Experiment 16: Microscope

Required Equipment from Basic Optics System

Bench

2 Convex Lenses (+100 mm and +200 mm)

Screen

Paper grid pattern (see page 57), or a 14 × 16 grid of 1 cm squares

Purpose

In this experiment, you will construct a microscope and determine its magnification.

Theory

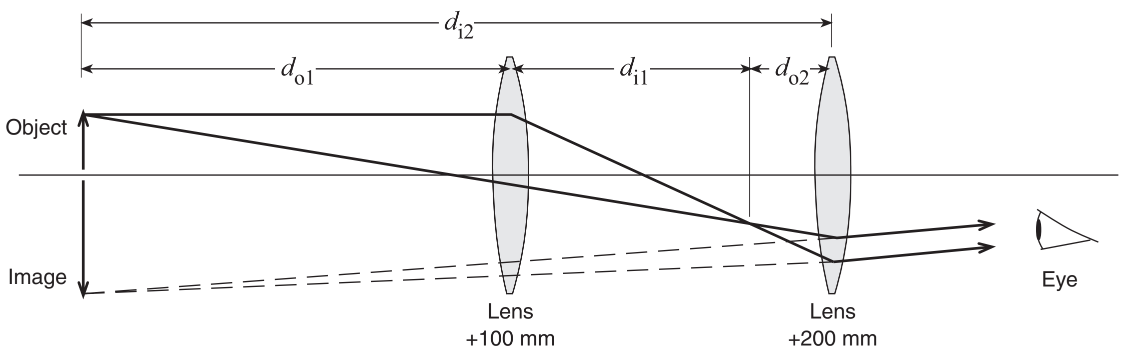

Figure 16.1

A microscope magnifies an object that is close to the objective lens. The microscope in this experiment will form an image in the same place as the object (see Figure 16.1).

The lenses are thin compared to the other distances involved, which allows the Thin Lens Formula to be used:

(eq. 16.1)

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

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, M, of a two-lens system is equal to the product of the magnifications of the individual lenses:

(eq. 16.2)

$$M = M_1 M_2 = \left(\frac{-d_{i1}}{d_{o1}}\right)\left(\frac{-d_{i2}}{d_{o2}}\right)$$

Set Up

1. Tape the paper grid pattern to the screen to serve as the object.
2. The +100 mm lens is the objective lens (the one closer to the object). The +200 mm lens is the eyepiece lens (the one closer to the eye). Place the lenses near the

middle of the optics bench and place the screen near the end of the bench (see Figure 16.2).

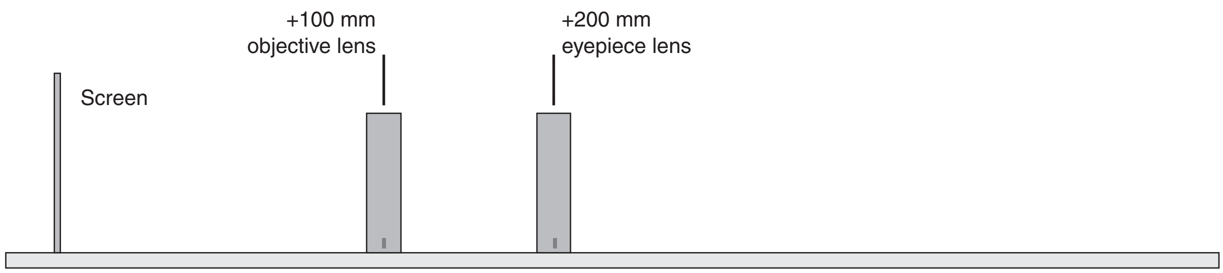

Figure 16.2

Procedure

1. Put your eye close to the eyepiece lens and look through both lenses at the grid pattern on the screen. Move the objective lens to bring the image into focus.

