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

Using a Laser Rangefinder and a Clinometer to Precisely Measure Total Tree Height

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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

+

or

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

www.nikonusa.com

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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!

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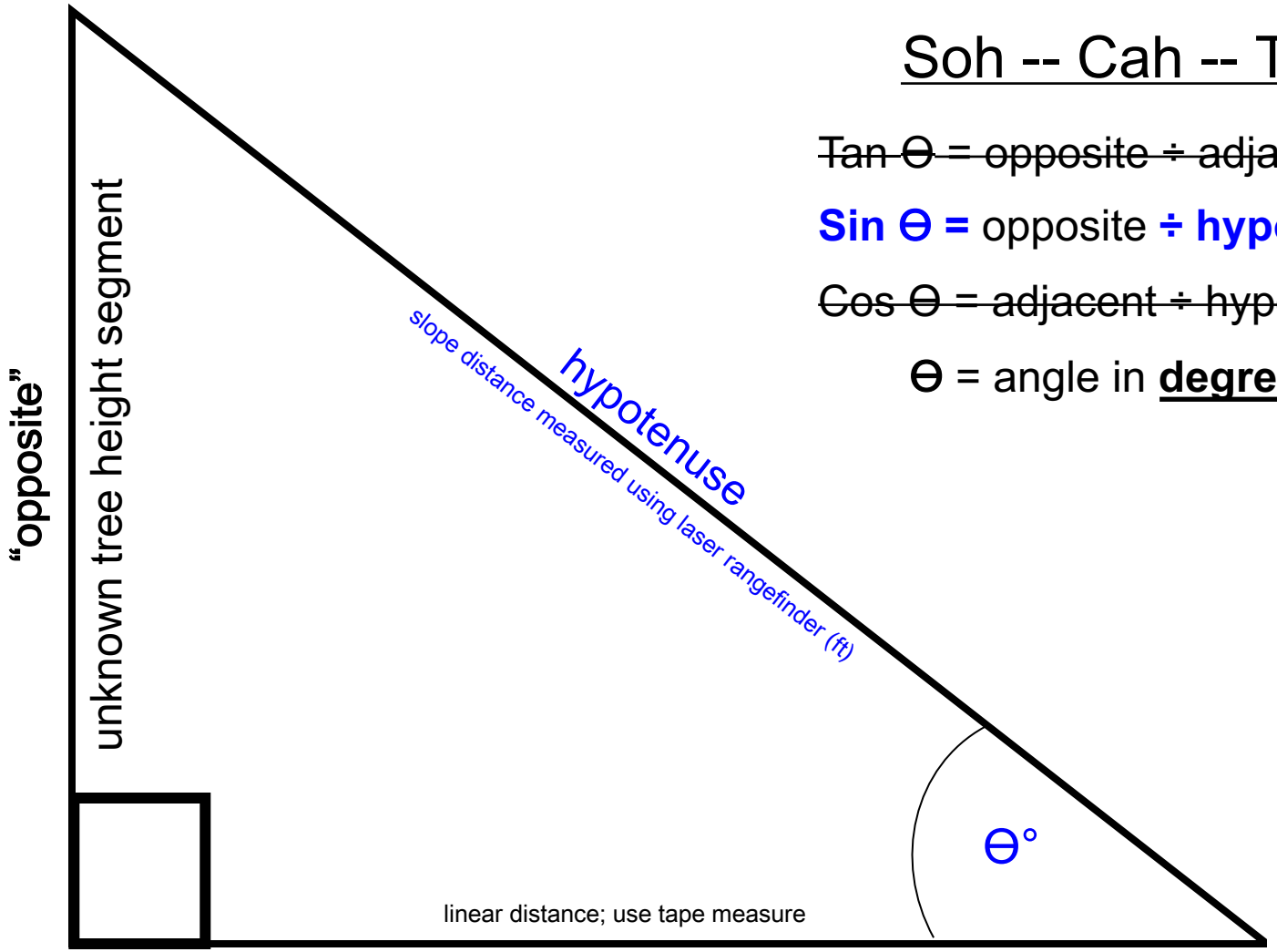
Building “Right Angle” Tree Triangles



