CONVERGING LENSES

EQUIPMENT

Optics Bench | *2 Convex Lenses*
Ruler

INTRODUCTION

The purpose of this experiment is to examine the properties of a converging lens, determine its focal length and calculate the magnification of a converging lens.

Lenses make use of the principles of refraction. A convex, or positive lens, has a symmetrically outward curved surface. It is often referred to as a converging lens because light rays that originate from the same *object point*, but arrive at different places on the lens, will converge to a single *image point* after passing through the lens. If two rays entering a lens are parallel, they will converge at a point known as the *focal point* of the lens. Refer to Figure 1a and 1b.

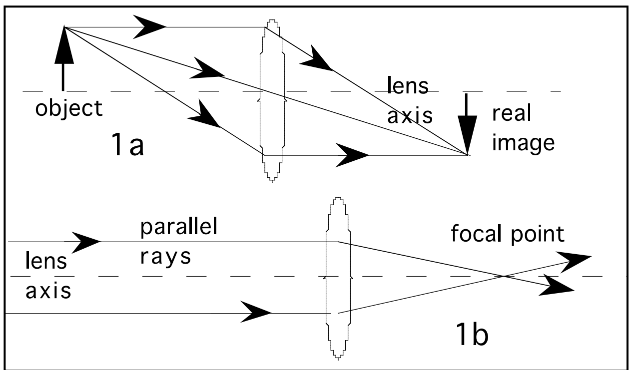


Figure 1

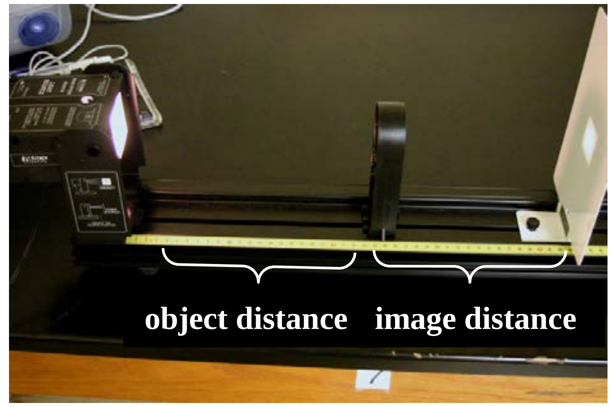
A positive lens, when placed in front of the eye, can produce an image of an object that is larger than the object. This property of magnification is easily examined by directly comparing the magnified image with the unmagnified object. The (almost) greatest amount of magnification for a lens can be seen when the object is placed at the focal point of the lens. *The virtual image is then formed at infinity.* The greatest magnification is observed when the image is made (by moving the object close to the focal point) to form at the near point of the observer.

In Part A of this laboratory exercise you will examine the behavior of the image created by a converging lens as an object is moved various distances from the lens. In Part B, you will determine the magnification of a positive lens.

In each part of the experiment, pay particular attention to the characteristics of the image (if any) produced by the lens. Characteristics include size, position relative to the object, and size of one image relative to another image.

As an introduction to Part A of this experiment there is a YouTube video that you should watch.. This video is short (4:06) and is a good overview of the behavior of a converging lens. The web address (URL) is https://www.youtube.com/watch?v=FxQQ6fILi3k

Figure 2



Lab set up -Positive lens, object & screen

PROCEDURE

A. Characteristics of a converging lenses with object at 'infinity'.

1. If you have access to a converging lens, take it to a window and 'point' it outside with a white card (or sheet of paper) behind it as a screen.

2. Aim the lens at some distant object seen through the window and slowly move the screen (card) nearer to and/or farther away from the lens until you see a sharply focused image on the card.

   The distance from the lens to the screen is the focal length of the lens. See Figure 3 below. This was taken in the lab with the lens 'looking outside' towards the observatory. The ruler has units of mm.

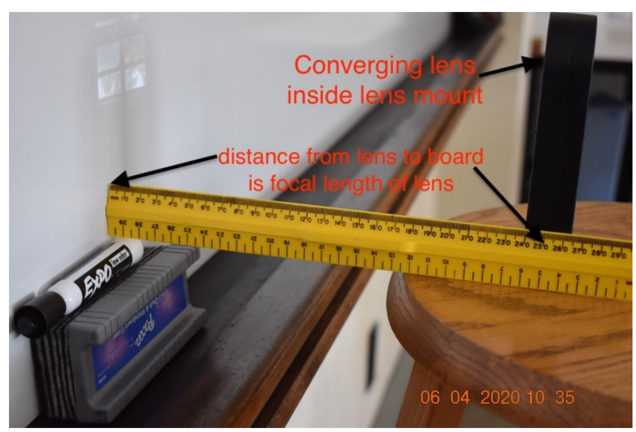


Figure 3.
Image projected on lab whiteboard

3. A closeup of the image is shown below. Please note the size and orientation of the image of the trees and

observatory dome on the screen compared to the actual objects.

Figure 4
Detail of image projected on lab white board

B. Characteristics of a converging lens with object near the lens using optical setup

In order to perform the 2nd part of this experiment you are asked to watch another YouTube video by Dr. Boyd F. Evans of Utah State.

