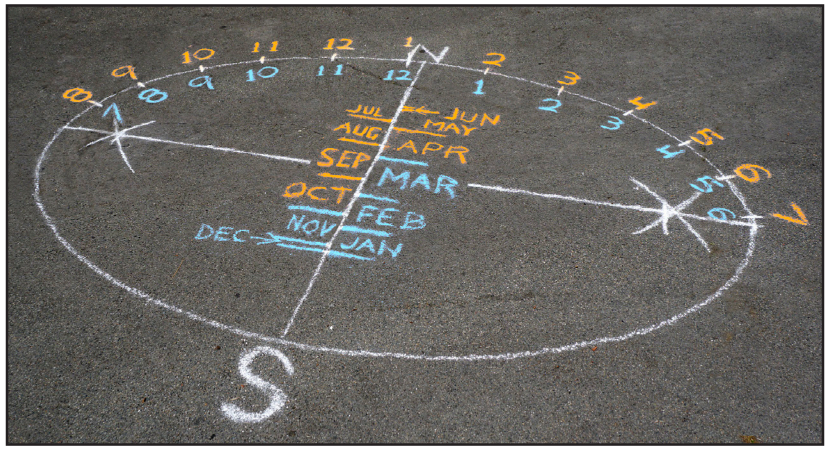
# Solar Schoolhouse Human Sundial
## Building a Sundial with the Online Calculator


### Project Description

Analemmatic sundials are sundials which have a movable gnomon (the gnomon is the part that casts the shadow). Humans are common gnomons for an analemmatic sundial, and the resulting sundials are usually called human sundials. Creating a human sundial is a wonderful project for 3 or more humans providing an opportunity to learn about the relationship of the earth to the sun and demonstrate that knowledge in a practical and entertaining way.

### Project Overview

Below is an overview of the nine steps needed to create an analemmatic sundial. Each step requires additional sub-steps that are detailed in this document.

1. Identify and measure desired location for sundial placement.
2. Go to www.solarschoolhouse.org/sundial to enter site information and obtain plans.
3. Assemble materials at site.
4. Find true north.
5. Measure and draw north-south and east-west axes.
6. Draw the sundial ellipse shape.
7. Measure and mark hour labels.
8. Measure and mark monthly gnomon marks.
9. Erase any unwanted chalk marks and decorate as desired.
10. Use your sundial to tell time!

## Materials

- A paved level area free from shade and large enough for your project
- Printout of the Solar Schoolhouse Human Sundial plans for your location
- Several sticks of chalk: any chalk will do, but “sidewalk chalk” is larger and easier to use.
- Twine & scissors: at least 25 feet is needed for a 12 foot wide sundial
- Tape measure and yard stick
- Magnetic compass or compass app on a mobile device
- Two brooms or poles
- Two chairs & a rock or similar weight (if using shadow tracing to find true north, *see Step 4*)

## PROCEDURE

### Step 1: Identify and measure desired location for sundial placement.

Locate an area to create your sundial. It should be paved, relatively level and get sunlight throughout the day. Be sure that the area is available to anyone you wish to use the sundial. The completed sundial will be in the shape of an oval or ellipse. Measure the site to determine the width of the ellipse. Record the width dimension to enter into the online calculator. *Note: you will need additional open space outside the perimeter of the ellipse to draw the hour numerals, typically an additional 2 feet in each direction.*

### Step 2: Create plans using the online calculator.

Go to the Solar Schoolhouse Human Sundial webpage (www.solarschoolhouse.org/sundial) and fill out the fields in the calculator. The data you enter will be specific to the site you have chosen.

### Step 3: Assemble materials at the site.

Bring all the materials you will need to the site. You will also need at least two other people to help with the drawing, measuring and marking of your sundial.

