# General Science 1110L Lab
Lab 7: CONVEX LENS

OBJECTIVE: To investigate the image formed by a certain thin convex lens and to determine its focal length.

APPARATUS: Convex lens, optical bench, light source, target image slide, lens mounts, and screen.

THEORY: A thin convex lens can be characterized by its focal length f, the object distance, d_o and the image distance, d_i. These two variables are related to the focal length, f, by the lens equation:

$$1/f = 1/d_o + 1/d_i \quad (1)$$

All the distances are measured from the center of the lens. If the object is placed very far away from the lens ($d_o \approx \infty$) then $\dfrac{1}{d_o}$ approaches zero.

converging lens

light rays

focal point (F)
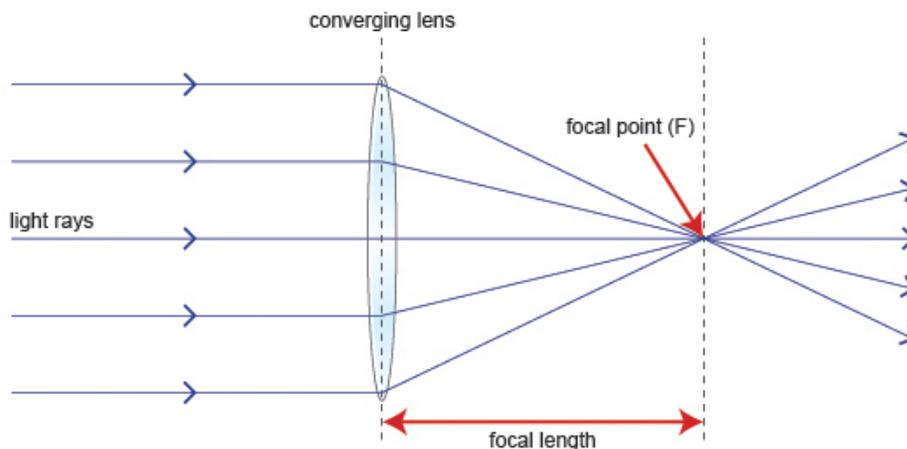
focal length

Ray Diagram for an Object Infinitely far away from the lens.

In this case, $d_i = f$. This allows us to determine the focal length of a convex lens.

If the object is not very far away from the lens, the lens equation must be used to calculate the focal length.   Solving for f from equation (1), yields

$$f = \frac{d_o \times d_i}{d_o + d_i} \quad \textbf{(1a)}$$

The magnification by a lens is given by:

$$M = - d_i / d_o \quad \textbf{(2)}$$

where the negative sign indicates the image is inverted. Figure 1 shows a ray diagram for locating the image of an object. If the absolute value of M, is greater than 1, the image is enlarged. If the absolute value of M is less than 1, the image is smaller than the object or reduced in size. If the absolute value of M =1, the object and image are the same size.

The image characteristics include the following: real or virtual, erect or inverted, and enlarged or reduced in size or same size. A real image is one for which the light rays converge so that the image can be formed on a screen. A virtual image is one for which the light rays diverge and cannot be formed on a screen, but can be observed through a lens. The image shown in Fig. 1 is a real, inverted, and reduced in size.
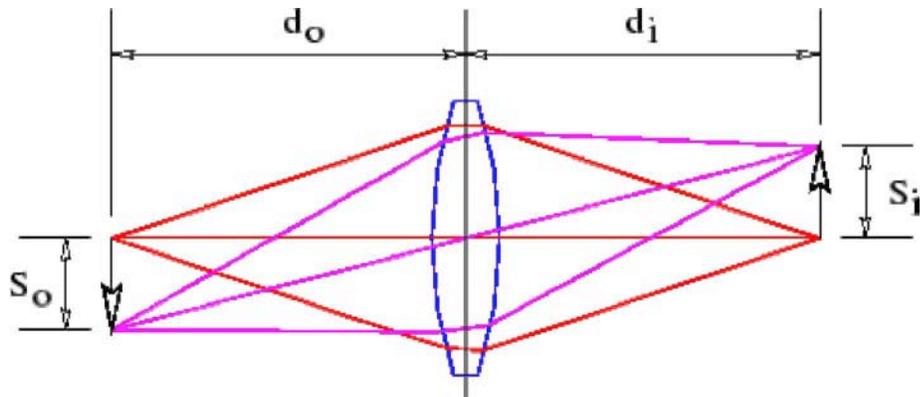
Figure 1. Ray Diagram

