# Galileo Telescope Solar Viewer

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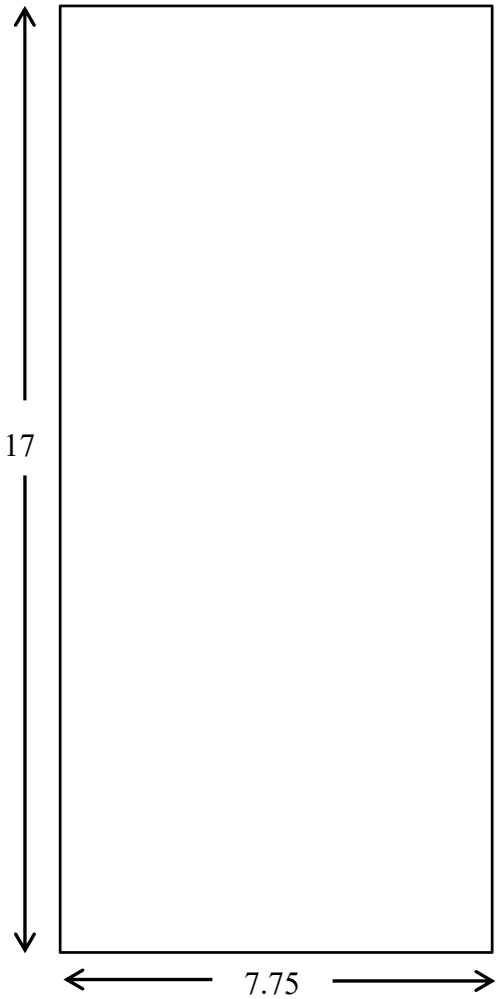
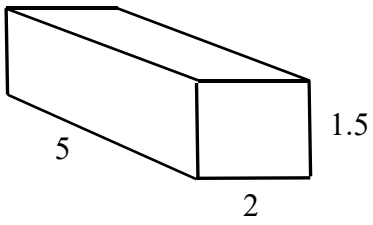
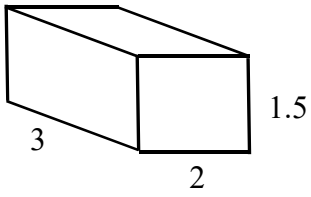



Materials: (all dimensions in inches)

3x plywood sheet 17 x 7.75 x ½
3x wood block cut from 2x4: 5 x 2 x 1.5 (mirror holders and attachment points for frame)
1 wood block from 2x4: 3 x 2 x 1.5 (eyepiece holder)
Objective and eyepiece from Galileo telescope
2x 1.5 x 2 front surface mirrors
4x 1-inch washers (for mirror holders)
Felt pad on hard plastic pad (for mirror holders)
4x ½ inch screws (for mirror holders)
14x 1-inch wood screws (frame assembly)
Shim material

Note: in the unit pictured here, we used one piece of ¾ -inch plywood for the base, because that is what we had on-hand.

WARNING: Do not look through the telescope directly at the sun, otherwise permanent damage to your eye can result. These plans are for building a mount that will allow you use the telescope to safely view the sun by projecting the image onto a surface inside the device.

Prepare Optics:

The optics are from a "Galileoscope", a telescope kit that was first created for the 2009 International Year of Astronomy to provide a low-cost but high-quality refracting telescope that you could assemble yourself. See http://galileoscope.org for information on the telescope and links to retailers. Note that the Galileoscopes are not safe to use for viewing the sun directly. Take apart the telescope and remove objective lenses and eyepiece. Cut the plastic telescope tube just below the optical sight (see picture below right) so that you have the short length of tube at the end that will hold the objective.

Our mirrors were purchased from First Surface Mirror (https://firstsurfacemirror.com/). They are 1.5x2x¼ inch first-surface mirrors, flatness 1 λ, total of $46.49 with shipping (purchased on 2017/06/08).

