Experiment 19
CONVERGING LENSES

EQUIPMENT

Optics Bench	*2 Convex Lenses*
Ruler	

INTRODUCTION

The purpose of this experiment is to examine the properties of converging lenses, determine their focal lengths and calculate their magnification.

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.

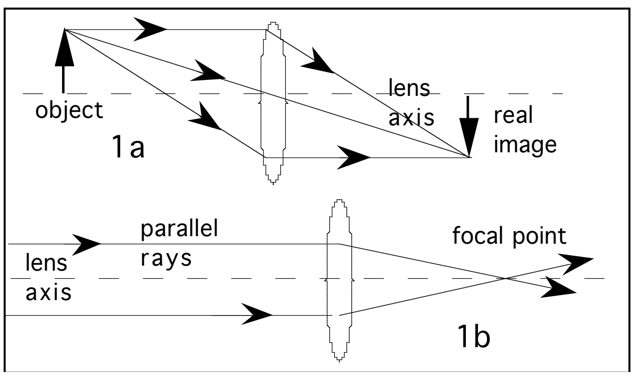
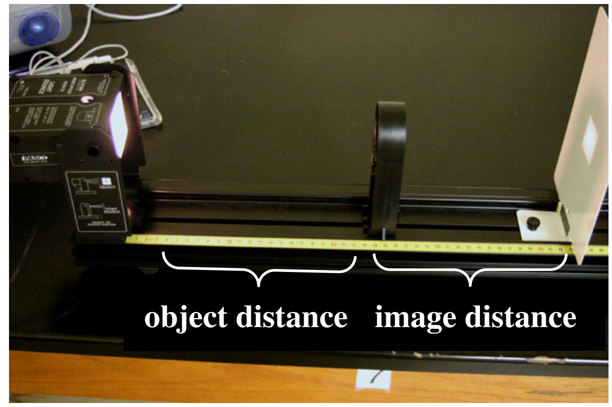


Figure 1

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 greatest amount of magnification for a lens is seen when the lens is placed at the near-focus (typically 25 cm) of the eye.

In this laboratory exercise you will first determine the focal length of a positive lens for an object at great distance. You will then observe the effect on focal length as the object is brought nearer to the lens. Next you will determine the effect of combining a positive and negative lens. Lastly, 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, brightness, position relative to the object, size of one image relative to another, etc.



PROCEDURE

A. Positive Lenses

The focal length of a positive lens is most easily determined by viewing the image of a distant object on the screen and measuring the distance from the lens to the screen.

1. Take your lens to the optics bench your T.A. has set up facing the window.

2. Point or aim the mounted lens at some distant object seen through a window and slowly move the screen nearer to and away from the lens until you see a sharply focused image on the card. Determine the distance from the lens to the screen. This is the focal length of the lens. Repeat this several times and average the results.

3. Now place the converging lens at the 45-cm mark. Move the screen until the light is in focus on the screen. Record the image distance. Now move the lens towards the light source in 5 cm steps, recording object distance and image distance until you reach an object distance of 20 cm. recording the object distance and image distance each step until you reach an object distance of 20 cm. Find the object distance at which the object and image distances are the same and the image is in focus and record on the data sheet.

B. Magnification

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 arms 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.

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?

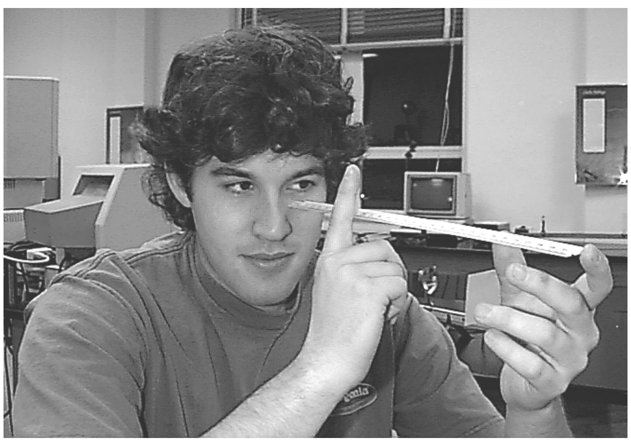
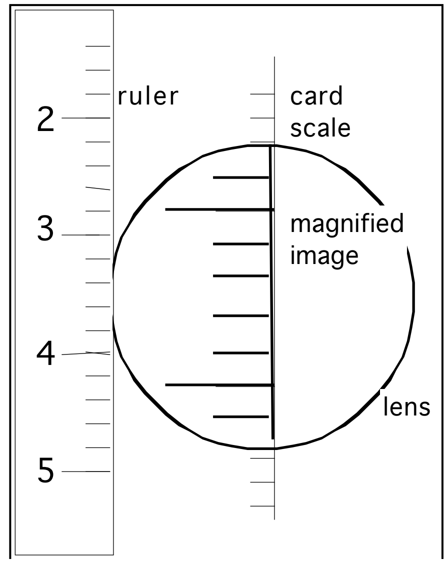


Figure 2

1. Measure the magnifying power of your lens in this manner. Find the near-focus point of your eye by placing a centimeter ruler at your eye, and find the closest point at which your finger is in focus (See Fig. 2).

   Place the lens and mount on the optical bench at a distance from the end at your near-focus point. Place the screen on the far side of the lens, with either a ruler propped against it, or a printout of two rulers taped to the screen. Viewing from the end of the optical bench, adjust the position of the screen until a magnified image of the ruled scale is seen. Adjust the position of the screen to achieve maximum magnification. Holding a centimeter ruler next to the magnified image, but outside of the lens area, (or using the other ruler on the printout) determine how many centimeters two *magnified centimeters* are in length. Refer to Figure 3.



Measured size **Magnified size**

Figure 3

2. The magnifying power of the lens may be found by dividing the measured size by the magnified size. Determine the power of your lens.

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.

When a converging lens is used as a magnifying glass, the 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 (i.e., the objects) are 'essentially' viewed at distances closer than the near-focus point of the eye.

When colored light passes through a lens, the different colored rays will tend to be focused at different points. This is known as chromatic aberration and is due to the fact that different colors of light tend to travel through media at different velocities.

Experiment 19
DATA SHEET

Name: ________________________

Table: ____________________ Section: _______

Part A: The focal length of a positive lens (Step 2).

Trial 1 ________________

Trial 2 ________________

Trial 3 ________________

Average ________________

Part A: Object and Image distances (Step 3)

Object Distance	Image Distance	Image vs. Object Size Larger/Same/Smaller
(from Part A) **infinity**		
60		
50		
40		
30		
25		
15		
Equal Image and Object Distance		

Part B.

Near focus of eye _______________

Near focus of eye with lens _______

The magnifying power of a positive lens.

Trial 1 _______________

Trial 2 _______________

Average _______________

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?

   You can visualize this by setting the screen (which models the film or electronic sensors in the back of a camera) at a fixed position and then moving the object (i.e., the light source) and then observing the movement of the lens when you try to focus.

2) Define focal point.

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

4) What was the ratio of the size of the object to the image when the object and image distances were the same?

5) The magnification of a magnifying glass is given by the relationship

Magnification = 1 + Near point/focal length of lens ~ Near point/focal length of lens.

You can see that the magnification for a given lens is greater for someone with a large near point (like your parents or grandparents), yet *with the same magnifying glass* you can see the object just as good as they can. **Explain this**.

Remember that the thing that a magnifying glass does is allow an object to be brought closer to the eye and **the closest an image can be brought the eye is the near point of the eye**.