ACTIVITY GUIDE

ASTROLABE

Earth Systems

Making a Simple Astrolabe

Used to determine the latitude of a ship at sea by measuring the altitude of the Sun or star, the mariner's Astrolabe was popular in the late 15th and early 16th Centuries.

Photo courtesy Adler Planetarium and Astronomy

Astrolabe

EXPLORING HOW THE ANCIENTS EXPLORED

The astrolabe was invented in Greece either by Hipparchus, a 2nd century B.C astronomer, or Apollonius of Perga, a 3rd century B.C. mathematician. For many centuries, it was used by both astronomers and navigators, and especially by the 15th century explorers who used it to determine latitude, longitude, and time of day

Overview of Activity

The astrolabe is a very ancient astronomical computer for solving problems relating to time and the position of the Sun and stars in the sky. Several types of astrolabes have been made. By far the most popular type is the planispheric astrolabe, on which the celestial sphere is projected onto the plane of the equator. A typical old astrolabe was made of brass and was about 6 inches (15 cm) in diameter, although much larger and smaller ones were made.

Astrolabes are used to show how the sky looks at a specific place at a given time. This is done by drawing the sky on the face of the astrolabe and marking it so positions in the sky are easy to find. To use an astrolabe, you adjust the moveable components to a specific date and time. Once set, the entire sky, both visible and invisible, is represented on the face of the instrument. This allows a great many astronomical problems to be solved in a very visual way. Typical uses of the astrolabe include finding the time during the day or night, finding the time of a celestial event such as sunrise or sunset and as a handy reference of celestial positions. Astrolabes were also one of the basic astronomy education tools in the late Middle Ages. Old instruments were also used for astrological purposes. The typical astrolabe was not a navigational instrument although an instrument called the mariner's astrolabe was widely used. The mariner's astrolabe is simply a ring marked in degrees for measuring celestial altitudes.

An astrolabe (pronounced AS'-tro-layb) is a device used for measuring altitude, including the height of objects in the sky.

Materials Needed

1 - piece of cardboard, manila file folder, or other stiff paper

1 - piece of dark thread or string 12 inches (30 centimeters) long.