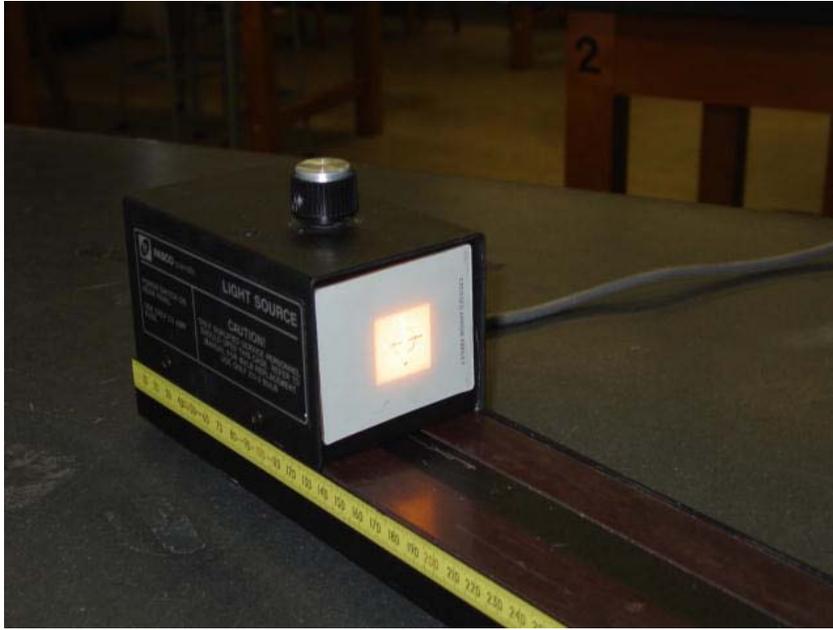**Figure 2. Optical Bench with Light Box, Lens, Screen.**

Figure 3. Light Box Front View with Object Slide

Figure 4. Crossed-Arrow Target.

In the picture above, in the front of the light box is the Crossed-Arrow target that will be the object in trials 2 and 3 in the experiment. The horizontal arrow has mm markings to help see when the image is at its sharpest focus. Compare the direction of the arrows to their image on the screen.
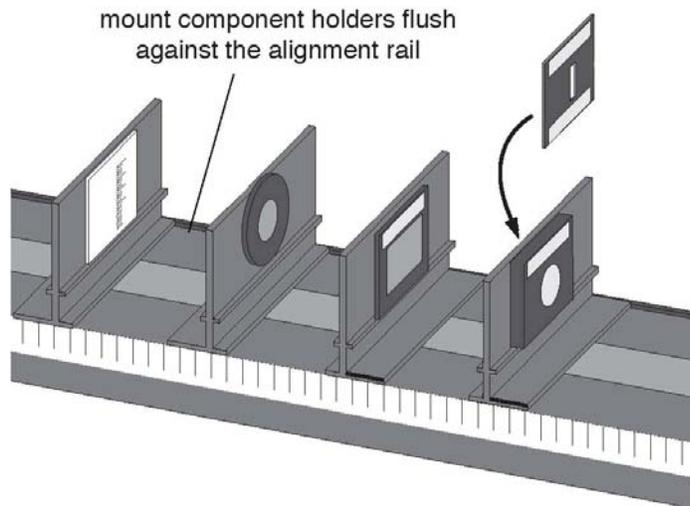
mount component holders flush
against the alignment rail

Figure 5 Using Component Holders

PROCEDURE

1. Focus the image of a distant object (a window of another building, for instance) onto the screen on the optical bench. Make sure no one blocks the light path.

2. Using the centimeter scale on the side of the optical bench measure the image distance, d_i , from the lens to the screen. This is also the focal length, f in this case, since the object distance is considered as infinity.

3. Record the measurement in the data table and describe the image.

4. Using the optical bench, place the light box at one end of the optical bench and the screen at towards the other end. Make sure the distance between the light box and the screen is at least 4 times the focal length you found using the distant object, approximately 35 to 40 cm.

5. Place a lens on the magnetic mount between the light box and the screen where the image will be observed. See fig. 4.

Figure 6. Lens on Mount

6. Move the lens towards the light box end of the optical bench until a sharp image is formed on the screen at the other end of the optical bench. Avoid the arrangement from which an almost same size image is formed.

