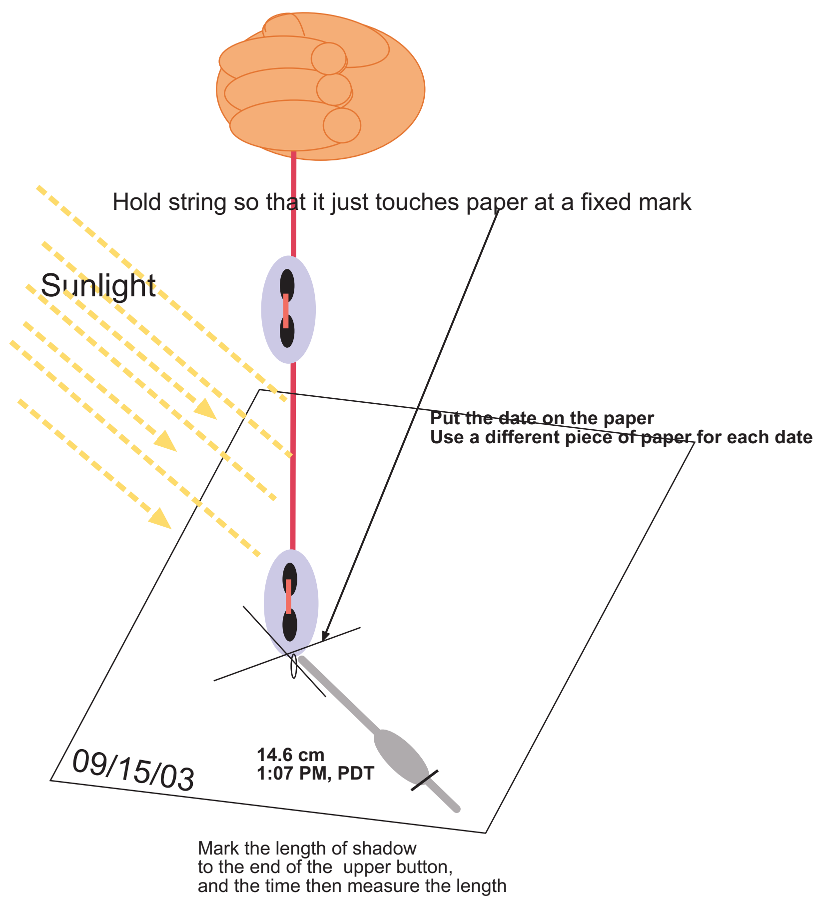
Observing Noon and Equation of Time

You will need to bring some of your observations to at least one instructor meeting.

Materials: Paper, watch or clock (and time reference), thin string or thick thread, 2 buttons or beads (they don't need to be the same), protractor, and ruler.

In this project you will be observing the Sun at local solar noon. Local noon is when the Sun is on the meridian and when the shadow of an object is smallest. If you have a properly set -up sundial, it reads 12 at local noon. The difference between local noon and noon as measured by a perfect clock (called local mean solar time) is called the "equation of time". What you will measure is the difference between local noon and zone time. Zone time is the time we normally use. It is like local mean solar time for folks at a latitude in the middle of the time zone. On top of all this, we use Daylight Savings Time which differs from local solar time even more.

Be certain that your schedule will allow you to observe at local noon. Local noon is not always at 12 PM on your watch and this is the difference you will be measuring. So you will need to be available to observe when noon occurs. In the continental U.S, noon can occur between about 11:10 AM (standard time) and 1:40 PM (daylight savings time). In Alaska, the time of local noon can be even earlier. You could make all your observations on the weekends.



You need a South-facing window or outdoor area and a horizontal surface on which to cast a shadow. It must have direct sunlight at noon, so no porches or overhangs.

Measure local noon at least 12 times spread over at least 6 weeks.

To measure local noon, you will need a vertical object and a piece of paper to use to record its shadow.