1 - small weight, such as a metal washer

1 - plastic drinking straw

1 - copy of an astrolabe drawing

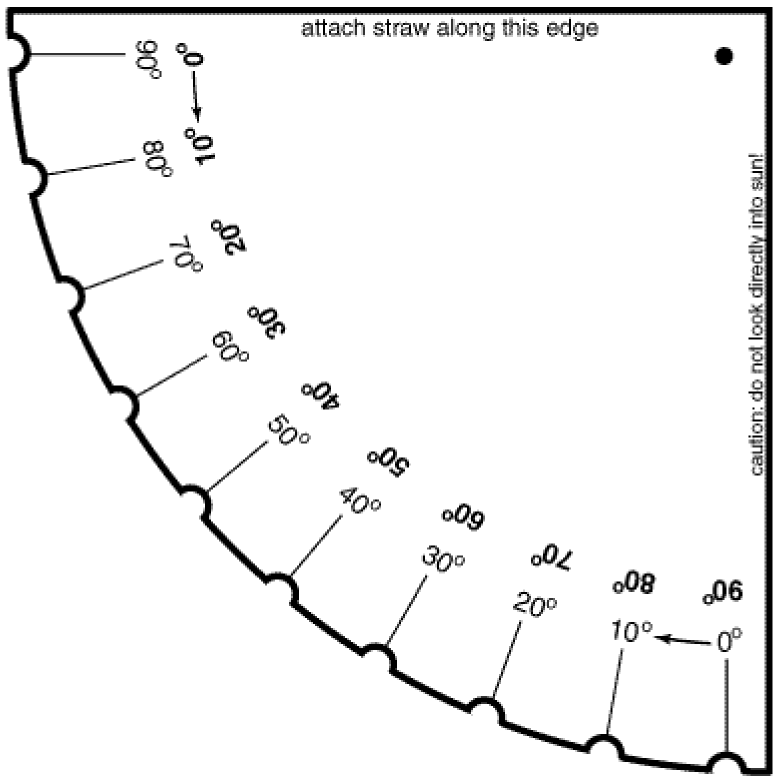
1 - container of glue or paste

1 - pair of scissors

1 - roll tape

1 - paper hole puncher

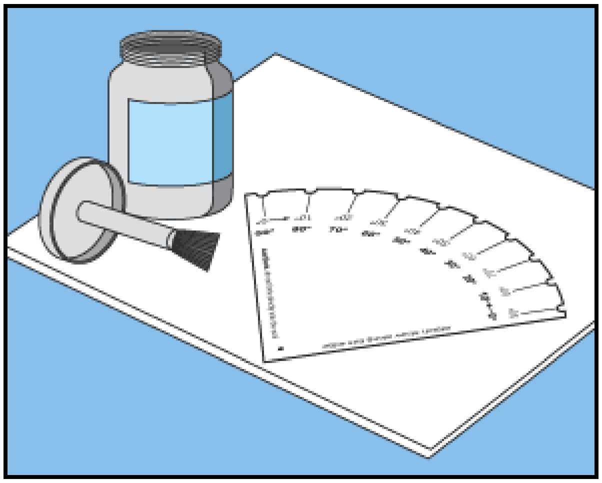
07 - Astrolabe Drawing

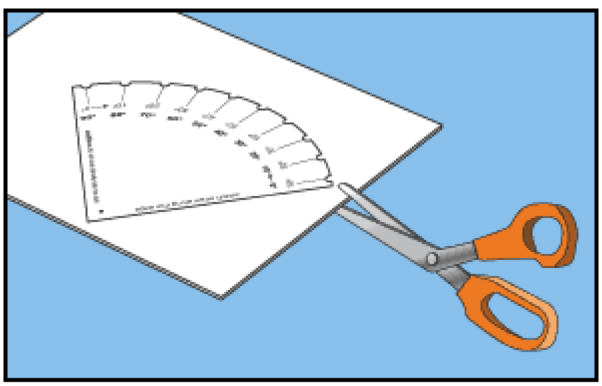


What to Do

1. Print out a copy of the **astrolabe drawing.**

2. Glue the copy of the astrolabe drawing to a piece of cardboard or file folder. Cut the astrolabe out with scissors.

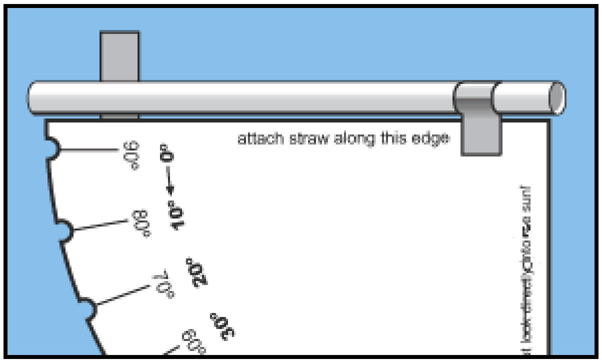




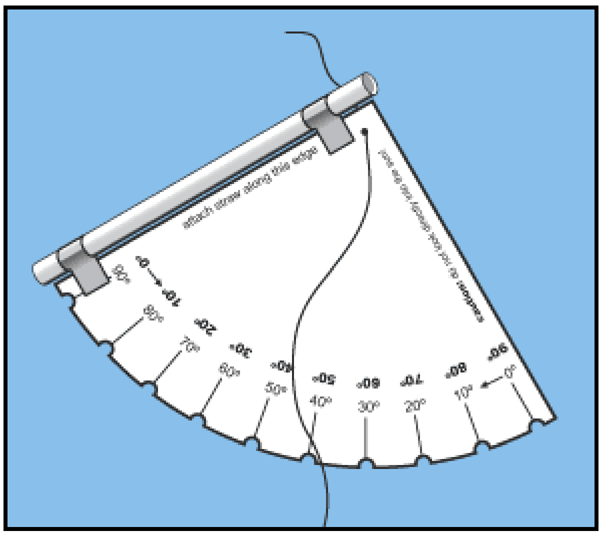
3. Using scissors or a paper hole-puncher, carefully make a small notch at each of the lines marked along the curved edge of the astrolabe. These notches will come in handy when you're measuring the angle between two celestial objects and you have to hold the astrolabe horizontally.

