# Thin Lenses

**Purpose:** To determine the focal lengths of converging and diverging lenses by different methods. To investigate the images formed by the converging lens.

**Equipment:** Optical bench, convex lens, concave lens, object which may be illuminated, and lamp.

**Introduction:** The location of object and image with respect to a lens as shown in figure 1 are given by the basic thin lens formula

$$\frac{1}{p} + \frac{1}{i} = \frac{1}{f} \qquad (1)$$

Where p = distance from the object to the center of the lens,
i = distance from the image to the center of the lens,
f = focal length of the lens.

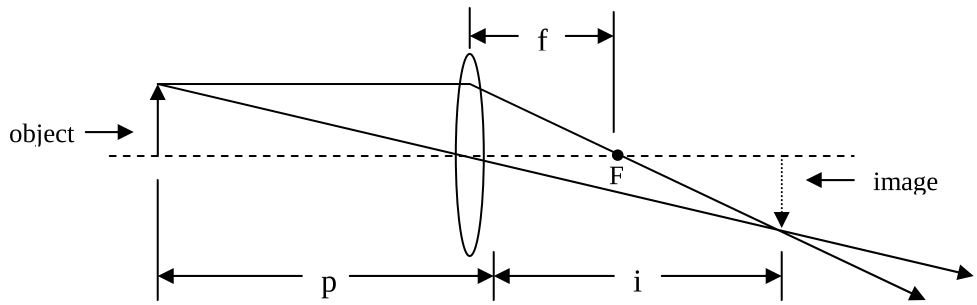


**Figure 1**

For positive values of i, the image is real and may be projected on a screen. For negative values of i, the image is virtual; that is to say, the rays of light coming from the object through the lens diverge and the eye in viewing these rays sees them as though they came from an image located on the other side of the lens. Such a virtual image cannot be projected onto a screen.

## Procedure:

## Part I: Focal Length of a Converging Lens

1. Focal length by parallel rays:

Rays of light from distant objects are essentially parallel. For the purposes of this experiment, a building or other object 30 meters or more away may be considered a distant object. Using two component holders, set up one of the convex (converging) lenses and the viewing screen on the optics bench. Focus the image of your distant object upon the screen. Since the incident rays are essentially parallel, the image formed will lie in the principal focal plane of the lens. The best focus is obtainable if no extraneous light strikes the screen so it will be helpful if the room is darkened during this phase of the experiment, with window shades up only high enough for a view of a distant object. Measure the distance from the center of the lens to the viewing screen when the best focus has been obtained. Repeat this method for another convex lens. Record the values of the focal length for the two lenses. Make a sketch in your lab report that explains the method used.

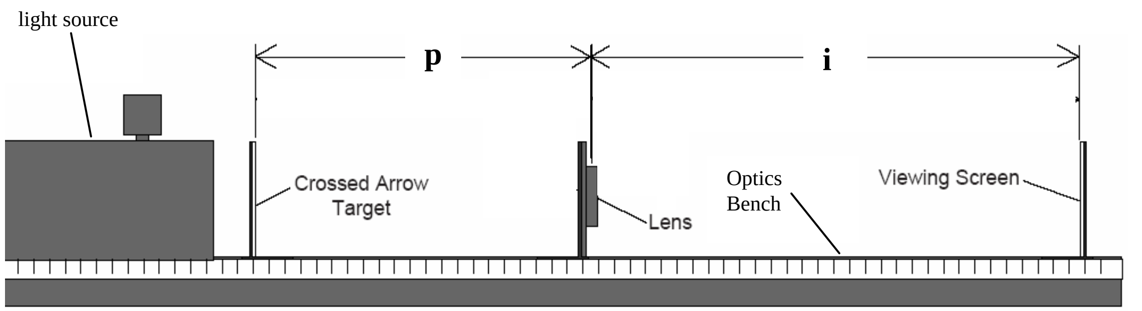


**Figure 2**

2. Focal length by using the thin lens equation:

Place the crossed arrow target (object) near the light source (see Figure 2) at a distance of 30 cm (p = 30 cm) from the ~75 mm focal length convex lens. On the other side of the lens adjust the position of the viewing screen to obtain a sharply focused image. The distance from the lens to the image is of course the image distance, i. Determine the focal length, f, using equation 1. Repeat for object distances of 25, 20, 15, and 10 cm. Find an average value for the focal length of your lens. Put all data in a neat data table. Make a sketch tracing the light rays for one of the above examples. Compare with your results in part 1 above.

Repeat this procedure for the ~150 mm converging lens. Two of the above object distances won't work for this new lens. Why? Choose two other appropriate object distances so you still have four sets of data to use in calculating the average focal length of the lens. Find the average percent difference from the mean for the four values of f.

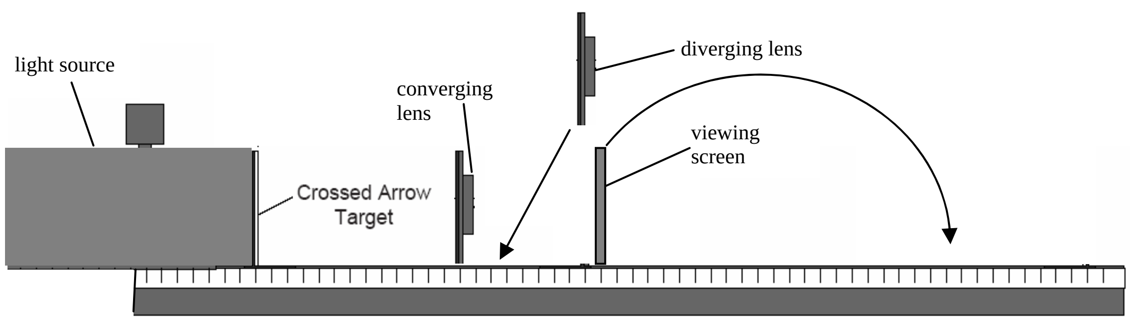


**Figure 3**

## Part II. Focal Length of a Diverging Lens

1. Set up the crossed arrow target as an object mounted directly over the opening on the light source. Slide the light source back until the crossed arrow is at the 10 cm mark on the optics bench. Place the +75 mm focal length converging lenses at 25 cm on the bench making the object distance 15 cm. Position the viewing screen to obtain a clear image (image 1) and record its position. Now, place the diverging lens (see Figure 3) between the first lens and the screen at the 30 cm mark on the optics bench. Its diverging action will cause the image to lie farther from the converging lens than it did originally. Move the screen out until the image (image 2) is again in focus and record its position.

2. With the data just collected, determine the image and object distances for the diverging lens. Using equation 1 find the focal length of the diverging lens.

3. Repeat step 1 and 2 with the +75 mm lens at the 30 cm mark and then finally at the 35 cm mark. For each case, after locating image 1, place the diverging lens (as you did in step 1) 5 cm to the right of the +75 mm lens in order to locate image 2.

4. Calculate the average focal length for the diverging lens from the three values just obtained. Find the average percent difference from the mean for the three values of f.