

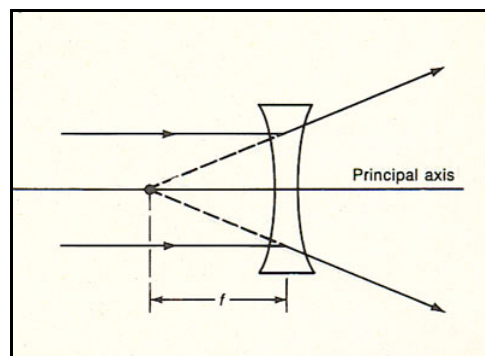
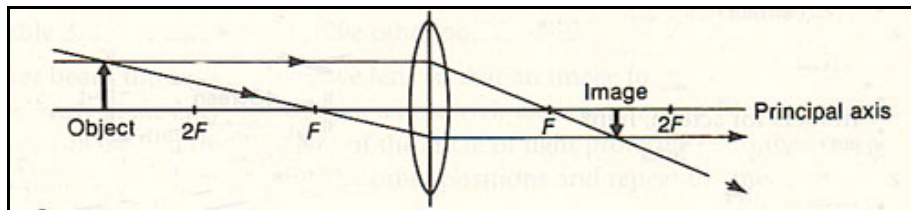


MND Physics

OPTICS: Convex and Concave Lenses

In general, a convex or converging lens is thicker in the middle than at the edges. A concave or diverging lens is thinner in the middle than at the edges. At some distance from the lens along the principal axis lies the focal point; there are two such points for the lenses we use, one on each side of the lens.

In this lab, you will first measure the focal length of the convex lens. You will then attempt to locate images for objects placed at several key positions along the principal axis, namely for an object beyond $2f$, at $2f$, between $2f$ and the focal point, at the focal point, and between the focal point and the lens. In the case of the concave lens, you will locate and describe the image formed from an object placed at an arbitrary length in front of the lens.



EQUIPMENT:

Double convex lens, double concave lens, meter stick, lens holder, candle and drip paper (object for part 1), low wattage white spherical light bulb and holder (object for part 2), small cardboard screen, metric ruler, 2 mounting brackets.



PROCEDURE:

PART 1 - THE CONVEX LENS

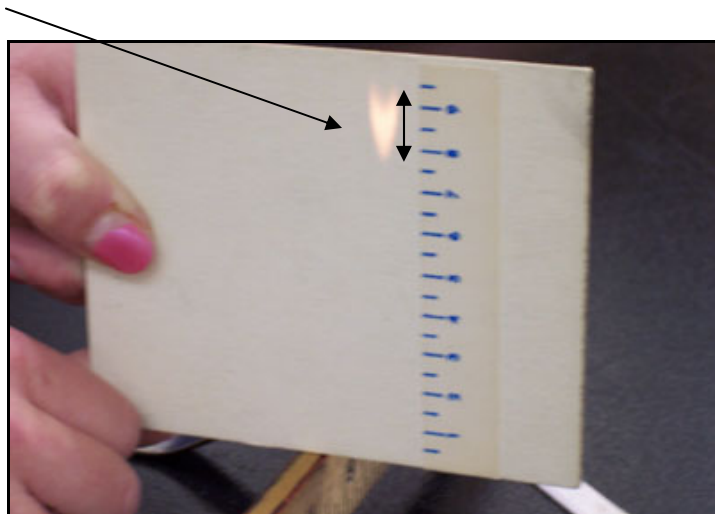
The purpose of part 1 is to investigate the relationship of object heights and distances to that of the image heights and distances. We will examine these relationships using the "5 cases for convex lenses" presented in class.

1. Determine the focal length of the convex lens. This procedure requires at least two people. A high wattage incandescent light bulb has been provided in the room annex which will act as a source of light at an "infinite" distance away. Locate a place in the room far from the light source as possible yet maintaining a clear line of sight to it. Place the lens and holder at the 50 cm mark on the meter stick. While carefully holding the meter stick and lens, aim the lens directly towards the light source (rest the lens and ruler on a stool or table top). Another person then moves the white cardboard screen until a sharp image of the light bulb can be seen on the screen. Record the distance from the lens to the screen (this is the focal length of the lens).

2. Setup your lens apparatus as shown here making sure to place a piece of paper underneath the candle (keep all wax off the table tops).



3. Place the object (candle) at exactly 3 times the focal length from the lens. Record this distance d_o in your data table.
4. Locate the image by moving the white cardboard screen back and forth on the top of the meter stick until the image is sharp. Record this distance d_i (the distance between the screen and the lens) in your data table. NOTE: make sure you always hold the screen perpendicular to the meter stick.
5. Measure and record the height of the image h_i (the image is the flame only).



