

Equatorial Sundial

An equatorial sundial has a *gnomon* or *style* (the stick that makes a shadow) tilted in alignment with the Earth's axis of rotation. The shadow of the gnomon then progresses uniformly each hour. This feature allows us to easily add a dial for figuring out the time in other places around the globe, but it is a little more difficult to build than simply poking a stick into the ground, because the sundial must be tilted at an angle corresponding to the latitude of your location. While the project can be constructed by children of most grade levels, it is a great project for children around the 4th through 6th grades, where their studies in geography, solar energy and astronomy are becoming more detailed. We'll soon have Northern and Southern hemisphere templates available.

Materials.

Sundial Templates (from the website:

<http://www.sci-experiments.com/sundial/sundial.pdf>)

Glue stick

Scotch tape

scissors

straightedge

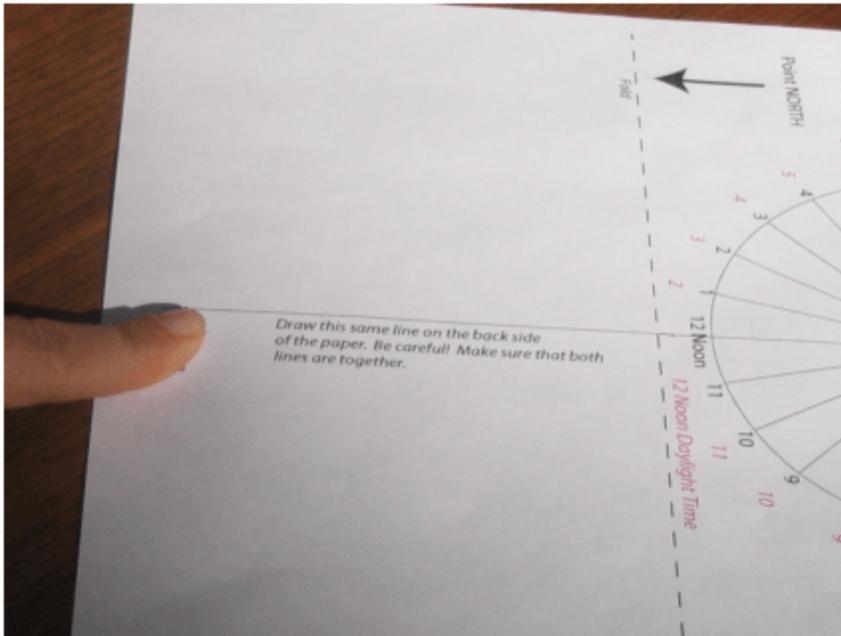
pencil

A dry sponge or a small piece of modeling clay (to poke holes in).

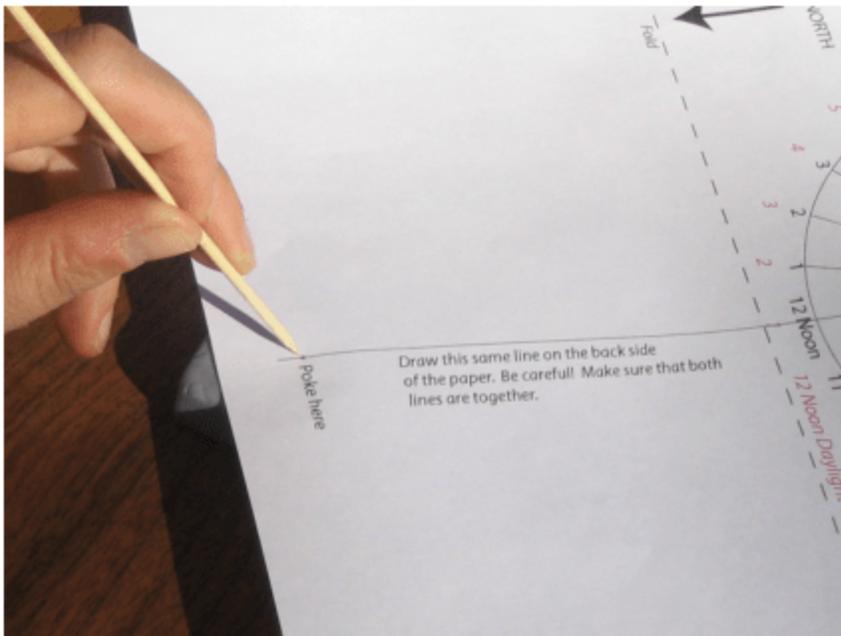
A fondue stick (a wooden dowel about 1/8" in diameter).