4. Cut a drinking straw to the same length as the sides of the astrolabe.

5. Tape the drinking straw to the edge of the astrolabe marked "Attach straw to this edge." Be careful to not tape the straw on the astrolabe, but just on the edge.

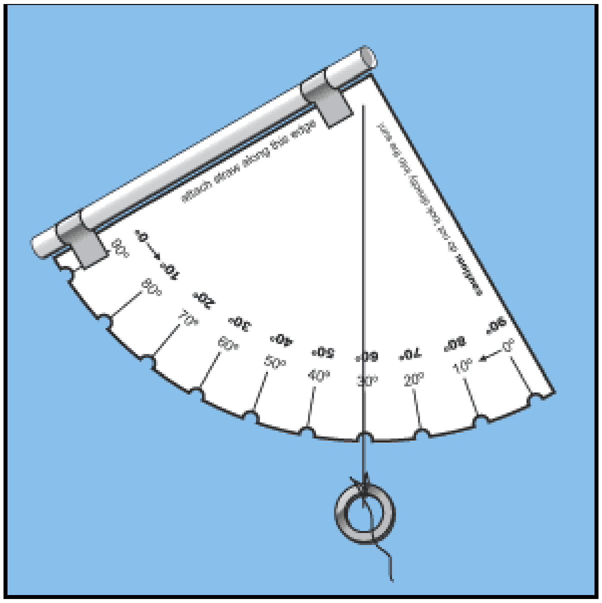


6 Carefully poke a small hole through the astrolabe where the "X" is marked, pass the string through it, and either knot the string at the back of the cardboard or tape it there.



7 Tie the small weight to the opposite (front) end of the string as shown.

You have now constructed an astrolabe!



What's Going On

The astrolabe was invented in Greece either by Hipparchus, a 2nd century B.C. astronomer, or Apollonius of Perga, a 3rd century B.C. mathematician. For many centuries, it was used by both astronomers and navigators, and especially by the 15th century explorers who used it to determine latitude, longitude, and time of day.

AstrolabeDerived from "Making Measurements of Objects in the Sky": from Science Resources for Schools: Doing Science, Vol 3, No. 1. Copyright 1985 by the American Association for the Advancement of Science & the Smithsonian Institution.

Using a Simple Astrolabe

An astrolabe can be used to measure the altitude of an object, including changes in the Sun's path over the course of the year. Tracking these changes can help explain why days are longer in the summer and shorter in the winter.

Workers at the observatory of Taqf ad-Din in Istanbul (in the year 1577) work with an astrolabe. The painting is from Shahinshah-nama (History of the King of Kings), an epic poem by "Ala ad-din Mansur-Shirazi.

Photo courtesy Johann Wolfgang Goethe Institut.

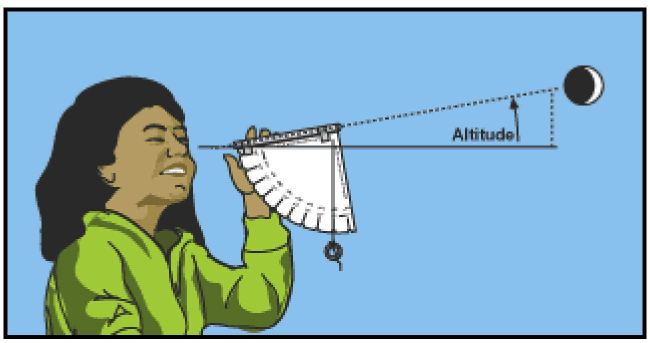
08 - Altitude of the Sun Chart

Date						
Time						
Altitude of the Sun	1					
	2					
	3					
	Mean or Average					

EXPERIMENT 1

Measuring the Altitude and height of Trees and Buildings

1. To become familiar with how an astrolabe works, practice measuring the altitude (angular height) of trees or buildings. To make a proper measurement, look at the top of the object through the straw.
2. Have someone read the altitude in degrees from the side of the astrolabe. The point where the string crosses the scale is the proper measurement.
3. Practice using your astrolabe by measuring and recording another tree or building of a different height.



