NYC STEM Summer Institute: Climate To Go!
Measuring the Diameter and Height of Plants

Standards
NGSS LS1A: Structure and Function
NGSS LS1B: Growth and Development of Organisms

Equipment
Tape measure or calipers
Clinometer (optional)

Why?
Observations are the foundation of science. When we quantify those observations with measurements we give ourselves the power to answer many important questions about the natural world, particularly questions about the size and scale of processes and about the rate at which things change. Measurements are also the basis for making accurate predictions about what will happen in the future.

Consider a familiar example. Ithaca is 60 miles by road from Syracuse. Using the car's speedometer we measure the speed at which we travel so that we can then predict how long it takes us to get there and the time when we will arrive – both useful things to know.

What?
In this activity we will measure the diameter and height of plants. To do this we divide plants into two groups – large plants and small plants – because the equipment and techniques for large and small things are a little bit different. We define a large plant as one that is taller than a person (it doesn't really matter if the person is short or tall – this is just a general definition). Small plants then are shorter than people.

For small plants, like the typical seedlings that we outplant in a forest restoration project, the height can be measured with a ruler, yardstick or tape measure. The diameter is most easily measured with a pair of calipers. For a large plant like a tree, we can measure the circumference with a tape measure and then convert that measurement to diameter. The height usually requires making an indirect measurement (described in the next section).

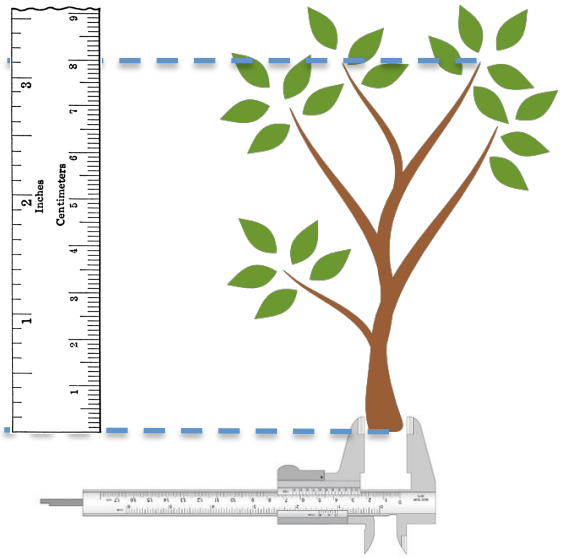


Figure 1: measuring height with a ruler and diameter with calipers

IMPORTANT: all measurements should be made in metric units. Height is measured in meters and diameter is measured in centimeters.

How?
Small plants: Measure the height with a ruler, yard stick or tape measure (make sure your ruler or tape is metric). The ruler should be placed on the ground next to the stem, and measure to the height of the tallest stem (ignore the leaves). If the plant has multiple stems, measure the tallest one. Record your measurement in meters.

Example: In Figure 1 the height of the plant is 8 cm. We would record this measurement as 0.08 meters (m). NOTE: you can record the height in centimeters in the field, as long as you are careful to convert to meters later.

Measure the diameter of a small plant with calipers. We will measure the diameter at ground level, a measurement called *basal diameter*. When using calipers it is helpful to first look at the scale and figure out where to read your measurement (sometimes there is more than one scale). You can check this by measuring an increment on your ruler to be sure you've got it right. Record your measurement in centimeters.

Figure 2: The circumference and diameter of a circle are related by the factor pi: π=3.14159. Measure the circumference of the tree (photo) in order to calculate the diameter.

Large plants and trees: To measure the diameter of a large plant we measure the circumference of the stem or trunk. The circumference is then converted to diameter (Figure 2). Measure the diameter at "breast height," a quantity usually abbreviated *DBH*. Again, it doesn't matter if the person measuring is short or tall, and it is more important to use a part of the stem that avoids branches and weird bumps. If the tree has multiple trunks, measure below the place where the main stem branches into multiple trunks. Record your measurement in centimeters.