Soh -- Cah -- Toa

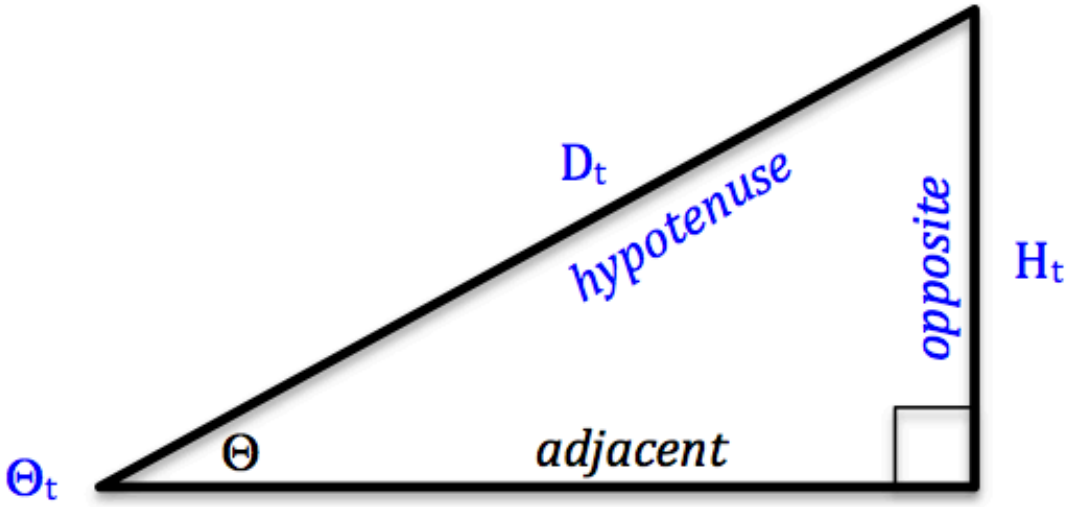
~~Tan Θ = opposite ÷ adjacent~~

Sin Θ = opposite **÷ hypotenuse**

~~Cos Θ = adjacent ÷ hypotenuse~~

Θ = angle in **degrees**

Top Triangle = Top Portion of Tree



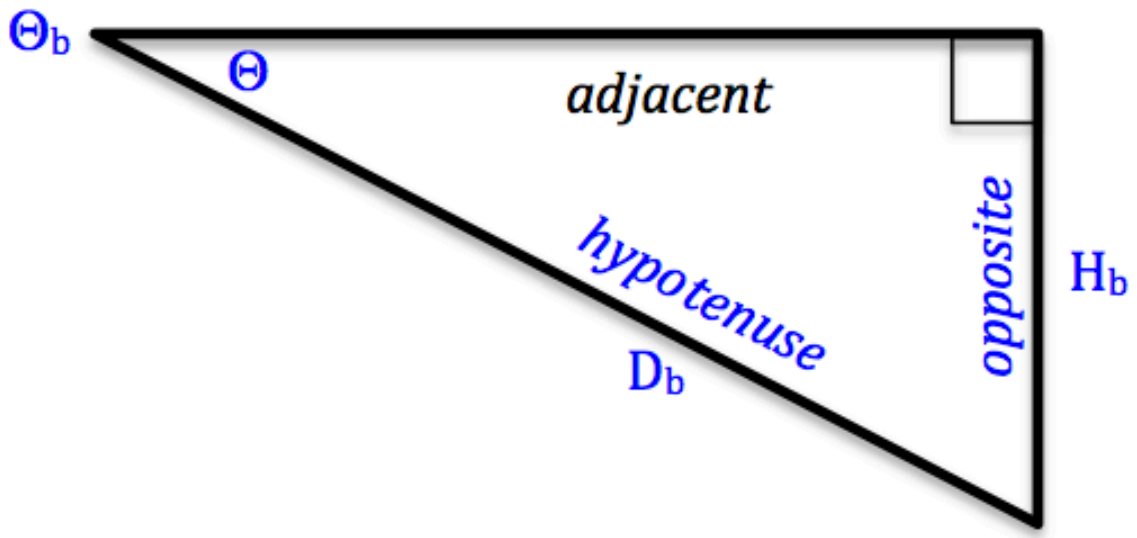
If, *Sine* Θ_t = *opposite* (H_t) ÷ *hypotenuse* (D_t).

Then, *opposite* (H_t) = *Sine* Θ_t × *hypotenuse* (D_t).

Where,

- Θ_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



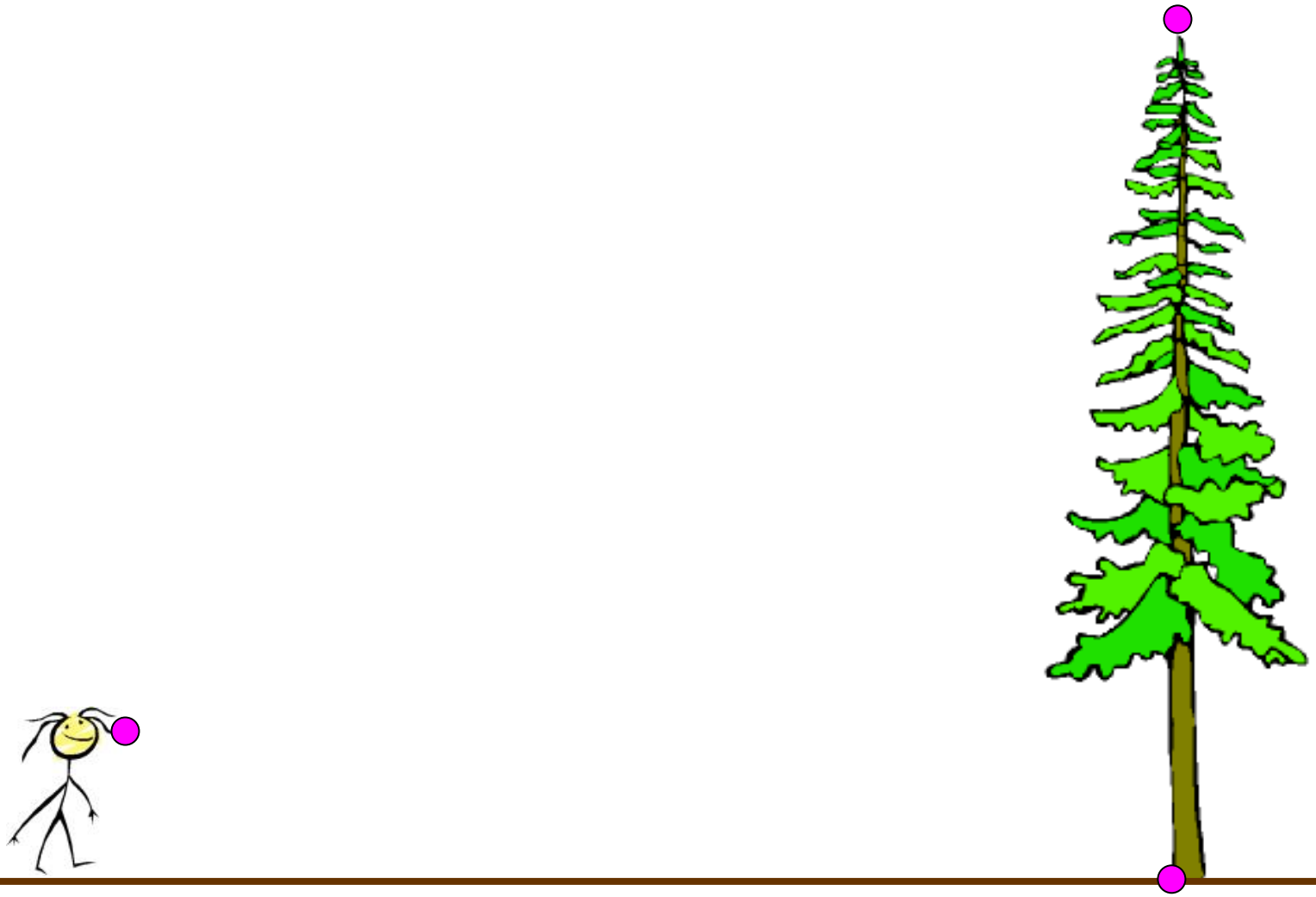
If, *Sine* Θ_b = *opposite* (H_b) ÷ *hypotenuse* (D_b).

