# Winter Tree Math

Watercolor by Vicki Tate

**In a Nutshell**

Students use a variety of methods and measuring tools to determine the size of trees on the refuge. By comparing their measurements among teams and with the Minnesota State Champion Trees, students will begin to understand the importance of protocols in data collection.

**Grade:** 2 - 3
**Season:** Winter
**Location:** Rapids Lake Education Center & Bloomington Visitor Center

**Learning Objectives**

After participating in this activity, students will be able to:

- Explain the difference between estimating and measuring.
- Describe the tools used to measure tree height, circumference, and crown spread.
- Give at least one example of how scientific protocol is important in measuring trees.
- Give at least two reasons why tree size might be important to wildlife.

**Literature Connections**

- ***Measuring Penny*** by Loreen Leedy
- ***How Long or How Wide?*** *A Measuring Guide* by Brian P. Cleary
- ***Grand Trees of America: Our State Champion Trees*** by Lisa Jorgenson
- ***The Big Tree*** by Bruce Hiscock

**Pre-Activities**

In Project Learning Tree activity, How Big Is Your Tree students use a variety of simple techniques to estimate height, length, and circumference of a variety of items found in the classroom.

**On-site Activities**

Students record the height, circumference and crown spread measurements from a variety of large refuge trees using established scientific methods and tools. They learn different methods that scientists use to “age” trees and determine the importance and value of trees to wildlife.

**Classroom Connections**

Calculate Champion Tree Points

Back in the classroom have students use the refuge tree measurements they collected during the fieldtrip to calculate Champion Tree Points for each tree species. To determine Champion Tree points use this equation:

Tree's Circumference (inches) + the trees' height (feet) + ¼ the trees' average crown spread (feet) = pts.

Compare the points to the values below. How many points away was their tree from the record holder? Are there any Minnesota Champion Trees in their city? To find the location of Minnesota's Champion Trees go to http://www.dnr.state.mn.us and search "big tree registry".

Start a Tree Growth Data Base

Using the same schoolyard trees from the pre-activity, measure the trees using the new techniques and standards students learned during their visit to the refuge. Compare how close the students' original estimates were to the actual measurements. Create a data log where students can record and compare measurements over time. How much do the trees in the schoolyard grow from year to year? Do the trees grow more some years than other years? What could account for the differences in growth rates?

**Teacher Resources**

- ***Minnesota Trees*** by Minnesota Department of Natural Resources
- ***All About Minnesota's Forests and Trees: A Primer*** by Minnesota Department of Natural Resources
- ***Winter Tree Finder*** by Mary Theilgaard and Tom Watts

| Tree Species | Points | Tree Species | Points |
|---|---|---|---|
| American Elm | 319 | Eastern Cottonwood | 528 |
| Basswood | 307 | Green Ash | 288 |
| Bur Oak | 335 | Northern Red Oak | 261 |
| Box Elder | 258 | Sugar Maple | 244 |

# Winter Tree Math
# Pre-Visit Activities

## Materials

- Classroom Math data sheet (1 per pair)
- Ruler (1 per pair)
- 12 -15 Tangent Height Gauges
- Tangent Height Gauge Guided Discovery Poster
- Example Tape Reel and Tape Measure

## Introduction

Follow the Project Learning Tree Activity # 67: *How Big Is Your Tree?* (page 284) with the following adjustments:

Ask students to think about when they visit a doctor for a checkup. What body measurements do doctors (or nurses) collect (weight, height, temperature, blood pressure)? Biologists use similar measurements for plants and animals. Ask students to imagine being a biologist working on a National Wildlife Refuge. When working with plants, what part of a plant do you think a biologist might want to measure and why? List the responses on the board. If the students don't include tree measurements add the category to the list.

Ask students why they think a refuge biologist would ever need to measure a tree?

**Different Conservation Professionals**

**Wildlife Biologists** manage the health of the land (habitat) for the benefit of wildlife. Trees that make up a refuge habitat are not harvested for homes, paper, or firewood. Wildlife Biologists often work at wildlife refuges.