A sunny day

Making the Sundial: Northern Hemisphere Templates

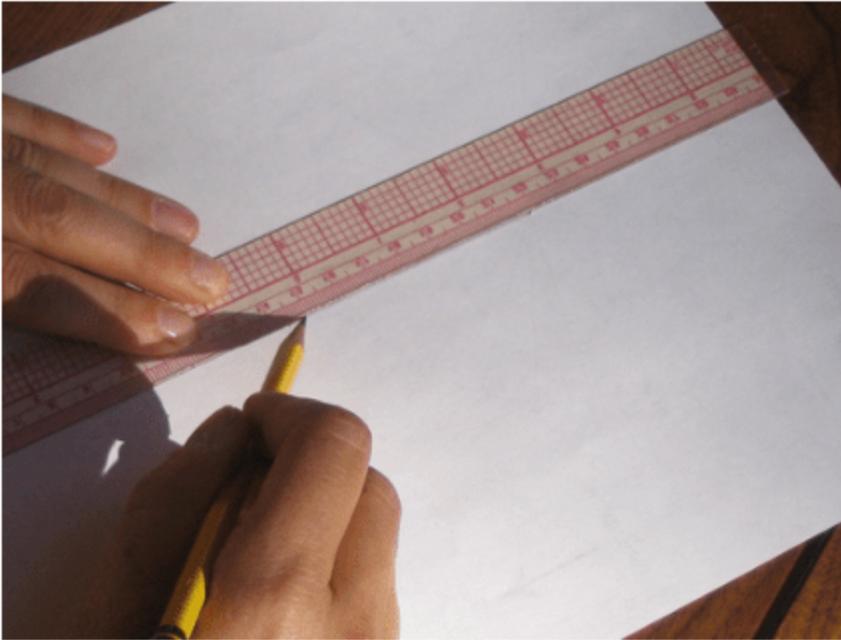


1. Find the Sundial Base sheet and study the printed face. There is a long solid line that extends the whole length of the paper. You will want to draw this same line on the backside of the paper in exactly the same place. See how to do this in the next two pictures.

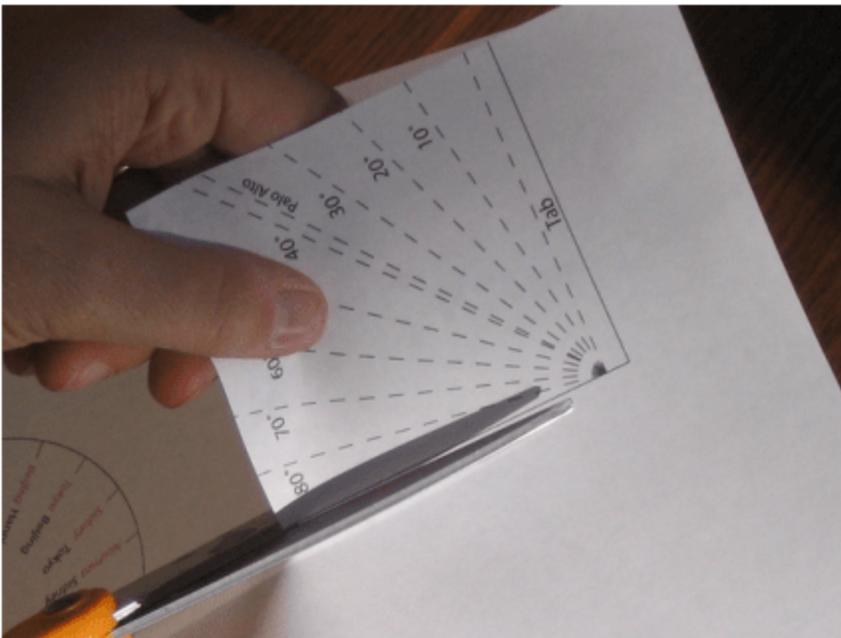


2. Find the two places on the paper Sundial Base where it says "Poke Here". Use the pointed dowel that comes with your kit to poke a very small hole through the paper at