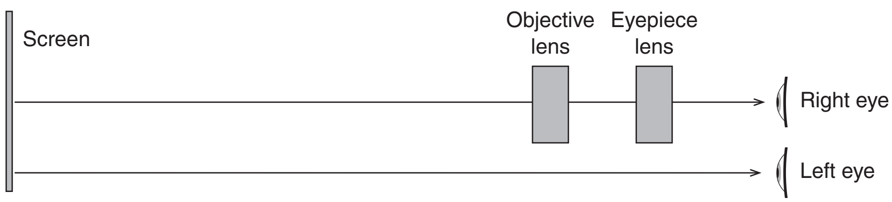

Figure 16.3

2. In this step, you will adjust your microscope to make the image occur in the same place as the object. To do this, you will look at both image and object at the same time and judge their relative positions by moving your head side to side. If the image and object are not in the same place, then they will appear to move relative to each other. This effect is known as parallax.

Open both eyes. Look with one eye through the lenses at the image and with the other eye past the lenses at the object (see Figure 16.3). The lines of the image (solid lines shown in Figure 16.4) will be superimposed on the lines of the object (shown as dotted lines in Figure 16.4). Move your head left and right or up and down by about a centimeter. As you move your head, the lines of the image may move relative to the lines of the object due to the parallax. Adjust the eyepiece lens to eliminate parallax. Do not move the objective lens. When there is no parallax, the lines in the center of the lens appear to be stuck to the object lines.

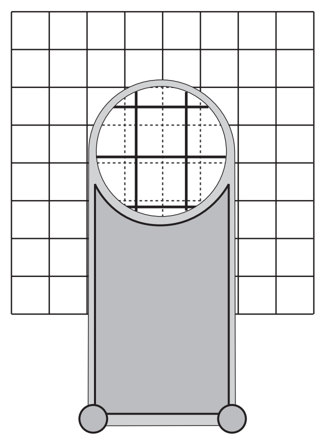

Figure 16.4

Note: Even when there is no parallax, the lines may appear to move near the edges of the lens because of lens aberrations. Concentrate on the part of the image seen through the centers of the lenses. Be sure that the eye looking at the object (the left eye in Figure 16.3) is looking directly at the object and not through the objective lens.

3. Record the positions of the lenses and the object in Table 16.1.

4. Estimate the magnification of your microscope by counting the number of object squares that lie along one side of one image square. To do this, you must view the image through the microscope with one eye while looking directly at the object with the other eye. Remember that magnification is negative for an inverted image. Record the observed magnification in Table 16.1.

Analysis

To calculate the magnification complete the following steps and record the answers in Table 16.1:

1. Measure d_{o1}, the distance from the object (paper pattern on screen) to the objective lens.

2. Determine d_{i2}, the distance from the eyepiece lens to the image. Since the image is in the plane of the object, this is equal to the distance between the eyepiece lens and the object (screen). Remember that the image distance for a virtual image is negative.

3. Calculate d_{i1} using d_{o1} and the focal length of the objective lens in the Thin Lens Formula (Equation 16.1).

4. Calculate d_{o2} by subtracting d_{i1} from the distance between the lenses.

5. Calculate the magnification using Equation 16.2.

6. Calculate the percent difference between the calculated magnification and the observed value.

Table 16.1: Results

Position of Objective Lens	
Position of Eyepiece Lens	
Position of Screen	
Observed magnification	
d_{o1}	
d_{i2}	
d_{i1}	
d_{o2}	
Calculated Magnification	
Percent Difference	

Questions

1. Is the image inverted or upright?

2. Is the image that you see through the microscope real or virtual?

Further Study

Image Formed by the Objective Lens

Where is the image formed by the objective lens? Is it real or virtual? Us a desk lamp to brightly illuminate the paper grid (or replace the screen with the light source's crossed-arrow object). Hold a sheet of paper vertically where you think the image is. Do you see the image? Is it inverted or upright? Remove the sheet of paper and hold a pencil in the same place. Look through eyepiece lens; you will see two images, one of the pencil and one of the grid pattern. Are both images inverted? Use parallax to determine the location of the pencil image.

Increasing Magnification

While looking through your microscope, move the objective lens a few centimeters closer to the object. Which way do you have to move the eyepiece lens to keep the image in focus? How close can you move the objective lens and still see a clear image? (Make a pencil mark on the paper grid so you have something very small to focus on.) What is the theoretical limit to how close you can move the objective lens?