**Foresters** have special knowledge in how to manage large forest areas. They often monitor the health of a forest and make determinations whether a forest is healthy enough to survive a harvest. Some foresters specialize in estimating how much lumber (used to make paper, build homes, make toilet paper and many other things) a selected harvest area will produce. Foresters may work for the US Forest Service or lumber companies.

**Arborists** specialize in the health of individual plants, trees and shrubs. An arborist is called upon when a disease brakes out in a specific tree or when a city government or city residents need suggestions on the best species of trees to plant in the area. Many cities/communities hire arborists.

- Biologists may measure the size of trees to estimate the amounts of cover and food sources for wildlife. Bigger oaks, for example, may produce a larger acorn crop and more cover for a wide variety of wildlife like song birds, turkeys, bats, squirrels, and raccoons.

- Biologists measure the size of trees to estimate their age. Older trees may be a sign that the land has not been disturbed. These trees tend to be big and are usually found in areas that have been undisturbed by development (for farms, homes and shopping malls). Undisturbed areas are more likely to be places where biologists may find endangered species of plants, animals, insects, or amphibians.

- Biologists measure the quantity of trees to determine if an area would be ideal to protect for a wildlife habitat. For example, some habitats are more desirable if they have less trees like Tallgrass Prairies and Oak Savannahs. Other habitats are preferred if there are more hardwood trees such as a deciduous forest.

Explain to students that people in the past often used their hands or their feet to measure things. Why do you think these tools were used? The answer to this question is that people in the past didn't have the scientific measuring tools we use today (like rulers) so they had to use tools available to them to estimate measurements. Are all estimations the same? Choose two student volunteers to demonstrate if their feet are the same size. Ask them to sit on the floor facing each other with their legs extended and soles of their shoes touching. Ask if you were trading with this person and you asked for a "foot" worth of fabric, would you get the measurement you really wanted?

**Activity One: Measuring in the Classroom**

Ask students to pick a partner. Pass out the Measuring in the Classroom data sheet and ruler to each team. Explain that each team will have about 10 minutes to measure the height of their chair, the length of their desk, the height of a wall, and two things of their choice. Using 3 "tools" they will take two estimates (using their hand, their foot) and one measurement (using the ruler) of each item.

1. Review both methods of *estimating* with the students.
    - What does a hand span look like?
    - What does a foot span look like?

2. Review how to accurately measure with a ruler. Keep in mind that some classes may have very little, or even no, measuring experience.
    - Bring to their attention where zero is on the rulers you are using. In some cases it is at the end of the ruler. In other designs, zero starts in from the edge.
    - Some rulers measure in inches only. Others have inches marked on one edge and centimeters on the other. Make sure students can tell the difference and are measuring with the inches edge.
    - Demonstrate, using two student volunteers, how to measure something that is longer than 12 inches. Have one student start at one end of a locker or a counter. Instruct the second student to mark the end of each 12 inch interval with a finger before the first student moves the ruler to continue measuring.
    - While measuring things in their classroom, remind them that their feet must always stay on the ground and to do their best with the tools that they are given.

Plan 10 minutes for teams to measure and record the results for as many items on the data sheet as possible. Instruct them to estimate using their hands or feet first, then use the rulers to get a measurement.

- Compare student estimates first. How accurate are the estimates? If students do not make the connection between hand or foot size and the number of hand or foot spans needed in the measurement, select a student from teams that came up with very different measurements. In front of the classroom compare the size of their feet or hands (or theirs with yours). Ask each volunteer to use a ruler to measure the length of his/her foot. Are these measurements the same? This is why one team's estimate may be different from another's.

- Were the measurements recorded using rulers more often the same? How does using a scientific tool, like a ruler, improve accuracy? Were all of your tools effective at measuring the wall?

- Did everyone measure the same way? Deciding together where to measure the height of the chair, the desk, or the exact same section of wall would improve the accuracy. This is called protocol: a simple plan on where to take the measurement.

**Activity Two: Guided Discovery of the Tangent Height Gauge**

Ask students how biologists might measure the height of trees. After a brief discussion of their ideas, ask them to select a partner. Provide each pair with a Tangent Height Gauge. Explain that this is another scientific tool used to measure trees. Their job is to figure out how to use it. Put the Tangent Height Gauge poster on the board on the question side facing out. Give the students 10 minutes to work in teams to discover the answers to the questions.

