Astronomy 101U Skylab #3 – "Hey! Don't Touch That!"

Introduction: The gnomon, a fancy name for a vertical stick stuck in the ground, is the oldest of all astronomical instruments. It can be used to analyze the Sun's motion across the sky.

Equipment: A smooth, sunny location, a stick (at least one foot long), a compass (to find North), a protractor, a watch, a ruler and a large piece of paper (optional).

Time Required: One full day (for a few minutes each hour).

What to Do: Construct a gnomon in a location which is exposed to the Sun all day. A flat, smooth (grass can make things uneven) surface is best; if the gnomon cannot be easily stuck in the ground, as on asphalt, then a small stand will help. A "plumber's helper" turns out to be ideal. If you want to record your measurements on paper, spread out a large sheet of paper (must be big to record the location of the tip of the shadow over the course of a day) around or under the gnomon.

Use a compass to find true north (note: compass needles point to magnetic north, which is approximately 8 degrees east of geographic north (or true north) in the Seattle area) and draw an East-West line on the ground through the gnomon. A possible setup (bird's eye view) is:

Diagram omitted from LaTeX version

From early morning to sunset, accurately measure the length of the shadow and the angle it makes relative to the East-West line, called the azimuth. Record your results along with the height of the gnomon above the ground. Make a scale drawing showing how the tip of the shadow moves in azimuth through the day. If you know a little trigonometry, you can use the ratio of the length of the stick to the length of the shadow to calculate the elevation of the sun at each time of observation (its altitude).

You will notice that the shadow is not shortest exactly at clock noon. Think about the reason for this! You will need to make many observations around TRUE noon – at least every ten minutes from 30 minutes before to 30 minutes after. Don't forget about Daylight Savings Time.

Questions:

(1) Notice that the shadow of the Sun is always North of the East-West line (azimuth). Will this ever change based on the time of year (if you do the experiment in Seattle)? Why or why not?

(2) "True" noon occurs when the shadow's length is shortest (sun is closest to being directly overhead). At what latitude would you have to make your observation in order for there to be no shadow at true noon on June 21 (the summer solstice)?

(3) Besides daylight savings time, why doesn't true noon occur at noon right on the hour? Hint: Think about the way time zones are set up. Where would you have to observe from in order for true noon to fall at exactly 1 pm Pacific Daylight Time?

(4) If you did this experiment again on the day after you did it the first time, would the shadow length be longer or shorter? Why?

(5) List at least four sources of error in this experiment and for each list a way, if one exists, for that error to be reduced or eliminated. Also, estimate the size of each error (in degrees for the angle or centimeters/inches/miles for the shadow length or seconds/minutes for time).