Experiment 9

MIRRORS AND LENSES

In this experiment you will learn to determine the focal lengths of mirrors and lenses. You will also verify the mirror and lens equation and the magnification Formula by direct measurement of the positions of object and image.

THEORY

Analysis of the geometry in ray diagrams for spherical curved mirrors and thin concave and convex lenses give us a relationship between the position of the object (s), the position of the image (s'), and the focal length (f). When these quantities are measured from the surface of the mirror or lens, the formula is

$$1/s \quad + \quad 1/s' \quad = \quad 1/f$$

This formula applies to all mirrors, thin glass lenses, and to all types of images. In addition, for spherical mirrors the focal length is half the radius of curvature of the reflecting surface. Finally, the magnification of a mirror or lens is given by the formula

$$h'/h \quad = \quad s'/s$$

where h' is the height of the image and h is the height of the object.

APPARATUS

optics bench	slit plate	lens on stand
light source	ray optics mirror	view screen
ray table and base	ray optics lens	arrow target
component holders	mirror on stand	

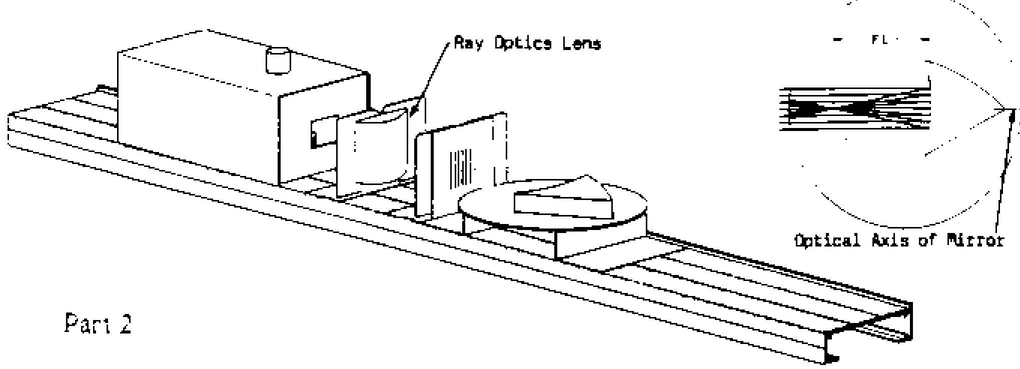
PROCEDURE

PART 1:

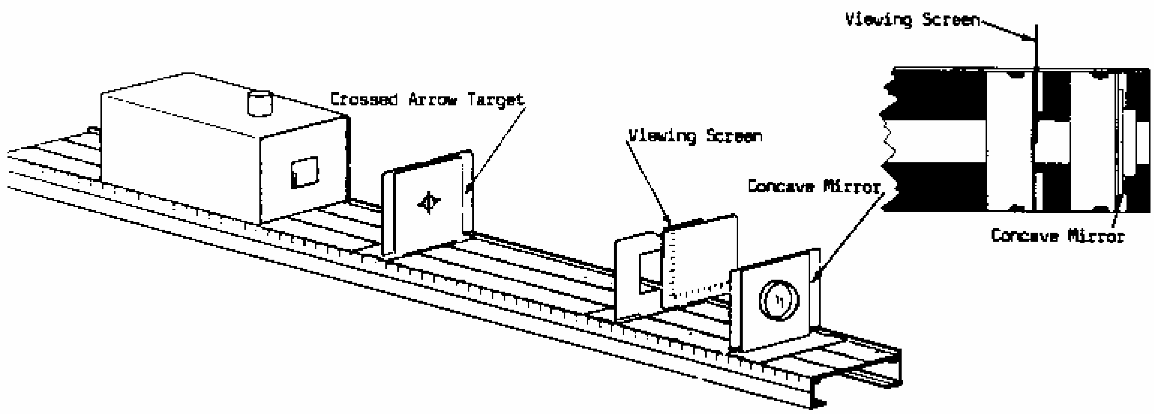
Set up the equipment as shown. Adjust the position of the lens and the slit plate to obtain parallel rays on the ray table. Trace the outline of the mirror on a piece of paper. Place the paper on the ray table and adjust the mirror on top so that the rays are parallel to the optical axis.

