Assignment 3
Due September 27, 2010

Text readings

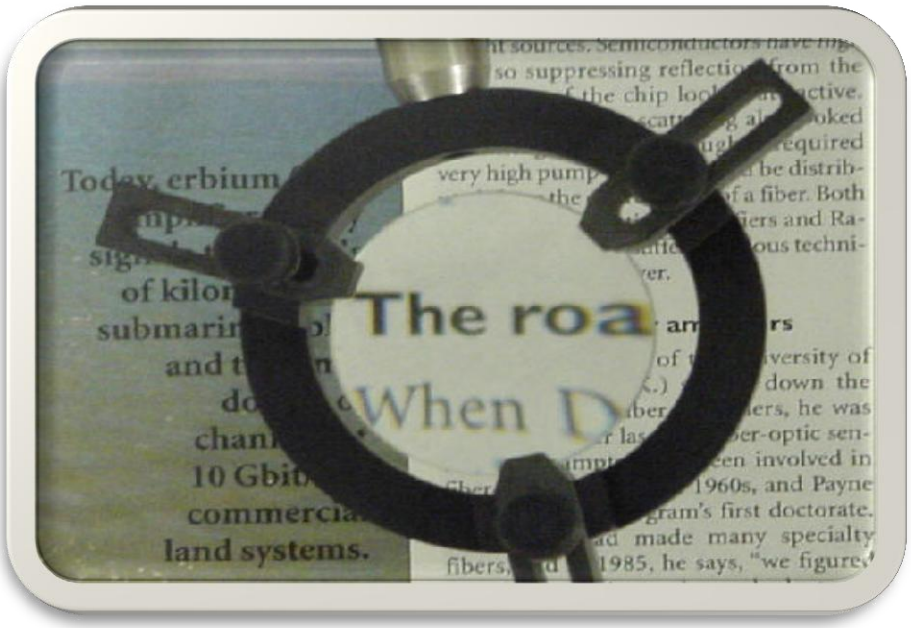
Stops section 5.3
Dispersing and Reflecting Prisms [sections 5.5.1 and 5.5.2]
Optical systems section 5.7
Lens Aberrations [section 6.3]
Be careful about our different sign convention.

Problems

The equipment will be available in Room 212B. Please work on these problems right away, so we can discuss your conceptual understanding, any needed theory and work out any problems.

Problem 1

Angular Magnification: In class you will be given a convex lens to use as a magnifier.



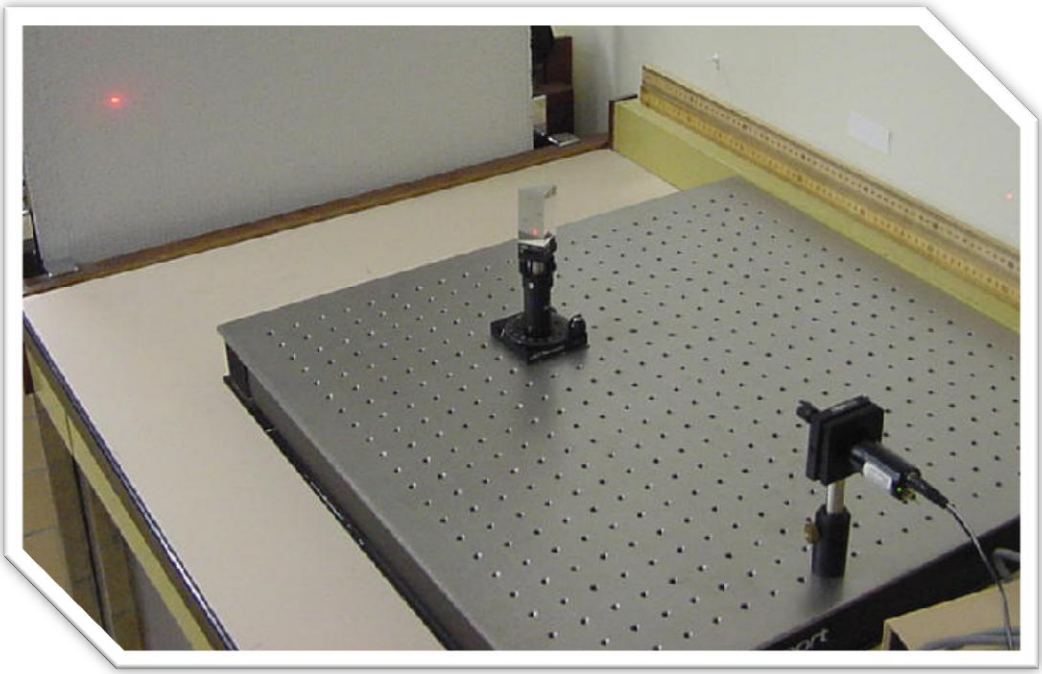
1. What is the focal length of the lens?
2. Look at an object at your near point (25 cm from your eye). What is the angular size of this object on your retina?
3. Now look at the object through the lens and adjust the object lens separation until you get a comfortable magnification of the object. What is the angular magnification in this configuration?
4. What is the lateral magnification? Compare it to the angular magnification.
5. Is the object virtual or real? Is the image virtual or real?
6. Draw ray diagram for the problem.