Then, *opposite* (H_b) = *Sine* Θ_b × *hypotenuse* (D_b).

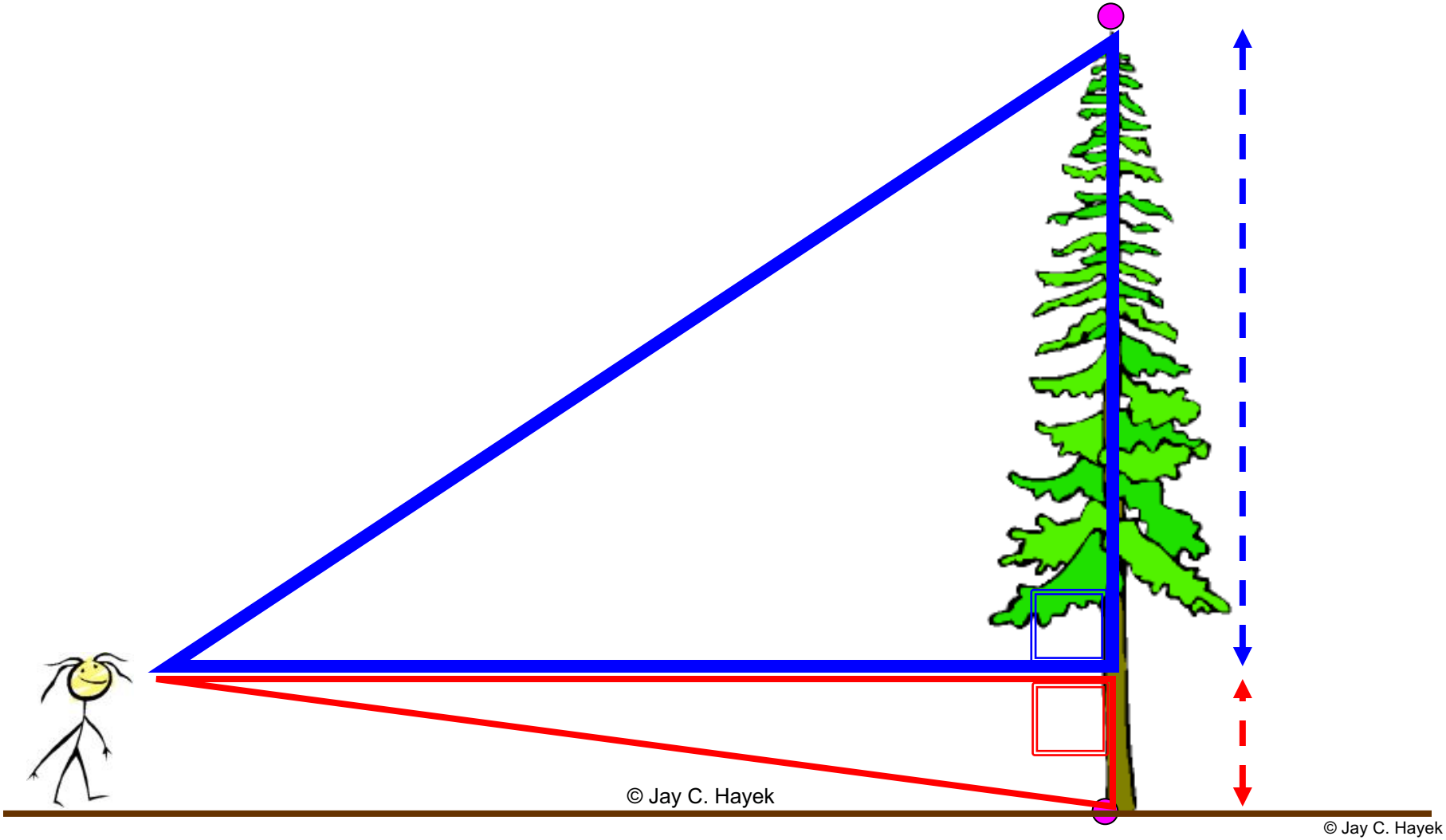
Where,

- Θ_b = clinometer reading, in degrees, to the base of the tree.
- *Hypotenuse* = D_b = laser distance to the base of the tree.
- *Opposite* = H_b = height of the bottom triangle.