Trace the reflected rays from the concave mirror surface, also mark the focal point carefully. Rotate the mirror and trace the reflected rays from the convex mirror surface. With the convex surface you will not be able to mark the focal point directly on the paper.

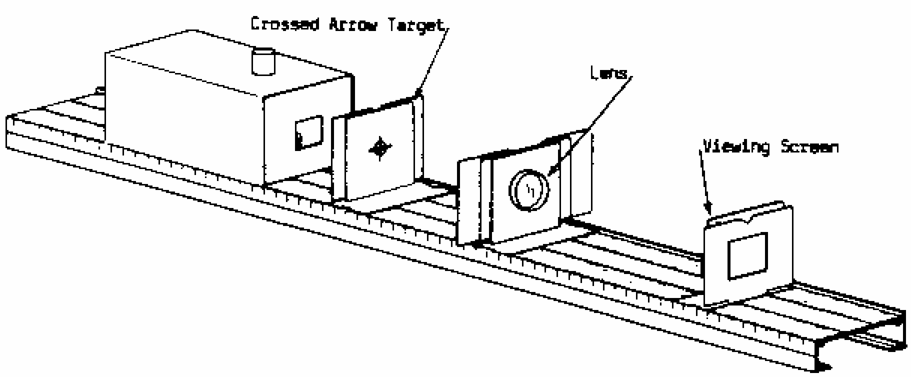
Part 1:



Part 2



Part 3.



PART 2:

Set up the equipment as shown, with the concave mirror facing the light. The viewing screen should cover only half the hole in the holder so that light reaches the mirror. Record the size of the arrow target.

Record the stated focal length value of the mirror. To verify this focal length value, position the mirror on the optical bench as far from the arrow target as possible. Vary the position of the viewing screen to find where the image of the arrow is focused. This image will be very small and close to the focal point.

Keep changing the distance between the mirror and the target. Each time moving the viewing screen to locate the best focused image (at its center). Record the position of the target (the object) and the position of the image in the table provided. Also record the size of the image.

Note the difference in the clarity of the image at its edge compared to its center. Also note the degree of color separation, if any, toward the edges.

PART 3:

Set up the equipment as shown. The viewing screen should now cover the entire hole in the holder.

Record the stated focal length value of the lens. To verify this focal length value, position the viewing screen on the optical bench as far from the arrow target as possible. Vary the position of the lens until the image of the arrow is focused on the screen. This image will be very small and close to the focal point.

Keep changing the distance between the lens and the target. Each time move the viewing screen to locate the best focused image (at its center). Record the position of the target (the object) and the position of the image in the table provided. Also record the size of the image.

Note the difference in the clarity of the image at its edge compared to its center. Also note the degree of color separation, if any, toward the edges.

ANALYSIS & RESULTS:

PART 1: Use your paper traces to determine the focal length of both concave and convex mirror surface. With a compass draw an arc of radius equal to twice the focal length you have just determined. Compare this arc to the curvatures of the mirror. Is it true that R=2f as we have asserted in class?

PART 2: Fill in the rest of the table below. Does the mirror equation and magnification formula hold up for this mirror?

PART 3: Fill in the rest of the table below. Does the lens equation and magnification formula hold up this lens?

QUESTIONS:

1. Discuss some of the most probable source of error. Do they seem sufficient to account for discrepancies in the results?

2. Where the images you measured real or virtual? Why were the images all upside down?

3. Why were the edges of the images blurry?

4. Explain why there was a separation of colors at the edges of the images formed with the lens, but the same thing didn’t happen with the mirror.

DATA			CALCULATIONS			
S_o (mm)	S_i	h_i	$1/S_i + 1/S_o$	$1/f$	h_i/h_o	S_i/S_o
500						
450						
400						
350						
300						
250						
200						
150						
100						
75						
50						

DATA			CALCULATIONS			
S_o (mm)	S_i	h_i	$1/S_i + 1/S_o$	$1/f$	h_i/h_o	S_i/S_o
500						
450						
400						
350						
300						
250						
200						
150						
100						
75						
50						