Problem 2

Index of Refraction Using a Prism: Determine the index of refraction of the prism using the following relation.

$$n = \frac{sin[(A + D)/2]}{sin(A/2)}$$

here A the apex angle and D the angle of minimum deviation. You need to measure the angle of minimum deviation and the apex angle of the prism. We will discuss the procedure in class. You will use a He-Ne laser and a rotation stage in addition to the prism.

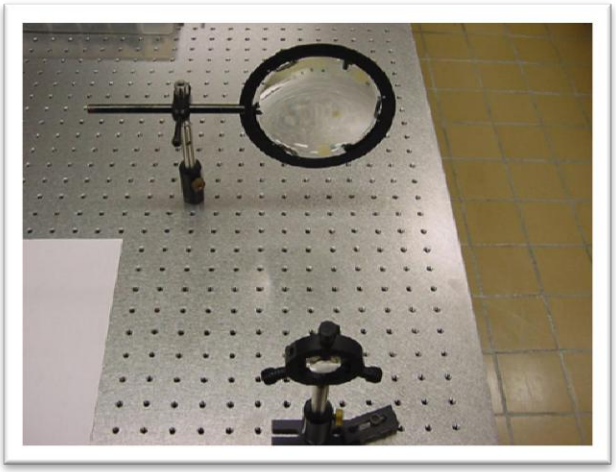


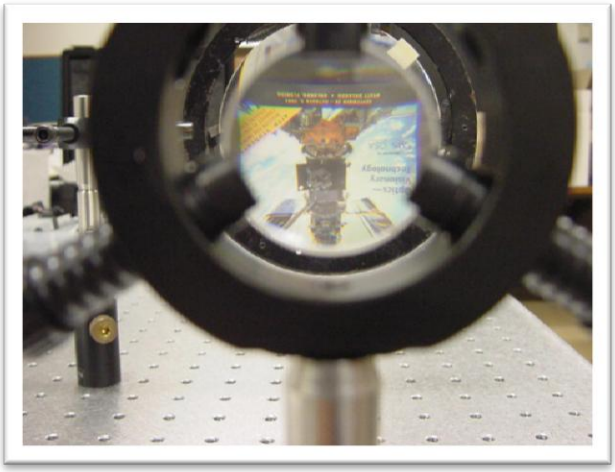
Show that the apex angle A is one-half the total angle between the reflections from the two surfaces making A.

Problem 3

Astronomical Telescope: The picture below left shows an astronomical telescope constructed of two converging lenses. This type of telescope is used as a laser beam expander and in spectrometers.

The picture on the right shows a view through the "telescope" at an image of the Hubble Space Telescope three meters away.