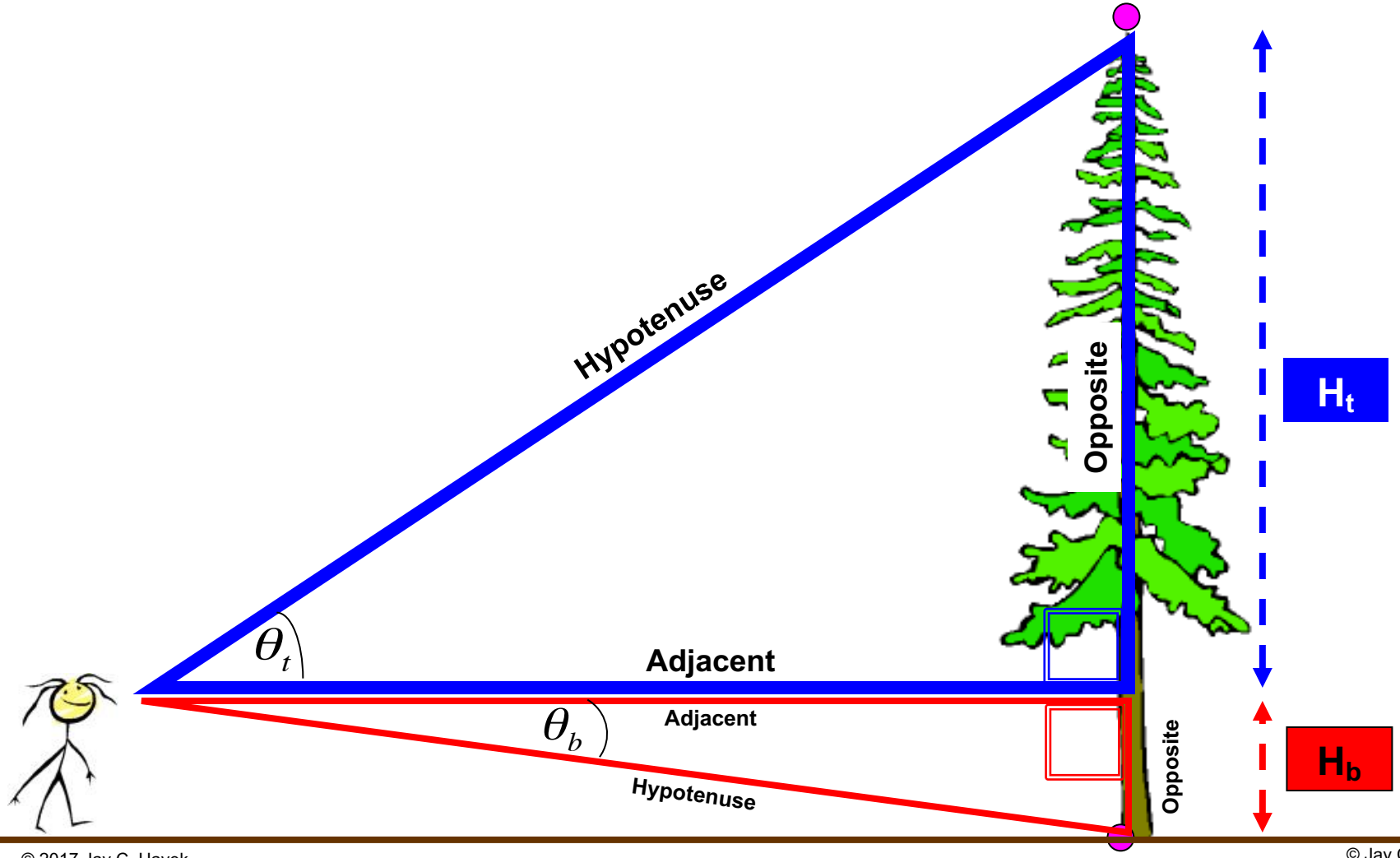
Build Two “Virtual” Right Triangles



Build Two “Virtual” Right Triangles



Build Two "Virtual" Right Triangles



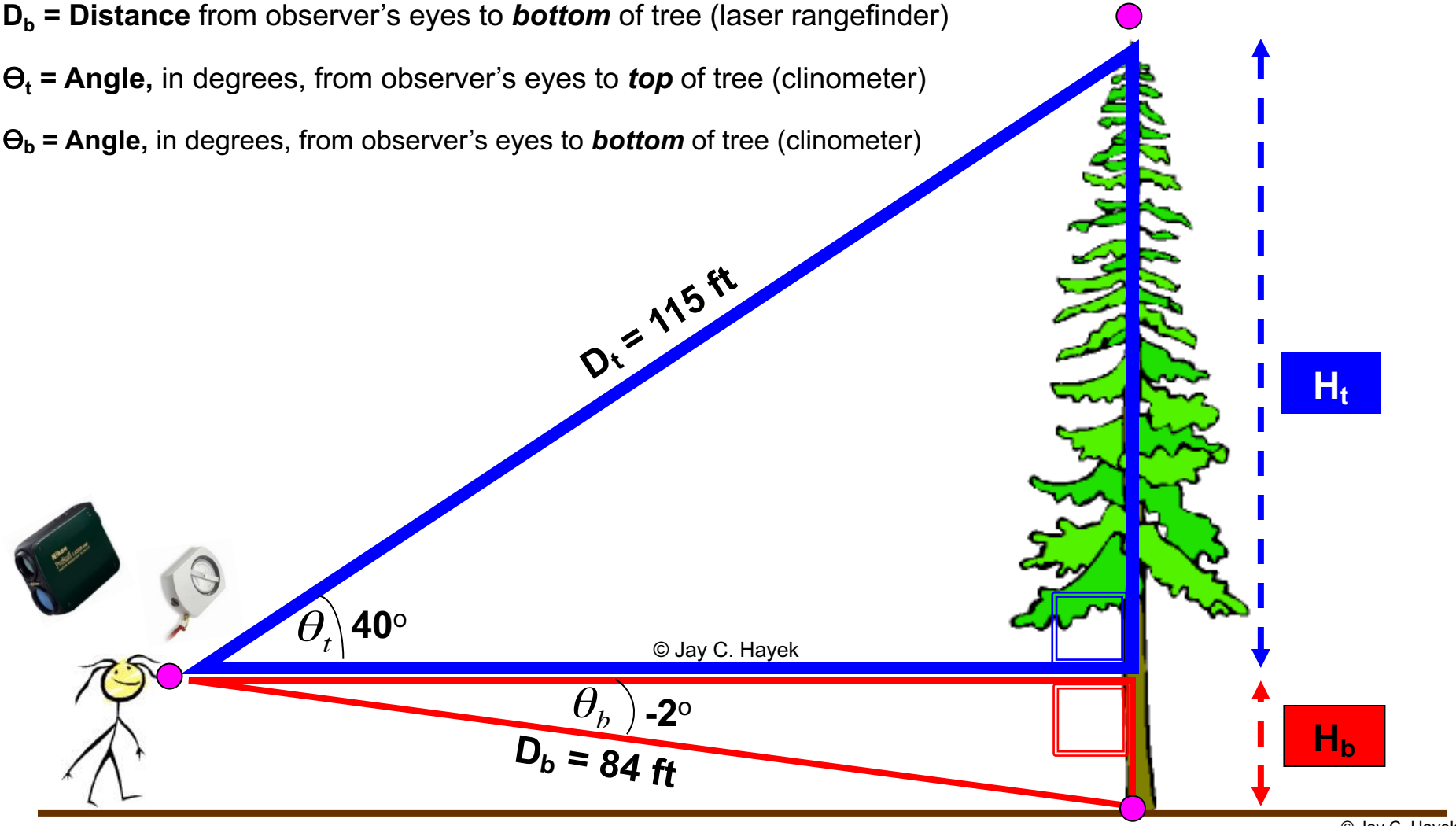
Sine Method with Clinometer & Laser Rangefinder

D_t = Distance from observer's eyes to ***top*** of tree (laser rangefinder)

D_b = Distance from observer's eyes to ***bottom*** of tree (laser rangefinder)

Θ_t = Angle, in degrees, from observer's eyes to ***top*** of tree (clinometer)

Θ_b = Angle, in degrees, from observer's eyes to ***bottom*** of tree (clinometer)



Not So Scary Math Computation

Top "Right" Triangle

Sine $\Theta_t = H_t \div D_t$

H_t = Sine 40° × 115'

H_t = 0.64 × 115'

H_t = **73.6** feet

Bottom "Right" Triangle

Sine $\Theta_b = H_b \div D_b$

H_b = Sine -2° × 84'

H_b = -0.035 × 84'

H_b = **-2.94** feet

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

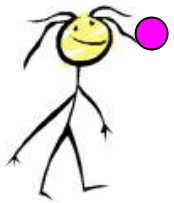
Total Vertical Height = (73.6) – (-2.94)

