

Making A Sundial

Student Objectives:

The student will:

- design, construct and demonstrate the use of a gnomon by constructing a sundial
- track the movement of a shadow cast by the gnomon over the course of a day
- predict the length of shadow at a specified time.

Materials:

- paper plates, 9 in. white (1 per student)
- plastic drinking straws (1 per student)
- pencils (regular, red and blue)
- rulers
- scissors
- tape
- sidewalk chalk (white or yellow)
- compass

Key Words

gnomon
sundial

Time:

Sundial construction (20 minutes)
Recording shadows on dial (four 10 minute sessions)
Reading, Science Journal and discussion (45 minutes)

Background Information

A sundial is an instrument that indicates the time of the day by the shadow, cast on a surface of an object, marked to show hours or fraction of hours. Although any object whose shadow is used to determine time is called a gnomon, the term is usually applied to a style, pin, metal plate or other shadow-casting object that is an integral part of a sundial.

It is not known when the sundial was invented, or who invented it. Sundials can be found in many ancient civilizations, including the Babylonian, Greek, Egyptian and Roman Ages. Sundials exist in most countries, in various forms, differing in construction according to the knowledge of astronomy and mathematics. Sundials are also abundant in the Far East and China and Japan, but not much is known in terms of their history.

The earliest extant sundial, an Egyptian instrument of 1500 BC, is a flat stone on which is fixed an L-shape bar whose short vertical limb casts a shadow measured by markings on the longer horizontal limb. In the 1st century AD, the sundial was greatly

improved by setting the gnomon parallel to the earth's axis of rotation so that the apparent east- to-west motion of the sun governs the swing of the shadow.

The oldest known dials at present are those of Grecian origin and were invented by Chaldean Berosus, who lived about 340 BC. Four of these sundials were discovered in Italy between the years 1746 and 1762. It is also evident that this form of sundial was used by the Arabians (who gave great study to gnomonic), and was also popular among the Romans.

The earliest known sundials in England are those of Saxon origin found on some of the oldest churches. Most of the early examples are semi-circular, and although the spaces into which the dial is divided vary considerable in number and size, they seem to point to the early Norse practice of dividing time into tides.

One of the earliest English historians records the fact that the hours were shorter or longer according to the seasons, and this testimony is born out by existing dials found on faced stones built into porches, windows, and corners of buildings. These dials consist of circles and half-circles, divided by lines which radiate from a hole in the center to the circumference. The number of lines differ considerable and the spaces are also of unequal size.

In later years the face of the dial was more divided, and gradually moved from being quite plain in appearance to taking a more ornate shape. Sundials continued to be placed into use long after clocks were available and in the 17th century many fine specimens were erected. Until watches began to be made in numbers the sundial ruled supreme. Clocks did not in any way diminish the popularity of sundials, but rather the clocks helped to keep sundials in existence, as clocks stopped running and lost time, sundials were long employed for setting and checking clocks.

Solar (or apparent) time indicated by sundials and clock (or mean) time is different and must be correlated by the use of tables showing daily variation in sun time. A correction must also be made for the difference in longitude between the position of a sundial and the standard time meridian of a given locality. Although sundials are still used in many areas, they are regarded today as adornments usually found in gardens. Sundials placed in gardens will not generally tell accurate time, however, except by coincidence.

The largest sundial in the world was constructed in 1724 in Jaipur, India. This sundial covers almost one acre and has a gnomon over 100 ft high surmounted by an observatory.

Procedure (construction)

1. Pass out materials to students, reminding them of the proper usage of scissors.
2. Ask the students to find the center of the paper plate and mark it with an X. Folding the plate in half going in both directions can do this.
3. With a pencil have the student make four registration marks along the edge of the paper plate, with one mark longer than the others. These marks will help the students to be certain that their plates are placed in the same location for each measurement. If possible, have the plates in the same location all day long, either by staking the finished sundials outside, or marking the ground where each dial is placed.

4. Have the student make four- $\frac{1}{2}$ inch cuts lengthwise in one end of the straw. These should be spaced evenly apart, not all together. Flare out the cut pieces and tape the four ends to the plate centered over the X that they have written on the paper plate. Make sure the students take their time in taping the straw so it is in the center of the plate and perpendicular to the plate.
5. Measure and cut the straw to a height of 2 inches.

Procedure (data collection, day 1)

1. The first time working with their sundials should be as early in the morning as possible.
2. Pass out pencils, rulers, and chalk. The students will need to have the sundial that they previously made.
3. Have the students place their sundials in a sunny spot of asphalt or concrete. Have them make four chalk marks, which line up with the ones on the edge of their sundial. Remind them that one of the marks on their sundial is longer than the others, so one of their chalk marks should also be longer. Have the students write their initials inside the sundial tracings. The marks will help them place their sundial in the same location when they come out later in the day.
4. Have the students carefully trace the straw's shadow on the plate with a pencil, and then darken in the shadow so it can be seen easily. At the top of the shadow the students record the time of day.
5. The students then measure the length of the shadow they traced and record it on their worksheet, along with the time of the day.
6. The students then draw a representation in the third box on their worksheet of where the sun is located in the sky. To do this, have the student stand on the north side of the plate (facing toward the south) directly in front of their straw. They should then record the position of the Sun on the worksheet. (Note: Warn them to never look directly at the Sun!)
7. Repeat steps 4 through 6, at least three more times before 2 pm.
8. After the last measurement, ask students to predict where they think the shadow of the straw will be at 2 pm and where the sun will be in the sky.
9. Using a red pencil, have them outline the predicted shadow on their sundial and the sun on their worksheet.