Make a vertical object by tying one button (or bead) onto the end of a piece of string. Tie the other button on the string about 6 inches away. Leave a tail of string on one end so that you can hold onto it. The idea is to hold the string with one button just touching a surface and the string taut. Then you can be sure that the string is vertical.

You will be holding the string as shown in the figure and record the time and length of the shadow.

1) Each day you observe provide a piece of paper with the date and a mark for the lower button to touch.

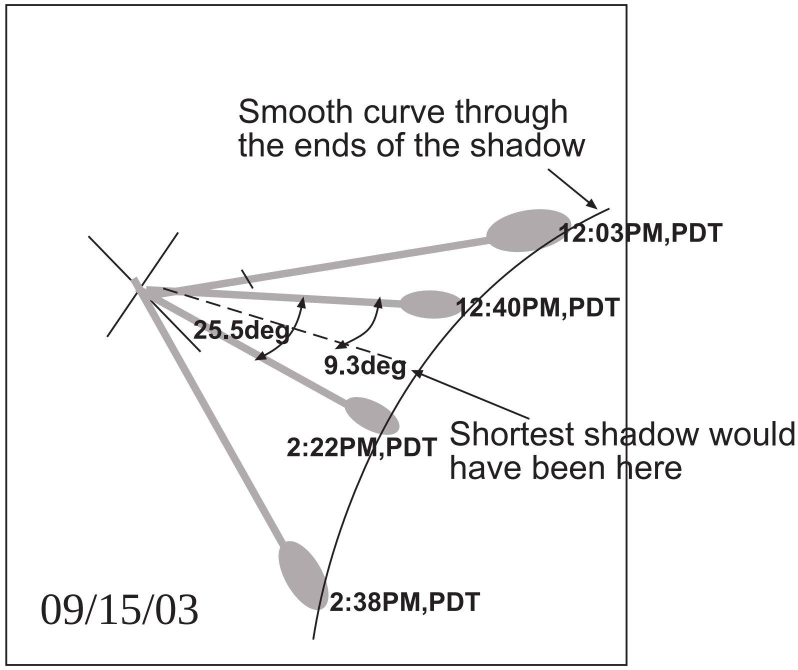
Make a mark at the end of the shadow, draw a line along the shadow and record the time and the length of the shadow.

Measure the shadow several times (AT LEAST 3) around local noon. You need observations BOTH before and after noon. You will know that you have data both before and after noon, because the length of the shadow will first decrease, then increase. It will probably take more than 3 observations for you to be certain that noon has passed.

2) Put a smooth curve through the ends of the shadows. You can sketch if you like, or can use a French curve or a spline. A spline is like a piece of wire inside of plastic. The idea is that it will bend smoothly to match any kind of curve without making any sharp corners or wiggles.

Mark on the curve where it comes closest to the point where the button touched, as shown below.

3) When you find the direction for the shortest distance, measure the angle between it and a nearby shadow. Also measure the angle between the two nearest observed shadows. To figure out just when the local solar noon occurred, interpolate, that is estimate in between.



$$\frac{\textbf{time between observation and noon}}{\textbf{time between two nearest observations}} = \frac{\textbf{angle between observation and noon}}{\textbf{angle between nearest observations}}$$

You know the angles and the times between the two nearest observations. The only thing that you don't know is the time between the observation and noon.

Solving

$$\textbf{time between observation and noon} = \textbf{time between two nearest observations} \times \frac{\textbf{angle between observation and noon}}{\textbf{angle between nearest observations}}$$

This gives the time AWAY FROM one of the actual observations to the time when the Sun was at noon. You can find this time interval and then add to one of the observation times.

Example: You observed at 12:40 PM and at 2:22PM. The angle between these two observations is about 25.5^{o} and the angle between the 12:40 observation and the line where the shortest shadow would have been is 9.3^{o}.

