LAB 4 THIN LENSES

EXPERIMENTAL GOALS

Chapter 6 of the *Lab Reference Manual* discusses the basic principles of thin-lens optics. In particular, the last section leads you partway through the derivation of a simple relationship (called the **thin lens equation**) between the object distance p, the image distance q, and the focal length f of a convex lens. In this lab, you will (1) complete the derivation of the thin-lens equation, (2) *test* your hypothetical relationship by making measurements of object and image distances for two different lenses and plotting them in such a way that your graph for each lens will be a straight line if your hypothesis is correct, and (3) estimate the lens' focal lengths (with uncertainties) from the *intercepts* of these graphs. You will also (4) plot the magnification M of the image (defined to be image size divided by object size) versus q/p, interpret the result, and justify it theoretically.

LABORATORY SKILLS you will be developing

One important educational goal of this lab is to teach you the model of light refraction known as *geometrical optics* or *ray optics* and to give you some practice using it. This lab and the *Lens Systems* labs later in the semester are the only places in the Physics 51ab sequence that this topic (which is useful background for both the MCATs and some upper-level physics courses) appears.

This experiment also gives you an opportunity to further develop and practice the uncertainty analysis, hypothesis-testing, and graphical analysis skills you have learned in the previous labs.

Finally, you will write just the *theory* section of a hypothetical formal lab report for this lab. This will give you some practice in writing an important part of a lab report before you have to write a full report for the pendulum lab later in the term.

SOME PROCEDURAL SUGGESTIONS AND NOTES

Each lab setup includes (1) a light box and stand and an image-viewing screen mounted on a 1.16-m optical bench, (2) two convex lenses, each about 4 cm in diameter and placed in an appropriate mount, with focal lengths (within ±10% or so) of 10 cm and 20 cm, and (3) a computer with *LinReg* and *PropUnc* installed. One side of the light box has a "target" displaying some concentric circles and arrows. If you plug in the box, the target illuminates, making it a good object for image formation. The arrows let you determine the image's orientation compared to object's, and one of the arrows has a scale drawn on it to help you compare object and image sizes. This box has already been attached to one end of the optical bench: leave it there. The lenses just snap into place on the bench. You can move a lens along the bench by squeezing the locking clip at the base of the lens holder to loosen to lens, and then move it to the desired location. When you let go of the locking clip, the lens will be locked in place.

If you have the light box turned on and a single lens on the bench, that lens should form an image of the target *somewhere*. The viewing screen provides a solid flat surface on which to project the image and thus locate it precisely. You can slide the screen along the bench when the thumbscrew holding it to the bench is loose, and then lock it in place by tightening that screw. You should be able to find *some* position where an image of the target is clearly focused on the screen. You can then use the metric scale on the side of the bench to determine image and object distances.

As usual, you should check your hypothesis and your procedure with your helper before taking many measurements. Your lab grade will depend on your work on the pre-lab exercises in the lab reference manual (which will be graded at the *beginning* of lab this week) and on the quality of your responses to your grader's questions during the checkout interview.

For this lab, you should also turn in a formally-written theory section describing your derivation of the thin lens equation. This should be between one and two pages long and typewritten or typeset using a computer. Carefully read at least sections 8.1, 8.3, and 8.6.1 in the *Lab Reference Manual* and look at the examples of theory sections at the end of that chapter before writing your theory section. It is due *next week at the beginning of lab* and will be graded separately from the rest of the lab.