Lab 7S

# Lenses, Focal Lengths And Refracting Telescopes

(Physics 7, Experiment #7)

**Materials:**

Long focal length lens, Short focal length lens, Optical Bench, holders, light, screen, meter stick

**Purpose:**

This exercise is designed to introduce you to convex lenses and allow you to make measurements of their focal lengths. Additionally you will set up and learn about a simple refracting telescope.

**Introduction:**

A lens is a circular piece of glass that is curved on each side. When light passes through the lens, the light is brought to a focus. Lenses are used in many applications including eyeglasses, cameras, microscopes and telescopes. When light comes into a lens from very far away, the light is focused at a point on the opposite side of the lens from the light source. The distance from the lens to the point where the light is focused is the focal length, f, of the lens. If the source of light is relatively close to the lens, the light will be focused further away from the lens than the focal length. Three important measurements used when working with lenses are:

1) The focal length of the lens: f
2) The object distance: $d_o$ ($d_o$ is the distance from the object to the lens).
3) The image distance: $d_i$ ($d_i$ is the distance from the image to the lens).

The relationship between these three quantities is given by the lens equation: $1/f = 1/d_o + 1/d_i$

If we solve this equation for f, we get: $f = \dfrac{d_o * d_i}{(d_o + d_i)}$ [Eq. 1]

Another important quantity used to describe a lens is its magnification, M. The magnification of a lens is the image size, $h_i$, divided by the object size, $h_o$, or $M = \dfrac{h_i}{h_o}$ [Eq. 2]

In the design of a simple refracting telescope, there are two lenses used. The light from the star (or other object) first passes through a long focal length lens called the objective lens, and then the focused light passes through a short focal length lens known as the eyepiece. The distance between the two lenses must be the sum of their focal lengths, $f_o + f_e$. Where $f_o$ is the focal length of the objective lens, and $f_e$ is the focal length of the eyepiece. For a refracting telescope the magnification is given by, $M = \dfrac{f_o}{f_e}$ [Eq. 3].

**Procedures:**

**Part 1**. Measuring the focal lengths of each lens by use of the lens equation.

Start by placing a lens, a light source and a screen in holders provided. Put the holders on the optical bench, with the lens near the middle of the optical bench, and in between the light source and the screen. See diagram 1. Use the optical bench to record the positions of the light source (object), lens, and screen (image). Record the information on your data sheet. Be sure to take into account the diameter of the light bulb when determining the light position! Subtract the appropriate numbers to determine the object distance, $d_o$, and the image distance, $d_i$. Then use the lens equation given above [Eq. 1] to calculate the focal length of the lens. Record $d_o$, $d_i$, and f on the data sheet. Repeat these procedures to determine the focal length of the second lens.

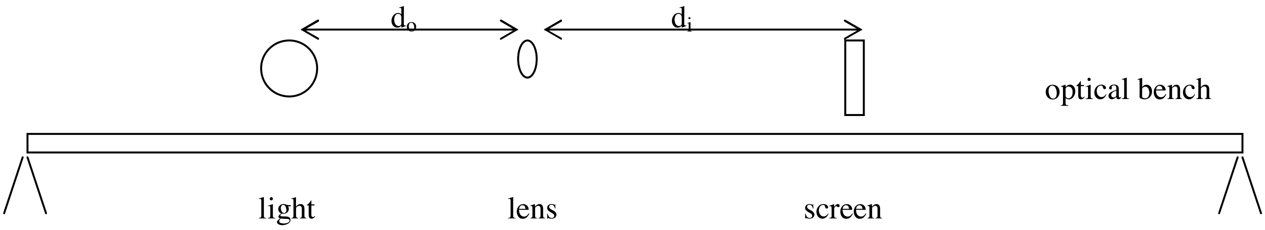


Diagram 1

**Part 2**. Making a simple refracting telescope.

Place the short focal length lens (eyepiece lens) near the end of the optical bench, and place the long focal length lens (objective lens) a distance of $f_o + f_e$ further along the bench. Sighting through the short focal length lens, slightly adjust the positions of the lenses until you are able to bring an object located on the wall into focus. Now, work with a partner to measure the image size and the object size. Have one person stand near the object being viewed, and the other person sight through the pair of lenses. While looking through the lenses have the person near the object use a meter stick to measure how big the *image appears to be*. Record this number under image size. Also the person near the object can measure how big the *object actually is*, and record this value under object size. Then use the formula given in [Eq. 2] above to calculate the magnification of the simple telescope. Also, using equation [Eq. 3] above, calculate the magnification of the telescope from the known values of the focal lengths.

## DATA TABLE

| | Light Position (cm) | Lens Position (cm) | Screen Position (cm) | $d_o = \lvert$ Light Position – Lens Position $\rvert$ (take absolute value) (cm) | $d_i = \lvert$ Screen Position – Lens Position $\rvert$ (take absolute value) (cm) | f [Eq. 1] |
|---|---|---|---|---|---|---|
| Lens 1 | | | | | | |
| Lens 2 | | | | | | |
| | | | | | | |
| | $h_i$ | $h_o$ | M [Eq. 2] | $f_o$ (longer focal length from above) | $f_e$ (shorter focal length from above) | M [Eq. 3] |
| Refracting Telescope | | | | | | |

**Questions:**

1) What is the percentage error between the two values of magnification calculated above? The formula for percentage error is: % error = [(Value 1 – Value 2)/(Value 1)] x 100%

2) What are some of the sources of error in this experiment? In other words, why do the two values of magnification calculated above not give the same answer?

3) What are some of the differences between a real refracting telescope and the simple refracting telescope you built during this lab? Mention differences in lenses and in construction.

Name of Student: ______________________________

Date Performed: ______________________________

Instructor's Initial: ______________________________