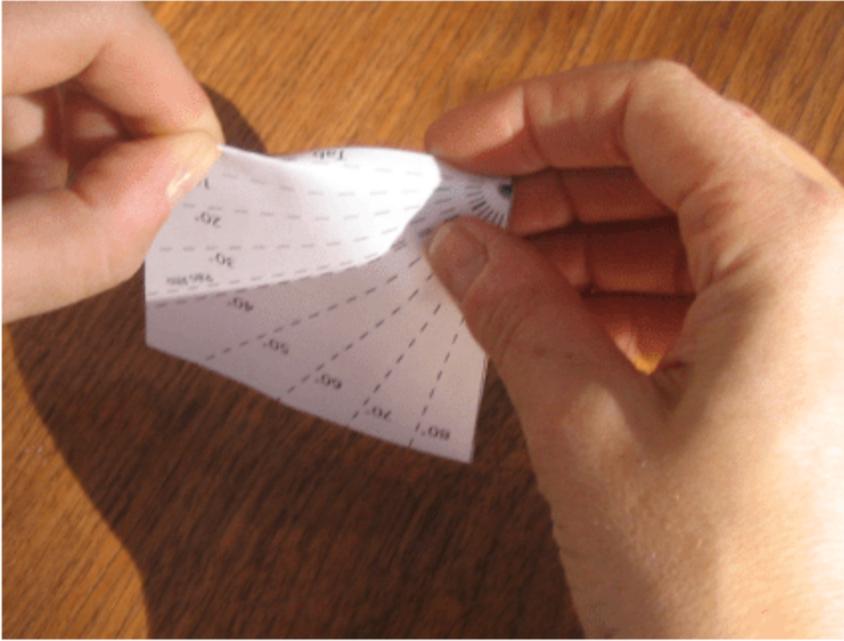
those two places. It makes it easy to poke if you put a dry sponge or a bit of modeling clay under the paper.



3. Now turn the Sundial Base over and draw a straight line between the two holes. Use a straightedge.



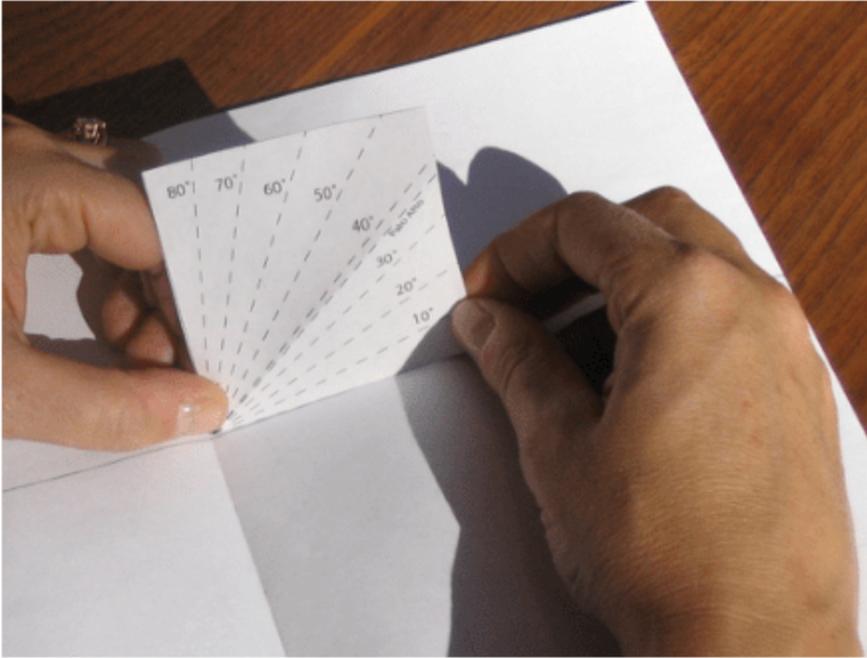
4. Cut out the Jack along the outside solid lines.



