

RAFT IDEAS

Topics: Time measurement, Earth motion, Observations

Materials List

- ✓ Paper
- ✓ 2 Drinking straws or a pencil
- ✓ Media tray from a CD case, with a hole in the center
- ✓ CD
- ✓ Copy of blackline masters of Sundial faces (see page 3)
- ✓ Tape or glue
- ✓ Protractor
- ✓ Magnetic compass

This activity can be used to teach:

CO Science Standard 3:
Earth Systems Science

- Shadows
- Sun position

Grades: K, 1, 2, 8, HS
CO Math Standard 4:
Shape, Dimension, and Geometric Relationships

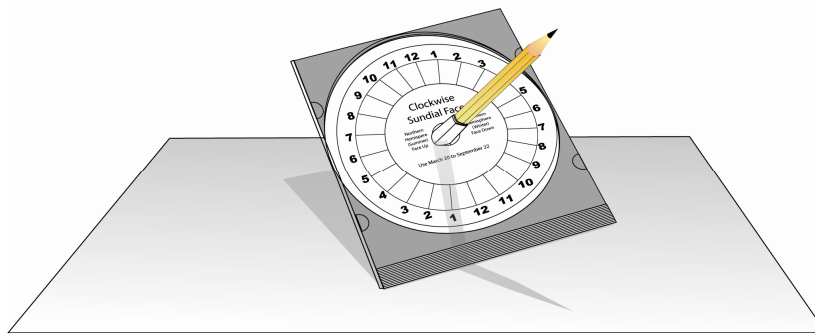
- Time Measurement
- Grades: 2, 3, 4



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Time for Shadows

An equatorial sundial, one of the first solar “powered” clocks



This quick to assemble equatorial sundial can easily adjust for daylight savings time!

Assembly

1. Cut a 5 cm x 28 cm (2" x 11") long paper strip.
2. Tightly wrap the paper strip around the middle of a straw or pencil.
3. Insert the paper wrapped straw or pencil into the center hole of a media tray. Slit another straw lengthwise and insert into the straw, if used, to stiffen the straw.
4. Adjust the diameter, as necessary, by cutting or by using a longer paper strip.
5. Copy the blackline master on page 3 and cut out the hour dials. (Alternate assembly: create a 12 cm (4 3/4") paper disk and use a protractor to draw hour radii at 15 degree intervals from 0 to 180 (or more – at the poles 360 could be used!). Label with the hours as shown on the blackline master.
6. From the center of the paper disk cut out a shape, circle or square, that will be a little bigger than the hole in the CD.
7. Tape or glue a dial to each side of a CD. Secure the CD onto the media tray with appropriate face showing. This action will slightly narrow the center opening and further secure the pencil, or straw, to the media tray.

To Do and Notice (Safety Note – Never look directly at the Sun!)

1. Research the latitude for the sundial location. Calculate the colatitude by subtracting the latitude from 90°.
2. Place the sundial on a level surface. The angle between the level surface and the media tray base of the sundial must be equal to the colatitude. Measure the angle with a protractor and adjust as necessary by moving the pencil in or out of the media tray. If using a straw, move or cut the straw to adjust the angle.
3. From about March 20 to about September 22 the hour dial and pointer must face northward and be on the top side of the media tray. From about September 22 to about March 20 the dial and pointer must face southward and be on the underside of the media tray. The easiest way to accomplish that is to flip the sundial over on those dates, remove and flip the hour dial, and adjust the pointer, as needed, to reestablish the correct angle (= to the colatitude). Adjust the hour dial as needed.
4. The pointer of the sundial must point northward or southward, depending on location and the time of year. Using true north, rather than magnetic north will increase the sundial's accuracy. The difference between the two (called magnetic declination) varies by location and is listed on some maps and on the Internet.
5. Adjust the dial so that the 6 AM/ 6 PM line is horizontal. If Daylight Savings Time (DST) is in effect, turn the dial so that the 7 AM mark is horizontal.
6. Observe the oriented sundial. Compare, as the months go by, to other clocks.

The Science Behind the Activity

Earth rotates on its axis once every 24 hours. As the Earth spins, the sun appears to move across the sky from east to west.

The Earth revolves around the Sun once a year. Over the years, patterns have been discovered in the apparent position of the Sun in the sky, the duration of daylight, and the positions of shadows. The axis of the Earth's rotation, rather than being perpendicular to the plane of the Earth's orbit around the Sun, is tilted about 23.4 degrees. The tilt gives rise to the changing seasons and the changing the height of the Sun above the horizon for times that are 24 hours apart. People in prehistoric times began using the movement of shadows to track the passage of time. The first sundials were probably simply shadows cast by sticks. At least 6,000 years ago Egyptians built stone observatories. These and other early observatories (Stonehenge in Europe), allowed people to make ongoing observations of repeating patterns, such as longer days in the summer and shorter days in the winter. Precise and on-going measurements eventually enabled predictions of special dates, such as the summer and winter solstices and vernal (spring) and autumnal (fall) equinoxes. This critical information helped people know when to plant and harvest crops or when to expect seasonal events, such as floods or animal migrations.