Now that you have an understanding of how an astrolabe works, you can use it to measure the motion of the Sun.

Activity : Measuring Altitude Using an Astrolabe

The challenge: Determine the height of a tall object on the school grounds such as a flagpole, a chimney, or other structure identified by your teacher. You will only be allowed the use of a meter stick. You may think that you don't have the knowledge to make such a measurement with so little equipment, but you would be wrong!

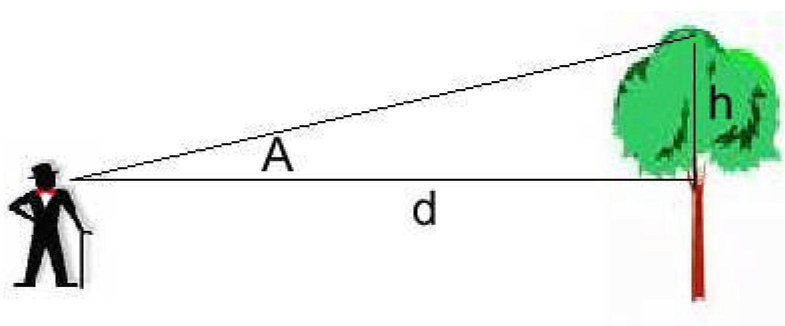
Key Concept

The measurement method known as triangulation can be used to indirectly determine the heights of tall structures or the altitudes of projectiles.

Objective: You will use your astrolabe to measure the height of a large object using tangent ratio.

Directions: First have the students use their astrolabe to measure the angle of elevation of different objects. This will require the students work with a partner. Have one person view the top of a tree or other tall object using the astrolabe. The other person will read the angle from the side. Have the students switch places and perform another measurement. Discuss with the students their results and note the variance between their measurements.

Next make a sketch showing how an astrolabe can be used to measure height or altitude.



Tangent Table			
Angle in degrees	Ratio	Angle in degrees	Ratio
10	.176	45	1.0
15	.268	50	1.088
20	.364	55	1.176
25	.466	60	1.268
30	.577	65	1.364
35	.700	70	1.466
40	.839	75	1.577

Procedures:

1. One student stands at base of object (building or tree) and walks away in straight line to an even distance (far enough to be able to site the top of the object).

3. Measure distance from base of object (building or tree) to student with altitude locator.

4. Measure height of student to eye level.

5. Student sites to top of object and finds number of degrees of angle marked by position.

6. Look up tangent ratio from above table and multiply by the distance between the object's base and the siting position. Subtract the eye level height of the student who found the angle. The result is the height of the object.

Make sure you point out the only distance that is easy to measure is from the person to the object along the ground (d). This will be the adjacent side of the triangle. The height of the object will be the opposite side. Since tangent is defined as opposite over adjacent, we can find the missing quantity (the height).

Go outside to measure a couple different objects. It is best to have two or three objects for them to choose from such as a building, a flag pole, and a tree.

Determine the Height of an Object				
Object	Distance From Base	Degrees of Angle	Tangent Ratio	Height of Object

EXPERIMENT 2

Measuring the Altitude of the Sun

1. Because it is harmful to look directly at the Sun, a new method for measuring the Sun's altitude must be used. Hold the astrolabe so that the straw points in the direction of the Sun. Do not look through the straw.

2. Aim the straw so that you see the shadow of the straw on your hand. Move the straw slightly until a small circle of light forms on your hand. The straw is now pointing directly at the Sun.

3. Ask someone to read the Sun's altitude (in degrees) where the string crosses the scale. Take note of the time of day the reading was made.

4. One day a week, at the same time each day, measure the altitude of the Sun with your astrolabe. Make three consecutive measurements and record them in the chart provided. Be sure to include the date.

