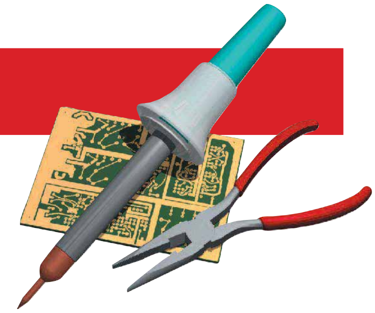


The Doctor is IN

Q Here's a practical question from Harry Woods, W2PAL: Standing on the ground, is there any way I can estimate the height of a tree or an antenna support structure?

A There are several methods for doing this; we'll present two. Both involve the application of a little trigonometry. Each method assumes flat and level terrain around the unknown structure and both involve sufficient sunlight such that a shadow is cast.

The first method requires the date and time at the location where the measurement is made. It further requires Internet access or some other convenient way to obtain solar position data. First, obtain the altitude of the Sun (in degrees) for the day and time that you wish to make the measurement. You can conveniently obtain this information from the US Naval Observatory Web site. Under *Positions of the Sun and Moon*, select *Altitude and Azimuth of the Sun or Moon During One Day* (**aa.usno.navy.mil/data/docs/AltAz.html**). You will need to enter the date and your location by city or town. The database currently contains about 22,000 locations, so if your town is not listed, choose the closest location.

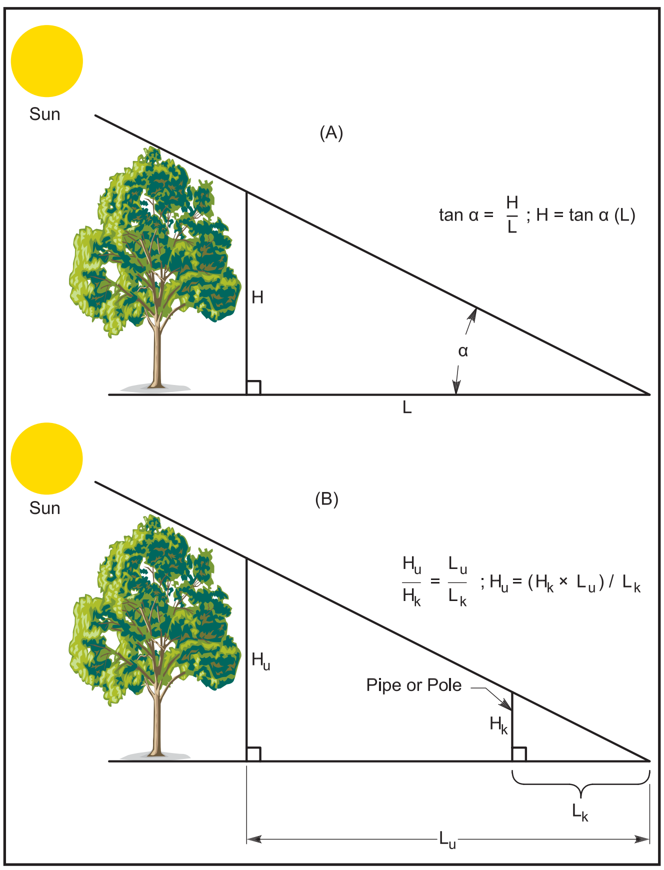


Figure 1—Using the Sun's angular position in degrees, it is relatively easy to calculate the height of an unknown object, as in A. Similarly, in B, the height can be calculated by comparing the shadow length of a known object with one of an unknown. Note that the pipe shadow should *not* be in the tree's shadow; it is shown that way on the drawing for brevity. Both shadow measurements need to be done at the same time. Use this method when the Sun's angular position isn't immediately available.

The rest is easy. Simply measure the length of the shadow being cast by the unknown structure at a convenient time selected from the Sun's data. The height of the unknown structure can now be determined by looking at Figure 1A:

$$\tan \alpha = H / L$$

where:

α = Sun's altitude (in degrees)
H = height of unknown structure
L = shadow length of unknown structure

then:

H = tangent of Sun's altitude in degrees (α) × shadow of unknown structure (L).

As an example: The Sun's altitude is 53.38° at the time, date and location of the measurement. The shadow cast by the unknown structure is 70 feet, 9 inches or 70.75 feet. The height (of the unknown structure) = tan 53.38 × 70.75 = 94.9 feet, or 94 feet, 11 inches.

The second method requires a structure of known height such as a pipe or pole. Install (or have a helper hold) the pipe perpendicular to the Earth's surface. A level or a plumb bob should be used. Now simply measure the length of the shadows being cast by the known and unknown structures. Be sure to make both measurements as simultaneously as possible. The height of the unknown structure can now be determined by the trigonometry of similar triangles, as shown in Figure 1B:

$$H_u / H_k = L_u / L_k$$

where:

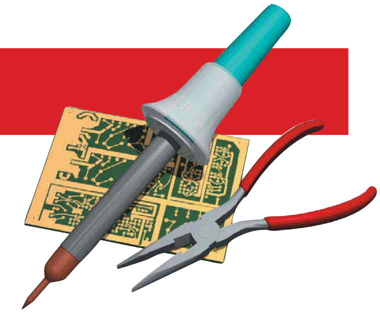
H_u = unknown structure height
H_k = known structure height
L_u = unknown structure shadow length
L_k = known structure shadow length

then:

$$H_u = (H_k \times L_u) / L_k$$

As an example: The shadow of the unknown structure is 70.75 feet. The shadow of the known structure is 8.95 feet. The height of the known structure is 12 feet. Height of the unknown structure = (12 × 70.75) / 8.95 = 94.9 feet.