**Figure 1. Optical components. The objective lens is from the Galileo telescope, the first-surface mirrors were purchased separately.**

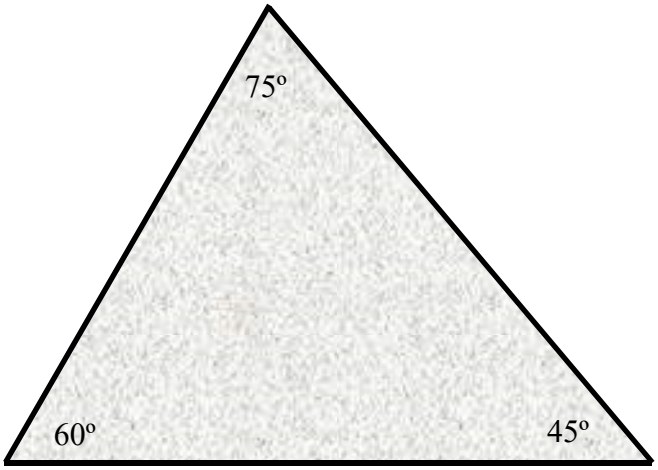
Triangular Frame:

Cut a 2.25 inch diameter hole in the center of one of the 17x7.75 inch plywood sheets for the main lens. The telescope front baffle will then insert into the plywood, and the lens holder will insert into the baffle from the other side.

Pre-drill thru-holes for assembling the frame. We put two screws near the end of each of the three rectangular panels to go into the blocks in the inside corners of the assembled unit. You can do this step after preparing the blocks.

Prepare the blocks:

Take the 5-inch blocks and cut a slice off of the long edge of each one at a 30º angle so that the remaining cross section has a 60º angle. These surfaces will be the ones that the plywood panels are screwed to assemble the frame. One of these pieces is now done. The other two parts double as mounting surfaces for the mirrors. The side that faces inwards must be at a 45º angle relative to the base in order for the mirror to reflect the optical path along one of the sides, and then normal to the base of the frame. The other block is the same, but the 45° corner is mounted on the front panel (facing the hole for the lens). Below is a diagram of the cross section of the blocks. Try to keep the block as close as possible to the full height of the original 2x4 so there is enough material to screw into when assembling the parts, and so the mirror fits on the surface that faces away from the panels.




Eyepiece Holder:
Take the 3-inch block and make a 1.25-inch diameter hole with its center 1 inch from the edge to hold the eyepiece. The top of the eyepiece holder should be about 9.25 inches from the edge of the panel (see assembly drawing on following page). You might want to not attach it until later when you check the focus. It is also good to make the 1.25-inch hole a little undersized so that the eyepiece is snug in the hole. Then you can make focus adjustments and have the eyepiece stay in the proper position. The eyepiece holder should be mounted in the center of the panel, aligned as well as possible with the sides of the panel so the eyepiece is not tilted with respect to the optical axis.