7. Use the scale on the sided of the optical bench to measure the object distances, d_o, the image distance, d_i, and describe the image. Record them in your data table. Read the theory part again for correct measurements and image description.

8. Calculate the focal length using lens equation (1) or (1a).

9. Calculate the magnification using equation (2) (must include the negative sign). Do not measure the sizes for magnification. It will not be accurate.

10. Now move the lens so that it is closer to the screen than it is to the light box. A sharp image will again be formed on the screen. Again, avoid the arrangement from which an almost same size image is formed.

11. Repeat steps 7 and 8.

12. Find the average value of the focal length using the first three trials and compare with the actual value marked on the lens.

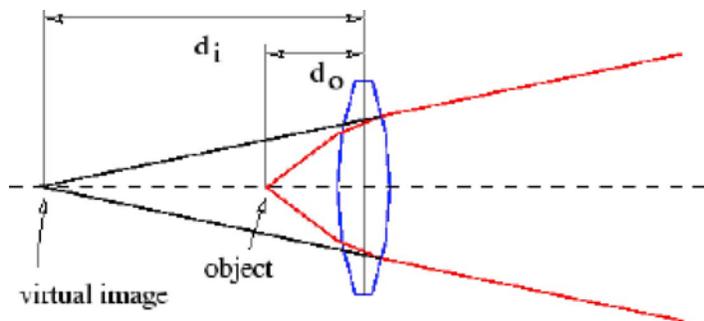**13. Determine the per cent error.**

Figure7. Virtual Image

14. Now place the lens at a distance from the light box that is less than the average focal length (do ‹ f). (Figure 5) See where the object d_o is located in relation to the lens. Can you get any image on the screen? Move the screen along its entire length. Is any image formed on the screen?

15. Now look into the lens from the screen side. You should see a virtual image that cannot be focused on the screen. Now describe the image. No measurement or calculation is needed for this arrangement.

DATA TABLE

Trial Number	Object Distance d_o(cm)	Image Distance d_i (cm)	Magnification	Image Description	Focal Length f (cm)
1	∞		omit		
2					
3					
4		omit	omit		

Average f = _____(cm)
Actual f = _____(cm)
% error = _____

Questions;
1. What are the most likely sources of error in this experiment?
2. List some everyday things that use lenses.

Lab Report Format:
Your lab report for this experiment should contain the following sections:
1. Title of experiment in center of the first page. Date to the left of the title. Experimenters name with partners name(s) under experimenters name to the right of the title.

2. Objective

3. Apparatus

4. Original Data: Neatly filled out data page.

5. Sample calculations: For this lab an example (ONE) calculation needs to be shown for each of the following: Focal Length for either trial 2 or 3. Use equation (1) or (1A), Magnification using equation (2) for either trial 2 or 3. Find the average value of the focal length using the first three trials. % difference between average value for the Focal Length compared to the Focal Length actually marked on the lens.

6. Results: State your results (in the form of **very short** sentences). Make sure the numerical results are properly rounded and have the correct number of significant digits. Give your experimental value for F.L.$_{average}$. How does your experimental value for the F.L. compare to the true value given on the lens itself (% error)?

7. Conclusions: Address the answers to the two discussion questions above.

PROPER MATERIALS, ETC. FOR YOUR REPORTS

1. ALL DATA IS TO BE RECORDED <u>DIRECTLY</u> IN YOUR LAB NOTEBOOK<mark>. <u>NO SCRATCH PAPER IS TO BE USED.</u></mark>
2. YOU ARE TO USE BLUE OR BLACK <u>INK ONLY</u> FOR RECORDING DATA AND DOING YOUR REPORTS IN YOUR NOTEBOOK.

3. REMEBER, ONLY THE FRONT OF THE PAGES IN YOUR LAB NOTEBOOK ARE TO BE USED FOR DOING YOUR LAB REPORT. <u>I WILL NOT LOOK AT ANY INFORMATIION ON THE BACKSIDE OF THE NOTEBOOK PAGES</u>.

4. <mark><u>DO NOT TEAR OUT ANY PAGES</u></mark> FROM YOUR NOTBOOK.

5.<mark style="background-color:#00ff00">DO NOT ERASE OR USE WHITEOUT FOR MISTAKES!!!!</mark>

All observations taken under the same experimental condition are equally valid and should be retained for analysis. Do not erase readings. If you must change a reading, draw a single line through it and then record the new measurement next to the old one.