1. How do you hold it?
2. Where is the level and how do you use it?
3. Where is the mirror and how do you use it?
4. What is a sight ring?
5. How do the sight rings help you measure the height of a tree?

After 10 minutes, compare student answers. Ask the students to look at the picture on the side of the height gauge. What other tools will they need to use to determine the height of the tree? Show students how they would use a tape measure and a tape reel to complete the tree height measurement using the Tangent Height Gauge.

**Wrap-up**

Review the terms estimate (an educated guess) and measurement (accurate, precise, correct answer) with the class. Is **estimating** a good method to use**?** It depends on the accuracy needed.

This is why scientists have developed and use standard measurement tools. Is this all that's needed to take accurate measurements…a good tool? No! The way you measure also matters.

If biologists were going to compare tree measurements from one site to another, it is important to have a “plan”, or a protocol, to improve accuracy? Explain that when they visit the refuge they will learn the methods biologists use to measure trees. They will make scientific measurements and compare those with the measurements of the Minnesota State Champion Trees – the largest trees in the state.

Remind students to wear appropriate clothing like warm jackets, scarves, mittens, hats, snow pants…..and most importantly snow boots. If conditions allow, students will use snowshoes for the outdoor activities.

**Winter Tree Math Classroom Measurements**

Record your estimates and measurements in the table.
Select a new table for each thing you measure.

| Your Desk | Estimate |
|---|---|
| **height** Foot Span | |
| **height** Hand Span | |
| | **Measurement** |
| **height** Ruler | |

| Your Chair | Estimate |
|---|---|
| **height** Foot Span | |
| **height** Hand Span | |
| | **Measurement** |
| **height** Ruler | |

| A Wall | Estimate |
|---|---|
| **length** Foot Span | |
| **length** Hand Span | |
| | **Measurement** |
| **length** Ruler | |

| Your locker | Estimate |
|---|---|
| **height** Foot Span | |
| **height** Hand Span | |
| | **Measurement** |
| **height** Ruler | |

| Your partner | Estimate |
|---|---|
| **height** Foot Span | |
| **height** Hand Span | |
| | **Measurement** |
| **height** Ruler | |

| Your choice | Estimate |
|---|---|
| **length/height** Foot Span | |
| **length/height** Hand Span | |
| | **Measurement** |
| **Length/height** Ruler | |

# Winter Tree Math
# On-site Activities

## Materials

Outside material (before the students arrive)

- Laminated Winter Tree Math Cards (hung on each corresponding tree with colorful plastic lanyard cord)

1 backpack per team filled with the following equipment:

- Clipboards (1 per team)
- Pencils (1 per team)
- Calculator (1 per team)
- Refuge Tree Measurement data sheet (at least 3 per team)
- 6' tape measures(1 per team)
- 100' measuring tape reels (1 per team)
- Tangent Height Gauges (2-3 per team)
- Winter Tree Math map (1 per team)
- Group Leader Guidelines (1 per group leader)

In the classroom

- Tangent Height Gauge Guided Discovery poster
- Tree Guide (1 per team)
- Trees of Minnesota Valley National Wildlife Refuge (Rapids Lake)
- Tree Bark Guide booklet (teacher)
- Example hypsometer

## Introduction

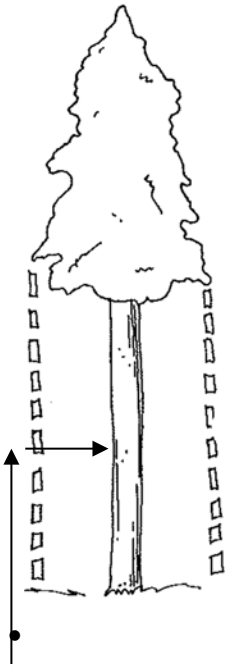
**(45 min)**

Prior to the students' arrival, hang the laminated Winter Tree Math Cards on the trees to be measured during this activity.

Review with the students the difference between estimating and measuring. Introduce students to the real scientific measuring tools (tangent height gauges and tape measures) and techniques (circumference at breast height) they will use during their field trip to measure refuge trees as accurately as possible. Using a student volunteer, chaperone, or staff person to simulate a tree, demonstrate how to take each of the following measurements.