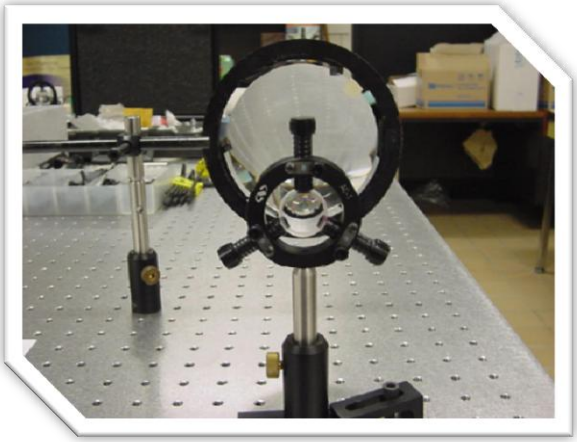


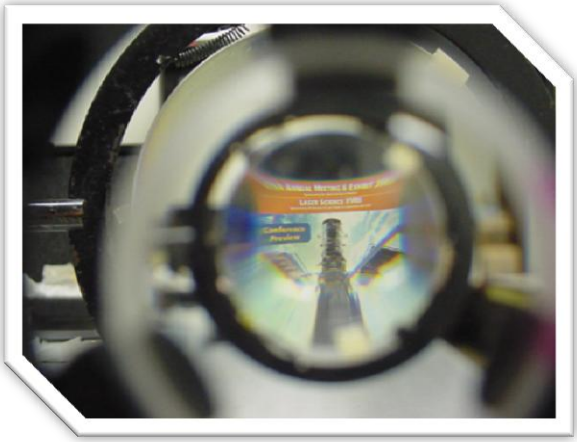


1. Determine the focal lengths of the two lenses, the object distance, and any other dimensions needed.
2. Predict the separation that the lenses must have to make the telescope. Predict the magnification of this telescope.
3. Describe what you see happening to the image as you increase the separation of the lenses through the value predicted in part 1.
4. At or near the predicted separation corresponding to an astronomical telescope, describe the image orientation and magnification.
5. Now if the bottom half of the large lens is covered by a piece of paper, what happens to the image of Hubble Space Telescope viewed through the system as on the picture below? Try blocking the bottom half of the small lens, can you still see all of the Hubble Space Telescope?
6. From the measurements in part 1 you should find theoretically the position and size of the aperture and field stops, entrance and exit pupils, and entrance and exit windows.
7. Base on the focal lengths of the lenses what is the telescope magnification? Is it consistent with what you saw in part 4.
8. Now while the telescope at or near the predicted separation hold a paper clip at the surface of the objective lens. Use an index card outside the telescope close to the eyepiece. Move the card relative to the eyepiece until you find a focused image of both the paper clip and the objective lens. Measure the diameter of the objective image (this is the exit pupil).
9. Calculate the magnification of the telescope using the diameter of the entrance pupil and the diameter of the exit pupil. Compare your result to that of part 7. Which method gives you the true magnification of the telescope?

Problem 4

Galilean telescope or Opera Glass: The picture below left shows a Galilean telescope constructed of a large converging lens and a smaller diverging lens. The picture on the right shows a view through the "telescope" at an image of the Hubble Space Telescope three meters away.





1. Set up the telescope as shown above.
   Change the separation of the lenses while watching the image of a distant object through the system. Measure the separation of the lenses when you judge the system to be a proper "Galilean" telescope.
2. Determine the focal lengths of the two lenses, the object distance, and any other dimensions needed.
3. Predict the magnification of this telescope.
4. Describe what you see happening to the image as you increase the separation of the lenses through the value determined in part 1.
5. At or near your separation corresponding to a Galilean telescope, describe the image orientation and magnification.

Problem 5

Book Problem: 5.37

Problem 6

Book Problem: 5.46

Problem 7

Book Problem: 5.80.

Bonus Problems

Problems 5.65 and 5.62