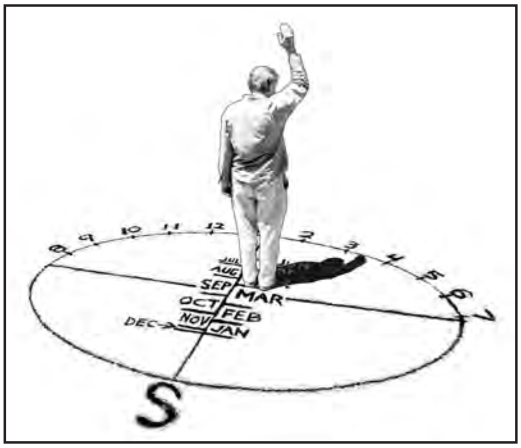
Solar Schoolhouse Human Sundial
Building a Sundial with the Online Calculator



Overview

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.

The Solar Schoolhouse has an online human sundial calculator that generates plans for making your own human sundial. All you need to generate plans is your zip code or your location's latitude and longitude measurements.

Access the calculator at:

www.solarschoolhouse.org/sundial

Materials

- Printout of the Solar Schoolhouse Human Sundial PDF 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
- Magnetic compass
- Two brooms or poles
- Two chairs & a rock or similar weight (if using shadow tracing to find true north)

Procedure

Step One: Generate plans on the Solar Schoolhouse website

Go to the Solar Schoolhouse Human Sundial webpage listed above, and complete the following steps. As an example, we'll make a 12 foot sundial for Daylight Savings Time at Sebastopol, CA. This is a good, workable size.

1. Enter the desired width of your sundial. Select "ft" from the drop down menu if you want to use a standard tape measure to lay out the sundial. We used 12 ft for our example.

2. Enter your location parameters: either your Zip Code or Latitude and Longitude.

3. Select your location's time zone.

4. Check on the radio button for either summer time (Daylight Savings Time) or winter time (Standard Time).

NOTE: If you want both summer and winter time marks on your sundial, you'll have to generate a pdf for each time, and draw two hour mark ellipses. Be sure to make the width of one sundial larger so the ellipses won't overlap. You can also subtract an hour for winter time if you've made a summer time sundial.

