The *Sine Method*: A Better Tree Height Measuring Technique

Using a Laser Rangefinder and a Clinometer to Precisely Measure Total Tree Height
Why the Sine Method?

- Aficionados with the Eastern Native Tree Society (ENTS) noticed an alarming trend concerning reported tree height measurements within state and national champion tree programs:
  - Many nominators and verifiers, some of whom are professional foresters, were overestimating tree heights by as much 40% !!!
Why the Sine Method?

- As a result of these widespread tree height measurement errors, and due to the advent of new and cheaper technologies such as laser rangefinders, the “sine method” was quickly adopted by the Champion Trees National Register, ENTS members, and by west coast tree height gurus.
Why the Sine Method?

• Eliminates significant height measurement errors introduced via the old baseline / tangent method:

1. Failure to compensate for leaning trees
   • i.e., uncorrected tangent horizontal offset distance

2. Failure to identify the actual topmost branch of the tree
   • i.e., standing too close to the tree when taking tree height measurements and failure to walk around the tree in order to find the tree’s “true top”
Equipment Needs & Tips

• **Clinometer:** Degrees and Percent Scales
  – Suunto Clinometer; Model number PM-5/360PC
    • Degrees (0-90º)
    • Percent (0-150%)
  – *Don’t* buy a Percentage / Topo clinometer!

• **Rangefinder:** I highly recommend purchasing a laser rangefinder with a “continuous scan” mode option – it will make tree measurements much more enjoyable!
  – Any brand laser rangefinder with ”continuous scan mode”
  – Nikon Forestry Pro II (has built-in sine measurement feature)
Equipment Needs

Nikon Forestry Pro II
(laser rangefinder w/ built-in clinometer)

www.nikonusa.com
Tree Measurement Tips

• Stand a **minimum of 150-200 feet away** from the tree you are measuring to ensure that you are hitting the top-most part of the tree’s crown with your laser rangefinder.

• Use your laser rangefinder’s *continuous scan mode* to explore the top of the tree’s crown for that “tallest” branch or leader.

• Measure forest-grown trees during dormancy since multi-layered, leaf-on canopies obstruct precision measurements!
Building “Right Angle” Tree Triangles

Soh -- Cah -- Toa

\[ \tan \Theta = \frac{\text{opposite}}{\text{adjacent}} \]

\[ \sin \Theta = \frac{\text{opposite}}{\text{hypotenuse}} \]

\[ \cos \Theta = \frac{\text{adjacent}}{\text{hypotenuse}} \]

\[ \Theta = \text{angle in degrees} \]

unknown tree height segment

“opposite”

slope distance measured using laser rangefinder (ft)

hypotenuse

adjacent

linear distance; use tape measure

© Jay C. Hayek
Top Triangle = Top Portion of Tree

If, Sine $\Theta_t = \text{opposite (} H_t \text{)} \div \text{hypotenuse (} D_t \text{)}$.  
Then, opposite (\(H_t\)) = Sine $\Theta_t \times$ hypotenuse (\(D_t\)).

Where,

- $\Theta_t$ = clinometer reading, in degrees, to the very top of the tree.
- Hypotenuse = \(D_t\) = laser distance to the very top of the tree.
- Opposite = \(H_t\) = calculated height of the top triangle.
Bottom Triangle = Bottom Portion of Tree

If, \( \text{Sine } \Theta_b = \text{opposite } (H_b) \div \text{hypotenuse } (D_b) \).
Then, \( \text{opposite } (H_b) = \text{Sine } \Theta_b \times \text{hypotenuse } (D_b) \).