# Assembly diagram for solar telescope

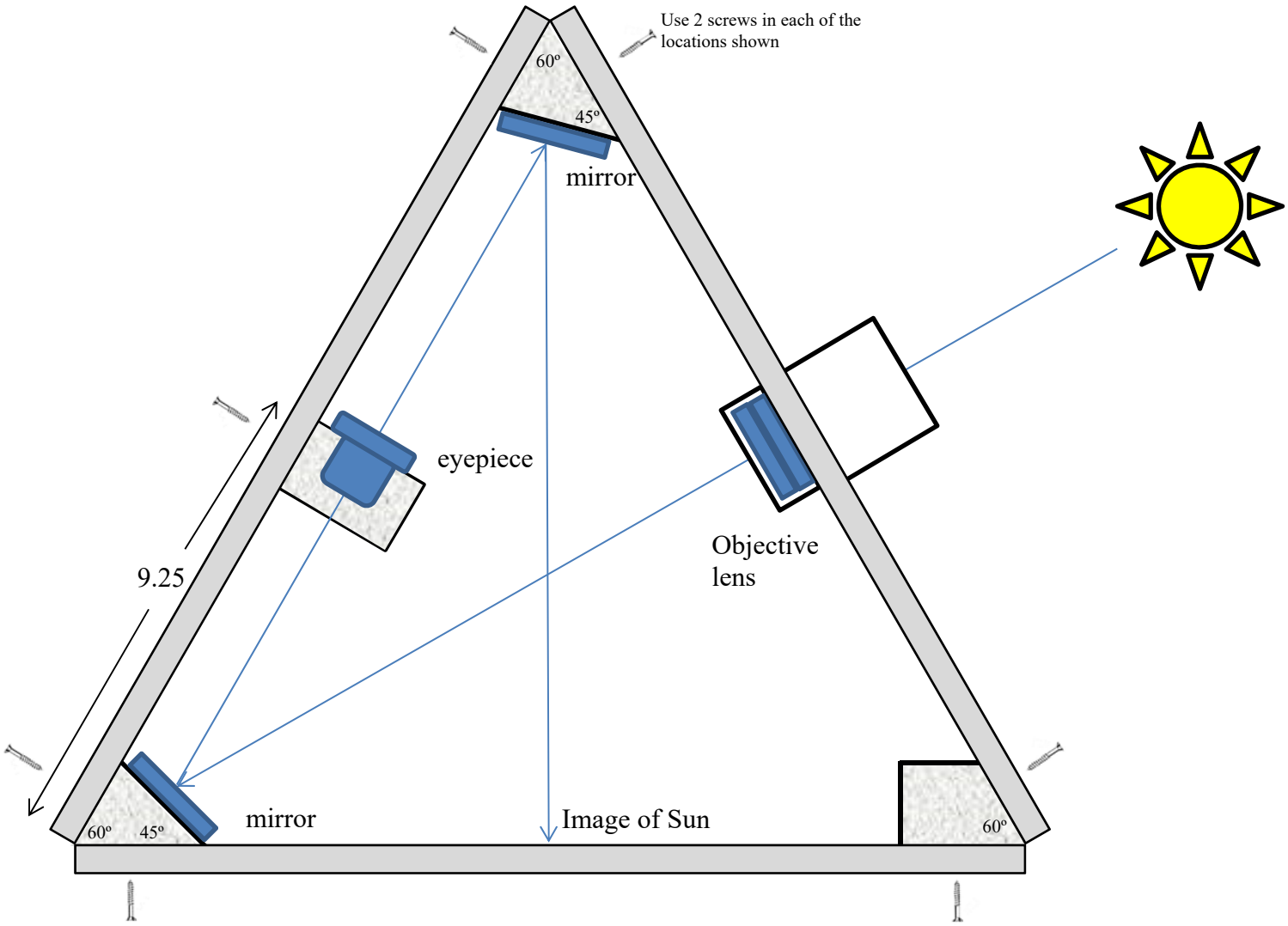


**Figure 2.** The three panels with blocks attached. The top is the base of the frame, the middle is the front-facing panel, and the bottom is the back panel with eyepiece holder.

**Figure 3.** A couple of the blocks attached to panels. The bottom one is for one of the mirror mounts. The top panel shows the front-facing block that does not hold a mirror.

**Figure 4.** The eyepiece holder.

**Figure 5.** One of the screws with felt pad to hold the mirrors in place.

Mirror Holders:

The mirrors rest on the wood blocks. In order to hold them in place, screws are used on either side of the mirror (see Figure 5). A piece of adhesive felt pad is attached to the back of a washer and a hole drilled in the pad. This is then screwed into the block close to the mirror to hold it down, with the felt resting against the edge of the mirror (try not to have it touch the front surface of the mirror to avoid scratches). You might have to place a shim behind the mirror to align the optical path parallel to the back panel to go through the eyepiece properly (see Figure 6).


**Figure 6.** The final assembly before painting. A shim can be seen on the lower left corner wedge that was necessary to align the mirror.

Assembly and alignment: (WARNING: do not look directly through the optics at the sun!)

Put the frame together by attaching the panels to the corner blocks. The panels should form an equilateral triangle. Make sure the blocks that double as mirror mounts are oriented in the proper direction. Use a clamp to temporarily hold the eyepiece holder in the right position so this can be checked. Then install the mirrors and objective lens, and make sure that when looking through the front of the frame towards the first mirror, you see the eyepiece holder and second mirror in the center. A laser pointer might be useful to help align the mirrors and lenses. Then install the eyepiece and see if you can focus an image of the sun. When you have confirmed that the eyepiece holder is at the right location, this can then be permanently screwed in.

To view the sun, a white card or piece of paper should be placed on the base to project the image on (see Figure 8). Clips could be installed on the base to hold the card in place. The inside of the frame and optics holders was painted black to minimize scattered light.