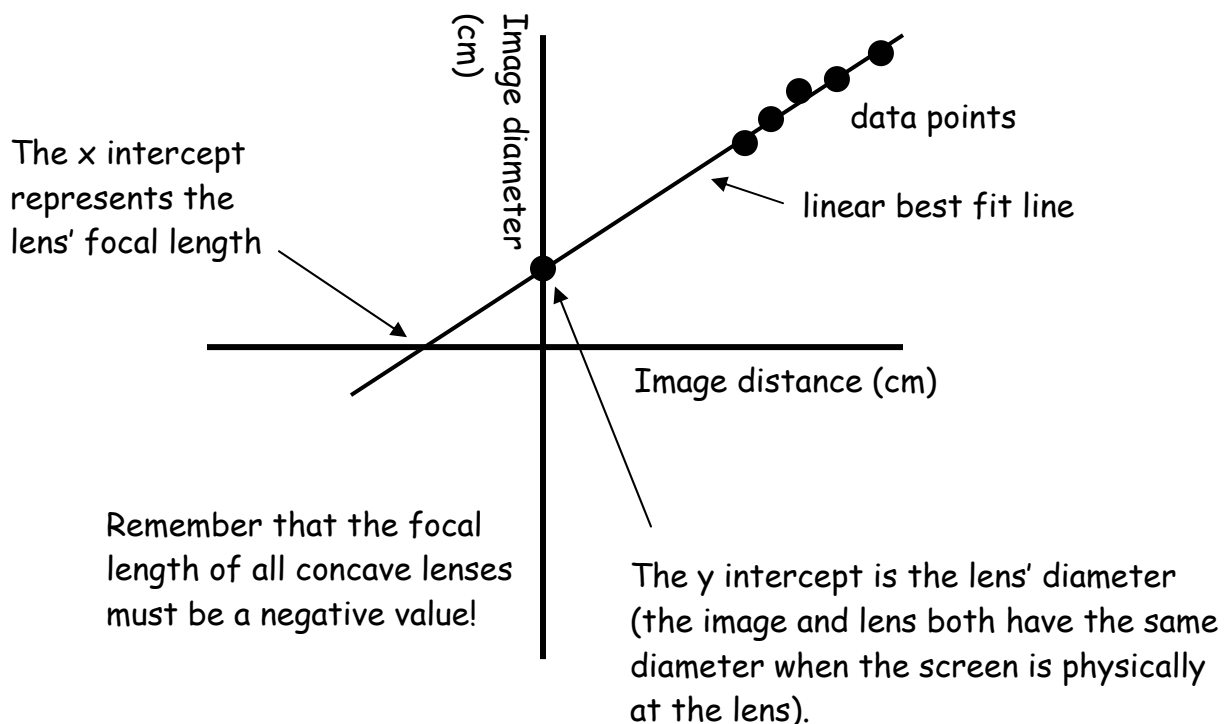
6. Measure and record the height of the object h_o (the object is the flame only).
7. Next, place the candle at exactly the $2f$ point. Repeat procedure steps 4, 5, and 6 and record your data.
8. Next, place the candle at a point exactly 1.5 times the focal length. Repeat procedure steps 4, 5, and 6 and record your data.
9. Next, place the candle exactly at the focal point. Recall that a "perfect point object" at the focal point will not form an image. However, your candle flame is not a "perfect" object. Explore whether or not you can locate a real image (or find a virtual one). Record your observations. Explain your findings.
10. Next, place the candle at a point exactly 0.5 times the focal length (at exactly half the distance between the lens and the focal point). NOTE: Recall what type of image is formed when an object is inside the focal length of a convex lens. You will have to come up with a different way to find the image! Once you find the image, estimate the height h_i . With h_i estimated, you can calculate the magnification, m . Then calculate d_i using the lens magnification formula.

PART 2 - THE CONCAVE LENS

The object of part 2 is to calculate the focal length of a concave lens. You cannot use the same procedure as in part 1 since the light rays diverge; it is impossible to measure the focal length of a concave lens directly. You will collect data and plot a graph; extrapolation of your data will provide the focal point of the lens.

1. Setup the equipment in the same manner as in part 1, replacing the convex lens with the concave lens and replacing the candle with the small electric light bulb.
2. Place the object (small electric light bulb) at a distance of 40 cm from the lens.

3. Use a full sheet of graph paper ($8\frac{1}{2} \times 11$ ") to use as the screen. Place the screen/paper far enough back from the lens so that the "image" fills approximately 75% of the width of the paper. The "image" consists of a dark circle inside a larger but brighter circle.
4. Measure the distance of the paper screen from the lens. At the same time, measure the diameter of the bright circle. Record your measurements.
5. Place the screen slightly closer to the lens and re-measure both the distance and the image diameter. Record your measurements.
6. Repeat this process until you have 5 data sets. The final or 6th data set is the actual diameter of the lens.
7. Use your data to plot a graph of image diameter vs. image distance. Place the image diameter on the vertical axis (y-axis) and the image distance on the x-axis.
8. Extrapolate the linear best fit line down to the x-axis. The line will cross the x-axis on the NEGATIVE x side (make sure to allow enough graphing space on the negative x-axis). Your graph should look something like this:



DATA: Part 1

Convex Lens						
Distance (cm)		CASE 1: Object beyond $2f$	CASE 2: Object at $2f$	CASE 3: Object between $2f$ and f	CASE 4: Object at f	CASE 5: Object between f and lens
Object:	d_o					
	h_o					
Image:	d_i					Must be calculated
	h_i					
	Type: (virtual or real)					

Record all distances in cm.

DATA: Part 2

Concave Lens	
Screen distance from lens (cm)	Diameter of bright circle (cm)
0.00 cm	Diameter of lens: _____

ANALYSIS:

PART 1

1. Calculate d_i for case 1, 2, 3, and 5 using the mirror-lens formula.
2. Compare the calculated result to your measured result (case 1, 2 & 3)
3. Calculate % error for case 1, 2, & 3 and discuss.
4. Discuss the importance of initially determining the correct focal length of your lens.

PART 2

1. Plot a graph as explained in the procedure and clearly indicate the focal length of the lens.
2. Is your result reasonable? Explain.

QUESTIONS:

1. Did you notice any defects in your lens? If so, what kind? Did the defects hinder your results in any way?
2. All of the lenses used in this lab suffer from chromatic aberration. State the definition of chromatic aberration. Assuming you wanted to eliminate the chromatic aberration from this lab, what procedural changes (if any) would you suggest?