Name

Telescopes

Do at Home Version

Note that this Lab is intentionally more difficult
than the one done in class!

Lenses were discovered roughly 700 years ago. They were mostly used as magnifying glasses, or for visual aids. It took humanity roughly another 300 years to figure out that if you combine two lenses in a particular fashion, you obtain a telescope. Galileo is often credited with inventing the telescope in the early 1600s. This is not true. Although he was the first scientist to point his telescope towards the heavens, he was not the first person to discover the telescope. The telescope was invented by an unknown Dutch lens maker. Galileo heard about this new *magnifying glass*, and was told that it consisted of two lenses inside a tube. Apparently, he then went home, played with the lenses and by the next morning had *invented* the telescope. He called his finding a *spyglass* and used this to get a promotion (well, human nature and politics have not changed much since then…). In this lab we'll do something similar. First we will analyze the properties of lenses. Then, we will *somehow* (*you'll figure this out*) combine two lenses and *rediscover* the telescope (*or spyglass, if you prefer*).

Image taken from the Yerkes Observatory site
http://astro.uchicago.edu/vtour/40inch/

You will build a telescope like this one (it is the world's largest refractor)
well – only a smaller version of it!

Collect the Telescope Kit from your Instructor

Part I: Do the Pre-Lab; Attach to Lab

Part II: Determine the Focal Length

Take the two lenses from the Telescope Kit and analyze them.

Are those lenses convex or concave lenses?

Explain *how* you reached this conclusion.

Pick a sunny day, go outside, take a piece of paper and a ruler, and figure out how to determine the focal length the lenses. Also, estimate the accuracy of *f*.

Small Lens $f =$ _____ ± _____ cm

Large Lens $f =$ _____ ± _____ cm

Explain *how* you determine the focal length of the converging lenses.

Explain how you determined the accuracy in the focal lengths.

Part III: Determine Image Properties

When you look through a lens, you'll notice that it may enlarge whatever you are looking at, or it may make it smaller. Let's figure out how that works. Take the two lenses from the Telescope Kit and analyze them. Compare the properties of an object to its image seen through a lens.

a) Look at an object that is roughly ***1 inch*** from the lens

	Large Lens	Small Lens
Is the image larger or smaller?		
Is the image upright or not?		

b) Hold all lenses ***close to your eye*** and look at an object at the other end of the classroom.

	Large Lens	Small Lens
Is the image larger or smaller?		
Is the image upright or not?		

c) Hold all lenses ***at arms length*** and look at an object at the other end of the classroom.

	Large Lens	Small Lens
Is the image larger or smaller?		
Is the image upright or not?		

d) Take the large lens and hold it at arms length roughly ten centi-meters away from a picture. Describe what happens if you decrease the distance between the lens and the picture to less than a centi-meter.

What happens to the size of the image? _____

What happens to the orientation of the image? _____

At some point the image will get blurred and disappear. Find that distance.

Distance at which there is no image: _____ ± _____ cm

Compare this measurement to the focal length of that lens and comment:

_____

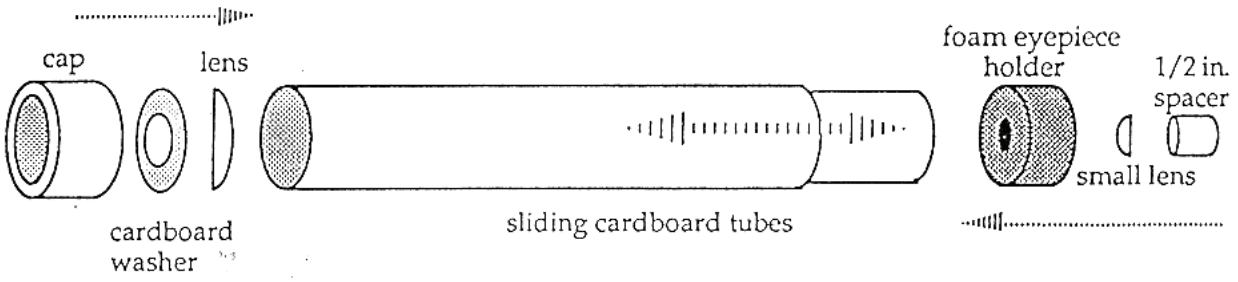
_____

_____

Part IV: Build the Telescope

Now that you've played with lenses and the formation of images, you know all you need to know in order to design and build your own telescope. A single lens cannot give you a clear picture, however if you combine two lenses in a certain configuration, you can get a larger and clear image. First build the telescope, and then slide the cardboard to and fro until you get a large but clear image.

