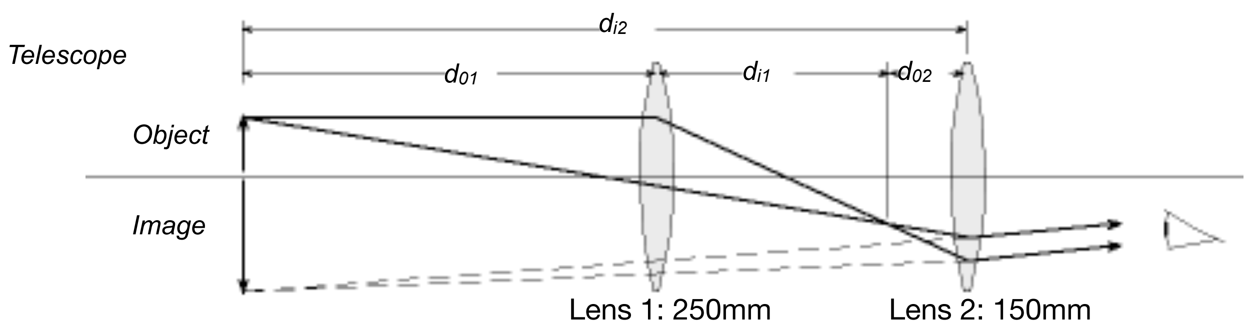
Lab 8: Building a Simple Telescope

Purpose

The purpose of this activity is to construct a simple telescope and determine its magnification.

Introduction

A simple astronomical telescope magnifies the image of an object that is far away from the telescope. The telescope is constructed with two convex lenses. The ray diagram for a simple telescope's arrangement of lenses (shown in the drawing) indicates that the image is in the same plane as the object. Having the image in the same plane as the object allows the distance to the virtual image to be determined.



For this experiment, it is assumed that the lenses are thin compared to the other distances involved. In this case the Thin Lens Formula may be used. This equation states:

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}, \quad \textbf{Eq. 1}$$

where f is focal length, d_o is the distance between the object and the lens, and d_i is the distance between the image and the lens.

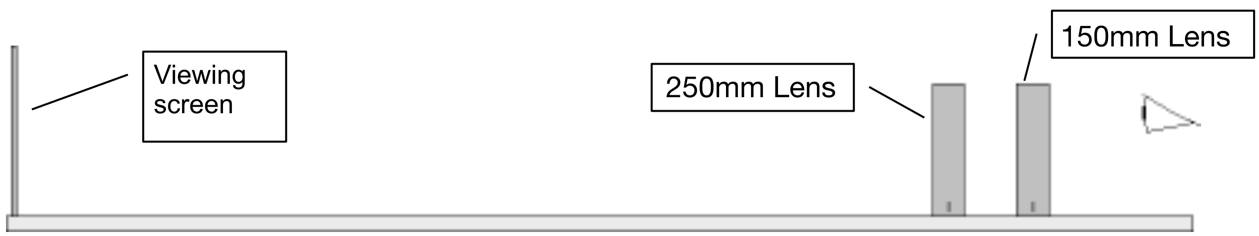
The magnification of a two-lens system is equal to the multiplication of the magnifications of the individual lenses:

$$M = M_1 M_2 = \left(\frac{d_{i1}}{d_{o1}}\right)\left(\frac{d_{i2}}{d_{o2}}\right), \quad \textbf{Eq. 2}$$

Setup

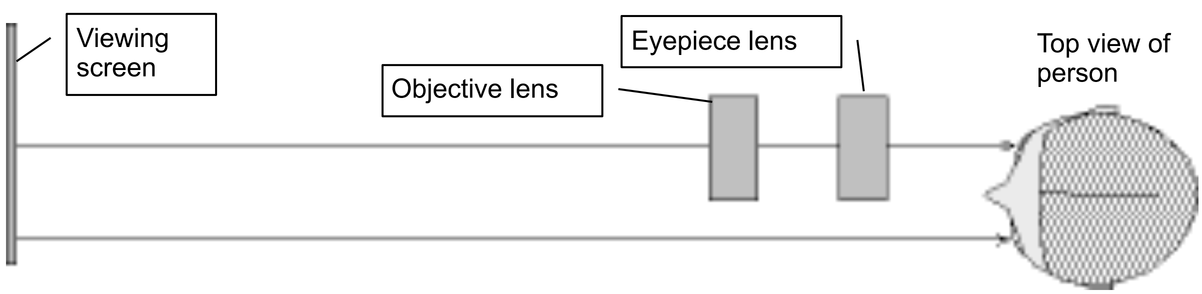
1. Use a copy of the grid (see the last page) as the object. Fasten the copy of the grid to the viewing screen. Mount the viewing screen on one end of the optics bench.

2. Mount the 250 mm F.L. lens and the 150 mm F.L. lens on the other end of the bench with the 250 mm lens nearer to the 'object' (the viewing screen).



Procedure

1. Put one eye close to the 100 mm lens at the end of the bench (the eyepiece lens). Focus the image of the object (grid pattern) by moving the 200 mm lens (the objective lens) forward or backward.



2. To eliminate the parallax, move the eyepiece (100 mm) lens until the image lines do not shift relative to the object lines when you move your head.

Parallax – an apparent shifting of the image due to the motion of the observer – occurs if the image is not in same plane as the object (grid pattern). To observe the parallax, open both eyes and look through the lens at the image with one eye while looking 'around the edge' of the lens directly at the grid pattern with the other eye. The lines of the image will be superimposed on the lines of the grid pattern. As you move your head up-and- down or back-and-forth, the lines of the image *may* appear to move relative to the lines of the grid pattern. If the lines move, it's due to parallax.

3. With the parallax eliminated, the virtual image is in the plane of the grid pattern. Record the positions of the two lens and the viewing screen in the Lab Report section.
4. Estimate the magnification of this simple telescope by counting the number of squares in the grid pattern that lie along one side of one square of the image. To do this, you must view the image through the telescope with one eye while looking directly at the grid pattern with the other eye.
5. Record the observed magnification as a ratio **Obs. Magnification.** = ________
6. Determine d_{01}, the distance from the grid pattern to the objective (200 mm) lens and record the distance. $\boldsymbol{d_{01}}$ **=** __________
7. Determine d_{i2}, the distance from the eyepiece (100 mm) lens to the image. Since the image is in the plane of the object, this is just the distance from the eyepiece lens to the grid pattern on the viewing screen. $\boldsymbol{d_{i2}}$ = __________

Analysis

1. Calculate d_{i1} using the value of d_{01} and the focal length, f, of the objective lens (250 mm) in the Thin Lens Formula (**Eq. 1**)
2. Calculate d_{02} using the value of d_{i2} and the focal length, f, of the eyepiece lens (150 mm) in the Thin Lens Formula (**Eq. 1**).
3. Calculate the magnification using the magnification formula (**Eq. 2**)
4. Calculate the percent difference between the observed (estimated) magnification and the calculated magnification:

$$\% diff = \frac{|\text{Observed} - \text{Calculated}|}{\text{Calculated}} \times 100 =$$