5. Enter a location name for your sundial.

6. Check on "Include dimensions and instructions."

7. Click "Go" to generate the plans.

8. You can save the plans as a pdf from the web page, or just print them out.

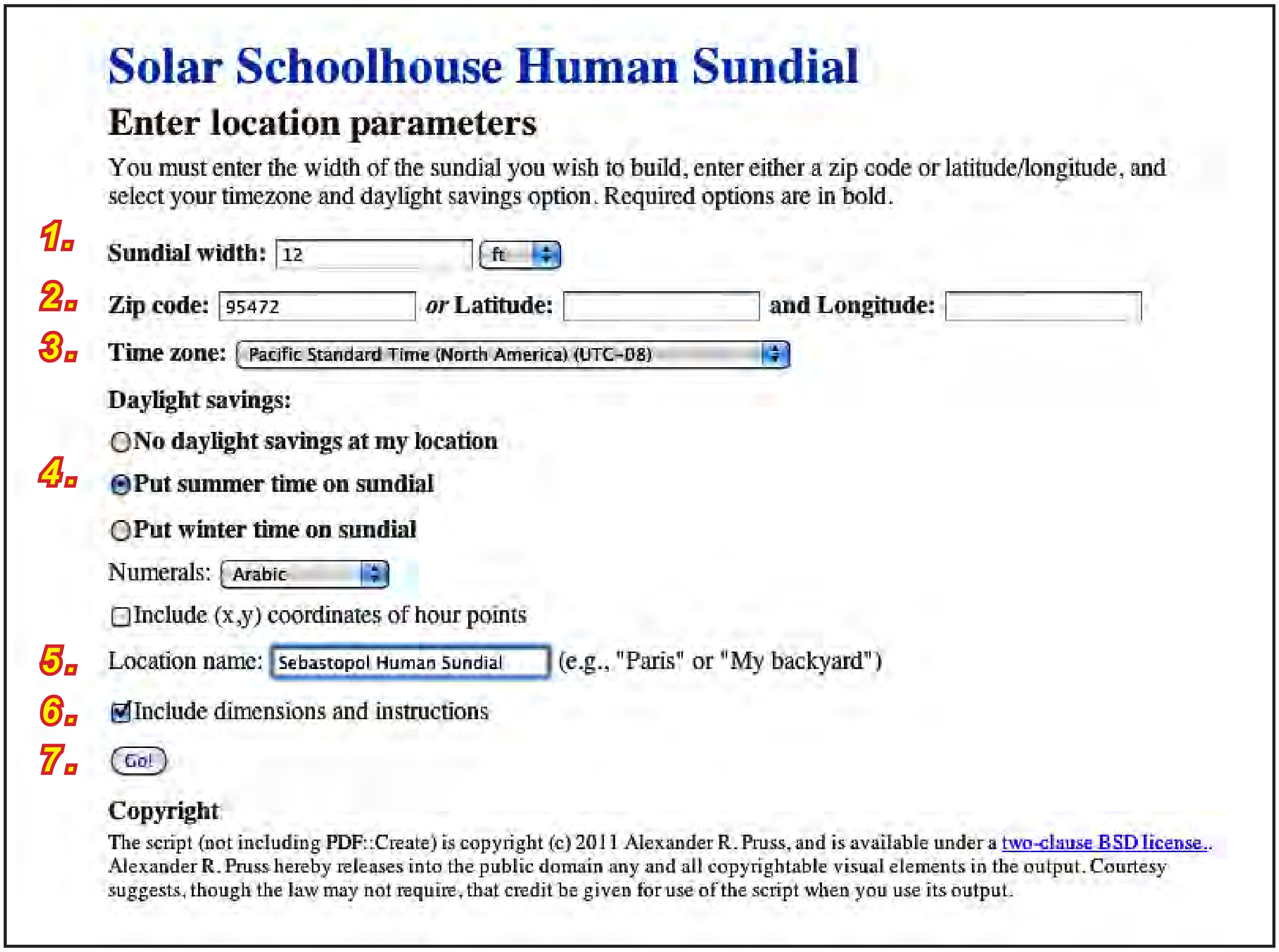


Fig. 1

Step 2. Draw the Axes.

You'll need an area that's not shaded, and large enough to fit the sundial.

The first page of your Human Sundial pdf shows two crossed lines (or axes). The longer, east-west axis is set to the sundial width you selected.

Our 12 foot sundial will need an area about 18 feet on the east-west axis, and about 10 feet on the north-south axis.

These axes will be drawn on the ground in chalk, and they'll need to be aligned to the true cardinal directions. The longer axis will be aligned east and west; the shorter axis will be aligned north and south. This means you'll have to find the directions for north, south, east and west.

Not only that, these axes need to be aligned to TRUE north, south, east and west. A compass points to the MAGNETIC north pole, a location in northern Canada. The sundial needs to be aligned to the TRUE north pole, which is one end of the axis around which the Earth spins.

This guide shows two methods of finding true north. The first method uses a magnetic compass. The second method uses the sun's shadow. The compass method can be done at any time of day. The shadow method must be done on a sunny day around noon. It can often be the more accurate method.

Method One: Finding True North with a Compass

The difference between true north and magnetic north is measured in degrees of *Magnetic Declination*. The magnetic north pole is moving very slowly, so these values change slightly over time. Below is a sample declination map that you can use for this project. Each line measures 1°. Estimate the value if your location is between lines.

