Course and Section_______ Names ___________________________

Date___________ _________________________________

LENSES AND MIRRORS EXPERIMENT

Introduction

In this experiment you will find images created by lenses and mirrors and study the laws that describe them.

Equipment

Optics bench, +200 lens, -150 lens, +50 or +100 mirror, light source, white screen, half-screen, ruler.

Theory

The equation relating the object distance *p*, the image distance *q* and the focal length *f* is

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f} \qquad (1)$$

The equation holds for thin lenses and mirrors. The signs of *p*, *q* and *f* depends on the case.

PART I - Converging lens

The goal is to calculate the focal length of the converging lens in two different ways.

Procedure

In this part the object is given by the two perpendicular arrows on the light source. The lens will form the image on the screen.

Step 1. Place the light box on one end of the bench, the white screen on the other end such that the distance between them is L = 110 cm. Place the converging lens between them.

Step 2. Move the lens back and forth until an image is formed on the white screen.

1. For how many different locations of the lens an image is formed?

2. Explain your previous answer using equation (1).

3. What is the height of your object? (the height of the arrow on the light source)

Height of the object h = _______________cm

Step 3. Measure *p* and *q* and the height *h'* of the image on the screen.

Step 4. Repeat all the measurements for L =100 cm and L = 90 cm. Use the table below to collect your data. Turn off the light source while not taking measurements.

Analysis

4. Calculate *f* using equation (1) for each case. Calculate also the ratio *h'/h* and *q/p*.

L (cm)	*p* (cm)	*q* (cm)	*h'* (cm)	*f* (cm)	*h'/h*	*q/p*
110						
110						
100						
100						
90						
90						

5. Do you get consistent values for the focal length? Find the average value of *f*

$$\bar{f} = \_\_\_\_\_\_ (cm)$$

6. Calculate $\sigma_{average}$: the error of the average value of *f*. σ_f is the standard deviation. You can use software or online resources.

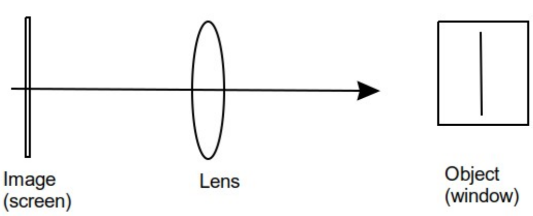
$$\sigma_{average} = \frac{\sigma_f}{\sqrt{N}} = \_\_\_\_\_\_\_\_$$

7. Look at the last two columns. How is the ratio *h'/h* related to the ratio *q/p*?

Procedure

In this part, the object is given by a far away light source as for example a window or a far away computer monitor. The lens will form the corresponding image on the screen.

Step 1. Remove the light source from the bench. Look around the room to find a far away light source. Move the bench and point it toward that light source, as indicated by the arrow in the figure.



Step 2. Adjust the position of the lens on the bench such that the image (of the window for example) is formed on the screen.

8. Is the image upright or inverted?

9. Is the image real or virtual?

10. Use equation (1) to find the focal length *f*

$f =$ __________ (cm)

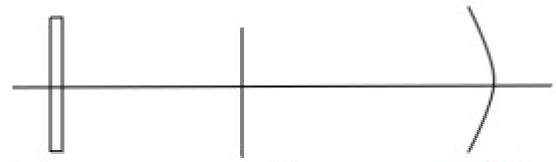
11. Calculate the percentage difference between *f* from questions 5 and *f* from question 10.

PART 2 – Converging Mirror

The goal is to calculate the focal length of the concave mirror.

Procedure

Step 1. Place the mirror on the bench with its concave side facing the light source, and the half screen in between them.



Step 2. Move the mirror and the half screen until the image is formed. Measure *p* and *q* and calculate the focal length.

Step 3. Repeat for other any two other values of *p.*

Analysis

12. Use the table below to collect your data.

p (cm)	*q* (cm)	*f* (cm)

13. Do you get consistent values for the focal length? Find the average value of *f*

$\bar{f} =$ ______(cm)

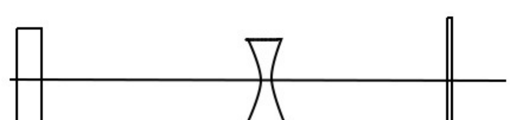
14. Your mirror has a focal lens of either 100mm or 50 mm (see the label on it). Calculate the percentage error.

PART 3 - Diverging lens.

The goal is to calculate the focal length of the diverging lens *f'*.

Procedure

Step 1. Place the diverging lens between the light source and screen. Adjust the positions of the screen and the diverging lens.



15. Can you find the image on the screen?

16. Look at the light source through the lens (from the right, in the figure). Can you see an image?

17. Is this image smaller or bigger than the object?

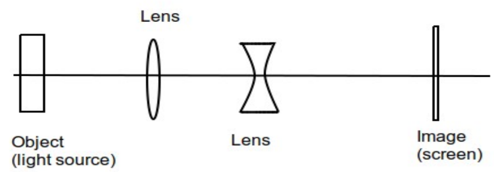
18. Is this image inverted respect to the object?

19. Is this image real or virtual?

20. The object is in the front of the lens. Is this image located in front or in the back of the lens?

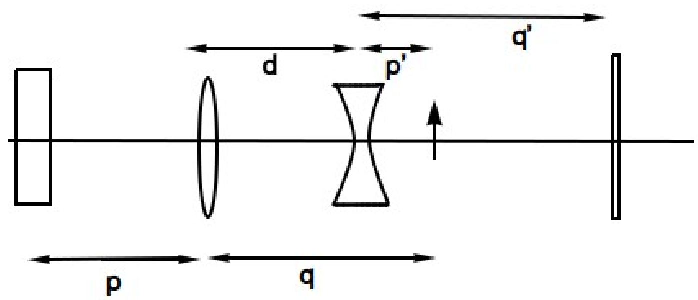
In order to produce a real image you also need to use a converging lens placed between the diverging lens and the source.

Step 1. Adjust the distances of the two lenses and the screen until a image is formed on the screen.



Analysis

Use this method to determine *f'*.
The black vertical arrow in the figure represents the image formed by the converging lens.
This image is the object respect to the diverging lens.



21. Measure *p* and use *f* of the converging lens and the equation (1) to calculate *q*

q = ________ (cm)

22. Measure the distance between the two lenses *d*

d = _________ (cm)

23. Calculate *p'* from *q* and *d.*

p' = ________ (cm)

24. Measure *q'* and calculate *f'*. In this case, when using equation (1), the sign of *p'* has to be set negative since the image (the black vertical arrow) formed by the converging lens is behind the diverging lens. Since *p'* is negative and the lens is diverging *q'* is positive.

f' = _______ (cm)

25. The diverging lens has a focal length f = -15 cm. Calculate the percentage error.

TURN OFF the light source (disconnected the cable).