Where,
- \( \Theta_b = \text{clinometer reading, in degrees, to the base of the tree.} \)
- \( \text{Hypotenuse} = D_b = \text{laser distance to the base of the tree.} \)
- \( \text{Opposite} = H_b = \text{height of the bottom triangle.} \)

© Jay C. Hayek
Build Two “Virtual” Right Triangles
Build Two "Virtual" Right Triangles
Build Two “Virtual” Right Triangles
Sine Method with Clinometer & Laser Rangefinder

$$D_t = \text{Distance from observer's eyes to top of tree (laser rangefinder)}$$

$$D_b = \text{Distance from observer's eyes to bottom of tree (laser rangefinder)}$$

$$\theta_t = \text{Angle, in degrees, from observer's eyes to top of tree (clinometer)}$$

$$\theta_b = \text{Angle, in degrees, from observer's eyes to bottom of tree (clinometer)}$$

$$D_t = 115 \text{ ft}$$

$$D_b = 84 \text{ ft}$$

$$\theta_t = 40^\circ$$

$$\theta_b = -2^\circ$$
Not So Scary Math Computation

Top “Right” Triangle
Sine $\Theta_t = \frac{H_t}{D_t}$

$H_t = \text{Sine } 40^\circ \times 115'$

$H_t = 0.64 \times 115'$

$H_t = 73.6 \text{ feet}$

Bottom “Right” Triangle
Sine $\Theta_b = \frac{H_b}{D_b}$

$H_b = \text{Sine } -2^\circ \times 84'$

$H_b = -0.035 \times 84'$

$H_b = -2.94 \text{ feet}$

Total Vertical Height = $(H_t) - (H_b)$

Total Vertical Height = $(73.6) - (-2.94)$

= 76.5 ft

Just plug in your measurements and solve for “H”... pretty easy!
No Adjustments are Necessary for Leaning Trees When Using the Sine Method!!!
Leaning Trees: Sine Method
Sine Method w/ Laser Rangefinder
Sine Method w/ Laser Rangefinder
Sine Method w/ Laser Rangefinder

$D_t = \text{Distance from observer’s eyes to top of tree (laser rangefinder)}$

$D_b = \text{Distance from observer’s eyes to bottom of tree (laser rangefinder)}$

$\theta_t = \text{Angle, in degrees, from observer’s eyes to top of tree (clinometer)}$

$\theta_b = \text{Angle, in degrees, from observer’s eyes to bottom of tree (clinometer)}$

$D_t = 84 \text{ ft}$

$D_b = 105 \text{ ft}$

$\theta_t = 35^\circ$

$\theta_b = -2^\circ$
Not So Scary Math Computation

Top “Right” Triangle

<table>
<thead>
<tr>
<th>Formula</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sine $\Theta_t = H_t \div D_t$</td>
<td></td>
</tr>
<tr>
<td>$H_t = \text{Sine } 35^\circ \times 84'$</td>
<td></td>
</tr>
<tr>
<td>$H_t = 0.5736 \times 84'$</td>
<td></td>
</tr>
<tr>
<td>$H_t = \text{48.18 feet}$</td>
<td></td>
</tr>
</tbody>
</table>

Bottom “Right” Triangle

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</tr>
<tr>
<td>$H_b = -0.035 \times 105'$</td>
<td></td>
</tr>
<tr>
<td>$H_b = \text{-3.68 feet}$</td>
<td></td>
</tr>
</tbody>
</table>

Total Vertical Height = $(H_t) - (H_b)$

Total Vertical Height = (48.18) – (-3.68)

= 51.9 ft

Just plug in your measurements and solve for “H”... pretty easy!
Nikon Forestry Pro II / 550

- It is extremely important that you utilize the “2-Points Mode” when using the Nikon Forestry Pro II or Forestry 550 model
  
  - The 2-Points mode utilizes the *sine method* automatically!
  
  - *Do not* use the 3-Points mode for measuring tree height!!!
Measurement example (two-point height measurement)

Image source: nikonusa.com

When the measurement is successful, you see the height from the base to the top displayed on the internal LCD with Hgt+Hgt2 (solid).
For more information, refer to the external LCD.
"Base" and "Top" can be switched.
Resources

- Univ. of Illinois Extension Forestry [Illinois Champion Trees StoryMap](#)

- Champion Trees National Register [Measurement Guidelines](#)