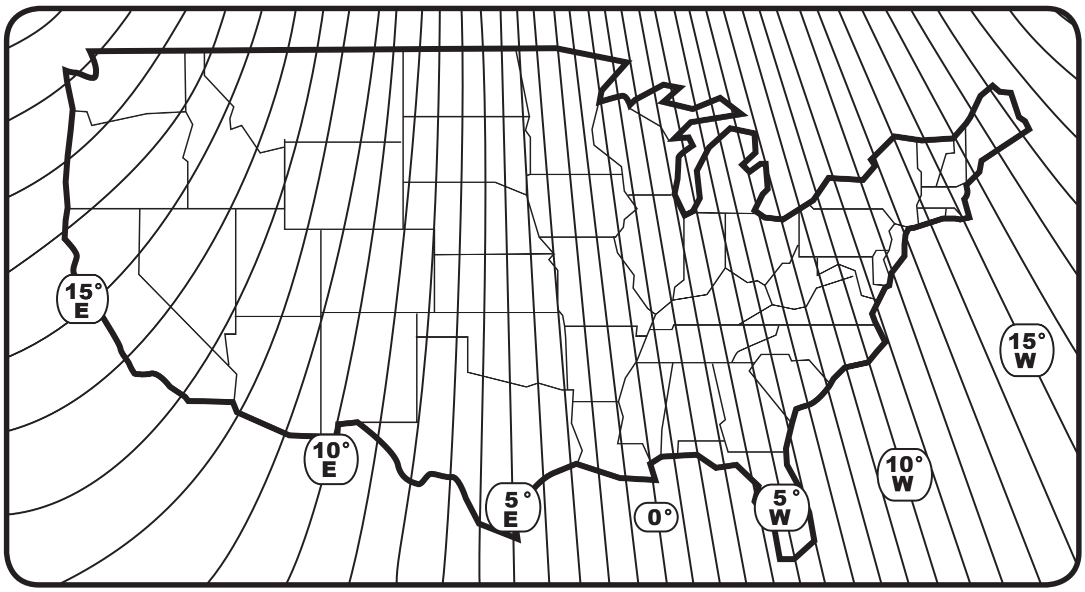


Fig. 2. Magnetic Declination map for the United States in 2004.

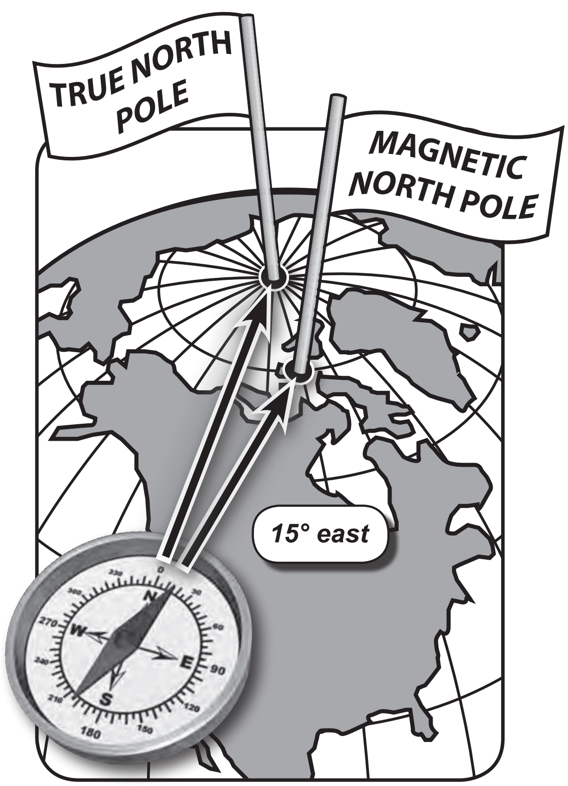


Fig. 3. San Francisco's magnetic declination is 15° E. A compass needle reads 15° to the right (or east) when the "N" points true north.

The National Geophysical Data Center has current online magnetic declination information at:

http://www.ngdc.noaa.gov

Note that the lines of declination are listed as either E (east) or W (west). East degrees are on the right side of the 'N' on the compass. West degrees are on the left side of the 'N' on the compass.

To find true north, point the compass needle to the number of degrees shown on the map. The '0' or 'N' position on the compass will then point to true north.

For example, San Francisco's magnetic declination is about 15 degrees east. When you point the compass needle 15 degrees to the right (or east) of north, the "N" of the compass points toward the true north pole. ***See Fig. 3.***

On the east coast of the United States, declination is measured in degrees WEST of the magnetic north pole.

In Boston, a compass needle would point 15 degrees to the left (west) of north when the "N" points toward the true north pole.

Local magnetic differences, caused by things like nearby cars, some electronic devices, and variations in the Earth's field, can also create errors.

Fig. 4. In Boston the needle points 15° to the left (west) when "N" points true north.

*Method Two: Finding True North Without a Compass**

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.

