

## **CALCULATE EARTH'S TILT USING BETSY PUGEL'S HANDY EARTH TILT CALCULATOR!**

Why take other people's word for it that Earth has a tilt? Measure it for yourself on December 21st!

### **Tools:**

- A stick-like object (For example: a stick; a ruler; a meter stick; a broom handle) to stick into the ground
- Tape measure or ruler/meter stick for measuring
- Pen/Pencil/Crayon and paper (to record your data)
- Graph paper (attached to this document)
- Calculator or the internet and search engine (as your alternate calculator)
- Warm clothes to brave the weather a few times throughout the day to make measurements

**Note: This will not work if it is a cloudy day.**

**Note #2: This method works in places that are north of the "Tropic of Cancer," which includes the Continental U.S. and Canada, Europe, most of Asia and the northernmost part of Africa.**

### **Two approaches:**

- (1) ***The Quick and Easy Version***, which will take about 10 minutes max
- (2) ***Winter Solstice Tilt Measurement, The Extended Remix***, takes a few hours, but makes you feel like a boss (science-style)

### **Directions:**

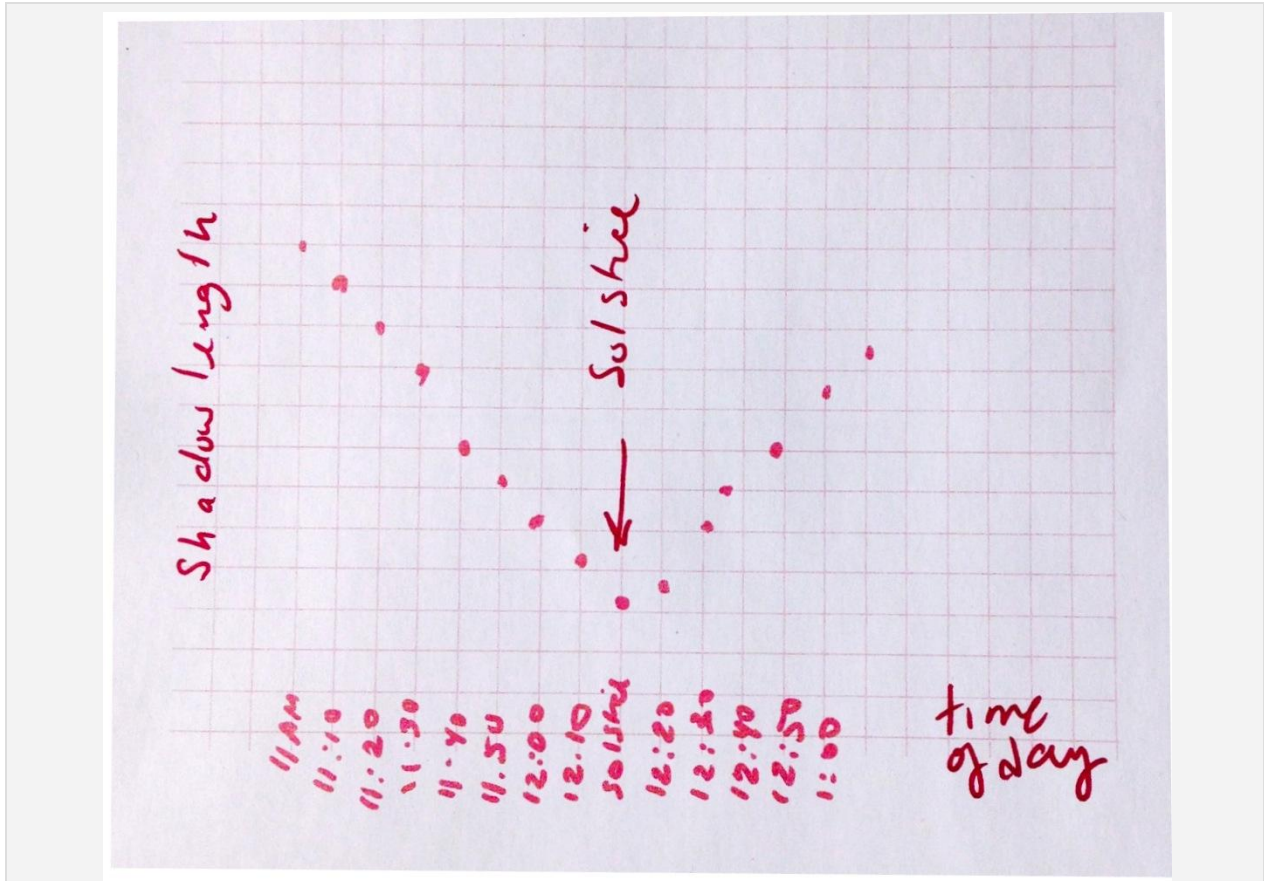
- (1) Check the table below for your time zone (assuming US conventions here).
  1. If you are doing *The Quick and Dirty Version*, make sure that you've been able to set everything up about 10 minutes before the official solstice time.
  2. If you are doing *The Extended Remix*, prepare everything to start 1 hour before the solstice time and allow for an hour after the solstice takes place
- (2) Find out your latitude (you can use a search engine to do this for you) or use our table to roughly identify where your latitude is.
- (3) Find some level ground and place the stick in the ground (or snow) so that the stick is vertical and so that you are able to measure the shadow that it casts. It's important that you are able to see the shadow for all of your measurements.
- (4) Measure the length of the stick above the ground. Write the length on the piece of paper.
- (5) Note the time and write that on your piece of paper.
- (6) Measure the length of the shadow of the stick.
- (7) If you are doing *The Quick and Dirty Version*, jump to the end of the instructions, where it says How do I calculate tilt?

(8) If you are doing *The Extended Remix*, you'll need to note the time and the length of the shadow every 10 minutes from one hour before the start of solstice to one hour after the time passes. You will end up with 6 data points in the first hour: the solstice point and 6 data points after the solstice takes place.

Extended Remix Version:

(1) If you do (8) as instructed, you will be able to plot the length of the shadow versus time using the graph paper

(2) The graph should look something like this:



The shadow will be the shortest at the solstice point in time.

How Do I Calculate Tilt?:

You'll need:

- a handheld calculator or a computer calculator with the  $\tan^{-1}$  button on it, or:
- [http://www.rapidtables.com/calc/math/Arctan\\_Calculator.htm](http://www.rapidtables.com/calc/math/Arctan_Calculator.htm)

For the Quick and Dirty Version:

- (1) Using any calculator, calculate the following:  $(\text{Stick Length})/(\text{Shadow Length})$ . Make sure that your answer is in degrees. We'll call this the Sun's Angle.
- (2) Subtract this number from your latitude:  $(\text{Your Latitude}) - (\text{Sun's Angle}) = \text{Earth's Tilt}$
- (3) Tada!

For the Extended Remix

- (1) Select the shadow length at the solstice. It should be when the shadow of the stick is the *shortest*
- (2) Using any calculator, calculate the following:  $(\text{Stick Length})/(\text{Shadow Length})$ . Make sure that your answer is in degrees. We'll call this the Sun's Angle.
- (3) Subtract this number from your latitude:  $(\text{Your Latitude}) - (\text{Sun's Angle}) = \text{Earth's Tilt}$
- (4) Tada!