## SECTION 1 [1] - HOW MANY IMAGES?

You are going to explore what image or images are formed if the source-screen distance is fixed and you vary the lens position along the rail between them.

Place the source and the screen exactly 521mm apart. Use a 125 mm focal length lens. Slowly move the lens from right next to the source all the way to the screen while observing the screen. Record what you observe below including any image distances and magnifications.

Calculate the image distances, object distances, and magnifications for each (if any) image you see. Show your calculations and compare them with the results.

## SECTION 2 – BUILD A PROBLEM

Start with the thin lens equation but fix the distance between the object and the image to a distance $L$, so you have the equation $L = d_o + d_i$. Solve for the image distance for a given focal length, $f$, and separation, $L$. ***Hint***: you will have to solve a quadratic equation. Also calculate the magnification for each lens position that gives an image.

Now, invent a problem with a fixed $L$ that fits on your breadboard and has two different lens position. The possible focal lengths you may choose from are 75, 100, 150, and 200 mm. Show your calculations to the instructor, and he will give you the appropriate lens.

Measure the image positions with uncertainty and compare them to your predictions.

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## SECTION 3 – AUTO-COLLIMATION

One method of measuring focal length is called *auto-collimation*. Set up a source, the 125 mm lens and a mirror that reflects the light back through the lens making an image of the source back on the source. ***Hint***: tape a black backed piece of white paper to cover half of the source, then look for an in-focus image on it.

Determine the focal length of the lens with uncertainty. Compare your result with the value on the lens. Resolve any disagreement.

## SECTION 4 – A TWO LENS SYSTEM

Consider an optical system consisting of a 25.4 mm focal length lens and a 35 mm focal length lens separated by 74 mm with the object 135 mm in front of the first lens. Consider the position of the first lens as the zero of your coordinate system.

Part a)

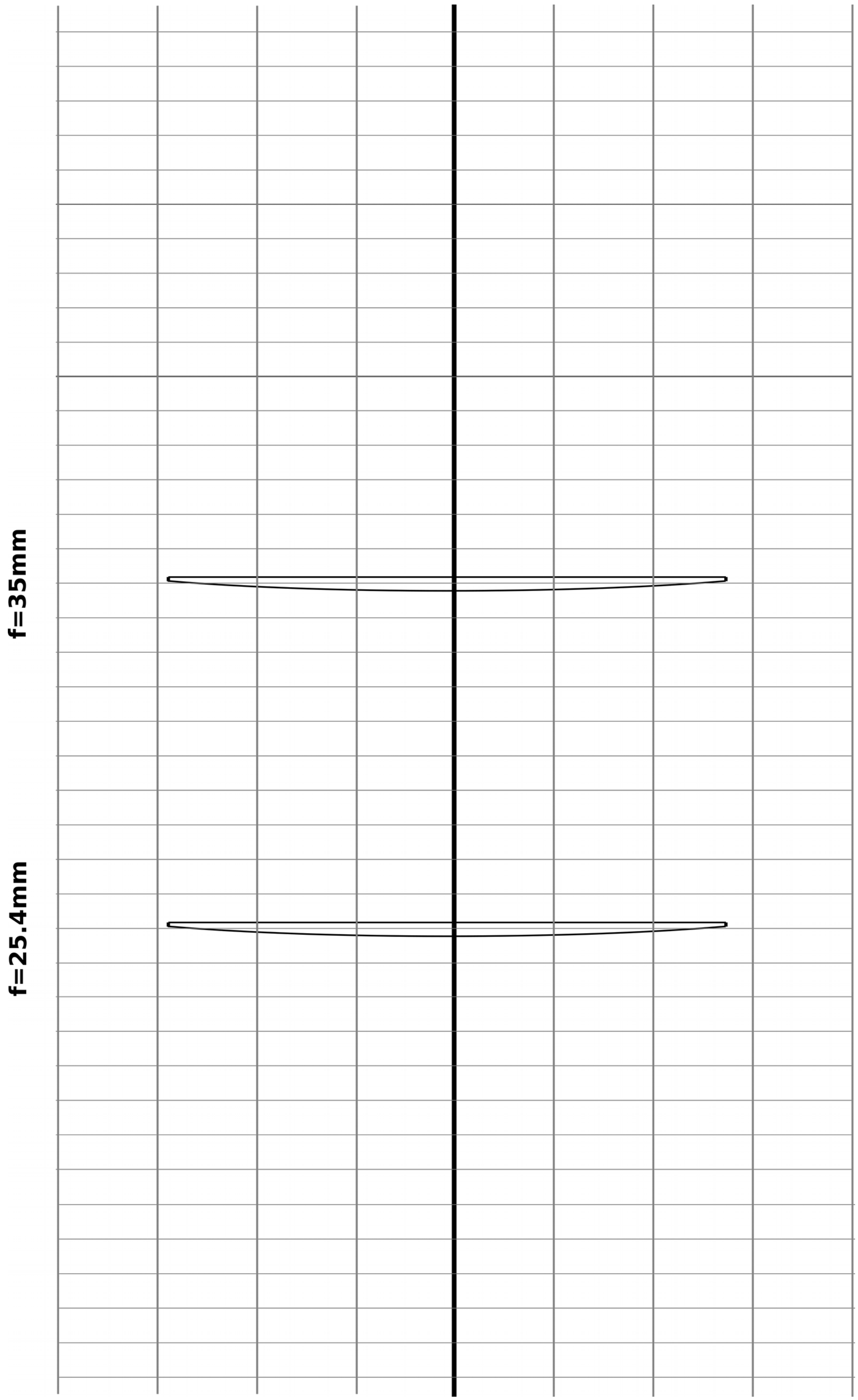
- Calculate the position and magnification of the image made by the first lens.
- Use the image made by the first lens as the object for the second lens and compute the position of the image made by the second lens.
- Finally, combine the two results to calculate the system image position and magnification.