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. 5.***

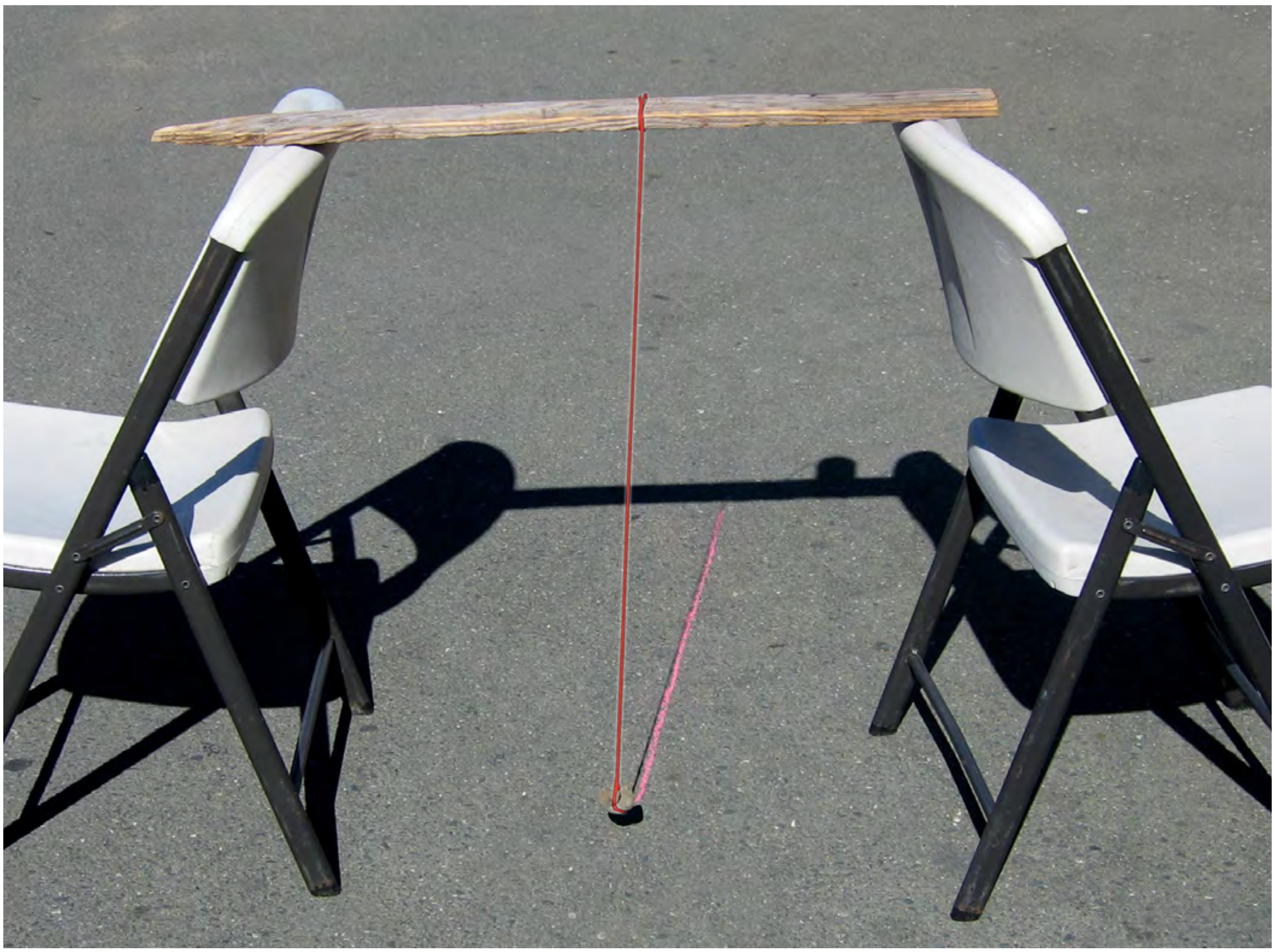


Fig. 5. Tracing a shadow at the exact middle of the day (solar noon).

If you're not able to trace the shadow at exactly solar noon, you can trace multiple shadow lines before and after solar noon. Start about twenty minutes before noon, and trace a shadow line approximately every 10 minutes until about twenty minutes after noon. The shadows will get longer until noon, and then start getting shorter again. The shortest shadow is the one closest to solar noon. You can also trace the shadows of a stick driven into the ground an a 90° angle.

