Geometrical Optics

Goal:
Employ the laws of geometrical optics to design and test a simple telescope. This lab is once again in the format of a "project" rather than a recipe: you are given a task to perform, the equipment with which to perform it, and little direction beyond that.

Equipment:

(1) 5x Lenses, biconvex and planoconvex, of assorted optical properties
(2) 1x Spherometer and instruction sheet
(3) 1x Optical bench
(4) 2x Lens holders and clamp stands
(5) 1x Lamp
(6) 1x White metal plate
(7) 1x 15 cm long mm ruler.

Reference:
Young and Freedman, Ch 34.

Part I - Design.
Design a two-lens telescope having the maximum transverse angular magnification possible with the lenses provided. The purpose of most telescopes is to resolve objects that are at great distances from us, such as stars. The goal is not to magnify the stars as such, but to magnify their angular separation so that we can resolve them. We will identify which two lenses of the five should be used, how far apart they should be placed, and what the resulting transverse magnification of the telescope will be.

1. Choose lenses for your telescope. Using the ceiling light (assumed to be an infinite distance away), estimate the focal lengths of each lens. Refer to the telescopes section of your textbook to choose the two lenses that will optimize your telescope.

2. Measure more precisely the focal lengths of the two lenses you chose. The optical bench provided offers an object (lamp) and a white metal plate on which to bring the image into focus. From the image and object distances, calculate the focal lengths of your two lenses. You may find these measurements easiest to carry out in the dark.

A spherometer is also provided to measure lens curvature (instructions are at the end of this document), if you so desire, as are an optical bench and associated paraphernalia (lens holders, lamp, and frosted glass sheet) for optical measurements.

3. Submit a design report. A design report with your proposed telescope specifications must be submitted to the TA before starting part II. It should include a carefully drawn ray diagram of your proposed telescope, a discussion of any approximations that went into your modeling, and a discussion of how those approximations might effect your design. The TA must sign off on this preliminary report before you proceed.

Part II -Construction and Testing.

1. Create your telescope. Remove the lamp and metal card from the optical bench, and mount your chosen lenses on the optical bench at your design separation.

2. Test your telescope. The TA will tape a colored index card on the whiteboard at the other end of the room. Your job is to view the card through the telescope, correctly identify the picture taped on the index card, and measure the angular magnification of your telescope.

Once you have the image of the index card in view through the telescope with one eye, carefully open the other eye. You will see a superposition of the image (telescope eye) and the actual card (unaided eye). Now have a team member mark with a dry erase marker on the whiteboard your perceived top and bottom of the image (telescope view). Measure the distance between the two marks, and divide by the real height of the object. This ratio is the angular magnification of your telescope.