Part b)

- Use the graph paper on the next page to do the ray trace by hand.

Show your calculations from part a) and your drawing from part b) to the instructor and get his or her approval to set this system up, measure it, and compare the results to your calculation.

Summary:


f=35mm
f=25.4mm

## SECTION 5 – PROF HUSTER'S TWO-LENS SIMULATOR

Your instructor will tell you which of these to do:

1) **Use SageMath Cloud**. Login to your SageMath Cloud account. Click on the tab Files, then navigate to the folder **`Lab06-Lenses2`**. Single-click on the file **`Two Lens Interactive-16a`** to start the Jupyter notebook.

**2) Use a local Jupyter Notebook**. In your home folder, make a folder for the Optics Lab course. Start a terminal by typing **`<Ctrl>+<Alt>+T`**. In the terminal change to your Optics folder and start the programs by executing

```
% cd YourOpticsFolder
% jupyter notebook
```


A browser window will start up with the jupyter notebook browser. Select **`Two Lens Interactive-16a.ipynb`** and the simulation will start.

To start the simulation, click on the menu item [**`Kernel`**] and select **`Restart & Run All`** from the dropdown menu.

You can select focal lengths from the dropdown menus. To adjust the distances, you can either use the sliders or click on the number and enter a new distance.

You can turn the matrix method ray tracing on or off. The simulation shows you the lens positions, the focal points, principal planes, image and object, and prints out the results.

Use the simulation to check your results from the previous section. Comment on your comparison.

## LAB 6 TASK SINGLE CONVERGING LENS

A light source with a test pattern is separated from a screen by a distance of 900mm. The image on the screen is upside down and exactly twice as large as the test pattern. You will have only one attempt at setting up this situation using any lens in the set. (The available focal lengths are 25.4, 35, 50, 75, 100, 125, 150, 200, 250, 300, 400, 500, 750, and 1000 mm.

**However …**

1) You must show all of your predictions to your instructor before turning on the light source.
2) You are only allowed one choice of lens. That is, you may **not** try various lenses and see which works best.
3) You have to position the lens before turning on the light source.