PHYS222
Uncertainty Notes for The Thin Lenses Experiment

The uncertainty for the **lens equation** (i.e., $\frac{1}{f}=\frac{1}{o}+\frac{1}{i}$) is given by the relationship

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

where δo and δi are the uncertainties in object and image distances respectively.

We can assume that the uncertainty in object distance δo (i.e., the distance from the lens to the object or light source) is small compared to the uncertainty of the image distance δi (i.e., the distance from the lens to the image). This is a good approximation if we fix both the light source (i.e., the object) and lens and **vary only the screen location while focusing.**

This yields an object uncertainty δo of approximately $\sqrt{\left(\frac{1}{2}mm\right)^2+\left(\frac{1}{2}mm\right)^2}=0.707\,mm=0.07\,cm$ which we can ignore. *This value is an order of magnitude smaller than the typical error δi in image distance.*

Thus, we can use the following approximation for the uncertainty of the lens equation

$$\boxed{\delta f \approx f\left(\frac{o}{i(o+i)}\delta i\right)} \qquad \text{Eq-1)}$$

where $\delta i = \frac{fuzzy_{left}-fuzzy_{right}}{2} = \frac{\Delta fuzzy}{2}$.

Since we make 5 measurements we will use the average of the 5 uncertainties in our final result to go along with the average of the 5 focal lengths. See table below for δi.

The **uncertainty for the conjugate foci equation** (i.e., $f=\frac{L^2-d^2}{4L}$) is given by

$$\delta f = f\sqrt{\left[\left(\frac{L^2+d^2}{(L^2-d^2)L}\delta L\right)^2+\left(\frac{2d}{L^2-d^2}\delta d\right)^2\right]}$$

For the same reasons given above we can ignore the uncertainty between light and screen (i.e., $\delta L \approx 0$) and use

$$\boxed{\delta f = f\left(\frac{2d}{L^2-d^2}\delta d\right)} \qquad \text{Eq-2)}$$

where $\delta d = \sqrt{\left[\frac{\Delta Fuzzy_{small\ image}}{2}\right]^2-\left[\frac{\Delta Fuzzy_{large\ image}}{2}\right]^2}$