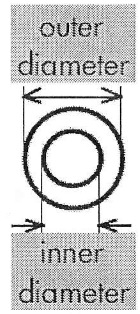
Earth Science / Ms. Burt Name:________________Partner:__________

LAB: Building a Simple Telescope

(This lab utilizes materials that were designed and provided by Project STAR.)
Measure the inner and outer diameters of the cardboard washer of your telescope.



Outer diameter __________ cm
Inner diameter ___________cm

Part A. Determining Image Properties
When you look through a lens, you will 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 2 lenses from the Telescope Kit and analyze them. Compare the properties of an object to its image seen through a lens. those lenses convex or concave lenses? Explain how you reached this conclusion.

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A1. Look at an object that is roughly ***1-2 inches*** from the lens

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

A2. Hold all lenses ***closer 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?		

A3. 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?		

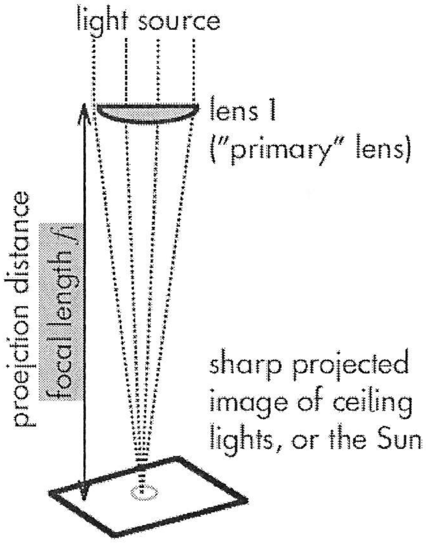
A4. Take the large lens and hold it at arms length roughly **10 cm** away from a picture. Describe what happens if you decrease the distance between the lens and the picture to less than 1 cm.

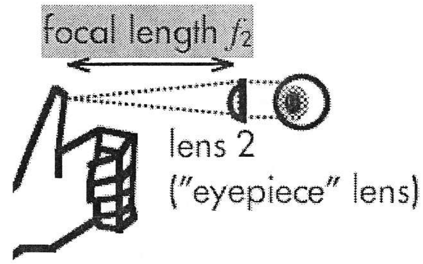
a) What happens to the size of the image? ____

b) What happens to the orientation of the image? ___________________________________

Part B. Determining Focal Length

B1. Separately measure the focal lengths of your large lens and small lens, as shown here. Determine why each lens is used differently. The primary lens *projects* a sharply focused image, such that its focal length is its "projection distance." The eyepiece lens is *looked through* to magnify things, such that its focal length is the *maximum* focusing distance that you can sharply resolve details (such as the fingerprints on your thumb).





Using this technique:

$f_{large} = f_1 =$ ________________ cm

$f_{small} = f_2 =$ ________________ cm

B2. **Observe the orientation of the image** on the tracing paper. With the image focused as sharply as possible, measure the distance between the lens and the tracing paper. This distance is basically the focal length f of the large lens.

$f_{large} = f_1 =$ ________________ cm Take the large lens and mount it at one end of the larger cardboard tube; slide the smaller tube into the other end of the larger one, and use a rubber band to hold a sheet of tracing paper over the open end of the smaller tube. Now point the tubes at the subject we've set up in the lab, and slide the smaller tube in and out until you focus a sharp image on the tracing paper.

Take the smaller lens from your telescope kit, and remove the lens from its foam mounting and hold it by the edges. Point the flat side of the lens toward a distant light-source and hold a sheet of paper behind the lens and parallel to its face. Move the paper closer or further from the lens until you see a sharp image of the light-source, and measure the distance from the curved face of the lens to the paper. (This really requires three hands; get your lab partner to help!) This distance is basically the focal length f of the small lens.

$f_{small} = f_2 =$ ________________ cm

B3. Compare these two techniques for determining focal length? Describe which you think is the more accurate for each lens size.

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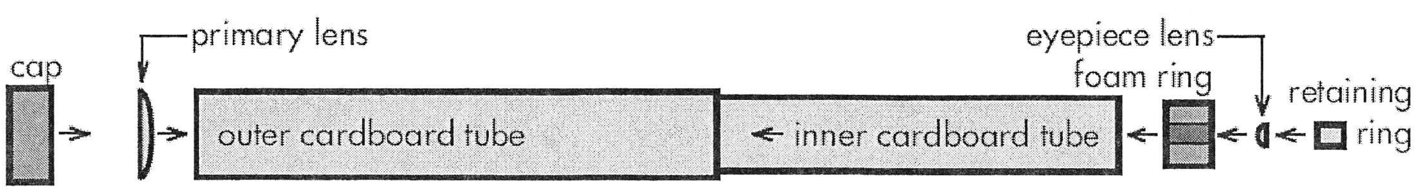
Part C. Building the Telescope

Now that you have examined the lenses and the images that are formed, 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.

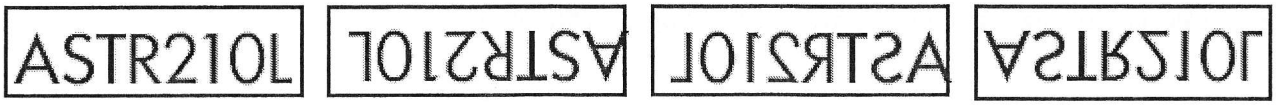
You're now ready to put the telescope kit together.