5. As the weeks progress, look at your measurements of the Sun's altitude. Can you detect a change? Is the altitude increasing or decreasing? Is there a pattern of change? How can you explain these changes?

Derived from "Making Measurements of Objects in the Sky": from *Science Resources for Schools: Doing Science, Vol 3, No. 1*. Copyright 1985 by the American Association for the Advancement of Science & the Smithsonian Institution.

The Astrolabe: An Instrument with a Past and a Future
www.astrolabes.org

Jean Fusoris was born in Giraumont in the Ardennes region of France ca. 1365. His father was a pewterer. He studied arts and medicine, attaining the bachelor's degree in 1379, returning after learning his father's craft for his master's degree which was attained in 1391. He served as one of the master's regents in Paris until 1400. He established a school and opened an instrument workshop in Paris making astrolabes, clocks and other instruments. He continued to study theology and accumulated various canonries. He was elected a member of the French embassy in England in 1415, where he met Richard of Courteny, bishop of Norwich. Norwich bought an astrolabe from Fusoris but did not pay for it. When Fusoris returned to England in an attempt to collect the debt, war broke out between France and England and he was arrested as a suspected spy when he returned. He was exiled to Mezieres-sur-Meuze and later to Reims. He continued to accept and fill commissions for instruments while in exile. He died in 1436. In addition to his instruments, Fusoris wrote a treatise on the astrolabe in which he detailed the improvements he incorporated into his instruments and other tracts on mathematics and astronomy.

Front of Fusoris astrolabe (Photo courtesy Adler Planetarium and Astronomy Museum)

Back of Fusoris astrolabe (Photo courtesy Adler Planetarium and Astronomy Museum)

The astrolabe in the picture is from the **Adler Planetarium and Astronomy Museum** in Chicago, IL, USA (catalog number: W-264). It is 16.3 cm in diameter (6.4 inches) with an overall height of 20.6 cm (8.1 inches). The mater thickness is 0.8 cm (.31 inches).

The mater limb is cast brass and soldered to the hammered back plate. The thone is functional and non-decorative and was cast with the rim of the mater. The limb has an hour scale labeled 12-12 twice with divisions for each 20 minutes. Inside the time scale is an unmarked scale of degrees with a division for each degree. The degree divisions can be used with the time scale by associating each degree with four minutes of time. The rete has 21 stars of which 20 are labeled. All Fusoris astrolabes had unique star pointers labeled Venter Ceti and Cornu (in the picture they are the two pointers near the limb at about 8 o'clock just below the rule) that are a signature for his instruments. Cornu (beta Arietis) is in the wrong position on all Fusoris astrolabes. All the numerals on the plate are Gothic script and were engraved.

The altitude arcs are drawn for each 2° and the azimuth arcs for each 10°. There are three plates (tympans) for 42°, 36°, 45°, 49° and 52°. The 36° side is probably a later addition as it is in a different hand, the numerals are not in the Gothic style and it includes a crespuscular arc.

The back of the instrument has an eccentric calendar scale, equal/unequal hour conversion scale and a shadow square. The alidade is not original. The date of the vernal equinox is March 11, which is accurate for the date of the instrument.

Fusoris was one of the first philosopher-churchmen to set up a commercial workshop to produce instruments. He was successful and at least 13 of his astrolabes survive. His workshop represented several turning points in the history of instrument manufacture in general and the history of the astrolabe in particular. First, it was unique at the time for a person of his prestige and position to establish a commercial enterprise. Prior to this time, most astrolabes were produced by individuals or nameless guild craftsmen. It cannot be said that Fusoris started a revolution in the instrument industry, but his shop certainly anticipated later *ateliers* headed by prominent scholars. His influence on the astrolabe cannot be overstated. He was the first integrate all of the astrolabe elements into a uniquely European instrument and the design elements of Fusoris' astrolabes become virtually universal. Among his innovations were dividing the limb by equal hours, the use of a rule *(ostensor)* on the front and improvements in the design of the alidade. His elegant and artistic design of the astrolabe components were a milestone compared to the bulky and awkward instruments that preceded his.