

College Physics II

Lab 4: Lenses

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Part 1: The Image of an Obscured Object

Set the lens at the center of the optical bench. Set the light (the object) at one end of the optical bench, and set the screen, onto which you will project the image, at the other.

Now move the screen up and down the bench, and note that, for a particular position of the object, there is only one position of the screen for which the image is in focus. As you move the object closer and closer to the lens, you will have to keep moving the screen further and further from the lens.

Set up the lens to project an upside-down image of your object (a lit-up arrow) onto your screen. Focus it well. Notice, now, that if you take an obstruction such as a book and block the top half of the object, the bottom half of the image will go dark.

Now ask yourself what the projected image would look like if you were to obstruct the top half *of the lens* by placing the paper on the side of the lens closer to the object. Would anything different happen if you placed the obstruction on the other side of the lens, the side closer to the image? Write down your predictions of what you would expect to see. As usual, I don't care if your predictions end up correct or not.

Now do the experiment and write down what happens. Does it match your predictions? What is your explanation for what is happening?

To hand in for part 1

Your predictions, results, and explanation.

Part 2: The Experiment

If you put an object on one side of a convex lens, then there will be an image on the other side of the lens. For a given object-to-lens distance O there is only one screen position at which the image will be sharp. I is the image-to-lens distance when the image is sharp.

Now, measure values of O and I for many different positions of the object and the lens. You should get at least 12 data points, with as widely separated values as you can manage. Get more points if you can; once you get the hang of it, measurements won't take long.

To hand in for part 2

Your data, in a table listing O and I values.

Activity 3: The Equation

If you were to look up the equation for a thin lens, you would find

$$\frac{1}{O} + \frac{1}{I} = \frac{1}{f} \quad (1)$$

f is the focal length of the lens. It is a property of the lens: when the object is infinitely far away, the image will become a single bright point at a distance $I = f$. You can't get $O \rightarrow \infty$, but in your data, with large values of O , you might see your corresponding I values start to approach f .

There is one complication about this equation. Depending on the type of lens you use, your O and I values can acquire a negative sign. Therefore, besides equation (1), you have three more possibilities:

$$\frac{1}{O} - \frac{1}{I} = \frac{1}{f} \quad (2)$$

$$-\frac{1}{O} + \frac{1}{I} = \frac{1}{f} \quad (3)$$

$$-\frac{1}{O} - \frac{1}{I} = \frac{1}{f} \quad (4)$$

ACTIVITY 3: THE EQUATION

Log on to the computer and use a graphing calculator that can plot equations and data; I suggest [desmos.com](https://www.desmos.com). Enter each of the four equations above, but with x for O and y for I ; for example: $\frac{1}{x} + \frac{1}{y} = \frac{1}{f}$. Add a slider for f , and set $0 \leq f \leq 25$ in steps of 0.1.

Drag your screen so that you see only the part where x and y values are positive only. After all, your data for O and I have only positive values.

Now enter your data points. For example, if you have O and I values of 1 and 2, and then also 5 and 0.1, you would enter your data as “(1,2),(5,0.1)”. Extend the list of points as you need.

After entering all your data, play with your slider for f to see what value you find that produces an equation that fits your data best. In a professional lab setting, you would use statistical tools to get a precise best fit to your data, but for our purposes, a visual estimation will be good enough. Once you have your best fit, write down the equation number and your f value for that best fit. Print out what you see on your screen.

Finally, since you will now have figured out the equation that describes your lens, you can test that equation. Pick an O value that you haven't tested before, and calculate what value of I you should get for that. Then do a measurement and see how closely your observed I value matches your prediction.

To hand in for Part 3

- Printout with all your graphs and data points
- Your equation for the lens with your value for f .
- Results of your attempt to experimentally verify your prediction.