***NOTE:*** *There will be trees to measure that do not fit common situations: a tree with a split trunk; a tree on a hill; or a tree intertwined with another. Expect student teams to come back with different measurements for these trees. Use this as an opportunity to discuss the need for scientific protocol…a method that everyone agrees to follow, ensuring that the data, in this case measurements, are comparable.*

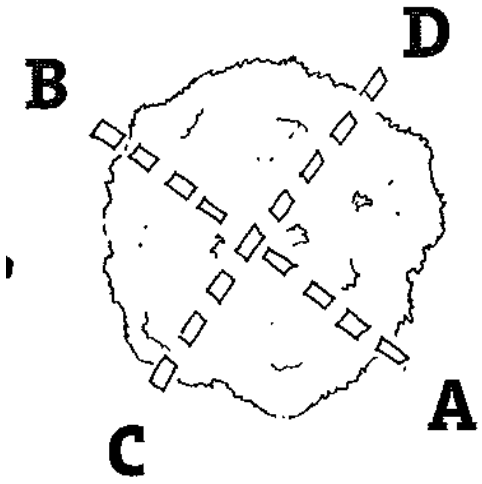
To measure the **Circumference at Breast Height**, use the small 6' tape measure.



1. Ask for a tall student or adult volunteer to be your tree trunk. Measure from the base of the trunk (ground level) up 4 ½ feet high (breast height for an average adult). The reason for measuring up 4 ½ feet is because not all trees are shaped the same. This number provides a standard of measuring. Have the volunteer keep their finger on the 4 ½ foot mark.
2. At breast height (the volunteer's finger) use the tape reel to circle around the simulated tree to measure circumference. Record this number on the data sheet.

To measure the **Crown Spread**, use the large 100' tape reel.
Students will look at the branching of the tree and then take the average of two measurements where the tree looks the widest. As illustrated below,

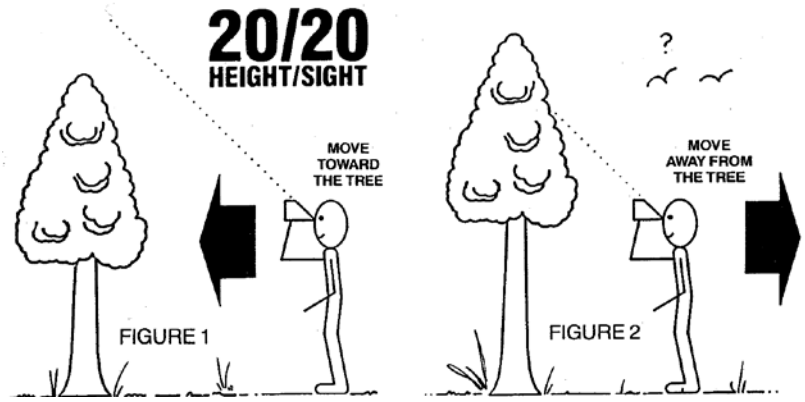
1. Ask another volunteer to be a tree. Ask them to spread their arms out to simulate branches. Select 2 more students volunteers. Have 1 student stand under the farthest branch from the trunk on one side (A) and the other student stand under the farthest branch from the trunk on the opposite side (B).
2. Ask a third student to hold the tape measure, pull the tape across to the second person and ask him/her to figure out the distance between the two students (points). Record the number on the data sheet.
3. Request the student "tree" to change directions and the other 2 students to move to the new farthest point locations and repeat the procedure above using the new points (C and D) under the opposite side of the crown. Record the number on the data sheet.
4. Add the two measurements together and divide by 2 for an average. Record this number on your data sheet as **Crown Spread**.



To measure **Tree Height** use the **Tangent Height Gauge**

After reviewing student responses to the guided discovery questions from the pre-activity, demonstrate for the class and parent chaperones, how to properly use the gauge to measure tree height.

1. Stand straight and measure the height of your eyes from the ground. Write down this number on your data sheet; it is needed for the final tree height calculation.