= 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



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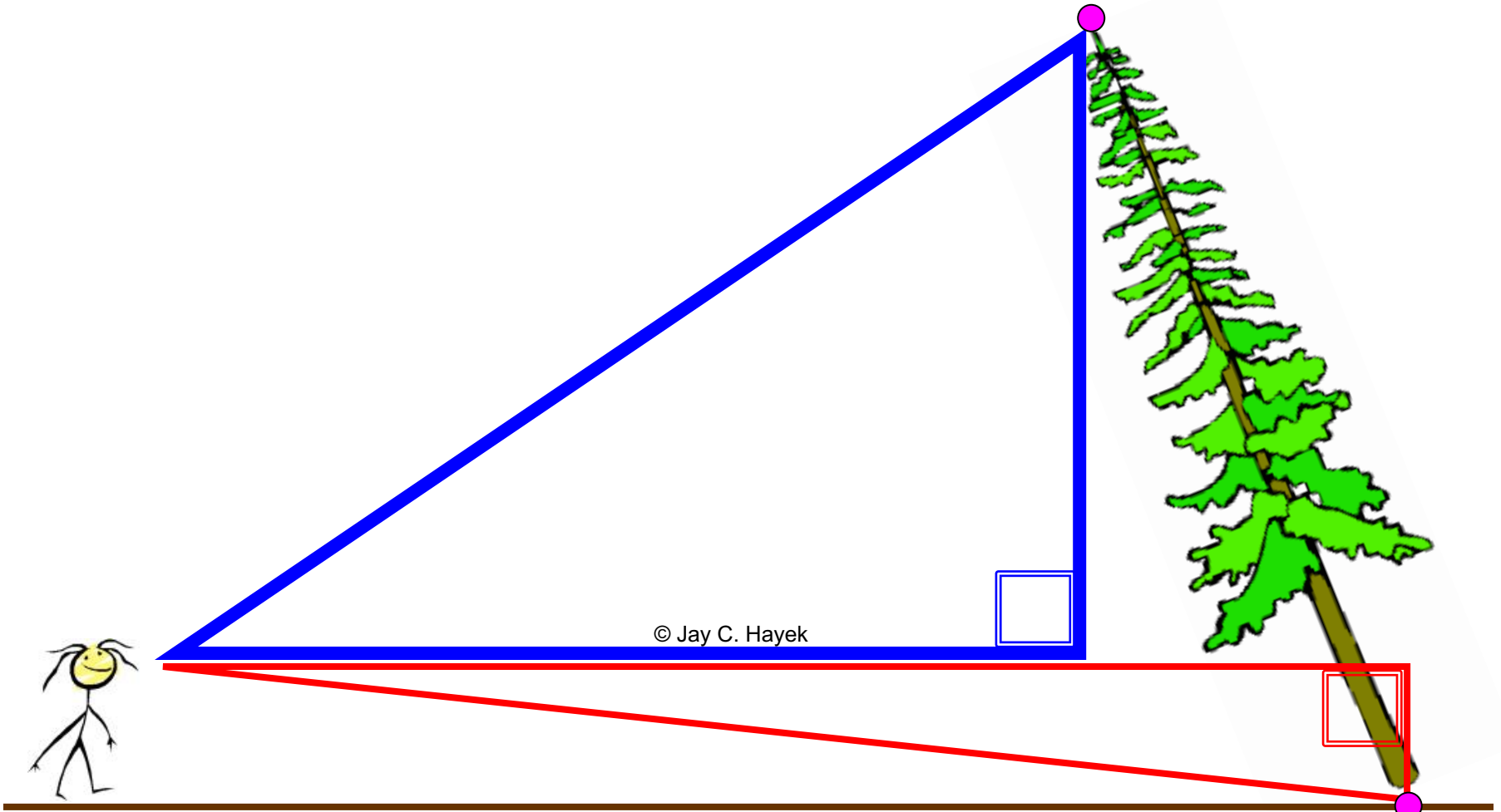
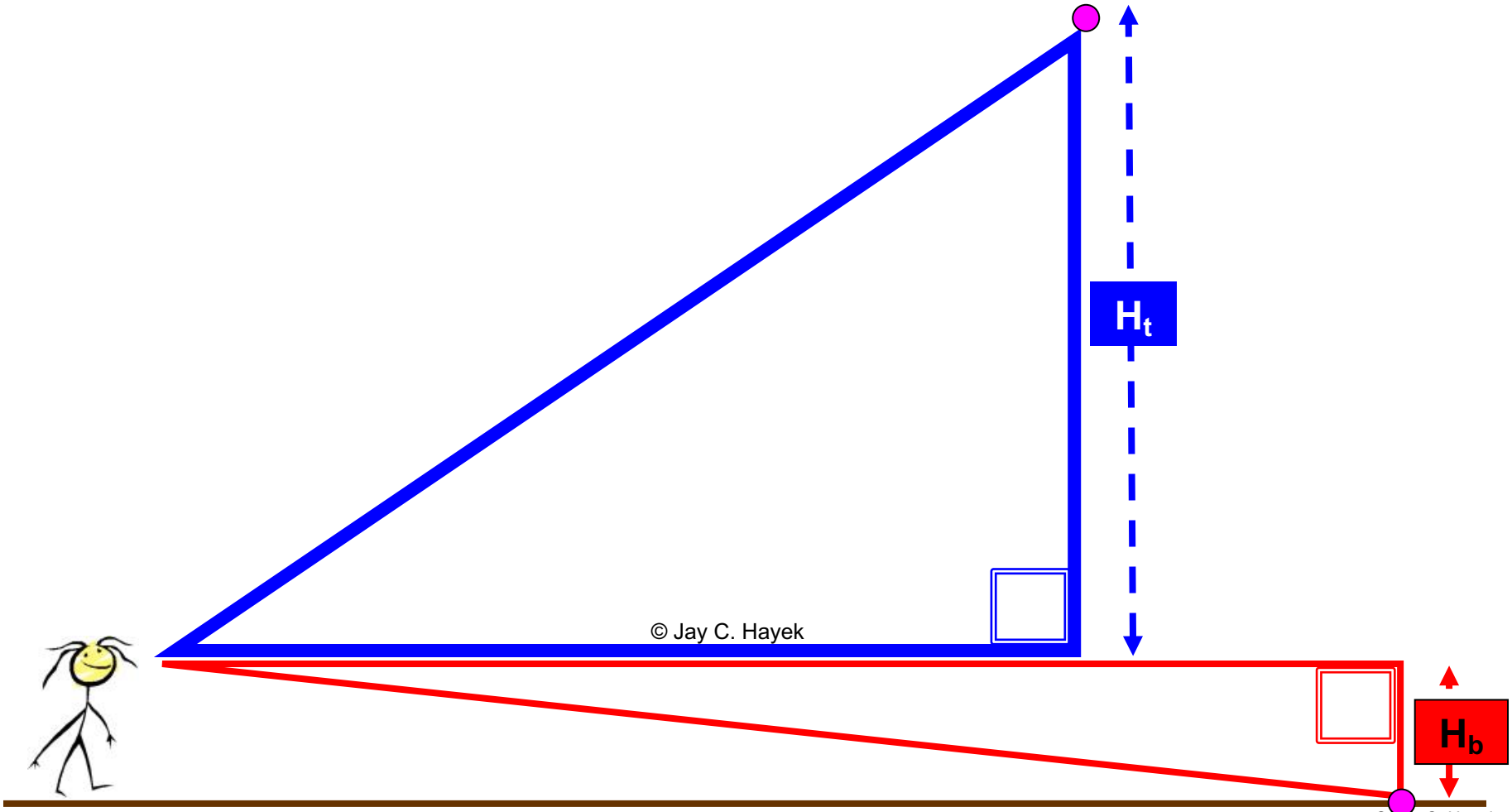
Sine Method w/ Laser Rangefinder