An Equatorial Sundial has the dial parallel to the Earth's equator with a perpendicular pointer (gnomon), which is thus parallel to the Earth's axis of rotation. The Equatorial Sundial is really a small model of the Earth with the dial representing the Earth's Equator, and the gnomon representing the Earth's axis. An Equatorial Sundial can be used at any latitude (locations north or south of the equator), as long as the gnomon is adjusted to point north or south depending on the season and location. An advantage of the Equatorial Sundial is that the hour markings are drawn at regular intervals (15 degrees) rather than in the more complex arrangements needed for other sun dials. In addition the dial can be adjusted by rotation so the sun dial's "time" can more closely match local clock time.

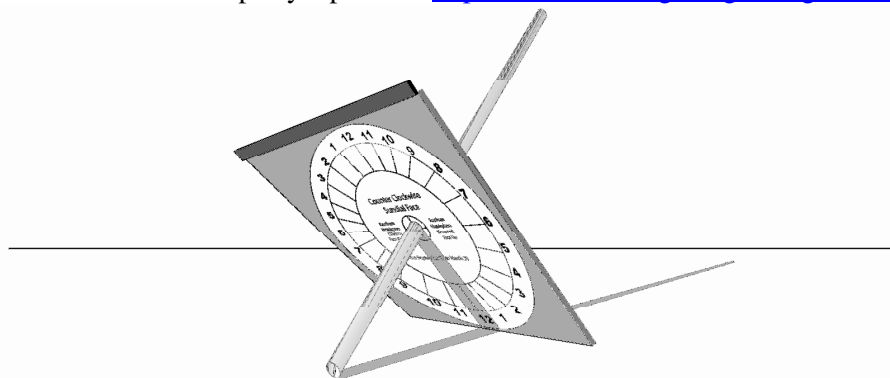
Sundial time and "clock" time are not always the same. Some areas use Daylight Savings time, which shifts the time one-hour "forward" during the summer months. The Earth is divided into 24 sections with the dividing lines running roughly from the North Pole to the South Pole. The exact boundaries of each time zone are often not straight lines due political boundaries or other large population center needs. There can be a significant difference between sun and clock time depending on how the time zone is configured and the location of the sundial within the time zone. Additionally, because of the elliptical orbit of the Earth and the tilt of the Earth's axis, sundials run a few minutes fast or slow, depending on the time of year. This issue is addressed by the Equation of Time which appears on many sundials as the analemma, a graphic that provides details on the corrections needed.

Taking it Further

Why does a sun dial need more than a 180° of markings closer to the poles? Why might the sundial and a clock show different times for a specific location?

Web Resources (Visit www.raft.net/more for how-to videos and more ideas!)