Time between two nearest observations = 1hr 42 minutes =102 minutes
Angle between observation and noon = 9.3
Angle between two nearest observations = 25.2^{o}

time between local noon and previous observation

So solving

$$= 102\text{min} \times \frac{9.3^o}{25.5^o} = 37.2\,\text{min}$$

This is the amount of time to ADD to 12:40PM to get to the time for solar noon. That puts solar noon at **1:17.2 PM**. NOT at 12:00PM. This difference is due to at least three effects

a) This example was done during daylight savings time when we lie to ourselves by “springing ahead.” We set the clocks ahead so that there is sunlight later in our day. The Sun, of course, doesn’t change. (Daylight savings time starts 2AM of the first Sunday in April and ends at 2AM after the last Saturday in October, in most of the United States , but not Arizona or Hawaii)

b) We all use zone time to set our clocks and watches. All the people within a time zone agree to use the same time. But the Sun is not at the same place in the sky at the same moment for all the locations in the time zone. The Pacific Time Zone has its center at longitude 120o, which is along the eastern border of California from Lake Tahoe north. DVC and the San Francisco Bay area are WEST of the middle of the time zone so the Sun gets to us later than the zone time says it should. Ideally no place should have the Sun be more than half an hour early or half an hour late compared to zone time. Look at the time zones for other places on Earth. See More Precisely 1–3 for example. Alaska and China both extend over what should be several time zones. But for political reasons, these entire political entities keep the same zone time. So the Sun can be hours away where zone time would predict in Alaska.

c) It is not exactly 24 hours from noon to noon. The Earth takes the same time to spin compared to the stars (the sidereal day 23hours 56 minutes 4.09 seconds. The direction to the Sun is not, however, fixed. As Earth orbits the Sun, the direction to the Sun (in toward the focus of the orbital ellipse) changes. Since Earth orbits faster when closer, and slower when further, the direction changes faster when Earth is closer and slower when the Earth is further from the Sun. The speed of the Earth is fastest near Jan 6, so this causes the interval from noon to noon to be longer in winter.

The direction to the Sun also seems to move slower and faster depending on the north-south position in the sky. The tilt of Earth’s axis makes the Sun appear to move north of Earth’s equator from March through June to September. The rest of the year the Sun appears south of Earth’s equator. During the times of the year near the equinoxes, March 21 and September 23, part of the Sun’s motion is north and south. So near these times, the tilt of Earth’s axis make it take more than 24 hours to go from noon to noon. The effects of the varying speed of Earth and Earth’s tilted axis combine to make noon be more than 16. minutes different from average.

For each day you observe, make a separate shadow-recording sheet. Draw the shadows and record the times of the observations. Make the smooth curve through the ends of the shadows and find where it gets closest to the mark (shortest shadow point). Then compute the time of local noon.

Record your data in the form of the table below, as well as on the shadow recording sheet. You need one block of such a table for EACH day.

Plot the time of noon (using standard time) against date. You can find linear graph paper to plot on the laboratory information page. Make each square on the graph paper indicate the same number of days (not months), so that the differing lengths of months do not affect your curve.

Put a smooth curve or a line through the points on each graph. If you need refreshing on how to plot, see the article about plotting on the laboratory information page.

Does the time of solar noon keep getting later? Getting earlier? Change direction?

What is the largest difference between zone time and local noon from your data?

Which do you think is more convenient to use, zone time or local solar time (what you would get from a sundial)?   WHY?

Turn in
All Recording sheets
Data tables
Answers to questions
Plot of time difference as a function of date
Objective and Conclusion

Use one of these tables for EACH DAY

Date	
Time of last observation before noon, obs 1	
Time of first observation after noon, obs 2	
Time between two observation	
Angle between obs 1 and 2	
Angle between obs 1 and direction of shortest shadow (noon)	
Time between obs 1 and noon	
Time of Noon	
Time of Noon in STANDARD TIME (an hour earlier than above, if it WAS daylight savings time)	