*The Solar Schoolhouse has another project for finding true north without a compass. See: *Teaching Solar- A Teachers Guide to Integrating Solar Energy Into Classroom Curriculum*, a Rahus Institute - Solar Schoolhouse publication.

If you've used a compass to find true north, align a tape measure with the side of the compass. Draw a chalk line that's the same length as the north-south axis in your Human Sundial pdf. Our example had a total north-south axis length of 7' 5 ½" (2 times 3' 8 ¾").

See Fig. 5.

If you traced a shadow, mark the specified end lengths on the chalk line.

To draw the east-west axis we'll first draw two sets of intersecting arcs.

Use a length of twine about one half the length of the east-west axis as specified in the Human Sundial pdf. For our example this is 6 feet, but it doesn't have to be an exact length.

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 broom handle at a specific distance from the mid-point of the north-south axis you drew in chalk. For this example we put the broom handle 3' 8" from the center of the north-south axis.

Fig. 5.

Hold the twine taut, and draw an arc as shown. Try to make the arc cross the point where you think the east-west line will be.

See Fig. 6.

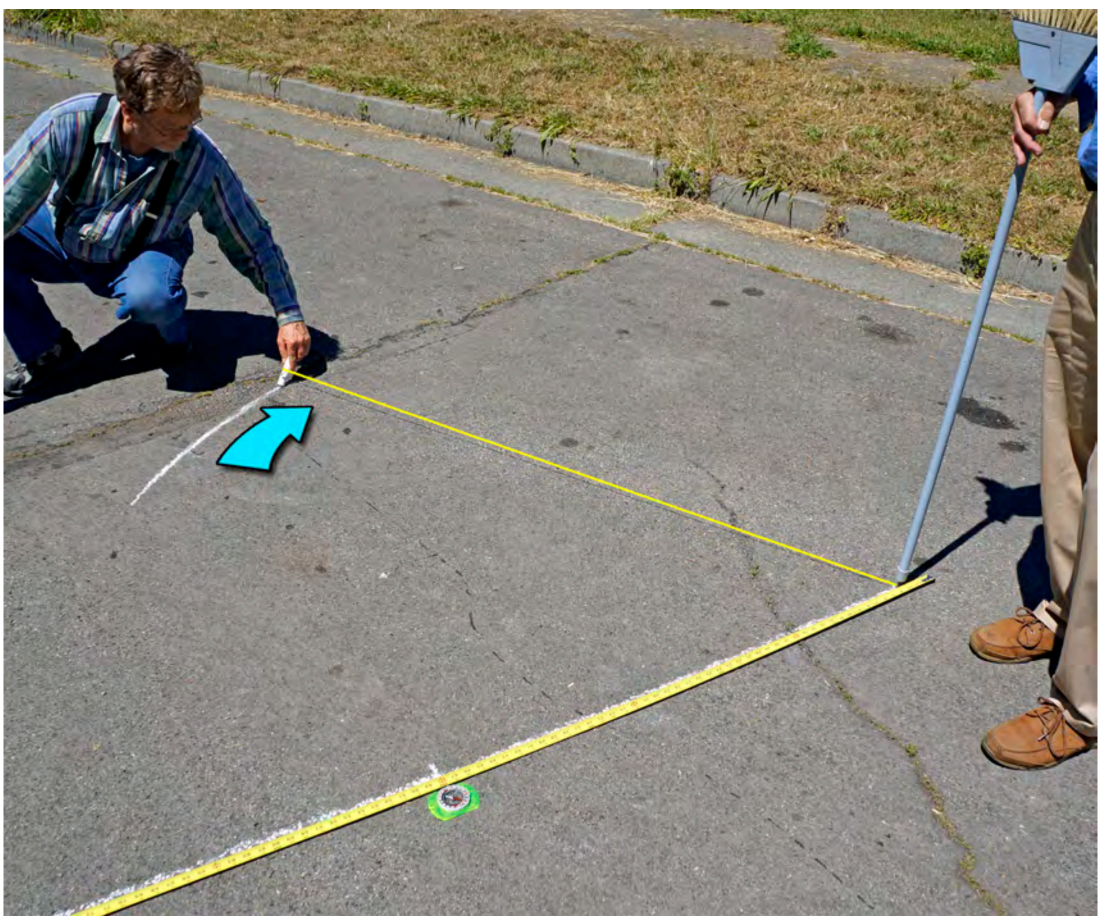


Fig. 6.