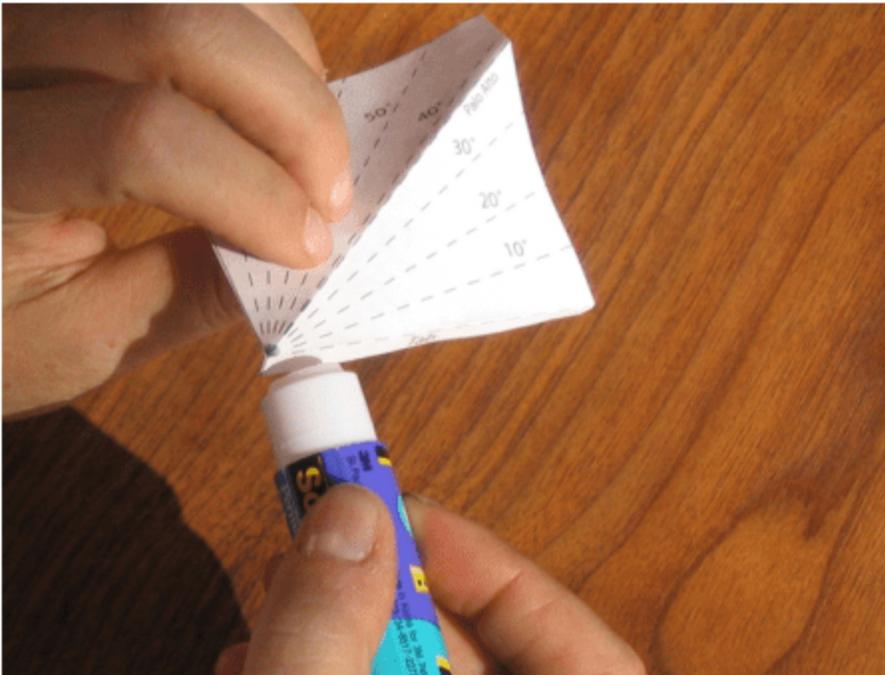
7. Fold the Jack along the dotted line that says "Tab".



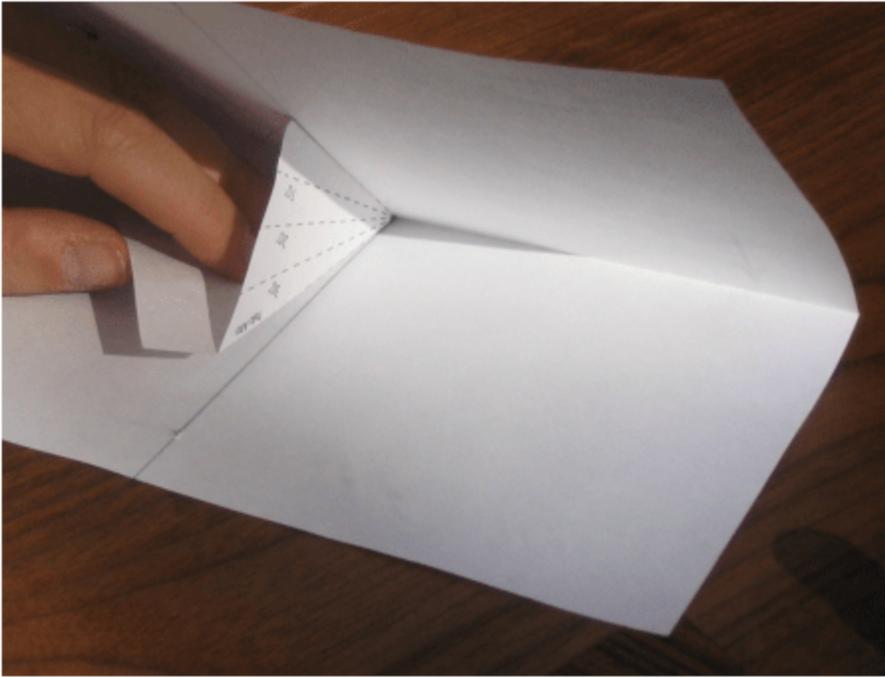
8. Fold the Jack along the dotted line that corresponds to your Latitude. The latitude for Nixon Elementary School in Palo Alto, California is 38 degrees.