Procedure (data collection, 2pm same day or next day)

1. Return the sundials to the marked locations (from day 1) at 2 pm, and have the students determine how close their tracings in red are to where the shadow of the straw is actually falling on their sundial. Then with the blue colored pencil the students should trace the actual 2 pm shadow and place the sun in its appropriate position on their worksheet.
2. Students should complete their Science Journal pages.
3. Lead a discussion of their findings and the reasons for the apparent motion of the sun. Allow students to modify their answers in their Science Journal as their knowledge of the subject increases.

Further Research

1. Decorate your sundial with 'sun' art.
2. Make a sundial that is suitable for a garden installation. Line a springform pan with waxed paper. Pour plaster of paris (or concrete mix) into pan. Sundials could be imprinted with objects (leaves, hands, etc) while still wet, or could have small objects (marbles, pieces of tile or stones) imbedded in them. Before plaster is set, stick a wooden dowel, plastic rod or metal rod into the center for the gnomon. Support the gnomon in an upright position until the sundial dries. One way to do this would be to tape strips of cardboard or heavy paper bracing from the gnomon to the sides in several places. Sundials may be painted with sun markings when dry.
3. Research Stonehenge. Make clay models of the circle of stones.

Related Reading

- *Anno's Sundial* by Mitsumasa Anno (Philomel Books, 1987)
This book cleverly uses pop-up models and sundials as experimental tools. The text clearly explain the basic concepts of solar time, seasons, latitude and longitude, and the sundial. At the end, Anno describes how to construct a sundial that will tell time accurately.
- *Tools of Timekeeping: A Kid's Guide to the History and Science of Telling Time* by Linda Formichelli & W. Eric Martin (Nomad Press, 2005)
From ancient civilization's earliest calendars and shadow clocks to the atomic clocks of today, the history of time measurement emerges in this interactive guide. The study of the evolution of timekeeping devices and the inventors of calendars and clocks is included and loaded with interesting facts and trivia. Fifteen hands-on activities help demonstrate humans' changing relationship with time over the centuries.

Internet Sites

<http://www.nsta.org/301>

National Science Teacher Association. Astronomy with a stick--Daytime astronomy activities.

<http://www.sundials.co.uk>

Sundials on the internet. Extensive links site includes sundial projects, books, societies, sundial trails all over the world and more.

<http://www.fsec.ucf.edu/bldg/active/fenestration/Disney/index.htm>

The Team Disney and Florida Solar Energy Center Sundial. A ariel photo and a photo of the gnomon of the Disney sundial installation can be found here:

<http://sundials.org/registry/regphotos/221.htm>

EnergyWhiz

Decorate your sundial and submit a photo of it to the EnergyWhiz website at:

<http://energywhiz.com/>. If your design is selected to include on the site, we will send you an EnergyWhiz t-shirt.

Making A Sundial

			.1	.2	.3	.4	.5	.6
Earth and Space	Standard 1	SC.E.1.2-	X					
	Standard 2	SC.E.2.2-						
Nature of Science	Standard 1	SC.H.1.2-				X		
	Standard 2	SC.H.2.2-	X					
	Standard 3	SC.H.3.2-						

Benchmark SC.E.1.2.1 - The student knows that the tilt of the Earth on its own axis as it rotates and revolves around the Sun causes changes in season, length of day and energy available.

Grade Level Expectations

The student:

Fourth

- knows that the tilt of the Earth causes the change of seasons, length of day, and the amount of energy available.

Benchmark SC.H.1.2.4: The student knows that to compare and contrast observations and results is an essential skill in science.

Grade Level Expectations

The student:

Third

- knows that to compare and contrast observations and results is an essential skill in science

Fourth

- knows that comparisons between experiments can be made when conditions are the same

Fifth

- uses strategies to review, compare and contrast, and critique scientific investigations
- knows that an experiment must be repeated many times and yield consistent results before the results are accepted.

Benchmark SC.H.2.2.1: The student knows that natural events are often predictable and logical.

Grade Level Expectations

The student:

Third

- makes predictions and inferences based on observations
- uses charts and graphs to understand patterns of change

Fourth

- makes predictions based on data from picture graphs, bar graphs and line graphs
- knows basic patterns, sequences and cycles occurring in nature

Fifth

- makes a prediction for a new investigation using the data from a previous investigation
- understands that change is constantly occurring and uses strategies to analyze different patterns of change.

Making A Sundial

gnomon – the raised projection on a sundial, which casts the shadow.

sundial – a sundial consists of the dial plate marked out with hour lines, and a "gnomon", the raised projection that casts the shadow. The inclined edge of the gnomon, called the "style", produces the working edge of the shadow that is used to tell the time. The style is oriented parallel to the earth's axis, pointing toward the point in the sky around which the (imaginary) celestial sphere rotates once every 24 hours, which is very close to the location of Polaris, the pole star visible at night.

Making A Sundial

Use the attached worksheet for placement of Sun in the sky as you read your sundial at specified times of the day.

Questions:

1. How did the shadows move across your plate?

2. When was the shadow the longest? Where was the Sun?

3. When was the shadow the shortest? Where was the Sun?

4. Why do you think the shadows change length?

5. How could you use a shadow to tell the time of day?

6. How accurate was your prediction for where the shadow would fall at 2 pm?



Sundial Data Sheet

Date _____

Time	How long is the shadow?	Where is the Sun in the sky? (Remember, NEVER look at the Sun!)
		
		
		
		
		
		