### Step 4: Find the direction of true north at your site.

True north and magnetic north are in different locations. A Human Sundial requires being aligned to true north. The difference between true north and magnetic north is measured in degrees of Magnetic Declination. Depending on which method you use to determine true north, you may need to find your location’s magnetic declination. *See map in Fig. 1.*

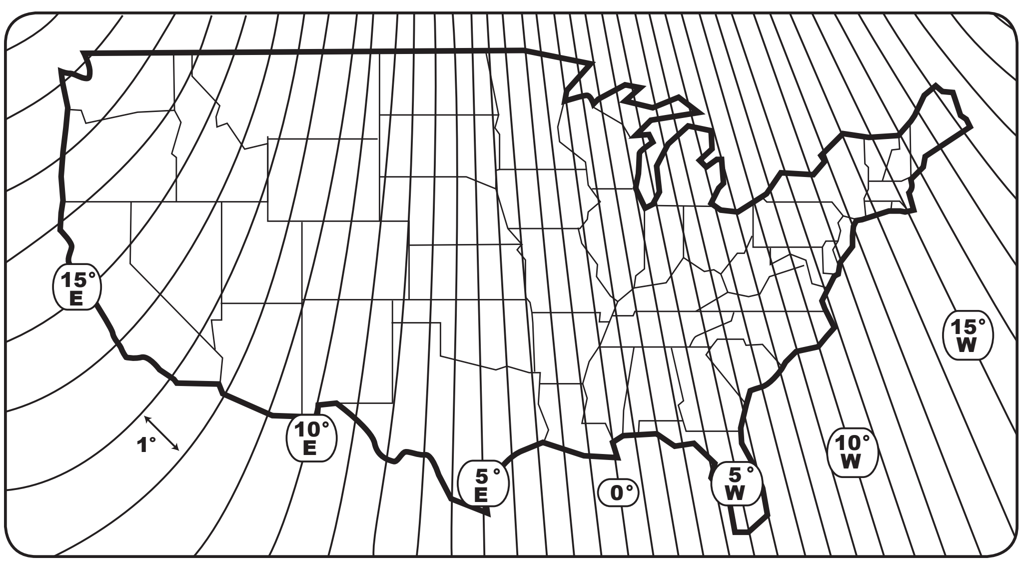



Fig. 1. Magnetic Declination map for the United States in 2004.

*The National Geophysical Data Center has current online magnetic declination information at: www.ngdc.noaa.gov*

There are a variety of ways to find true north, here are thee options:

### Finding North: Magnetic Compass

Refer to the magnetic declination map (Fig. 1) and find your site location and its magnetic declination measured in degrees. The lines of declination are listed as either W (west) or E (east).

To find true north, rotate the compass until the needle points to the number of degrees of magnetic declination shown for your location. The '0' or 'N' position on the compass will then point to true north. On the compass declination degrees *west* are located on the left side of north, and degrees *east* are located on the right side.

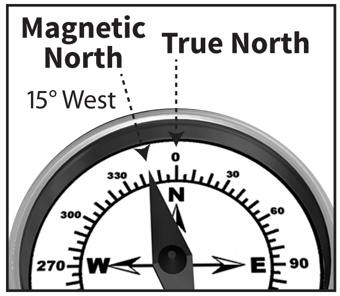



Fig. 2: Boston 15° W

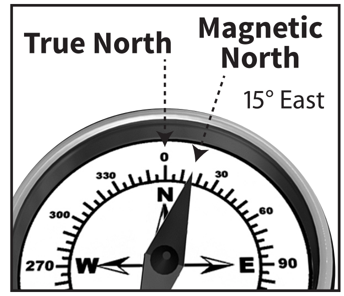



Fig. 3: San Francisco 15° E

*Example: Boston's magnetic declination is 15° west, so true north is located by rotating the compass until the needle points 15° to the left of the 'N' (or 345°). San Francisco's magnetic delination is 15° east, so true north is located by rotating the compass until the needle points 15° to the right of the 'N'. See Fig. 2 and 3.*

### Finding North: Mobile Device with a Compass App

Some mobile devices come with compass apps, and there are many apps that can be downloaded and installed. If using a mobile device compass to determine true north find out first if the app uses magnetics or GPS (Global Positioning System) to indicate north. If your app uses GPS, the north on your app will be true north. If you app uses magnetics, use the same method as a magnetic compass.

