4C Lab – Optical Instruments

Goal: To examine the properties of thin lenses and construct optical instruments

Equipment List:

- Optics bench
- Laser bench (optional)
- Box of lenses
- Component holders (3)
- Light box with target
- 3 x 5 card
- 2 meter stick

Pre-lab exercise: Determine the position of the image formed with the telescope

Background: The thin lens equation:

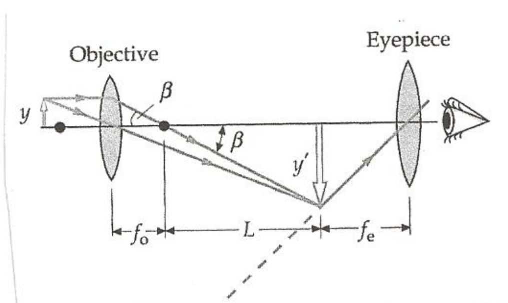
$$\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}$$

Describes the relationship between the image distance, s, the object distance s' and the focal length f. This equation also holds for a system of lenses using the image formed by the first as the object for the second.

Procedure – Part 1: The Simple Magnifier

1. Find the 48mm lens. Measure the focal length by forming the real image of a distant, real object (a tree outside, the moon, your lab partner).
2. Using the crossed arrow target on the light box, find the focal length using the thin lens equation. Measure s, s'. Find *f*.
3. Measure *y* and *y'*. Find the lateral magnification, $m = -s'/s = y'/y$ using both ratios and compare.
4. Repeat for the 252 mm lens. This one is a bit trickier, but with a bit of thought and patience completely doable. (Hint: Make sure the lens is not closer than 252 mm to the target and start with the 3 x 5 card 1.5 m away)

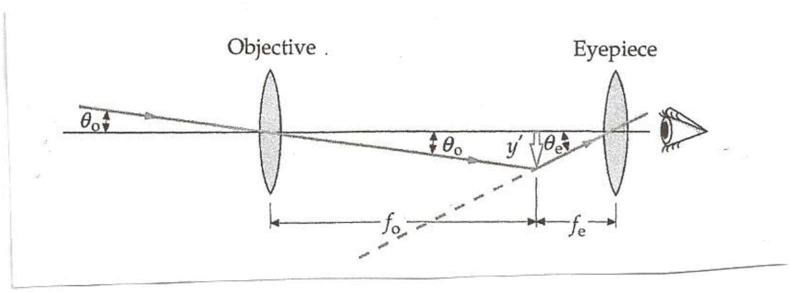
Part 2: A compound microscope – Looking at small things at short distances



1. Place the 48 mm lens, the objective, on the track so that the crossed arrow target is just beyond the first focal point. Find the image. It will be real, enlarged and inverted.
2. Place the 127mm lens, the eyepiece, so that its first focal point coincides with the image formed by the 48mm lens.
3. Determine the tube length of your microscope *L*. This is the distance between the second focal point of the objective and the first focal point of the eyepiece.
4. Try to view the crossed arrow target through the eyepiece. Measure how far away the lens is from your eye.
5. Find the magnifying power of the microscope: The lateral magnification of the objective is $m_o = y'/y = -L/f_o$. The angular magnification of the eyepiece is $M_e = x_{np}/f_e$, where x_{np} is the near point of the viewer (the nearest point the viewer can focus), and fe is the focal length of the eyepiece. The magnifying power of the microscope is the product of the the two:

$$M = m_o M_e = -\frac{L}{f_o}\frac{x_{np}}{f_e}$$

Part 3. The Telescope – Looking at large distant objects.



1. Place the 252 mm lens, the objective, on the bench.
2. Looking at a distant object with the lens (something outside, the open door, the exit sign?) find the position of image using the 3 x 5 card. Measure the height of the object on the 3 x 5 card. This is y'.
3. Remove the 3 x 5 card and put the 48 mm lens at one end. The distance between the two lenses should be exactly the sum of the focal lengths.
4. Try to view something using this telescope. It is challenging to look through both lenses at once, but give it a try. Choosing an object far away helps. Is the image upright or inverted?
5. Calculate the angular magnification of the objective:

$$\tan\theta_o = -\frac{y'}{f_o} \approx \theta_o$$

and the angular magnification of the eyepiece:

$$\tan\theta_e = -\frac{y'}{f_e} \approx \theta_e$$

6. The magnification of the telescope is:

$$M = \frac{\theta_e}{\theta_o} = -\frac{f_o}{f_e}$$

7. Estimate the magnification you see and compare with the calculated values.