PhyzLab:
Image a Nation

an investigation of the relationship between image formation distances

• Purpose •

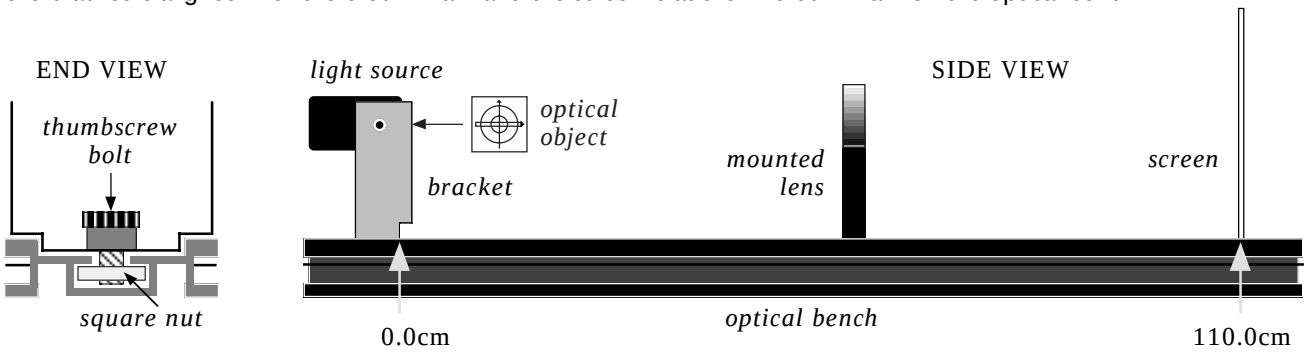
In this activity, you will investigate the algebraic relationship between object distance, image distance, and focal length when forming images using a converging lens. This relationship is the founding principle behind any imaging device that uses a lens, such as contact lenses, glasses, cameras, telescopes, binoculars, and movie projectors.

• Apparatus •

___PASCO Basic Optics System
- ___optical bench
- ___light source in bracket
- ___power supply
- ___mounted lens: f = +200mm (+20.0cm)
- ___white metal screen

• Set-Up •

1. Arrange the apparatus as shown below. Notice the orientation of the notch at the base of the bracket; secure it onto the optical bench using the nut and bolt in the central longitudinal channel in the optical bench. Also secure the screen to the optical bench. The lens fits onto the optical bench by a flexible flange in its base. The optical object ("target" pattern) is facing the lens. The light source will lock into place in the orientation shown below. The notch in the bracket is aligned with the 0.0cm mark and the screen is at the 110.0cm mark on the optical bench.



2. Attach the power supply cord—through the bracket—to the light source and plug it in.

• Procedure •

1. Place the lens 5cm from the screen and move slowly toward the light source until an image comes into sharp focus on the screen. The image should be neither hazy nor blurry when focused.
   a. Observe the characteristics of the image. Record its orientation (upright or inverted) and relative size (enlarged or reduced) compared to the original object. If you're not sure whether the image is enlarged or reduced, you can measure the image of the 2cm scale to find out. (If the image is longer than 2cm, the image is enlarged, and so on.)

   b. Record the position of the lens on the table below.

2. Continue to move the lens toward the light source until a second image comes into focus on the screen.
   a. Observe the characteristics of the image. Record its orientation (upright or inverted) and relative size (enlarged or reduced) compared to the original object.

   b. Record the position of the lens on the first table on the next page.

3. Move the screen 4-6cm closer to the light source (vary the distance each time). For example, you could move it from 110cm to 104cm, then from 104cm to 99cm, and so forth on successive trials. Repeat steps 1 and 2 above. Keep repeating until you have 12 points of lens position of data.

• Data •

Object Position x_O (cm)	Screen Position x_S (cm)	First Lens Position x_1 (cm)	The image is... (upright or inverted; enlarged or reduced)	Second Lens Position x_2 (cm)	The image is... (upright or inverted; enlarged or reduced)

Object Distance o (cm)	Image Distance i (cm)	o^2	i^2	1/o	1/i	$1/o^2$	$1/i^2$

o + i (cm)		$i^2 + i^2$ (cm2)		1/o + 1/i (1/cm)		$1/o^2 + 1/i^2$ (1/cm2)	

• Analysis •

Object distance is the distance from the object to the lens. **Image distance** is the distance from the lens to the screen.

1. Use the information above to process the data from the first table above to the second table on the previous page.

2. Determine and record f, f^2,1/f, $1/f^2$ where f is the focal length of the lens (in centimeters).

f = f^2 = 1/f = $1/f^2$ =

3. Use your calculator or a spreadsheet to determine o^2, i^2, 1/o, 1/i, $1/o^2$, $1/i^2$.

4. Use your calculator or a spreadsheet to determine o + i, $o^2 + i^2$, 1/o + 1/i, $1/o^2 + 1/i^2$. Record the average of each.

o + i = $o^2 + i^2$ = 1/o + 1/i = $1/o^2 + 1/i^2$ =

5. Examine your findings from questions 2 and 4. Which one of the following statements is true?

__ o + i = f __ $o^2 + i^2 = f^2$ __1/o + 1/i = 1/f __$1/o^2 + 1/i^2 = 1/f^2$

• Continued Procedure •

1. Arrange the apparatus using the +100mm (+10.0cm) lens to form an enlarged image of the object on the screen. Measure and record the object distance and image distance. Verify the equation you selected in the Analysis section using your knowledge of the focal length of the lens (printed on the lens mounting).

2. a. Take that lens, a meterstick, and a blank sheet of paper to an open window, hallway, or outside.

b. Arrange the lens and paper so that a focused image of outdoor scenery (**distant** trees, buildings, etc.) appears on the paper.

c. Carefully measure the distance from the lens to the paper. This is the image distance. The objects are so far away that the object distance is considered to be infinite. Consider what effect a large value of o has on the equation you selected in question 5 of the Analysis section.

d. In what way—if any—does the image distance relate to the focal length of the lens?

3. Obtain a lens with an unknown focal length. Determine its focal length. On a separate sheet of paper (or the back side of this one), briefly describe your procedure(s), record your data, and show your calculations and result.