Physics 319 Optics
Lab Exercise
Thin Lens Geometrical Optics

There is no formal write-up necessary for this lab exercise, fill in the blanks as you go, and use the Maple V software as instructed.

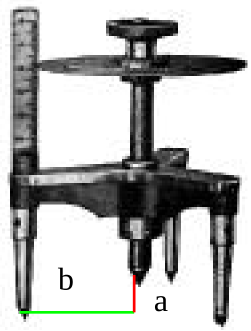
Part 1 The Lens-makers Formula

In this section you will estimate the power of a lens using the thin lens version of the lens-makers formula.

You will begin by measuring the radius of curvature of each surface of the lens with a spherometer, as pictured below.

First put the spherometer on a flat glass surface and adjust the screw so the central point is just touching the glass. Measure the distance from the central point to one of the legs with a caliper.

Now put the spherometer on the lens surface and find the sagitta (labeled a in the figure below).



Apply the formula:

$$R = \left(\frac{b^2 + a^2}{2a}\right).$$

where a is the measured saggita, and b the distance from the center point to one leg.

Find the radius of curvature for each surface:

R1=__________ . **R2=__________ .**

Now apply the lens-makers formula in the form:

$$P = (n_{lens} - n_{air})\left(\frac{1}{R_1} - \frac{1}{R_2}\right).$$

Remember to assign the correct sign to each radius, positive if it is convex as viewed from the direction that the light is incident. For n_{lens} you will need to estimate. The index for glass runs from 1.5 to 1.7 depending on the glass. Take 1.6 as a crude estimate.

Give a value for the power of the lens and estimate how uncertain this value is due to the uncertainty in the index of refraction of the glass.

P= ____________ +/-____________.

Now repeat your calculation using the Maple V program as directed in the associated handout. Print and turn in the result along with this sheet.

Part 2 Finding The Focal Length

Take the lens for which you found the power in part 1. Take it to a window along with a meter stick and a white sheet of paper. Using the lens project an image of a distant object on the white paper and adjust the distance between the lens and the paper until the image is in focus. Make a crude measurement of the distance from the lens to the paper. That is your focal length f_2.

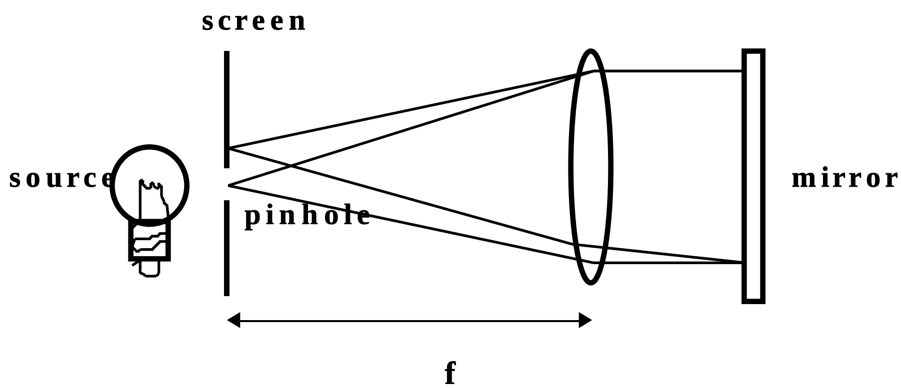
f_2= ________ .

The power of the lens ought to be related to the focal length by

$$P = \frac{1}{f}$$

Does this result fall within your range calculated in part 1?

Part 3 Finding f by Autocollimation



Set up an incandescent source, a screen with a pinhole, the lens for which f is to be determined and a front surface mirror on the optical bench in the configuration shown. When the distance from the pinhole to the lens is precisely equal to the focal length the rays leaving the pinhole will follow the path shown. All the rays comming from the pinhole must exit the lens parallel to each other, i.e. collimated. After bouncing off the front surface mirror the parallel rays on the return trip will be focussed to a single point on the screen. When the image of the pinhole is a small in focus spot, then the distance from the screen to the lens is just ewwqual to the focal distance. Measure this distance and compare it to your results for f above.

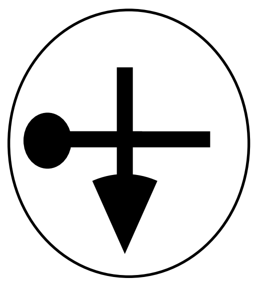
f= ________ .