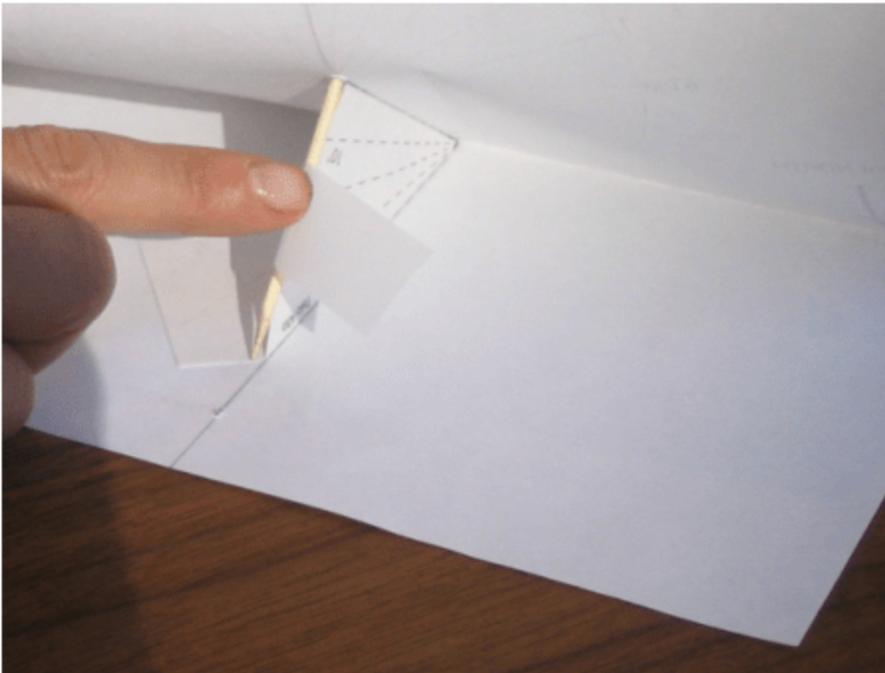
9. Look at this picture! Align the Tab fold on the Jack with the pencil line on the backside of the Sundial Base. The left edge of the Jack (LEFT thumb in the picture) aligns with the fold on the Sundial Base. The right edge of the Jack (RIGHT thumb in the picture) aligns with the poked hole in the Sundial Base.



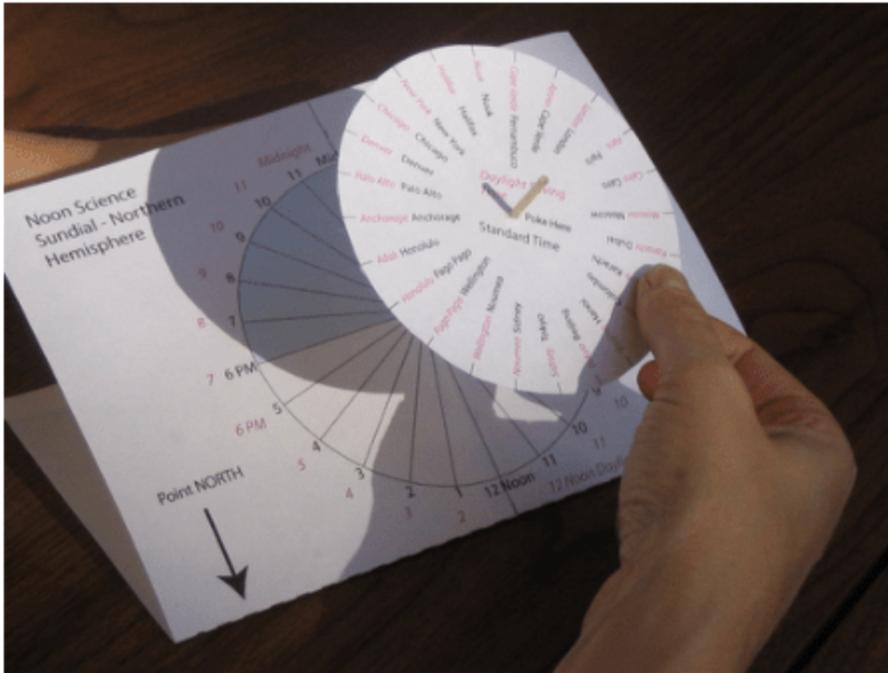
10. Glue the tab onto the Sundial Base using a glue stick.



