§ 1 Introduction

In this laboratory you will learn more about lenses. Please send your work and answer to the problems to your lab instructor.

§ 2 The math of lenses

You have made estimates of the focal length of your lenses. We are going to do a second measure of the focal length that at the same time expands the usefulness of knowledge of the focal length.
(a) First you are going to mount one of your lenses, the one that it thickest in the middle. Some of you received a lens that is in a sleeve/holder, you will need to remove the lens from the holder at this point. The mounting of the lens is demonstrated in this video.
(b) A long table (2m) or some other flat open space will be needed to set up the experiment. This part of the lab needs to be done in a darkened room, so close the shades or wait for night and turn off the lights. Watch this video to see how to set up the experiment. Once you have formed a clear image of the object, answer the following questions.

▷ Problem 1
Describe the orientation of the image, compare with the orientation of the object.

▷ Problem 2
Cover the left half of the lens with a piece of cardboard. What happens to the image? Was the change in the image what you expected? Can you explain why the images changes in the way it does?

▷ Problem 3
Cover the left half of the object with a piece of cardboard. What happens to the image?

▷ Problem 4
Cover the top half of the object with a piece of cardboard. What happens to the image?
(c) Leave the object at the end of the tape measure at the position zero. Place the lens at each of the locations x_{lens} in the chart below. For each location of the lens, locate the position of the image and record this position in the chart below as x_{image}, in addition measure and record the width of the smile in the image as h_i. For some locations of the lens it will not be possible to form an image, mark these with none.

x_{object} [cm]	x_{lens} [cm]	x_{image} [cm]	h_i [cm]	d_o [cm]	d_i [cm]	$\frac{1}{d_o}$ [1/cm]	$\frac{1}{d_i}$ [1/cm]	$\frac{h_i}{h_o}$ [-]	$\frac{d_i}{d_o}$ [-]
0	120								
0	100								
0	80								
0	70								
0	60								
0	50								
0	45								
0	40								
0	35								
0	30								
0	25								
0	20								
0	15								
0	10								

You can turn on the lights now.

After the measurements are made do the following calculations for each row. You might want to use a spread sheet or some other computational tool.

$$d_o = x_{\text{lens}} - x_{\text{object}}$$

$$d_i = x_{\text{image}} - x_{\text{lens}}$$

Note that d_o is the distance from the lens to the object and d_i is the distance from the lens to the image. Now compute the remaining columns $\frac{1}{d_o}$, $\frac{1}{d_i}$, $\frac{h_i}{h_o}$ and $\frac{d_i}{d_o}$, where h_o is the width of the smile on the object.

▷ PROBLEM 5

Make a graph of $\frac{1}{d_i}$ versus $\frac{1}{d_o}$. Fit a straight line to the graph. Does it fit well? In an ideal world the slope would be -1. Is this approximately true for your graph? In an ideal world the y-intercept would be equal to the inverse of the focal length $\frac{1}{f}$. Use your y-intercept to estimate the focal length. Does this estimated focal length agree with the estimate you made in the previous lab?

▷ PROBLEM 6

Make a graph of $\frac{h_i}{h_o}$ versus $\frac{d_i}{d_o}$. Fit a straight line to the graph. Does it fit well? In an ideal world the slope would be 1, and the y intercept would be zero. Is this approximately true for your graph?