**Figure 7.** Effects of sunlight on the eyepiece. Left: The rear surface of the eyepiece showing heat damage. Right: The fix as implemented. A 1.25-inch washer with 0.5 inch center hole was attached to the back of the eyepiece.

Eyepiece modifications:

After using the telescope several times prior to and then during the August 21, 2017 eclipse, we noticed that the back of the eyepiece had become slightly damaged due to the focused sunlight when not properly aligned. Figure 7 shows the places where the plastic had partially melted. We implemented a fix by attaching a 1.25-inch washer with 0.5 inch center hole to the back of the eyepiece. This will reflect the light if it is not aligned with the eyepiece and prevent it from heating the plastic. We also removed the plastic stop from the inside of the eyepiece, as it had also been slightly damaged from the sunlight.

**Figure 8**. An image obtained during the August 21, 2017 eclipse, looking down from outside the front of the frame (visible in the upper right of the image). A white card is used to display the image projected by the optics. For the eclipse, a lazy susan was used to track the sun in azimuth. We did not have the cradle mount, so a box was used to adjust the altitude of the scope to track the sun.

Camera phone holder

In order to take images and time lapse movies of the eclipse, we built a removeable shelf that can be used to hold a camera phone on the frame that can be positioned to view the card at the bottom of the frame. A 6x3 inch board was used, and slots were cut from one of the sides as shown in the diagram below. The holder is then attached to the triangular frame near the top by putting it on the frame using the slots to hold it. By making the slots oversized, the tilt of the camera can then be adjusted so that it is centered on the projected image of the sun. The phone is extended over the edge of the holder to be able to image the base. A rubber band around the inner section of the shelf then will hold the phone and keep it from slipping.

