

## APPENDIX C

### WHERE IS THE MOON? CONSTRUCTING AN ASTROLABE

National and state standards in various ways call for students to learn that people have invented instruments (sometimes referred to as tools) that have helped humans learn more about the natural world. The standards also call for students to learn how to use simple instruments/tools such as magnifying glass, compass, and microscope.

MOON Project students use their eyeballs and possibly their fists to measure the Moon's angle above the horizon. Following these directions, your students can make a tool/instrument called an astrolabe to help them make those measurements more precise. Once made, they should continue to use their astrolabe as they make their Moon measurements.



(Photo courtesy Adler Planetarium and Astronomy Museum. The Mariner's Astrolabe was used to determine the latitude of a ship at sea by measuring the noon altitude of the Sun or the meridian altitude of a star of known declination.).

It was not possible to determine longitude at sea in the early days of European transoceanic navigation, but it was quite easy to determine latitude. To go to a place of known latitude, the ship sailed to that latitude and then sailed east or west along the latitude line until the place was

reached. To find the latitude of the ship at sea, the noon altitude of the Sun was measured during the day or the altitude of a star of known declination was measured when it was on the meridian (due north or south) at night. The Sun's or star's declination for the date was looked up in an almanac. The latitude is then  $90^\circ - \text{measured altitude} + \text{declination}$ .

A number of devices were used to measure the Sun's noon altitude. Among them were the quadrant, cross staff and, later, the back staff and the mariner's astrolabe. All these devices had a single use; to measure the altitude of a celestial body above the horizon. The Mariner's Astrolabe, which was popular in the late 15th and early 16th centuries, was a simple brass ring, graduated in degrees with a rotating alidade for sighting the Sun or a star. The ring was cast brass, quite heavy and cut away to keep it from blowing around in the wind. It was not a very good instrument and errors of four or five degrees were common.

It should be noted that **any instrument used to measure altitudes above the horizon can be called an *astrolabe***. The term astrolabe is often used in a context that is not the same as the classic planispheric astrolabe.

Materials needed to make a simple astrolabe:

1. A piece of cardboard (approximately 8.5" x 11" [i.e., approximately 22 x 28 cm]).
2. A drinking straw.
3. A piece of string (about a foot [30 cm] long).
4. A weight (such as a nut or washer) to which you can tie the string.
5. The reverse protractor – see drawing on the next page.
6. Glue.
7. Sharp object to punch a hole in the cardboard.
8. Scissors to cut the cardboard.
9. Scotch tape.

Directions for making the astrolabe:

1. Using a photocopier, make a copy of the reverse protractor on the next page such that the straight edge of the protractor is the same length as the longer straight edge of the cardboard (i.e., about 28 cm or 11 inches).
2. Use a few dabs of paste to paste the protractor to the cardboard with the straight edge of the protractor lining up with the longer straight edge of the cardboard.
3. Cut out the cardboard around the protractor.
4. Poke a hole in the cardboard about  $\frac{1}{4}$  inch (.5 cm) from the straight edge of the cardboard, directly above the  $0^\circ$  mark. It may be helpful to start the hole with a straight pin and then widen the hole with scissors. Make the hole as close to the straight edge as possible.
5. Tie the weight to one end of the string. (Once tied to the string, the weight should not extend beyond the curved edge of the protractor.)
6. Thread the other end of the string through the hole and tie it in place.
7. Tape the straw to the straight edge of the cardboard.
8. Trim the two ends of the straw so that the ends do not extend quite to the end of the straight edge.

Directions for using the astrolabe to measure the angle of the object above the horizon:

1. Hold the astrolabe with the straight edge of the cardboard on top, parallel to the ground, with the string hanging down. (If the straight edge is parallel to the ground, then the string should cross the  $0^\circ$  mark on the protractor.)
2. Use one eye to look through the straw at the Moon (or whatever celestial body you're trying to position), allowing the string to hang free.
3. With the cardboard astrolabe still in place and the straw pointing toward the Moon, when the string stops swinging, use your index finger and thumb to pinch the string against the cardboard. Your thumb should be on the back side of the cardboard opposite your index finger so that the string will be held in place against the cardboard.
4. Use the lines radiating from the point toward the curved edge to estimate the angle between the object you're observing and the horizon. (For example, if the string is positioned half way between the  $40^\circ$  and  $50^\circ$  lines, the object you're observing is about  $45^\circ$  above the horizon.)

Because of the crudeness of this tool, you probably cannot measure any more accurately than within 5-10° of the object's actual position, but your estimate is probably better than "eyeballing" the object's position or using your fist to make the estimate.