11. Glue the other flap of the Jack to the other surface of the Sundial Base. Line up the folded edge of the Jack with the pencil line on the backside of the Sundial Base.



12. Push the dowel through the top of the Sundial Base through the small hole that you poked. Tape the dowel along the edge of the Jack.



13. Poke a tiny hole in the center of the Time Zone disk and place it on top of the dowel.



12. The assembled sundial looks like this.

Using the Sundial - Northern Hemisphere

1. Aiming Your Sundial.*

When the Sundial is assembled, point the stick True North. You can find Magnetic North with a compass, but you will need to know the Magnetic Declination where you live to change to True North. In Palo Alto, True North points about 15 degrees to the West of Magnetic North. Check the link below:

<http://www.ngdc.noaa.gov/seg/geomag/jsp/Declination.jsp>

Or, you can locate True North by finding your home on Google Maps (<http://maps.google.com/>). The Google maps are oriented to the true compass directions. In other words, the top of the map points to True North. Print out your Google map, tape the edge of your sundial along the bottom edge of your Google map so that the stick points to the top of the map. Then take the Google map outside and align the map with some recognizable landmark (such as your street).

2. The Shadow Knows

When you've aligned your sundial properly, the stick points in the same direction (parallel to) the axis of the Earth's rotation. So the shadow of the stick moves around the stick by the same amount each hour. But in the summer, the Sun will be above the surface of the sundial, and in the winter, the Sun will be below the surface of the sundial. This means that, in the summer, the shadow of the stick will "fall" on the top of the sundial, and in the winter, the shadow of the stick will "fall" from the bottom of the sundial.

3. Time Zone Disk

Align the Time Zone Disk so that the Sun's shadow points to the city nearest you (Palo Alto if you're at Nixon School). Now you can see what time it is in other parts of the world. But you will need to know if you are currently in Daylight Saving Time or Standard Time. If you look at a world map, you will discover that the time zones can have strange shapes in certain parts of the world. And not all countries use Daylight Saving Time, so this is why we need two scales on the Time Zone Disk.

4. A note for our friends in the Southern Hemisphere.

We've not yet completed the Summer Hemisphere templates. In essence, everything is upside down: the stick points South, the hours increase in a counterclockwise direction and the Time Zone Disk is in the reverse direction. So look for a Southern Hemisphere version to appear soon.

*An important wrinkle in the process (probably better for the kids older than third grade).

Well, it turns out that there's another little complication that we didn't tell you about. The procedure we've described for pointing your sundial will give you exactly the correct time at Greenwich, England, but it may not give you exactly the correct time at your location. This is because of the SIZE of a time zone. If time zones corresponded exactly in width to the amount the Earth rotates in an hour, they would represent a 15 degrees-wide slice cut out of the Earth's surface. And we define the local time to be the same EVERYWHERE in that 15 degree slice. But the Sun "rises" one hour earlier on the eastern-most edge of that slice than on the western-most edge of the slice.

So let's get specific and talk about Pacific Standard Time since that's where we are (Nixon Elementary School in Palo Alto, CA). The longitude here is roughly 122 degrees West (of Greenwich, England). So if we divide $122 / 15$, we get 8.13 slices that are 15 degrees of longitude "wide" separating us from Greenwich, England. So we are exactly 8.13 hours away from Greenwich, England. But because we are in the Pacific Standard Time zone, we say that we are actually 8 hours away from Greenwich, England. So by pointing our sundial directly North, it will actually read 0.13 hours, or 7.8 minutes, TOO EARLY.

So let's take another example. Let's say you live in Las Vegas, NV. which is also in the Pacific Standard Time zone (our neighbors way down in Southern Nevada). First of all, you'd have to fold the Jack portion of your sundial for a latitude of about 36 degrees, but you'd also need to know that Las Vegas is at a longitude of 115 degrees West. This represents 7.66 "slices" from Greenwich, England, which is 0.34 hours, or 12 minutes less than a full 8 "slices". So aligning the sundial to True North at Las Vegas, NV will make the sundial 20 minutes TOO LATE when compared to the time on a local clock.