Put the broom handle on the other end of the north-south line. Make sure it's at the same distance from the mid-point of the north-south line that you used for the first arc (3' 8" for our example). Draw a second chalk arc that crosses the first arc.

See Fig. 7.

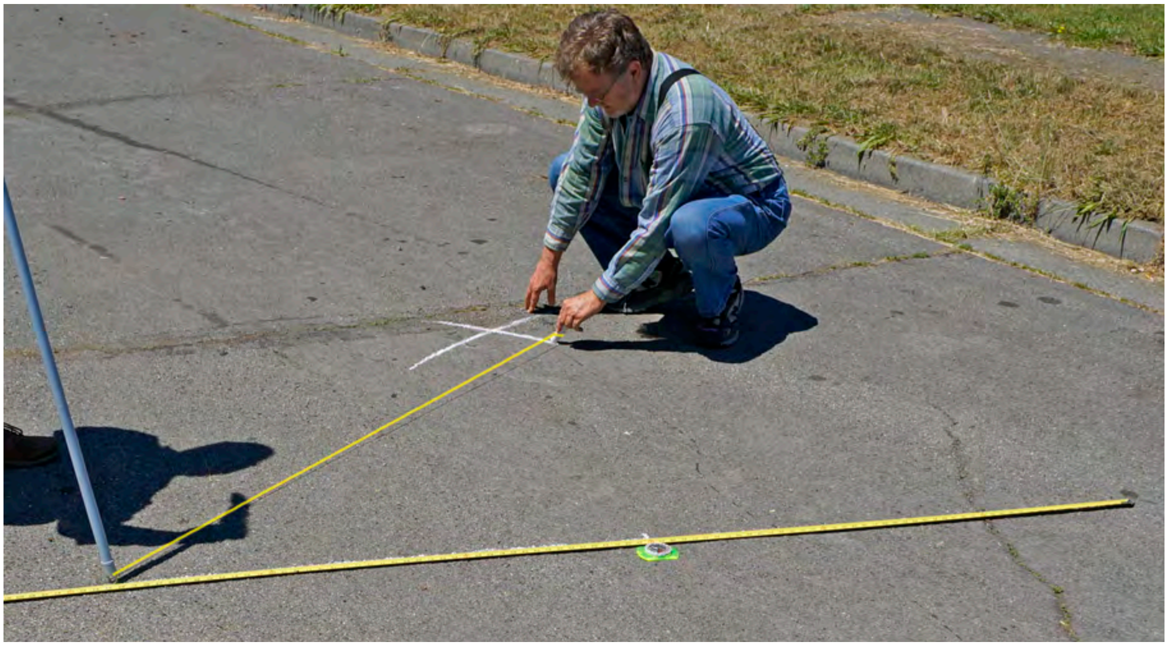


Fig. 7.

Repeat this process to draw two intersecting arcs on the other side of the north-south line. Then extend the tape measure to the east-west axis distance shown on the Human Sundial pdf (for our example: 12 feet).

Put the mid-point of this distance (e.g. 6 feet) at the mid-point of the north-south line. Make sure the tape crosses the intersections on both sets of arcs, and draw a chalk line of the proper axis length.

See Fig. 8.