This video is essentially what you would have done in this part of the experiment using the same equipment that is used in your lab experiment. The video URL is

https://www.youtube.com/watch?v=xbfB3Ns6_bs

1. You are now ready to complete Table 1 on page 3 below.

This part of the lab procedure uses a simulation in which the **object (blue stick on the left of screen**) is moved to the various object positions listed in the table. **As the object (blue stick) is varied the resulting image (red stick) correspondingly changes position and size.**

The image distance as well as the size and orientation of the image is to be filled into table 1. When making measurements of object or image distance and height, use the graph and axes, which are labeled in cm units. Do not use the numbers in the upper left of the screen, which do not represent the actual distance and height values. *Please note the object distance at which the object and image distances are the same and record on the data sheet.*

The distance where the object and image are the same distance from the lens and are the same size is twice the focal length (i.e., half this distance is the focal length of a converging lens).

URL of simulation https://youtu.be/sP9SiavSadQ

The simulation starts with the object at a distance at 45 cm from the screen (i.e., object distance of 45 cm). See Table 1. You will probably have to zoom in to properly see the numbers on the graph axes. Stop, start or rewind movie at your convenience. Complete Table 1.

C. Magnification of a converging lens

A simple magnifying glass is just a positive lens with a handle attached. If you remove the positive lens from your bench, but leave it in its mount, you will have a magnifying glass.

As objects are brought closer to the eye they have the effect of appearing larger. That is, we see them in more detail. But, as something gets closer and closer, a point is reached where the object is no longer in focus.

Try this experiment: hold your thumb up at arm's length. Slowly bring your thumb closer to your eye. How close do you get before you reach the "out of focus" point? This point is the near-focus point of your eye. Using a magnifying glass foreshortens the near-focus and lets you see objects in greater detail by bringing them closer to the eye.

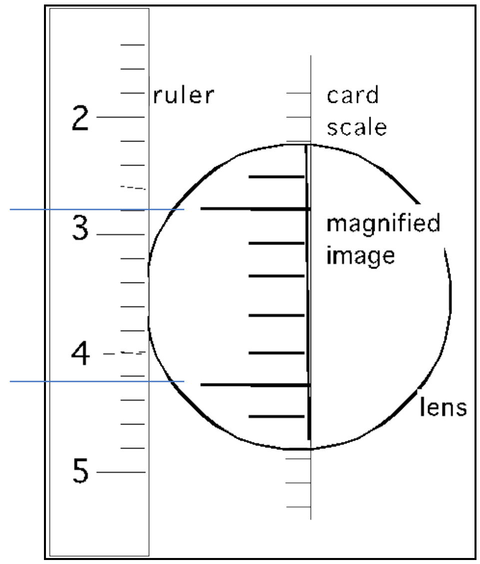
If you have a magnifying lens do the following. Repeat the experiment with your thumb, but this time put the magnifying glass a few centimeters from your eye. Now, how close can you get to your thumb before it is out of focus?

Figure 5

1. Find the near-focus (near point) of your eye by placing a centimeter ruler at your eye and measuring the distance that finger or thumb starts to be slightly out of focus. **Record this 'near point' below.**

2. If a ruler is placed directly behind a magnifying glass the size of the image seen through a magnifying glass and the unmagnified ruler are approximately the same size and the magnification is roughly one. See Figure below. Note that ruler behind lens (larger tape) is the same size as the ruler (small tape) in front.

3. If an object (in this case a ruler) is moved away from the lens nearer to the focal length (focus) of the lens, the viewer sees a magnified image. The closer the object is brought to the focus, the larger the magnified image. You should note that the image is a virtual image and is upright. See Figure 28.49 of text and Figure 6 below.



Measured size **Magnified size**

Figure 6

3. The magnifying power of the lens may be found by dividing the measured size by the magnified size.

If we note that in the figure above, **the magnified size of a one cm interval is ~ 1.47 cm, the magnification is 1.47** since

magnification= $\frac{magnified\ size}{measured\ size} = \frac{1.47cm}{1.0cm} = 1.47$

SUMMARY

A positive lens produces a real image that is inverted when the object is outside the focal length of the lens. A real image is one from which light rays will extend to the viewer's eye. For distant objects, the inverted image is smaller than the object.

Parallel rays from a distant object converge at the focal point of a lens. A screen placed at the focal point makes a focal plane. Thus the image of an object is produced at the focal plane of the lens.

Magnified images are not inverted, however, because the object is inside the focal length of the lens. Magnified images are larger than objects because they are viewed at distances closer than the near-focus point of the eye.

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DATA SHEET

Name: ________________________

Section: _______

Part A: The focal length of the positive lens with object at infinity (See step 2 & Figure 3).

Focal length ________________ cm

Part B: Object and Image distances

Table 1

Object Distance	Image Distance	Image vs. Object Size Larger/Same/Smaller
45		
40		
35		
30		
25		
22		
Equal Image and Object Distance		

Focal length of lens in Part B ______cm.

Part C: Object and Image distances

Near focus of your eye _______________

QUESTIONS

1) Was the image distance of your lens longer or shorter for near versus far objects? Bearing this in mind, would the lens of a camera need to be moved toward or away from the film to focus an image at 1 meter after having been set at infinity? Explain your answer. See simulation and imagine lens is the front of the camera and the film is located at the image.

2) Define focal point of a converging lens.

3) What happens to the size of an object as the object is moved nearer to and further from the converging lens?

4) What is the difference between a virtual image and real image and where did you see both in this experiment?

5) **The diameter of the lens in the photo below was measured to be 4.5 cm with a regular (unmagnified ruler).** What is the magnification of this image? To do this, use the magnified ruler to determine what the diameter of lens would be. Then divide 4.5 cm by this value. Show all work.