Sine Method w/ Laser Rangefinder



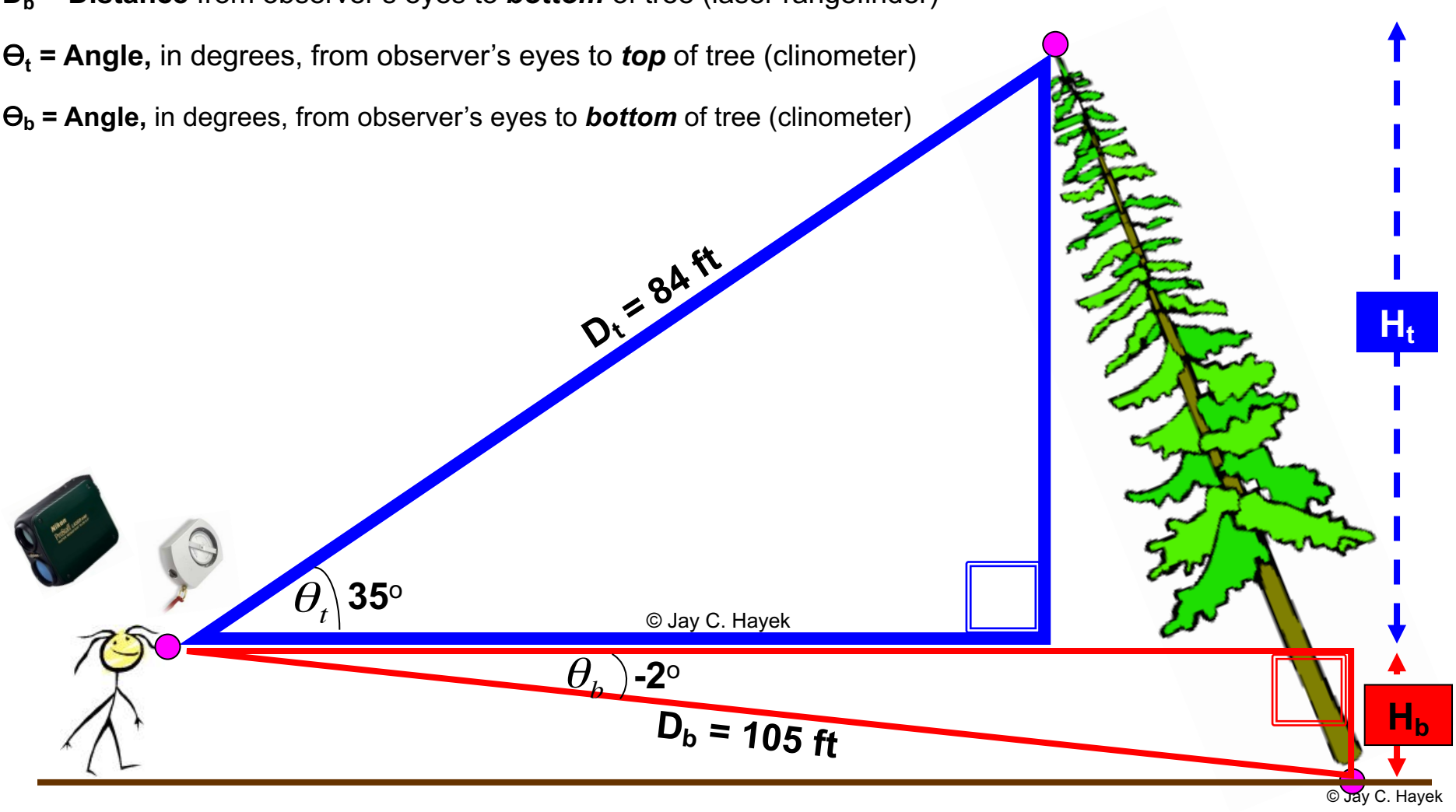
Sine Method w/ Laser Rangefinder

D_t = Distance from observer's eyes to ***top*** of tree (laser rangefinder)

D_b = Distance from observer's eyes to ***bottom*** of tree (laser rangefinder)

Θ_t = Angle, in degrees, from observer's eyes to ***top*** of tree (clinometer)

Θ_b = Angle, in degrees, from observer's eyes to ***bottom*** of tree (clinometer)



Not So Scary Math Computation

Top "Right" Triangle

Sine $\Theta_t = H_t \div D_t$

H_t = Sine 35° × 84'

H_t = 0.5736 × 84'

H_t = **48.18** feet

Bottom "Right" Triangle

Sine $\Theta_b = H_b \div D_b$

H_b = Sine -2° × 105'

H_b = -0.035 × 105'

H_b = **-3.68** feet

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!

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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 !!!

