Student Name ______________________________ Date ____________________

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Department of Electrical Engineering and Computer Science
6.237 Modern Optics Project Laboratory – Fall 2024

Geometric Optics: Zoom-lens systems for 2-D Imaging

LABORATORY EXERCISE - 1B MODIFIED

Near-Eye Terrestrial Zoom Telescope: Design and Analysis

Experimental Goals

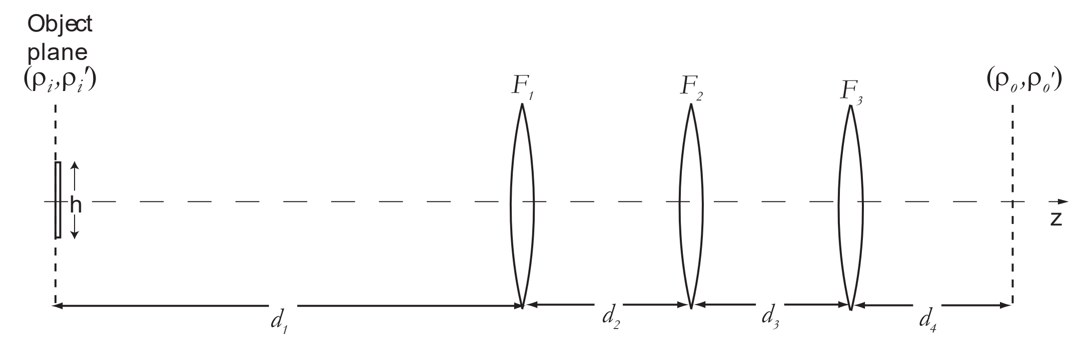
Your goal in this modified Lab exercise is to assemble a terrestrial telescope (upright magnified image is desired) using the lenses provided, and then verify your telescope design using the ABCD matrix approach.

Your terrestrial telescope will be a refractor (lenses-only). For the telescope, the image will be formed on the human eye. The design of a simple 3 lens telescope system is shown below. Unfortunately, it has a fixed magnification but assembling it will still be instructive. This 3-lens design is basically the same as that used in binoculars.

In Lab Procedures

3-lens System

A typical 3-lens system is shown below. You will find the 3-lens telescope system from last week already set up when you arrive at the MOL.

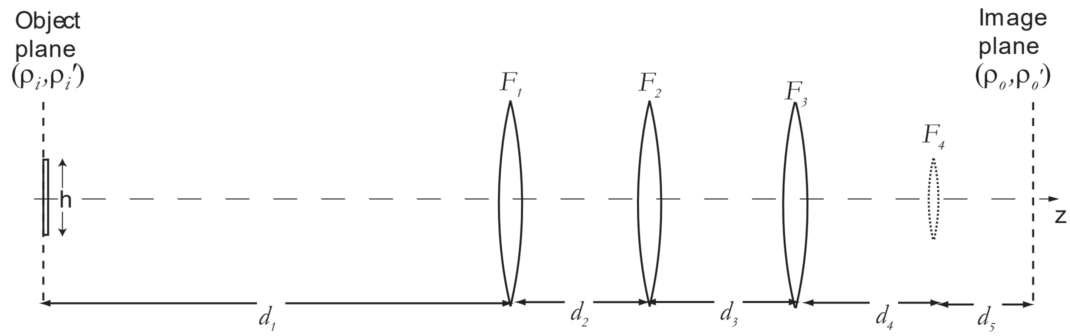


Instructions

1. After you have optimized the image, carefully and accurately measure and record the distances between the lenses, as well as the object distance. (You will be swapping lenses in and out of the system, and you may have to recreate this default system quickly)
2. Do your best to estimate the position of the final virtual image for the eyepiece (you will be calculating it for your report).
3. Do your best to estimate the magnification (you will be calculating it for your report)
4. Identify the first and second intermediate images and carefully measure and record their locations.
5. Use the illuminated eye chart at the far end of the Lab as the object of interest.
6. Carefully measure and record the focal lengths of all the lenses (5 in total) provided using the distant eye chart as the object.
7. Take a photograph of the 3-lens system for your Lab report

4-lens System

A 4-lens system will have the zoom feature that we desire, so we will add a third lens to the 3-lens system and explore its zoom features. The goal here is to demonstrate the variable magnification property of your instrument by moving one or more of the inner lenses while keeping the outermost lenses at *approximately* their same locations. Below is a diagram of a typical 4-lens system.



Instructions

1. Reassemble the 3-lens system as you found it when you arrived in the Lab (make sure the light from the object is going through the centers of all the lenses).
2. To convert the 3 lens-system to a 4-lens zoom system, first place one of the two spare lenses at the location of the first intermediate image. Make sure the light from the object is going through the center of this lens also. You should notice that it has almost no effect on the system performance (why?).
3. Now move this 4^{th} lens (let us call it $L2_{new}$) away from the first intermediate image position by a small amount and move $L3_{new}$ (old L2) to resharpen the image.
4. Explore the design space with $L2_{new}$ on either side of the intermediate image that was formed by L1.
5. Settle on a zoom magnification that you like for your system and record all the d's and F's.
6. Do your best to estimate the position of the final virtual image for the eyepiece (you will be calculating it for your report).
7. Do your best to estimate the magnification (you will be calculating it for your report)
8. Take a photograph of your final 4-lens system for your Lab report

Lab Report

Your Lab report should include all your system specifications for both the 3-lens and the 4-lens system including any computer code, hand-calculations or other materials used in the design. Be sure to specify the focal lengths, locations of the lenses and the object, and your best estimates of the system magnification and the distance of the virtual image from the eyepiece for both the 3-lens and the 4-lens system.

1. In your report draw the ray-tracing diagram that is applicable to your final 3 lens telescope.
2. Plug your 3-lems measured values into your 3-lens ABCD matrix and compute both the location of the virtual image and the magnification of each system.
3. Do the computed locations of the final images and magnifications agree with your experimental observations?
4. Comment on any deviations you found between the theory and the experimental results.
5. Comment on the performance of your telescope (including distortions/aberrations in the image). Did it operate as you expected? Why or why not?
6. Comment on what could be done to correct or prevent the distortions/aberrations.
7. Repeat 1-6 for your final chosen 4-lens system, and include an explanation of why when $L2_{new}$ is inserted at the location of the first intermediate image it has almost no effect on the system performance.