Q Dick, KF4NS, asks: Why are the tabs on rechargeable batteries welded instead of soldered? I am preparing to rebuild a 12 V rechargeable battery pack with 10 cells of the same rating, with tabs already connected on top and bottom. The only problem I see is one concerning the orientation of the tabs. In order to rebuild the pack using the original case, I have to connect the battery tabs at angles other than their pre-welded direction. I have soldered tabs to rechargeable batteries in the past, using whatever conductive material I can find, but what is the proper material to use and of what width and thickness?



The Doctor is IN

The Doctor had quite a few comments to his reply to Harry Woods, W2PAL, relative to finding the unknown height of a tree (June 2004, p 56). Representative of the many replies was this one received from Larry, WR1B, and Dan Wolfgang, of ARRL HQ. Thanks go to Larry and Dan and to all the other readers who offered similar comments on the Doctor's tree height solutions. The Doctor must confess—he was never a Boy Scout!

With mild amusement, we read your June 2004 column in *QST*. The question from Harry Woods, W2PAL about how to estimate the height of a tree, tower or other structure is indeed a practical one. Obviously, neither W2PAL nor the good Doctor was ever a Boy Scout, or at least not a First Class Scout.

I would suggest that W2PAL contact a Boy Scout troop in his area and ask the Scoutmaster to bring the Troop to his location for some height-measuring practice. The Scouts will use one of two techniques to estimate the height of his tree. Once that contact is made, perhaps he would like to invite the Scouts back to his station during the third weekend in October for the Jamboree on the Air (JOTA), October 15 to 17, this year.

The first method the Scouts might use is called "The Stick Method." Start with someone of known height. (It is easiest if you can find someone who is 5 feet tall, although four footers or six footers will work equally well.) Have this person stand at the base of the tree. If you can't find anyone to help with the task, pick a board, post or other straight object of known length and stand it at the base of the tree.

Back up some reasonable distance (that does not have to be measured) and hold a short, straight stick at arm's length in front of you. Close one eye and sight along the top of the stick, moving your arm so the top of the stick is even with the top of your helper's head. Place your thumb at a spot on the stick that aligns with the base of the tree and your helper's feet. Now simply move your arm with the stick up until your thumb aligns with the top of the helper's head and note where the top of the stick seems to touch the tree. Move your arm up again until your thumb touches the new spot and again note where the top of the stick seems to touch. Continue this procedure until you reach the top of the tree. See Figure 1.

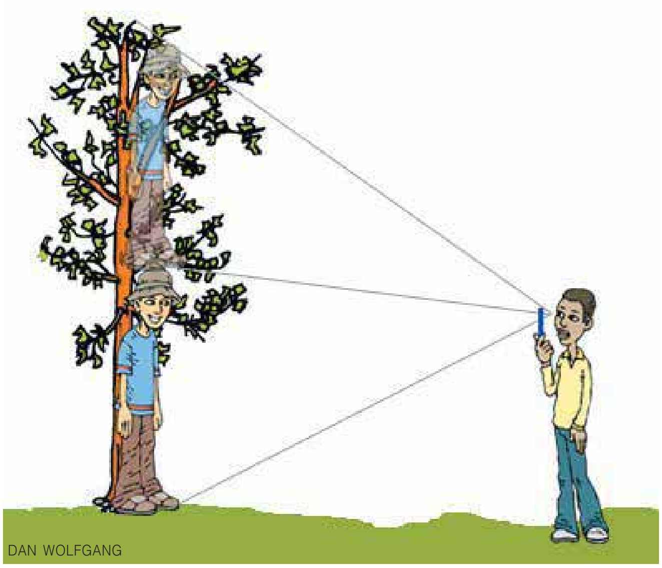


Figure 1—The "Stick Method" of estimating heights involves counting the number of times a known height will fit into the total height of the object. The "Felling Method" is described in the text.

To estimate the height of the tree, simply multiply your helper's height by the number of times you moved the stick upward. For instance, if you started with a 5 foot helper and measured the tree to be 10 "stick lengths," you have a 50 foot tree.

The second method the Scouts may use is called the "Felling Method." This will probably result in a more accurate measurement than the stick method. In fact, it could be at least as accurate as the date, time, location and Sun angle from the "Internet Method," as originally proposed by the Doctor.

You will still need a straight stick (probably a bit longer than that used with the other method) and a cooperative helper. Again, you will step back some reasonable (unmeasured) distance from the tree. Holding the stick at arm's length in front of you, close one eye again, and sight over the stick at the tree. Position the top of the stick so it appears to touch the top of the tree and then position your thumb along the stick so it appears to touch the ground at the base of the tree.

Now, rotate your wrist so the stick is horizontal, along the ground. Keeping your thumb at the base of the tree, have your helper move so he or she is standing where the top of the stick now touches the ground. Mark this spot. The most critical part of this measurement technique is ensuring that the line from you to the tree and then to your helper forms a 90° angle along the ground. The Scouts will now count their steps between the mark and the tree, multiply by the length of their stride, and give you the height of the tree with a fair degree of accuracy. (If your step is 2 feet and it takes 50 steps to cover the distance between the mark and the tree, you have a 100 foot tall tree.) If you need even better accuracy for your measurement, stretch a tape measure along the ground and measure that distance. Before the Doctor's computer can dial up the Internet and access the US Naval Observatory Web site, you will know the height of the tree at least as accurately as the Sun angle, shadow measurement and trigonometry calculation will provide!

We might point out that either of these methods works at any time, whether or not the sun is shining. You may need a powerful flashlight to make the measurements at night, but they will certainly work on rainy, snowy and cloudy days when there is no sunlight to cast a shadow. The methods also work well in a forest, where it may be difficult or impossible to find the entire shadow of that one tree you want to measure. There are similar methods for estimating distances, such as the width of a stream or river, although those become a bit more elaborate. Ask your friendly Scouts to demonstrate that technique.