through glass lenses (“geometrical optics”). We will determine the index of refraction of the glass, and use this to compute the speed of light in glass.

Suggested Reading Assignment:

The section on refraction of light in the chapter about “Electromagnetic Waves”, and the sections on lenses in the chapter about “Images” in your Physics I textbook.

E.g., Section 33-8, and Sections 34-6 through 34-7 of Halliday, Resnick, and Walker, 7th edition.

Pre-lab Questions:

1. How are focal length f , image distance d_i , and object distance d_o related? When is each negative? Contrast f for concave lenses with convex lenses. Which is converging? How does a “virtual image” differ from a “real image”?
2. What is the Lensmaker’s equation? When is either radius of curvature negative? For a spherometer (see next pages) what is R as a function of h and L ?
3. For a typical ray diagram, there are an infinite number of rays that *could* be drawn, but we typically only draw three of them. Describe these three rays.
4. There are three possible configurations for each type of lens, depending on where the object is placed relative to the focal point (i.e., in front of, at, or behind the focal point). Draw a ray diagram to scale for each of the six cases. Note that “to scale” always means “proportionally correct”, rather than “life size”. Choose numeric values for the focal length, object height, and object distance for each case and determine:
 - a) whether the image is real or virtual,
 - b) the magnification of the image, and
 - c) whether the image is upright or inverted.

Compare the measurements of your scale drawings with the computed predictions of the thin lens equation. How can the magnification m be determined from d_o and d_i ?

5. An object of height $h = 6$ cm is located at $x_{o1} = 5$ cm. A lens ($f_1 = +10$ cm) is located at $x_{L1} = 30$ cm. A second lens ($f_2 = -15$ cm) is located at $x_{L2} = 40$ cm. The image of the first lens is the object for the second. Find: d_{o1} , d_{i1} , x_{i1} , x_{o2} , d_{o2} , d_{i2} , x_{i2} , m_1 , m_2 , and m_{total} . Draw a ray diagram to scale for this problem.
6. What is the smallest possible value for the index of refraction? What is the index of refraction for air? For water? For an ordinary glass? For polycarbonate plastic?
7. What is the value for the speed of light in vacuum? What is the relationship between the speed of light and the index of refraction?