### Finding North: Using the Sun

One of  the simplest way to find true north is to trace the shadow cast by an object that's perpendicular to the Earth's surface at the exact middle of the day. This time of day is also called Solar Noon. Solar noon is the time midway between sunrise and sunset. Sunrise and sunset times are often listed in local newspapers and weather websites. Just calculate the number of hours between sunrise and sunset, and divide it in half. Add that to the sunrise time, and you have the time for solar noon.

The object casting the shadow at solar noon needs to be at a 90° angle perpendicular to the Earth's surface. An easy way to get this perpendicular line is to tie a rock or similar weight on one end of a length of twine. Tie the other end of the twine to a broom handle or board supported between two chairs.

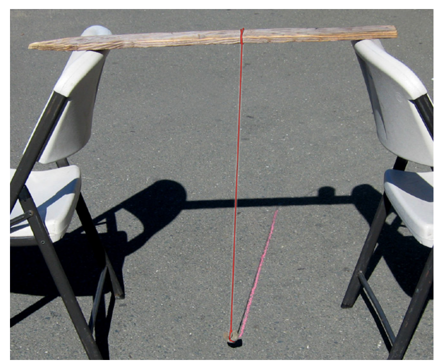


Fig. 3

Make sure the rock is off the ground, and wait until it stops swinging. Then trace the shadow line with chalk. If the shadow is traced at solar noon, the chalk line will be aligned with true north and south. The end of the shadow closest to the rock points toward true south; the other end points toward true north. *See Fig. 3.*

## Step 5: Draw the axes.

The first page of your plans (labeled Step 2) shows two perpendicular lines (or axes) and specifies dimensions for them. The longer, east-west axis is set to the sundial width you entered into the online calculator.

**North–South Axis:** Once you have located true north, put your compass or phone on the ground near where you want the top of your sundial ellipse to be. Make an "X" mark on the ground at true north. Move your compass or phone to near where the bottom of your ellipse will be. Make another "X" mark at true north. Use a tape measure or other straight edged object and draw a connecting chalk line between the two marks to create your north-south axis. Use a tape measure to mark the top, middle and bottom of your axis based on the dimensions in your plans. *See sample on page 6.*

**East–West Axis:** The east-west axis should be exactly perpendicular (at a 90° angle) to the north-south line. To find a perpendicular direction, first draw two sets of intersecting arcs. Use a length of twine one half the length of the east-west axis as specified in your plans. (For the sample on page 6, it would be 3’8⅛” in length.)

Measure and mark a spot on the axis equidistant from north and from the south marks. Tie one end of the twine around a piece of chalk, and tie the other end around the end of a broom handle. Place the end broom handle

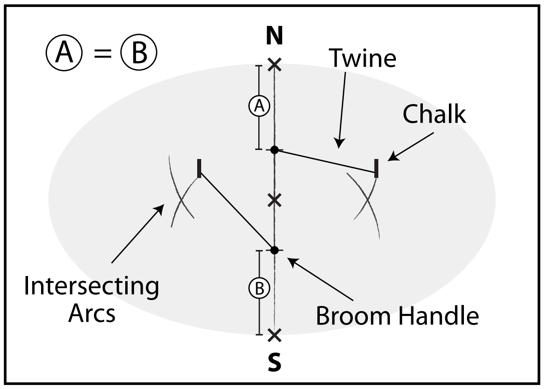



Fig. 4: Drawing intersecting arcs.

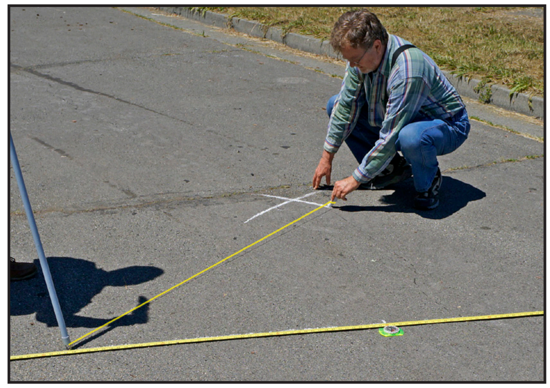


Fig. 5: Drawing intersecting arcs.

on the mark closest to north. While one person holds the broom straight up, the other person holds the twine taut at ground level, and draws arcs on the left and right sides of the north-south axis as shown. Try to make the arc cross the points near the middle of the north-south line. *See Fig. 4 and 5.*

Put the end of the broom handle on the mark closest to the south line and repeat this process to draw two arcs intersecting the first pair. Use a tape measure or other straight edged object and draw a connecting chalk line intersecting both arcs and the mid-point to form your west-east axis.

