Optics Bench Laboratory

INTRODUCTION

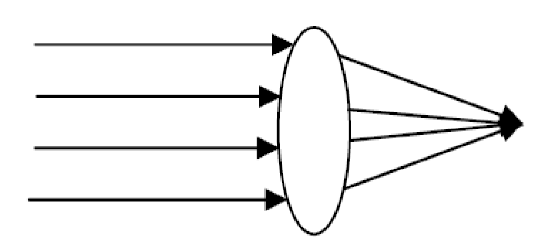
Visible light is a form of radiant energy and is a part of the electromagnetic spectrum, which includes lower energy waves we cannot see (such as infrared), and similarly higher energy waves that are invisible (such as x-rays). Light behaves like a wave and can have different speeds and wavelengths. Light rays travel in a straight line and can be reflected and refracted.

Refraction of light is a common phenomenon in which the paths of light rays are bent as they travel through different media. Refraction is based on the principle that light travels at different speeds through different materials. For example, when light rays pass from air to water, their speed is slowed and the light rays are bent or refracted.

Lenses are made of transparent materials and use the principle of refraction to bend light and enhance an image for viewing. When light rays strike the surface of a lens, they are refracted as they pass from air through the material of the lens. When they emerge on the other side and pass from the lens to the air, they are refracted again.

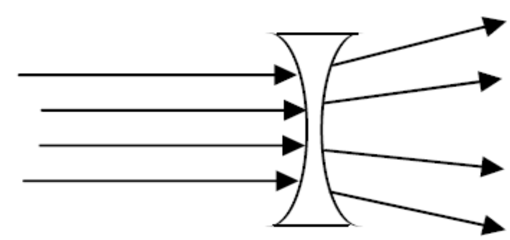
Convex lenses are curved so that the center of the lens is thicker than the sides. These lenses refract the light rays toward the center of the lens. For this reason, they are called **converging** lenses.

A **plane convex** lens has one curved surface and one flat surface. A **double convex** lens has two curved surfaces.



Concave lenses curve the opposite way; the center of a concave lens is thinner than the sides. Light rays are spread apart, away from the center, as they pass through a concave lens and thus it is called a **diverging** lens.

Plane concave lenses have one flat surface and one curved surface whereas **double concave** lenses have two curved surfaces.



Light rays that are parallel to each other and pass through a convex lens will all be refracted to converge at a single point called the **focal point** (***f***) of the lens. Only light rays that come from an object that is very far or "infinitely" far away are parallel. When light rays come from an object that is closer than this, the rays are not parallel and do not converge at f but at some distance greater than f from the lens. Where the light rays converge, an **image** is formed. This image is either **erect** (right side up) or **inverted** (upside-down).

The following experiments will demonstrate the principle of refraction with a convex lens and a concave lens. An **optics bench** is used to align the lenses and objects in a straight line for better viewing. These activities will enhance the scientific skills of observing, measuring and controlling variables.

OBJECTIVE

For this lab you will be 1) determining the focal length of a double convex lens using the thin lens formula, and 2) determining the focal length of a concave lens by using a convex lens.

For the first objective, after taking measurements you will insert them into the thin lens formula, which relates focal length (*f*), object distance (d_o), and image distance (d_i), as follows: $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

This formula applies to thin lenses of negligible thickness, such as those we will use. Keep in mind the image distance (d_i) is negative if the image (real or virtual) appears on the same side as the object itself.

MATERIALS

Your kit contains the following items:

Meter stick and two supports

38 mm double convex lens

38 mm double concave lens

Screen and screen holder

Object marker

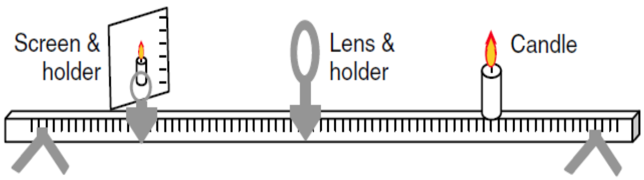
Lens holder

Light bulb and holder

Battery holder and battery

Procedure Part 1: Find Focal Length Of Convex Lens

1. Set up the optical bench with the light bulb (or candle) at one end, the screen at the other end, and the convex lens in the middle.



2. Adjust the screen, light bulb, and or the lens until the light focuses to a point projected on the screen.

3. Record the distance between the light bulb and the lens (d_o) and the distance between the lens and the screen (d_i). Record these values in Table 1, *accounting for the fact* the bulb position is either behind or in front of the position of the clamp on the light bulb holder.

4. Using the thin lens formula, calculate the focal length of the lens and record in Table 1.

5. Repeat Steps two through four three more times, entering values in Table 1.

6. Calculate the average value of the focal length in Table 1.

Procedure Part 1: Find Focal Length Of Concave Lens

1. Set up the optical bench with the light bulb (or candle) at one end, the screen at the other end and the convex lens in the middle as before.

2. Adjust the screen until the light focuses to a point projected on the screen. The location of the screen on the meter stick will be considered the location of the virtual object for the concave lens. Mark this location in Table 2.

3. Place the concave lens between the screen and the convex lens.

4. Slowly move the screen back and forth.

If the concave lens causes the light rays to become parallel, then the image on the screen will not change size as it is moved.

If the image changes size, then move the location of the concave lens.

Slowly move the screen again to determine if parallel rays of light are emitted from the concave lens.

Record the location of the lens in Table 2, when parallel rays of light are emitted.

5. The focal length of the concave lens is the distance between the virtual object and the concave lens. Record the focal length in Table 2.

6. Move the convex lens to a different location and repeat Steps two through five three more times, entering values in Table 2.

7. Calculate the average focal length in Table 2, and calculate percent discrepancy, comparing your experimental value to the theoretical one (on the lens envelope).

Table 1. Determining the Focal Length of a Convex Lens

Trial	d_o (cm)	d_i (cm)	Focal length (cm) $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$
1			
2			
3			
4			
		Average focal length	

Table 2. Determining the Focal Length of a Concave Lens

Trial	Virtual object location (cm)	Concave lens location (cm)	Focal length - difference between virtual object and concave lens locations (cm)
1			
2			
3			
4			
		Average focal length	

Percent discrepancy for the focal length of the concave lens:

Actual focal length: ____________ cm

Experimental focal length: _____________ cm

POST LAB QUESTIONS

1. You look through a converging thin lens with a focal length of 14 cm at a crayon lying on a table 19 cm away from the lens. About how far from your eye should you have the lens in order for the crayon to be in focus?

2. A pencil is placed 25 cm away from a convex lens. The image appears 15 cm away from the lens. What is the focal length of the lens?