

## Astronomy 4 Term Project

### Making and Using the Galilean Telescope

**Introduction:** The refracting telescope, invented around 1608 in Holland by a spectacle lens grinder named Hans Lippershey, was first used to explore celestial phenomena by Galileo. In 1610, Galileo published the results of his telescopic observations in a book entitled *Siderius Nuncius* or *The Starry Messenger*. By challenging the reigning Aristotelian cosmology, in claiming that the Moon is a mountainous, earthlike body rather than a perfect sphere, that more stars exist than appear to the naked eye, that four small satellites circle Jupiter, and by interpreting his observations as a defense of Copernican heliocentrism, Galileo catapulted himself into public controversy and won the patronage of the powerful Medici family.

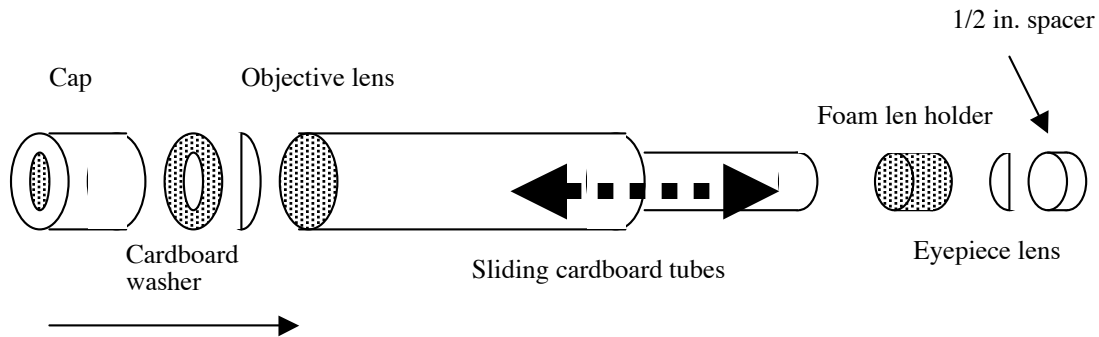
**Task:** You will build a telescope similar to Galileo's, with a magnification of about 20 times, which is better than most commercially available binoculars and comparable to the best telescope built by Galileo. With this instrument you will try to repeat some of Galileo's most important observations—the texture of the lunar surface, the shape of Saturn, the composition of the Milky Way, the satellites of Jupiter, and the number of stars in the Pleiades—and will thereby explore the limitations and difficulties faced by Galileo as he struggled to convert the spyglass, as he called it, into a scientific instrument that would produce credible empirical data about the heavens.

**Procedures:** Before beginning this project, you should read Galileo's *Siderius Nuncius* (trans. Albert van Helden, Chicago 1989), especially pp. 35-86, which is available on closed reserve for this course in Kresge Library. You should also secure from a TA a telescope kit with the following items: 1 foam lens holder, 1 43 mm lens, 1 17.5 mm lens, 1 pair of telescoping tubes, 1 eyepiece spacer, 1 cardboard washer, 1 plastic cap. Before assembling your telescope, you'll want to wipe off any dust on the lenses with a soft cloth (a T-shirt works great) or some lens tissue.

Put the cardboard washer and the large lens (the objective lens) flat side down (being careful not to smudge the lens with your fingers) in the plastic cap. Slide the large tube into the cap, making sure that it is pushed in all the way. Note that both lenses are plano-convex, i.e., one side is flat, the other side curves outward.

Using a small piece of cloth or tissue to prevent smudging, push the small lens (the eyepiece lens) into the foam lens holder. Slide the spacer into the foam holder so that it pushes against the flat part of the lens. Push the spacer into the holder just far enough so that the end of the spacer is flush with the end of the foam holder. With the curved side of the lens facing toward the tube, slide the foam holder into the end of the smaller of the sliding tubes. The foam holder should be flush with the end of this tube.

Look through the telescope, and move the large sliding tube toward/or away from your eye until you see a magnified image of a distant object. You will find that the setting of the tubes for a sharp focus differs slightly from person to person due to variations in the optics of individual eyes. You should see an inverted (upside-down), enlarged image of the distant object.



Some words about the basic operation of a simple telescope. The objective lens (long focal length) collects light from a distant object, and forms a small, upside-down image near the focal point. The eyepiece lens (short focal length) then acts as a simple magnifier to enlarge this small upside-down image. The tube of the telescope is only a physical support to make sure the lenses remain in proper relationship to each other.

Find a site unpolluted by streetlights or other lights for making your observations. The darker your site, the better. And if you wait for twenty minutes or so, your eyes will adjust to the darkness and become able to see fainter objects in the sky.

**Observations:** We would like you, if possible, to make the following observations which Galileo made in 1610. For each, you should write a brief description of what you saw and to compare your observation with Galileo's reports. As did Galileo, you undoubtedly will want to sketch the images you observe. Keep a log of all your observations, with times and dates, descriptions, and sketches. You also should record a brief description of the weather—clear, hazy, windy, etc.

Note that not all observations may be possible due to changing visibilities of the targets and the changing seasons. For a map of the sky, visible in Hanover, at any given date and time, see <http://SkyandTelescope.com/observing/skychart>. You will also want to familiarize yourself with the telescope in daylight before observing at night for the first time.

- 1) Lunar surface: Wait until the Moon is waxing or waning, preferably around its first or third quarter. Look closely at the moon with your naked eye, and then through your telescope. Do you see "mountains," "craters," and "seas?" Do you see what Galileo describes on pp. 40-45?
- 2) The Pleiades: Sometimes called the "Seven Sisters," this group of stars in the constellation Taurus is now called an "open cluster" (also known as Messier 45). To help you locate the cluster (at RA 3h 45m, DEC +24°), you may want to consult a star atlas, such as Ian Ridpath and Wil Tirion, *The monthly sky guide*, 5<sup>th</sup> ed (Cambridge, 1999), Kresge Ref QB63.R525 1999] How many stars do you see with your naked eye? Through your telescope? Did Galileo get his diagram right on p. 61? The Pleiades will be visible only through early May (why?), so observe it soon.
- 3) The Milky Way: This whitish band runs through the constellation of Gemini, and should be visible in the western sky after sunset, through early May. Look at it with your naked eye and with your telescope. Are you able to resolve it into the "congeries of innumerable stars distributed in clusters," as described by Galileo (p. 62)?

- 4) The shape of Saturn: Consult *Sky & Telescope* skycharts to determine when Saturn will be visible. Does it appear, through your telescope, as three “stars,” as Galileo described in a letter of 1610, written after he had published the *Siderius Nuncius* (see p. 102)?
- 5) The moons of Jupiter: You will be familiar with these moons from having completed the first A4 project. But now try to observe the moon with your Galilean telescope. Read his descriptions on p. 64-86. Do you see what he observed?
- 6) Try looking at other targets (i.e., Mars, Venus, bright stars). Describe and sketch what you see.

**WARNING:** Do NOT look at the Sun with your telescope!!

Turn in your observational log with descriptions and sketches of what you saw and answers to the various questions posed in this guide. Describe any observational techniques or modifications made to your telescope in order to improving viewing. If you can't view a target due to a its lack of visibility, briefly state when you would be able to view it.