Build a telescope using the Project STAR Telescope Kit: http://www.starlab.com/psprod.html



Which lens would you use as the eyepiece and which as the objective. Why?

_____

_____

Did you notice anything strange about the image?

_____

_____

Measure the distance between the two lensesd = _____ ± _____

Go back to part I of the lab and copy the focal lengths of both of the lenses that you used.

$f_{\text{large convex}}$ = _____ ± _____

$f_{\text{large convex}}$ = _____ ± _____

Let's understand the Physics of Telescopes… Figure out the correlation between the focal lengths of the two lenses and the distance between the two lenses.

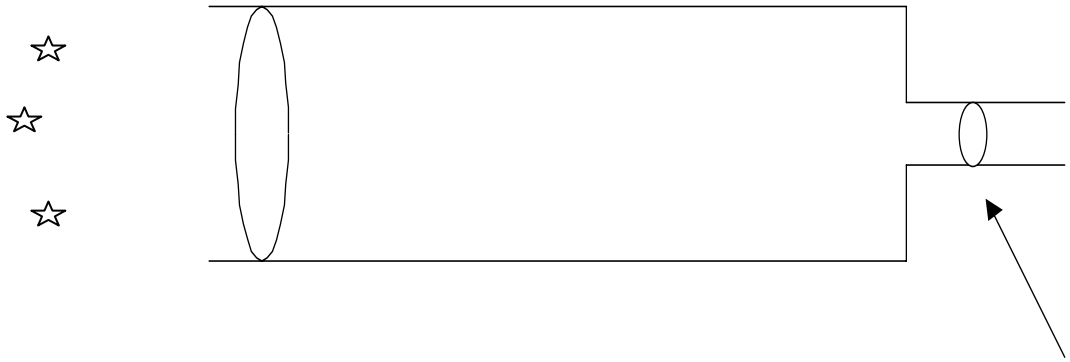
_____

_____

You may keep this telescope – but only if you promise to use it (otherwise please return it).

Part V: Understand Telescopes

1) Consult Figures 4 and 12 of the Pre-Lab. Draw the path of three light rays of distant stars as they pass through the objective and then through the eyepiece. Consult you textbook if you like. [Hint: The light rays from distant objects are parallel — and the light rays leaving the telescope are also parallel. (Recall, our eyes can easily focus parallel light from distant objects).] Use a ruler. Label the focal lengths of both lenses.



2) If you used an even stronger lens as an eyepiece, what would this do to the image you would see through the telescope? Explain your answer.

3) If you used larger objective lens, what would this do to the image you would see through the telescope? Explain your answer.

4) If you used a concave lens as an eyepiece, what would this do to the image you would see through the telescope? Explain your answer. [This is not an easy question, so think about your answer]

5) Draw the path of three light rays of distant stars as they pass through the objective and then through the eyepiece. [Hint: The light rays from distant objects are parallel — and the light rays leaving the telescope are also parallel. Use a ruler. Label the following: distance between lenses, $f_{large\text{-}convex}$, and $f_{small\text{-}concave}$.

6) Which type of telescope do you prefer – the one you drew in question (1) or question (5)? Explain.

7) Reflecting telescopes are somewhat similar to refracting telescopes with the difference that a concave mirror replaces the objective lens. Read the appropriate paragraphs in your textbook and make a schematic drawing of a simple reflecting telescope.

8) Today many telescopes are Reflecting Telescopes. What are the advantages of reflecting telescopes over refracting telescopes?

9) Objective of the Lab

10) Describe in a few sentences what you have done

11) Summarize your basic results