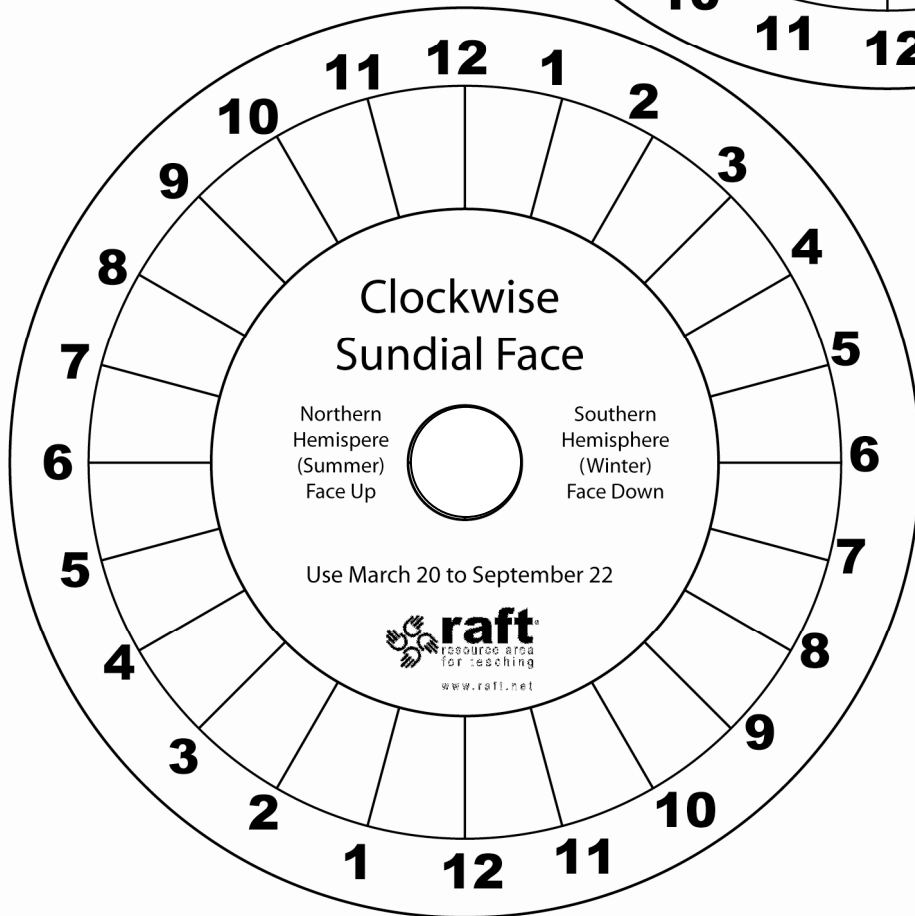
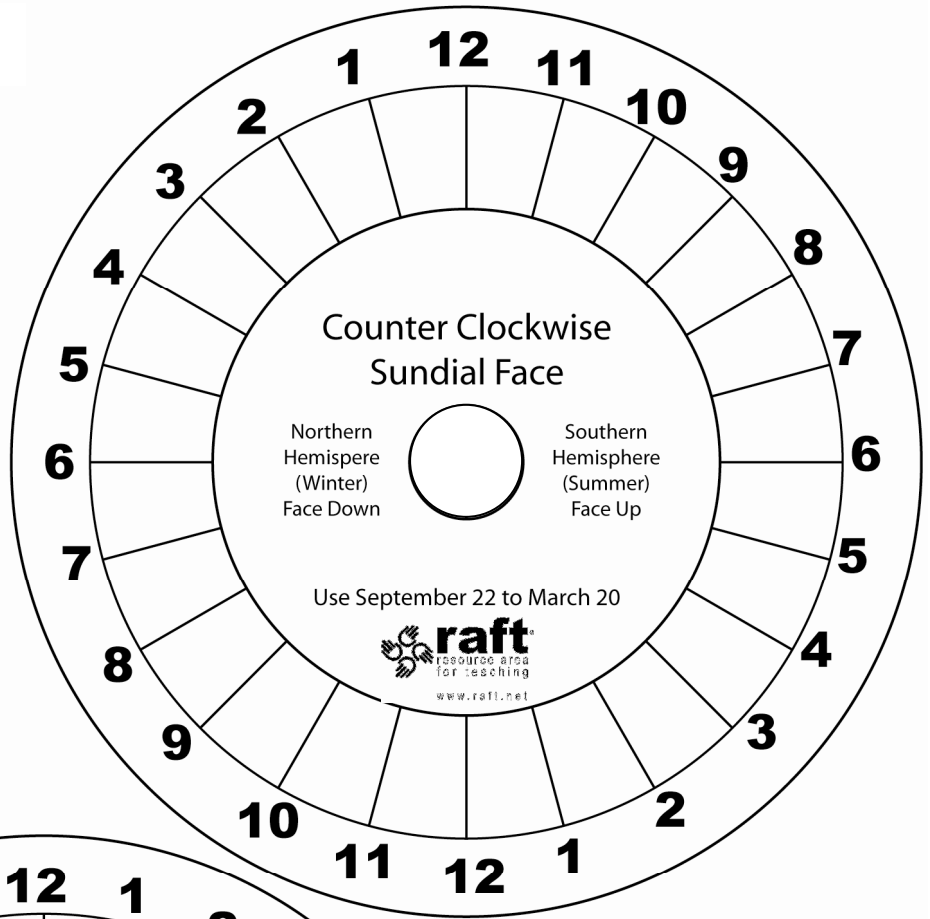
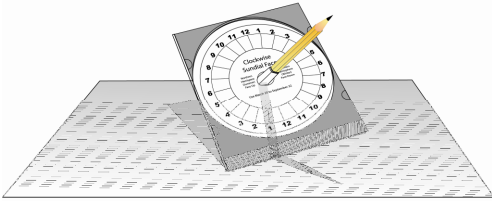
- General sundial info - <http://perso.orange.fr/blateyron/sundials/gb/index.html>
- Latitude and longitude, annotated sources - <http://www.hmssurprise.org/Resources/whereami.html>
- Latitude and longitude in degrees & times zones - <http://www.zipinfo.com/search/zipcode.htm>
- United States maps by zip code - <http://www.census.gov/cgi-bin/gazetteer-tbl>



During the winter in the Northern Hemisphere, time is read on the downward facing Counter Clockwise Sundial face.

Time for Shadows

During the winter in the Northern Hemisphere and summer in the Southern Hemisphere, time is read on the Counter Clockwise Sundial face.



During the summer in the Northern Hemisphere and winter in the Southern Hemisphere, time is read on the Clockwise Sundial face.