Carefully assemble the telescope without the cardboard washer under the red cap.



- Be careful not to smudge lenses with your fingers. Use small piece of cloth or tissue to prevent smudging.
- Remove the tissue paper.

C1. Take turns looking through the telescope at a well-illuminated *distant* object (at least across the room, or utside the window). Slide the outer/inner cardboard tubes in/out to focus. If this distant object was a sign that says 'ASTR 10L," circle the view below of how it would appear through the telescope.



(A) (B) (C) (D)

C2. Measure the distance between the two lenses (one may be imbedded inside of the foam ring):
Telescope length L is _______________ cm

C3. Go back to Part B of the lab and copy the focal lengths of both of the lenses that you used.

f_{large} = ________________cm

f_{small} = ________________cm

C4. 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 (L).

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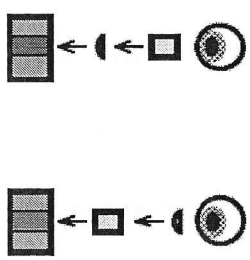
Your telescope should still be assembled *without* the white cardboard washer under the red cap.
(a) The foam ring can be assembled in either of two ways: with the small cardboard retaining ring between the eyepiece lens and your eye, or with the eyepiece lens between the cardboard retaining ring and your eye. One configuration is preferred over the other, due to "eye relief." Carefully compare the views through the telescope with the foam spacer assembled either way, and describe how you experienced this difference in eye relief.
Decide on the preferred foam spacer configuration for future use.



Describe the difference in eye relief:

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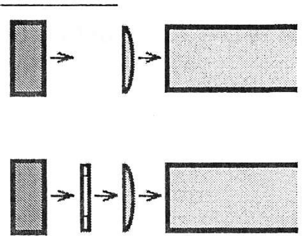
(b) The red cap can either be assembled either with or without the cardboard washer next to the primary lens. One configuration is preferred over the other, if the outer portion of the primary lens suffers from defects. Carefully compare the views through the telescope with the red cap assembled both ways, and describe any difference(s).
Decide on the preferred red cap configuration for future use.
Descriptions of different views, without and with cardboard washer:



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The *light-gathering power* of a telescope is a rating of how much light it is able to collect (higher *LGP* is better), and is proportional to the (circular) area of the primary lens. You know how to calculate the area of a circle, $A = \pi r^2$.

Light gathering power LGP in $cm^2 = \pi\,(\text{radius})^2$ which is the same as $= \dfrac{\pi\,(\text{diameter})^2}{4}$

Given the inner diameter opening of your cardboard washer (which limits how much light can be collected by the primary lens), calculate the light-gathering power of the Project STAR telescope.

Project STAR LGP = __________ cm^2

FOR LEVEL 1 STUDENTS:

The *angular resolution* of a telescope is the measure of the smallest details that can be sharply focused (smaller θ means smaller details are discernable), as measured in arcseconds.

$$\text{Angular resolution } \theta\ [\text{arcseconds}] = 250{,}000 \times \frac{\text{wavelength } \lambda\ [\text{cm}]}{\text{diameter } D\ [\text{cm}]}.$$

Calculate the angular resolution of the Project STAR telescope, given the inner diameter opening of its cardboard washer, and a visible light wavelength of $\lambda = 5.50 \times 10^{-5}$.

Project STAR angular resolution θ = __________ arcseconds.

Extra Credit:

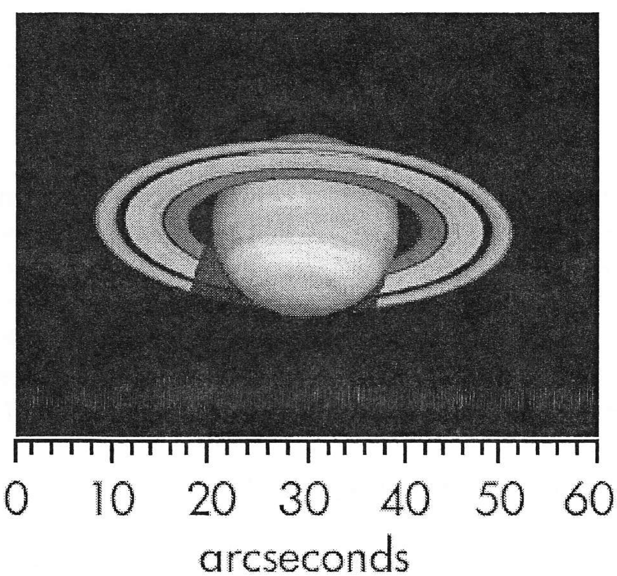
Shown at right is an highly magnified, scaled diagram of Saturn as it would ideally appear in the San Luis Obispo, CA sky. Estimate the angular size for each of the following features, to the nearest arcsecond.

Saturn width (planet only) = ___ arcseconds.

Width of rings = 10 arcseconds.

Gaps between rings = ___ arcseconds.

Width of stripes on Saturn = ___ arcseconds.



Which of the above details (if any) of Saturn should be resolvable with the Project STAR telescope?