A Two-Lens Microscope

In any multi-lens optical instrument, the objective lens and all other lenses positioned before the eyepiece must produce a real image; then the eyepiece will enlarge that real image. For this to happen, the eyepiece should be fairly close to the image being magnified.

Converging lenses of different focal lengths are needed in this investigation. If the focal lengths of the lenses are not labelled, they can be found by aiming parallel light rays (from a ray box or a distant light source) toward the lens, finding the focal point on a screen, and measuring the focal length. The purpose of this investigation is to determine how the eyepiece and objective lenses are best arranged in a microscope.

**Question**

How are the eyepiece and objective lenses arranged to form a two-lens microscope?

**Prediction**

(a) Based on the various lenses, predict which arrangement of two lenses will result in the best microscope.

**Materials**

- converging lenses of various focal lengths
- optical bench apparatus with corresponding supports
- screen holder
- small letter or symbol

**Procedure**

1. Determine the focal lengths of two or three different lenses.
2. Determine how the magnification of a distant object viewed through a lens depends on the focal length of the lens. (Hold the lens about 30 cm from your eye.)

3. Determine how the magnification of an object near a lens depends on the focal length of the lens. (Again, hold the lens about 30 cm from your eye.)

4. Choose two lenses and place them in the supports on the optical bench so that they are separated by the sum of their focal lengths. Place the screen holder slightly beyond the focal point of the objective lens near one end of the optical bench. Insert a piece of paper with small print into the screen holder.

5. Look through the eyepiece and move the lenses and your eye back and forth until you find the clearest and largest image. The image should be inverted and larger than the object if the system is acting like a microscope. Estimate the magnification of your image.

6. Repeat steps 4 and 5 using various combinations of lenses; for example, objective $f = 5$ cm and eyepiece $f = 5$ cm; objective $f = 5$ cm and eyepiece $f = 10$ cm. Determine which combination gives the largest and clearest image.
7. When you have exhausted all possibilities with your lenses and have a successful arrangement of lenses, record the distance of the screen holder from the objective lens. Also record the focal lengths of the lenses and distance between the lenses.

**Analysis**

(b) Calculate the image distance \( d_i \) produced by the objective lens. How do you know the image is real?

(c) Calculate the magnification of the specimen by the objective lens.

(d) Use the image distance \( d_i \) and the distance between the lenses to determine the distance of the real image from the eyepiece. This distance is the object distance \( d_o \) for the eyepiece.

(e) Use \( d_o \) for the eyepiece and the eyepiece's focal length to determine the position of the image produced by the eyepiece. How do you know from your calculation that the image is virtual?

(f) Determine the magnification of the eyepiece.

(g) What is the total magnification of your simple compound microscope?
(h) Answer the Question.

Evaluation

(i) How does your calculated value of the magnification compare with your estimation? Calculate a percent difference.

(j) Suggest improvements to the procedure.

(k) Look through your microscope again to compare what you see with what you calculated. How does your calculated value compare with what you see?