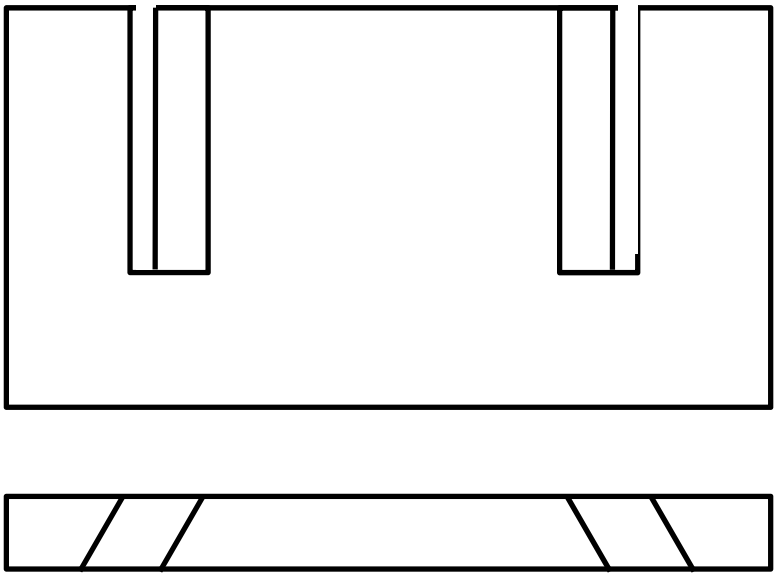
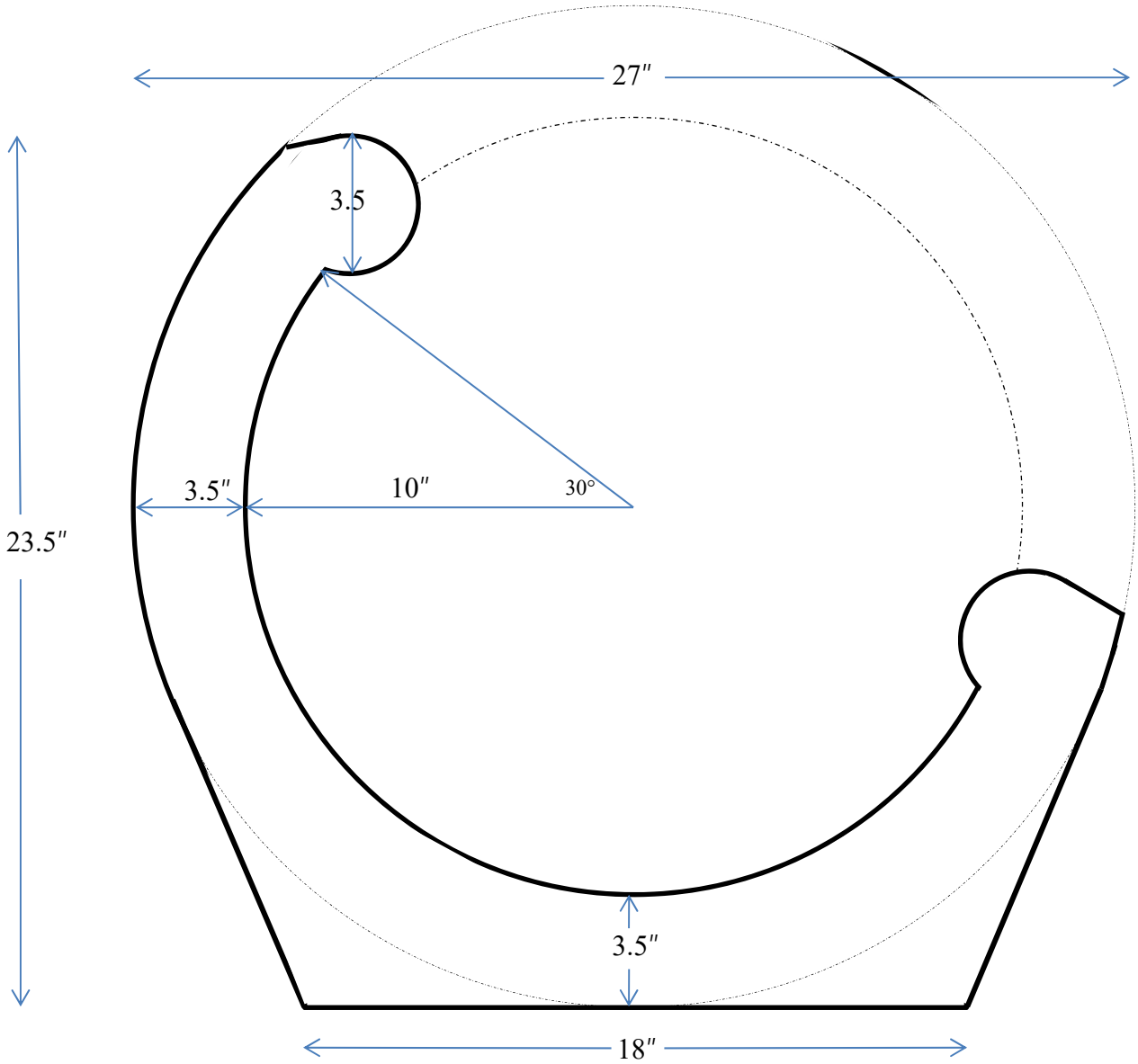


**Figure 9.** The camera phone holder in use. The end of the phone with the camera should be inside the frame, and not too far as to block the sun's image. Rubber bands around the phone keep it from slipping off the shelf

Cradle Mount




The mount consists of two parts with the outline as shown above, with six 6-inch spacers in between them to form the cradle. The surface that supports the frame is a 180° arc with radius 10 inches, rotated so that the end of the arc on the left is at a 30° angle from horizontal (see figure above). To lay out the shape, make the center of the arc 13.5 inches above the base, and draw a 10” radius arc and then a 13.5” radius arc around it. Connect the base to tangents of the 13.5” circle. Make circular forms of diameter 3.5” that define the end of the arcs, with their centers near the 10” circle.

If this pattern is flipped vertically and then translated to interlock to fill the minimum space, both parts can be obtained from a single plywood sheet of about 32x36 inches in size, and the finished side will face outwards when the parts are attached. We first drew the pattern on the plywood and then rough-cut it slightly oversized and flipped it over and traced it on the remainder of the sheet. After cutting the second piece, we clamped the two pieces together and cut it again close to the original pattern. We then filed and sanded the parts into their final form so they are mirror images of each other.

This mount will allow the solar telescope to be oriented anywhere from the horizon to straight overhead. At angles of 30° or less, the telescope would point at the sun to the right in the above diagram, and the back end raised to reach angles less than 30°. When the sun is higher than 30°, the front of the telescope would face to the left between the arms of the cradle, and then be tipped up to reach higher altitudes.