Investigation Instruments: Clinometer

Constructing and Using a Clinometer

A clinometer is an instrument used for measuring angles. In GLOBE, you use it to find the angle for calculating tree heights. It is also used to determine obstacles at an Atmosphere Study Site. The calculations work by applying the principles based on the properties of right triangles. You construct and use the clinometer by following the directions and using the formula below. The clinometer also lends itself for additional hands-on teaching exercises of trigonometric principles. Did you know that NASA has a satellite called the Ice, Cloud, and land Elevation-2 (ICESat-2) satellite that measures the height of our planet, including trees?

Required Material

- *Clinometer Sheet* and *Table of Tangents* (located in the *Appendix*)
- Piece of stiff cardboard at least the size of the sheets referenced above
- Drinking straw
- Metal nut or washer
- 15 cm of thread or dental floss
- Glue
- Scissors
- Something to punch one small hole
- Tape

Image BIO-CL-1: Students using a Homemade Clinometer

Construction

1. Gather the materials for each clinometer.
2. Glue a copy of the *Clinometer Sheet* onto a same-size piece of stiff cardboard (cut cardboard if necessary).
3. Glue a copy of the *Table of Tangents* to the other side of the cardboard.
4. Punch a hole through the marked circle on the *Clinometer Sheet*.
5. Push one end of the thread or dental floss through the hole and tie or tape it on the *Table of Tangents* side of the cardboard. Colored thread or floss will allow it to be seen easier.
6. Tie a metal nut or washer to the other end of the thread so that it hangs in front of the *Clinometer Sheet*.
7. Tape a drinking straw along the designated line on the *Clinometer Sheet*, to use as a sighting device.
8. *Optional:* The cardboard and both the *clinometer* and *table of tangents* sheets can be placed in a sheet protector or laminated to ensure longer life. The straw would then be placed on the outside of the plastic and the hole for the thread with the washer would be punched through the entire instrument (plastic cover, cardboard and sheets).

   Note: A clinometer measures angles to determine the heights of objects without directly measuring them. It is a simplified version of the quadrant (a medieval measuring instrument), and the sextant (an instrument used to locate the positions of ships). Like these instruments, the clinometer has an arc with graduated degree markings that go from 0 to 90 degrees.

How to Use a Clinometer

1. Locate a spot where the top of the tree can be seen (don't select a spot that causes you to look nearly straight up at the tree top) and you are at the same elevation as the tree (level ground);
2. Sight the top of the tree through the clinometer's drinking straw. Have a colleague read the degrees of angle by noting the number where the thread crosses the arc on the Clinometer Sheet (See Figure BIO-CL-2 below).

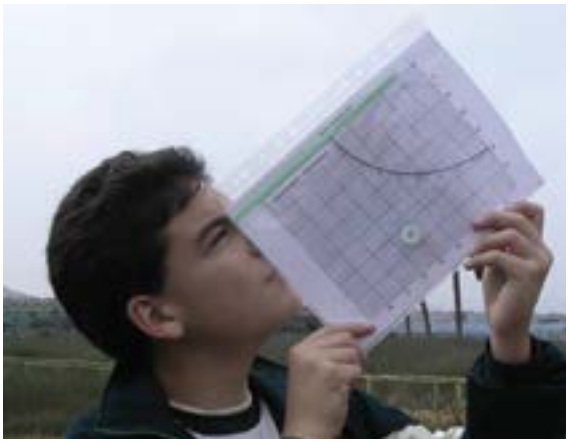


Figure BIO-CL-2. A boy using a clinometer

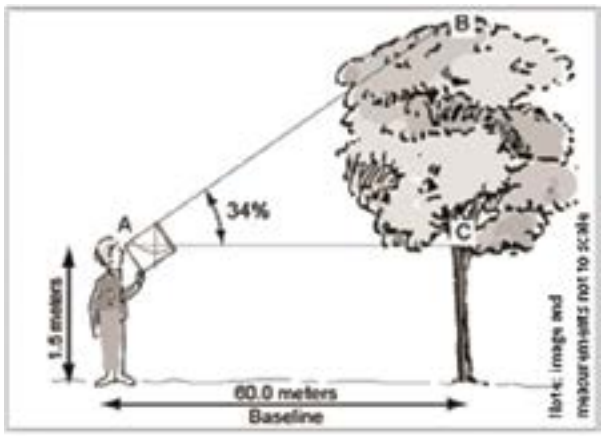


Figure BIO-CL-3. Example clinometer measurements

3. Measure the horizontal distance from you to the object that is being measured.
4. Measure the height of your eyes from the ground.
5. If you know the angle of elevation (the number where the thread crosses the arc on the clinometer sheet), your eye height, and the distance between you and the object (as in Figure BIO-CL-3 above and Figure BIO-CL-4 on next page) you can calculate the height of that object using a simple equation (below).
6. Don't forget to add your eye height to the calculated value.

BC = AC x Tan ∠A

Length BC is the height of the tree above your eye height

Length AC is the distance from you to the base of the tree

Tan ∠A is the tangent of the angle where the thread crosses the arc on the Clinometer Sheet

Using the example values in Figure BIO-INS-CL2, the calculation is:
BC = 60.0 x 0.67*; therefore BC = 40.2

The height of the eye must also be included to find the height of the tree.

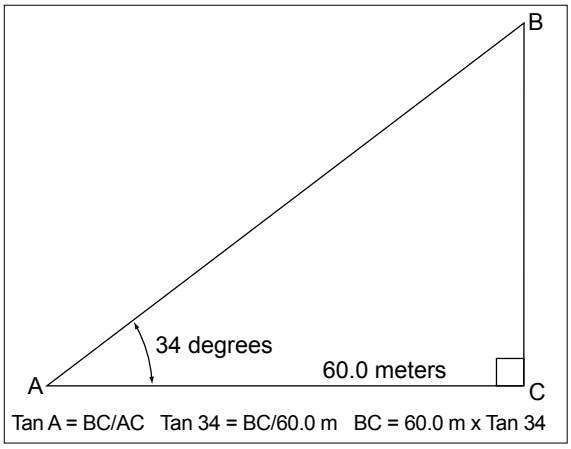
40.2 + 1.5 = 41.7 meters

*this is the Tangent of 34

Hint: It's often helpful to practice measuring heights of a known object (such as a flagpole or the school building) before measuring trees.

Note: Adjust your distance from the tree so that you are at least as far away from the tree as the tree is tall. For the most accurate measurement, adjust your distance so that the angle of the clinometer is as close to 30 degrees as possible.

Figure BIO-CL-4. Trigometric Equation



Frequently Asked Questions

1. What if my students are too young to understand the math used to determine tree height?

For younger students, if the angle BVW is 45 degrees, the distance from the tree will equal the height of the tree above the student's eye level. This can be illustrated for students by drawing an isosceles right triangle without any additional explanation of the mathematics involved. Run a tape measure from the student's eye to his or her feet and then to the base of the tree. This distance will equal the height of the tree. See the *Alternate Technique to Measure Tree Height on Level Ground: Simplified Clinometer Technique Field Guide* in the *Biometry Protocol*.

2. What if the tree is leaning?

If the tree is leaning, just measure to the top of the tree as usual.

3. If I cannot be on the same level as the base of the tree I am measuring, how do I estimate the height of the tree? Or what if there is no level ground to measure the tree heights?

There are three methods to handle this problem. They are presented in the *Biometry Protocol's Alternate Techniques to Measure Tree Height Field Guides*. Use the one that seems the most appropriate.