Extend the tape measure to the east-west axis distance shown on your plans (for the sample on page 6 it would be 12 feet). *See Fig. 6.*

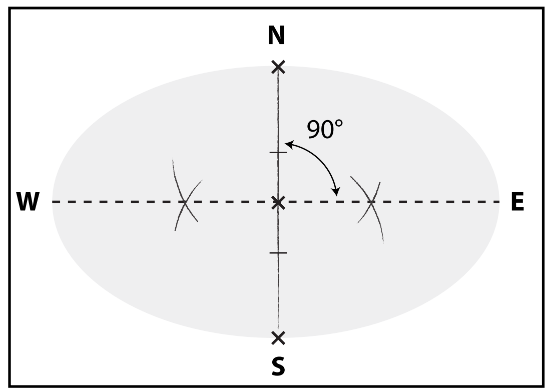



Fig. 6: Drawing the west-east axis.

## Step 6. Draw the sundial ellipse shape.

The length of the loop of twine needed to draw the ellipse is located on page 2 (labeled Step 3) of your plans. Cut a length of twine approximately 1 foot longer than that length to allow for the knot. Fold the twine in half. From the folded end, measure one-half the distance of the specified loop. Tie a knot at this exact point. *See the sample on page 6.*

Refer to page 2 (labeled Step 3) of your plans, note the position of the two circles along the west-east axis. These are the focal points you will use to draw the ellipse. Measure and mark this distance on each side along the east-west axis. (For the sample on page 6 the distance is 4’8⅞” from the north-south axis.)

Have two people place and hold one upside-down broomstick on top of each of the two fixed points. Put the twine loop around the outside of each broomstick at ground level. Hold the brooms firmly to keep them in place. Using a third person, put a piece of chalk within the loop of twine. Keeping the twine taut, use the loop as a guide to draw an ellipse. *Each person holding the broom will have to step over the twine as the ellipse is drawn around their feet. See Fig. 7 and 8.*

Fig. 7 and 8: Drawing the ellipse using the twine loop as a guide.

### Step 7: Measure and mark hour labels.

Refer to page 3 (labeled step 4) of your plans which shows the position of the hour labels. The position of each hour marker is based on it's relative position to either the west, north and east cardinal points. Use a tape measure to measure the specified distances between hour placement and mark and label the locations for each hour. Add quarter-hour marks evenly between hour markers. *See Fig. 9.*

*Please note that unlike a clock, the noon, 6 PM and 6 AM positions may not align with the north, west and south axes.*

If you wish to include daylight savings time markers add another set of numbers outside the circumference of the first set. Each daylight savings time hour is one hour later. *See sample on page 7.*

Fig. 9: Marking the hour locations.

### Step 8: Measure and mark monthly gnomon marks.

Page 4 of your plans (labeled Step 5) shows the position of the monthly gnomon marks. Draw tick marks along the vertical north-south axis at the indicated distances from the horizontal east-west axis. With chalk, write out the names of the months as diagramed on page 5 (labeled Step 6) of your plans.

### Step 9: Erase any unwanted chalk marks and decorate as desired.

With a wet cloth, rub out the chalk marks used to measure and draw your sundial. Decorate as desired.