Measuring the height of a large plant involves some tricky moves.

(1) One method is to acquire a long pole that you can calibrate ahead of time so that you can measure a tree that is taller than you are. You will need two people; one to hold the pole next to the tree and another to stand back and read the measured height.

(2) Another method is to measure the height of a person. Have that person stand next to the tree and take a photograph of the tree and your human yardstick. Using your photograph you can estimate the height of the tree in person-units that you can then convert to meters (Figure 3A).

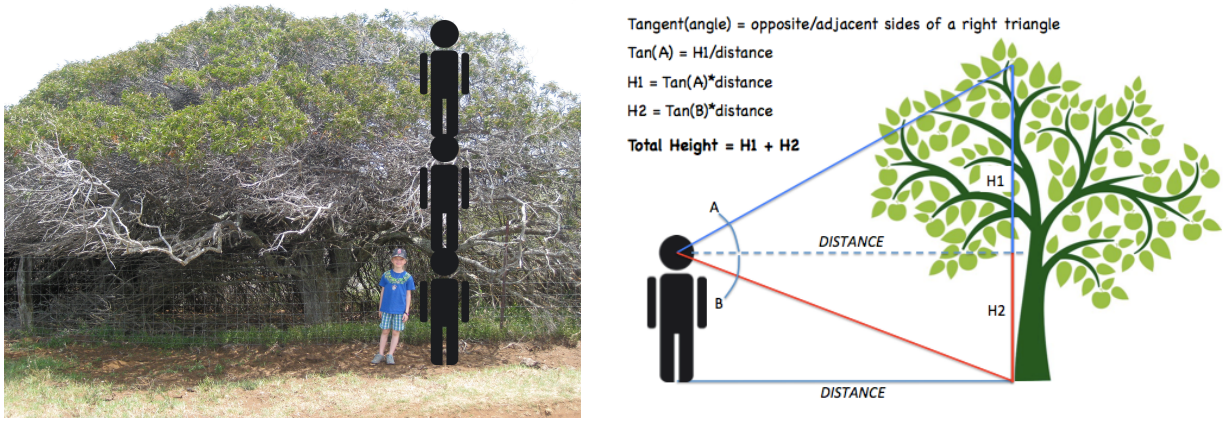
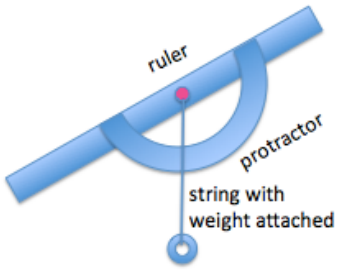


Figure 3: (A) Ellie is 1 meter tall, therefore the Koai'a tree is 3 meters tall. (B) Using angles, distance and trigonometry to find the height of a tree.

(3) The third method involves measuring angles and using trigonometry.

- Stand back from the tree – about as far away as the tree is tall.
- With a tape measure, measure the distance on the ground between your feet and the tree trunk. Record this distance in meters.
- Use a clinometer to measure the angle between your eye and the top of the tree. Record this angle (A).
- Use the clinometer again to measure the angle between your eye and the bottom of the tree trunk. Record this angle (B).
- Make a sketch with two right triangles and solve trigonometrically for the vertical side of each triangle (Figure 3B).
- Sum the vertical sides (H1 + H2) to find the height of the tree.

NOTE: a simple clinometer can be made using a protractor, a ruler, string and a fishing weight. Alternately, many compasses come with clinometers built in, or you can buy one at a hardware store. To use the homemade clinometer, hold the ruler to your eye and sight along it. Pinch the string to the



protractor when the sight-line is right so you can read it (or have a second student read it while the first student sights to the tree). Because of the way that the scale is marked on a protractor you will need to record the *complementary angle* (90-A), rather than the angle read directly off the protractor.

Each of these three methods for measuring height will be fine for this project. Choose the one that best suits your situation and available materials.

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