Part 4 Determination of f via thin lens equation

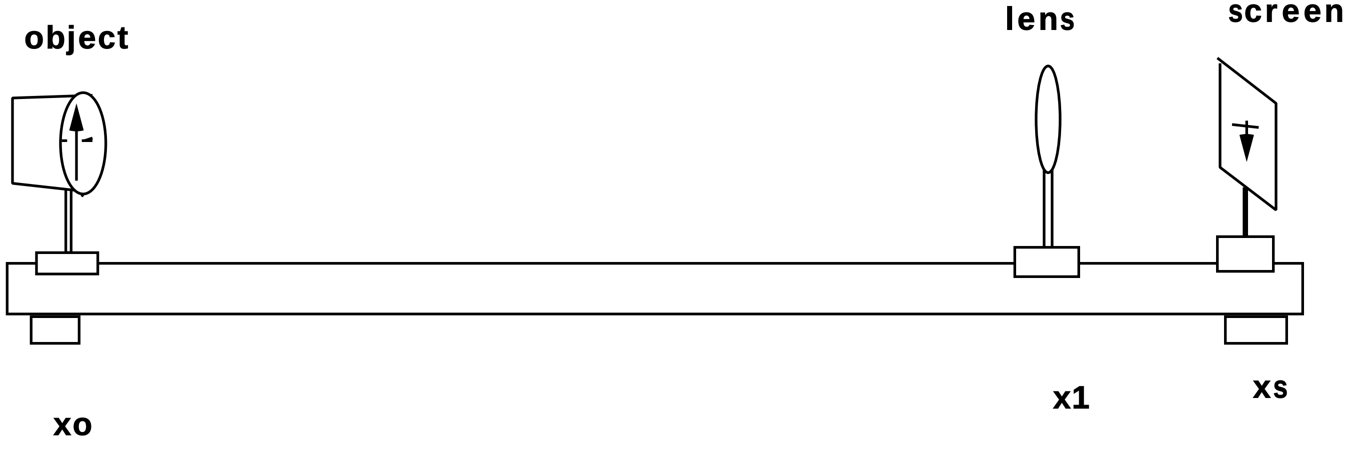
In this section you will determine the focal length of a lens by a method using an equivalent to the thin lens equation:

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}.$$

In this investigation the object will be a frosted glass lamp with a symbol in this form:



Put the object on the optical bench along with lens #1 provided and the screen in relative positions about as shown in the figure. The object lamp should be at one extreme end and the screen at the other.



Adjust the position of the lens until there is a small in focus image visible on the screen. The optical bench has rulings on the side from which you can determine the positions xo, x1, xs of the object, the lens and the screen. Estimate the uncertainty in x1 by finding the smallest range of values that you feel sure contains the location of the lens for the best focus. For example if you feel sure that the best focus is somewhere between .214 m and .218 m
then report your value for x1 as 216 +/- .002.

xo __________ ,

x1 __________ +/-___________.

xs __________ .

Without moving the object or the screen move the lens to a position as indicated in the figure below. Find the location x2 at which the lens must be placed in order to see a larger in focus image at the screen. Find an estimate for the uncertainty on x2 as well.

x2 __________ +/-___________.

The value of the focal length is to be found via the equation :

$$f = \frac{L^2 - d^2}{4L}$$

Where L is the distance from the object plane to the screen and d is the distance that the lens was moved, i.e.

$$L = |xs - xo|$$

$$d = |x2 - x1|$$

using the Maple V exercise 1 as in the previous case. We will also find the uncertainty on the measurement due to the uncertainty in the measurement using:

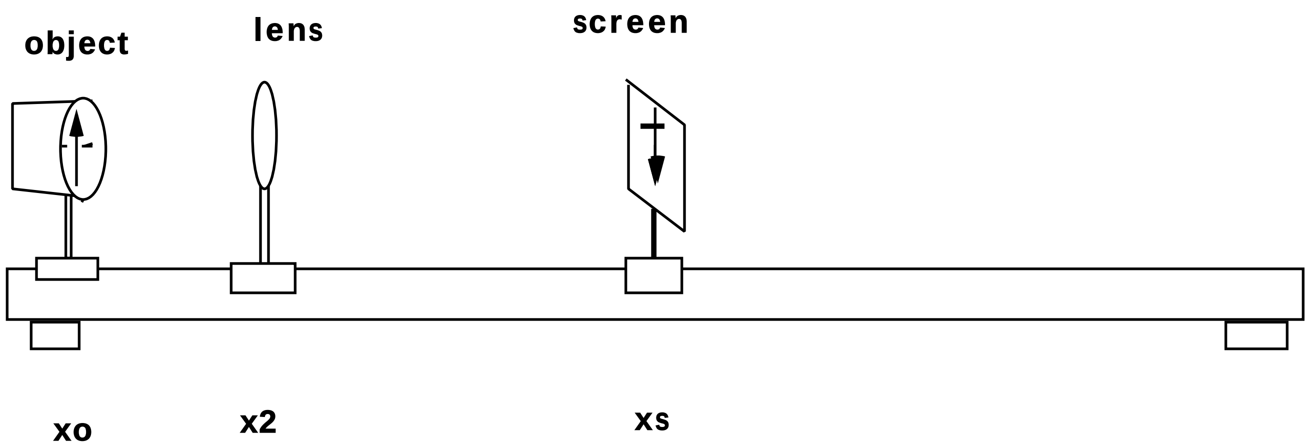
$$\delta f = \left|\frac{\partial f}{\partial d}\right| \delta d \quad ,$$

$$\delta d = \sqrt{\delta x1^2 + \delta x2^2}$$

where dx1 and dx2 are the uncertainties you put for the values of x1 and x2 respectively. Again attach the Maple V session to this sheet.

Part 4 Determination of f for a Diverging Lens

Place lens #1 and the screen onto the optical bench in locations as shown and adjust the position of the lens until there is an in focus image on the screen.

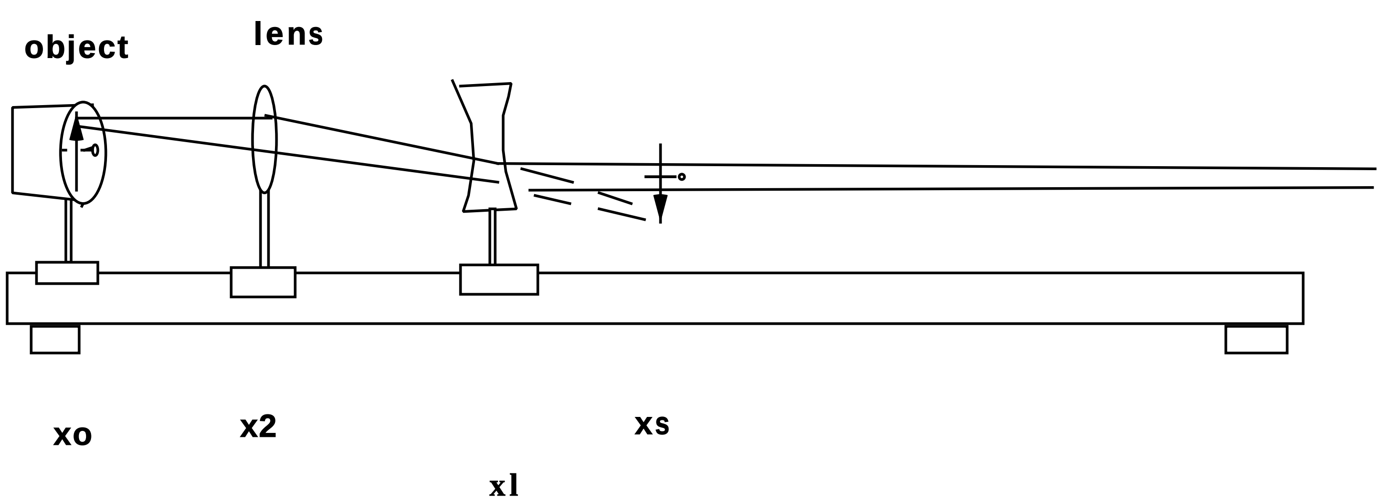


Record the position of the screen only.

xs=__________ .

Now remove the screen, without moving lens #1 or the object.
Put lens #2, the diverging lens with which you are provided, at a location as indicated in the diagram below. The image from lens #1 is now serving as a virtual object for lens #2 (virtual because lens #2 prevents rays from actually converging on the original image point)

Adjust the position of lens #2 until the image comes into sharp focus on a distant wall.



The distance between the current location of the negative lens and

the former position of the screen is equal to the focal length of the lens.

$$f = -|xs - x1|.$$

What is the focal length for the diverging lens?

f=_______________.