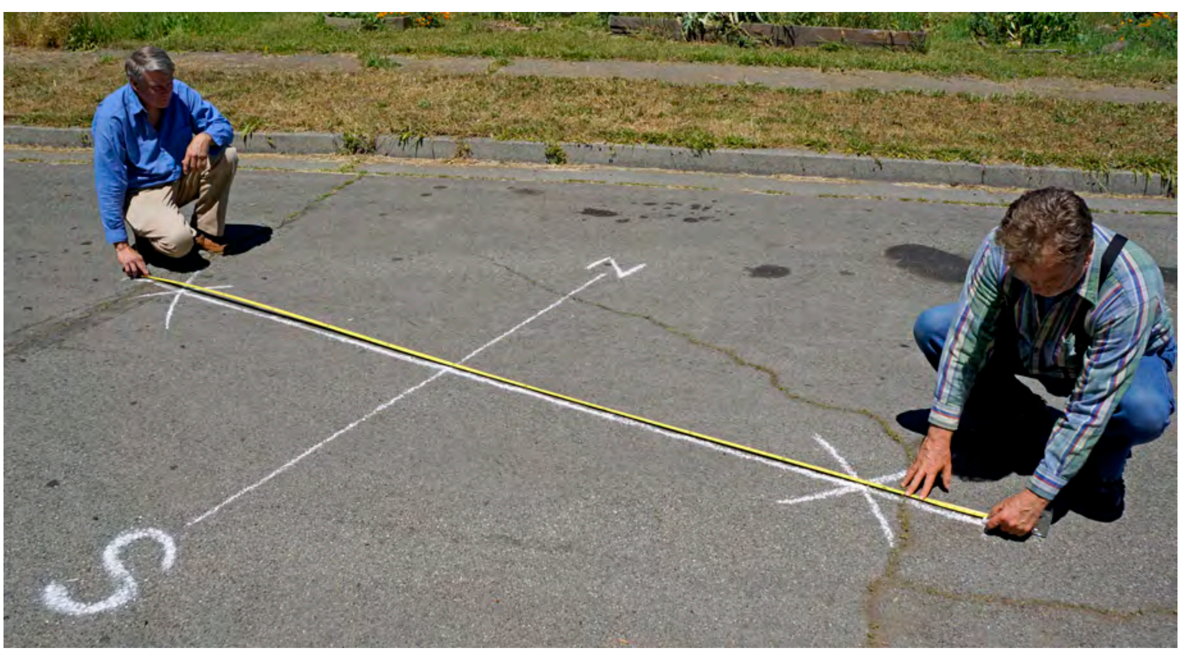


Fig. 8.

Step 3. Draw the Ellipse

Page 2 of the Human Sundial PDF specifies the length of the loop needed for drawing an ellipse. Cut a length of twine several inches longer than this. In our example this loop length was 21'4¾," so we cut 28" of twine.

See Fig. 9.

Fig. 9.

Fold the twine in half. From the folded end, measure one-half the distance of the specified loop. For our example this was 10' 8⅜." Tie a knot at this exact point.

On page 2 of your PDF, note the position of the two tiny circles. These are the fixed points (or *foci*) we'll use to draw the ellipse. Measure out this distance on one side of the east-west axis, and mark a point. For our example, this was 4' 8⅜" from the north-south axis. This was very close to our intersecting arcs, but it won't always be.

Mark the equivalent point of the other side of the east-west axis.

See Fig. 10.

Fig. 10.

Fig. 11.

Place 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.

Fig. 12.

Put a piece of chalk within the loop of twine.

Keeping the twine taut, draw an ellipse.

Fig. 13.

Each person holding the broom will have to step over the twine as the ellipse is drawn around their feet.

See Fig's. 11. 12. 13.

Fig. 14.

Step 4: Draw the Hour Labels

Page 3 of the PDF shows the hour labels, and the length of the chords (lines) that connect each of their respective arcs.

Use the tape measure to locate the hour marks, and draw chalk lines and respective numbers.

On our example sundial, the 8am, 9am and 10am marks are measured upwards from the west end of the east-west axis. ***See Fig. 14.***

The 11am, 12 noon and 1pm marks are measured back from the top end of the north-south axis. ***See Fig. 15.***

Fig. 15.

You may not want to enter all the hour marks, only those when people will normally be at the location. ***See Fig. 16.***

Fig. 16.

Step 5: Draw Monthly Gnomon Position Tickmarks

Page 4 of the PDF shows the position of the monthly gnomon marks. Draw the tickmarks at the indicated distances from the horizontal east-west axis. ***See Fig. 17.***

Fig. 17.

Step 6: Indicate Monthly Gnomon Positions

Page 5 of the PDF shows the final layout of the monthly gnomon marks. Draw the month labels as shown. ***See Fig. 18.***

Fig. 18.

Using the Sundial

To tell the time, 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. If you've made a summer (Daylight) time human sundial, subtract one hour to tell the time in the winter.

See Fig. 19.

Fig. 19.

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/