Assignment #3: Thin Lens

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Introduction

This experiment aims to determine the focal length, f, of a convex lens by utilizing the thin lens equation,

$$\frac{1}{f} = \frac{1}{o} - \frac{1}{i} \tag{1}$$

Where o is the distance from the light source to the lens—object distance—and i is the distance from the lens to the screen–image distance. See Fig. 1 for a apparatus diagram. Once the focal length is determined, the error on this result will be quantified, and compared, utilizing both the standard error propagation technique and statistical analysis.

Results

Using the relationship, $f = (o \cdot i)/(o + i)$, the experimental focal length was determined to be approximately 0.216 ± 0.001. Where the δf was determined using the standard error propagation procedure. As seen in Fig. , the statistical error—by eye—is approximately $\pm 1\sigma$, which means $\delta f \approx 0.005$ meters.

Table 1: Comparing Statistical and Propagated Errors

Statistical	0.005 [m]
Propagated	0.001 [m]

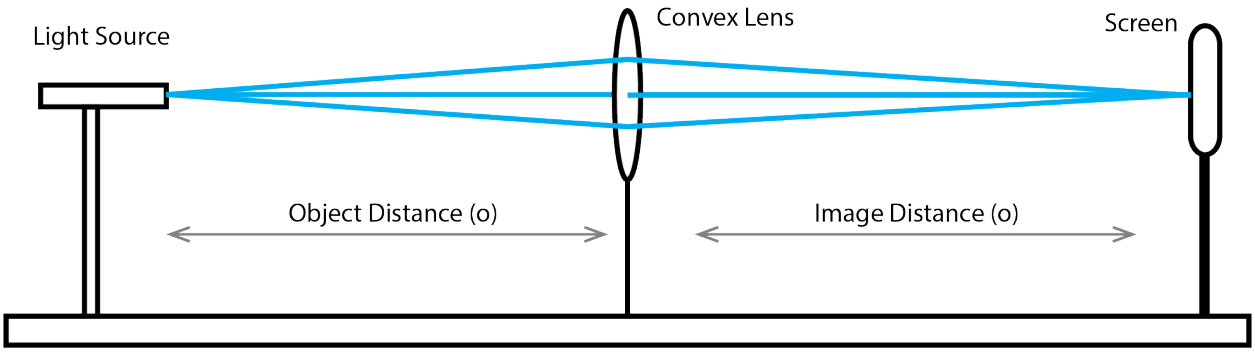

Figure 1: Experiment Apparatus (Kahihikolo 2017)

Discussion

If given a highly accurate craftsman ruler, the results obtained in this experiment would have been much better. The ruler we used had a large amount flex, meaning it formed almost parabolic shape, which adds a large amount of error in our measurements that could not be accurately accounted for. Assuming no additional errors, the error due to the measurements is equal to one half the smallest mark—meaning $\pm 1/256$ inch, or $\simeq 9.9 \times 10^{-}9$ meters.

As seen in the error propagation formula, the error in f scales proportional to the sum of the individual errors. So, using a more accurate measuring apparatus would yield an increasingly accurate determination of f.

$$\delta f = \sqrt{\left(\frac{\partial f}{\partial o}\delta o\right)^2 + \left(\frac{\partial f}{\partial i}\delta i\right)^2} = \sqrt{\frac{o^2}{(o+i)^2}\delta o + \frac{i^2}{(o+i)^2}\delta i}$$

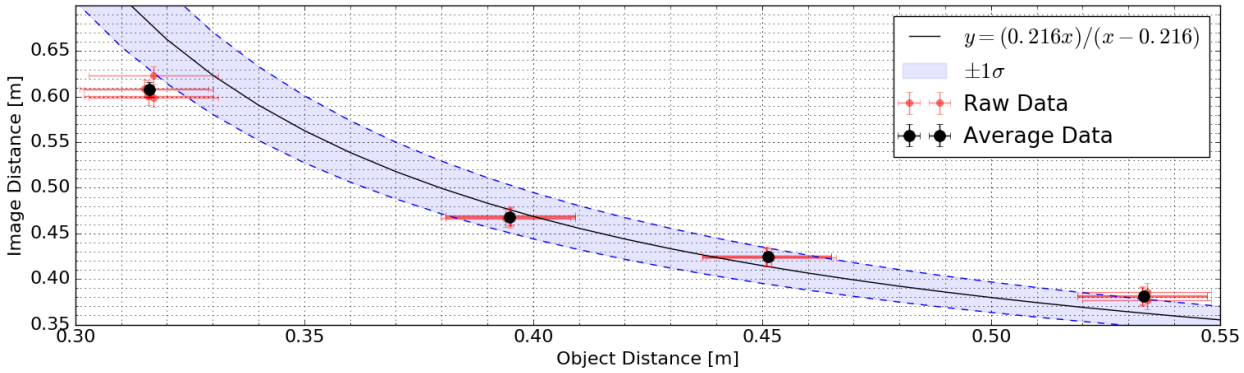

Table 2: Raw Data Table

Object Dist (m)	δ Object Dist	Image Dist	δ Image Dist	Total Dist	Total Dist (m)	δ Total Dist	Offset
0.317	0.01414	0.623	0.01	0.97	0.94	0.01	0.03
0.315	0.01414	0.609	0.01	0.954	0.924	0.01	0.03
0.316	0.01414	0.608	0.01	0.954	0.924	0.01	0.03
0.317	0.01414	0.599	0.01	0.946	0.916	0.01	0.03
0.316	0.01414	0.601	0.01	0.947	0.917	0.01	0.03
0.395	0.01414	0.466	0.01	0.891	0.861	0.01	0.03
0.395	0.01414	0.47	0.01	0.895	0.865	0.01	0.03
0.395	0.01414	0.469	0.01	0.894	0.864	0.01	0.03
0.394	0.01414	0.467	0.01	0.891	0.861	0.01	0.03
0.395	0.01414	0.468	0.01	0.893	0.863	0.01	0.03
0.451	0.01414	0.425	0.01	0.906	0.876	0.01	0.03
0.451	0.01414	0.425	0.01	0.906	0.876	0.01	0.03
0.452	0.01414	0.424	0.01	0.906	0.876	0.01	0.03
0.451	0.01414	0.424	0.01	0.905	0.875	0.01	0.03
0.451	0.01414	0.424	0.01	0.905	0.875	0.01	0.03
0.533	0.01414	0.38	0.01	0.943	0.913	0.01	0.03
0.534	0.01414	0.377	0.01	0.941	0.911	0.01	0.03
0.533	0.01414	0.382	0.01	0.945	0.915	0.01	0.03
0.534	0.01414	0.386	0.01	0.95	0.92	0.01	0.03
0.533	0.01414	0.381	0.01	0.944	0.914	0.01	0.03