Image source: nikonusa.com

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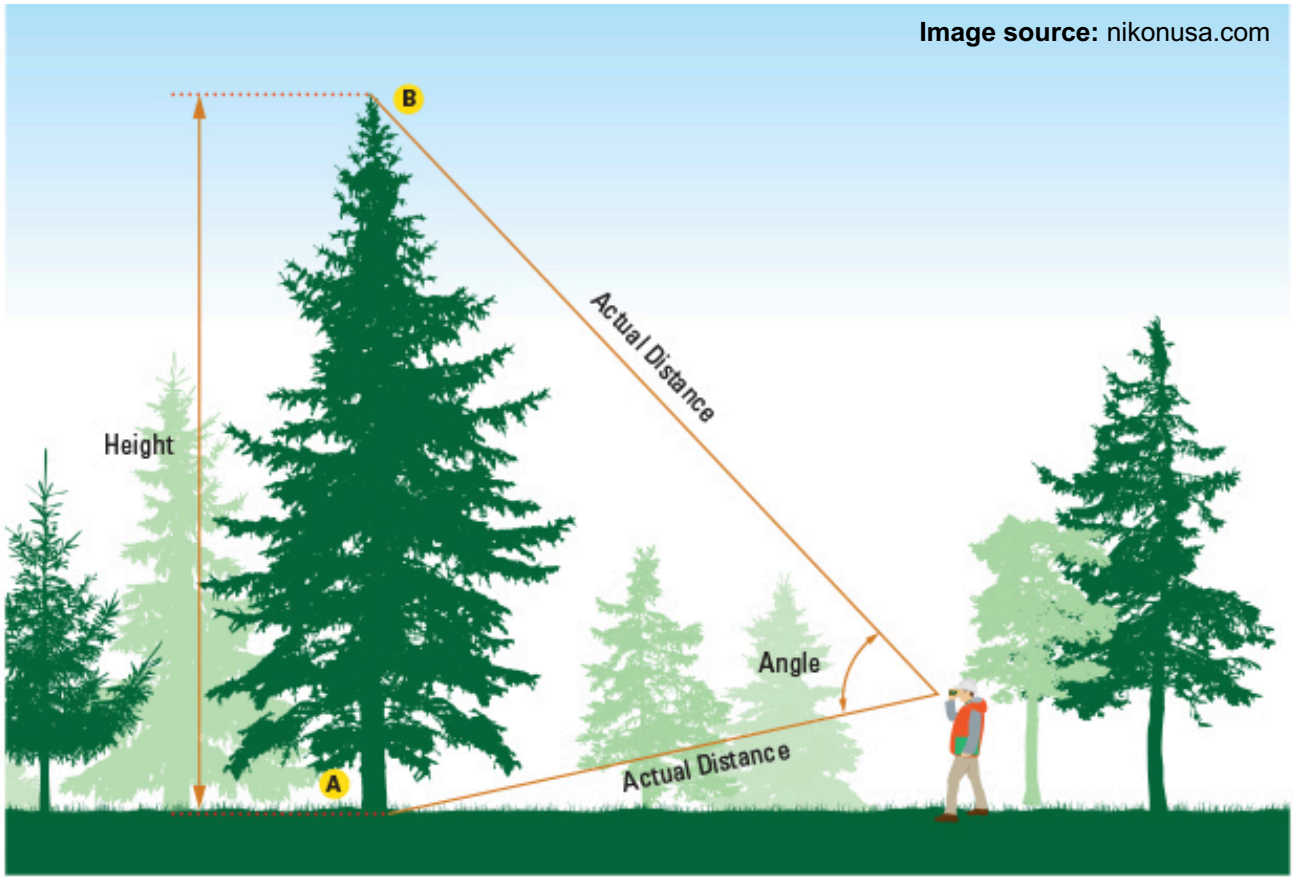
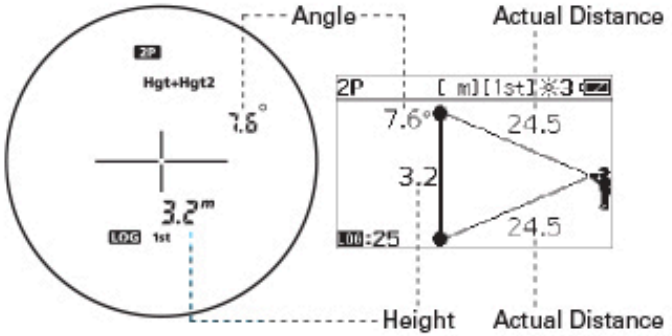


2-Points Mode



Measurement example (two-point height measurement)

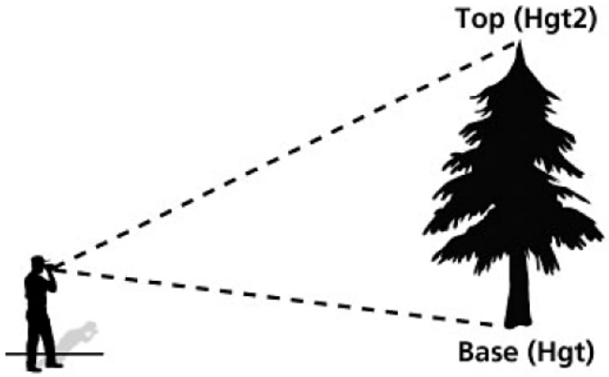
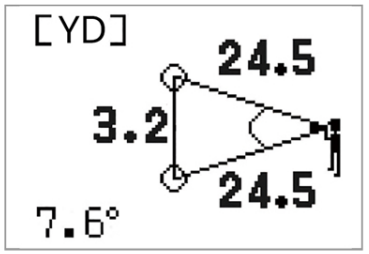


Image source: nikonusa.com

Internal display

Hgt and Hgt2 are solid

External display



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
- Bragg, Don C. 2008. An improved tree height measurement technique tested on mature southern pines. South. J. Appl. For. 32(1): 38-43
- Bragg, Don C.; Frelich, Lee E.; Leverett, Robert T.; Blozan, Will; Luthringer, Dale J. 2011. The sine method: an alternative height measurement technique. Res. Note SRS-22. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 11 p.
- Bragg, Don C. 2014. Accurately measuring the height of (real) forest trees. Journal of Forestry. 112(1): 51-54.

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