### Step 10: Using your sundial to tell time.

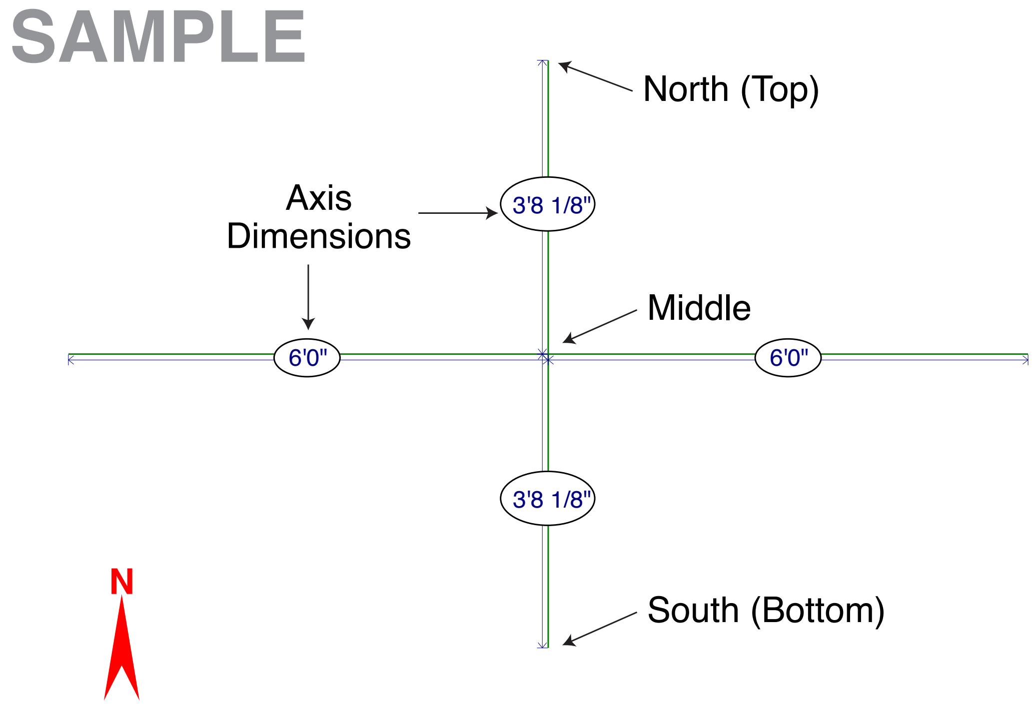
Once you have completed your sundial, it is ready for use. Stand on the marker for the current month, and read the hour where your shadow crosses the ellipse. You may have to raise your arm to reach the hour markers in the middle of the day or during the summer months.

### Share Your Human Sundial

The Solar Schoolhouse welcomes feedback on our projects. Please use our contact page to send us photos or emails, and let us know if we may share your stories with others: http://solarschoolhouse.org/contact/

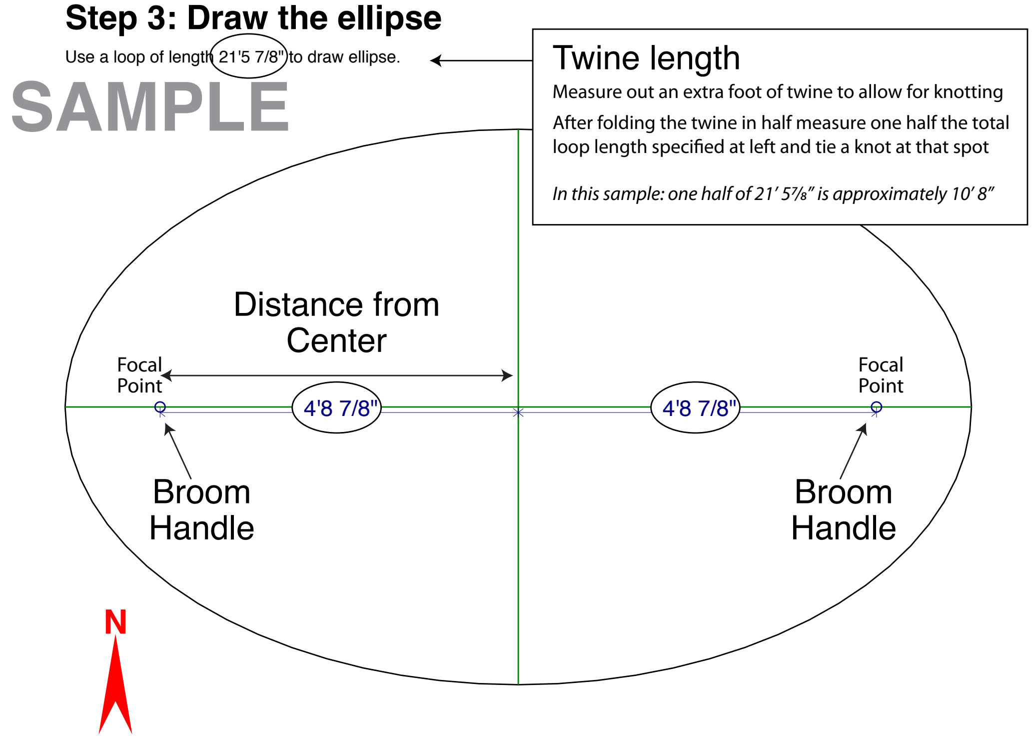
## Solar Schoolhouse Sundial- Step 2: Draw the axes

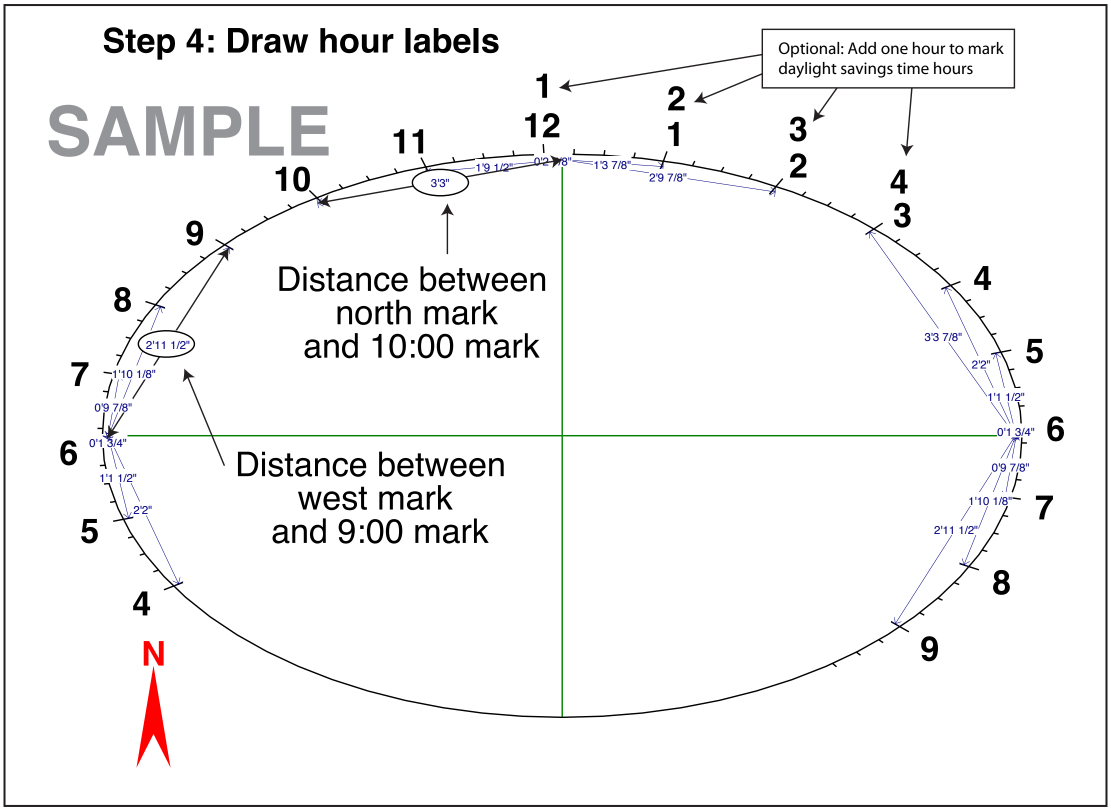
Make sure to align the N arrow to true north (not magnetic)




## Step 3: Draw the ellipse

Use a loop of length 21'5 7/8" to draw ellipse.




Step 4: Draw hour labels
SAMPLE
Optional: Add one hour to mark daylight savings time hours
Distance between north mark and 10:00 mark
Distance between west mark and 9:00 mark
3'3"
2'11 1/2"
N