2. While holding the gauge using the handle, line up the top of the tree through both sight rings (holes) on the top. Keep the bubble inside the level centered. Ask another student to tell you when it's level or look in the mirror. If the top of the tree is below your view, move closer to the tree. If the top of tree is above your view, move away from the tree.

3. Once the top of the tree is centered in the sight rings and the bubble is centered in the level tube, measure the distance between you and the base of the tree trunk. Write this number on your data sheet.

4. Add your distance from the tree to the height of your eye. The answer is the height of the tree you measured. Record the **Tree Height** on the data sheet.

## Measurement Hike

**(45 min)**

Divide students into groups equal to the number of adult leaders. Each group MUST have an adult with them. Pass out the backpacks with all the equipment (clipboard, data sheet, pencil, tree height gauges, measuring tape, measuring reel and calculator) to the leaders.

Explain that teams should finish all estimates first and then measurements for a tree before moving on to another. If there is enough time, allow students to measure multiple trees. The adult leader should complete a data sheet for each tree the team measures.

## Data Analysis

**(20 min)**

Instruct each team to transfer the tree measurements recorded by the group leader to their own journal page. Pass out a copy of the Refuge Tree Guide to each team. Make a simple chart on the board, such as the one below, to collect measurements for one tree from each team. Lead the class in a discussion of the measurements and discoveries.

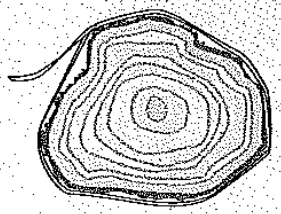
| | **Bur Oak** | | **Cottonwood** | | **Elm** | | **Hackberry** | |
|---|---|---|---|---|---|---|---|---|
| Circumference | | | | | | | | |
| Crown Spread | | | | | | | | |
| Height | | | | | | | | |

**Discussion Questions**:

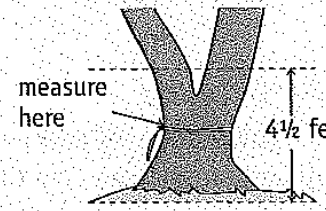
- How did the tree measurements compare to the Minnesota Champion Tree? (have students refer to the Refuge Tree Guide and put the Champion measurements in the second highlighted column for comparison)
- Which tree had a measurement closest to the Minnesota Champion Tree?
- Which tree(s) were hardest to measure? *(this might be determined by a wide variable of measurements of the same tree between teams)*

Discuss what made the tree hard to measure. How did each team decide to deal with the challenge? Explain the protocol scientist established for any of the challenging situations they might have encountered. Refer to the graphics here, taken from the DNR publication Minnesota's BIG Tree Registry.

## HERE'S HOW TO FIND THE CIRCUMFERENCE OF HARD-TO-MEASURE TREES:

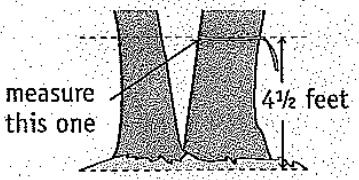


1. When a tree has deep convolutions or indentations, measure without pressing into the indentations.

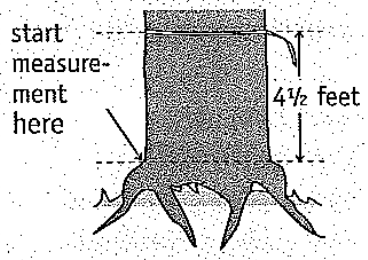



2. If a single tree has a double stem that forks below 4½ feet above the ground, measure at the narrowest place below the fork.

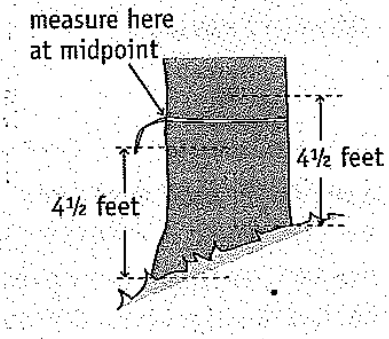
If the tree forks at ground level, measure the largest stem at 4½ feet.




3. When the base of a tree is "heaved" (tree roots exposed usually due to the effects of erosion, along with tree movement and growth patterns), the measuring point begins where the root mass ends and the tree trunk begins.




4. If a tree is growing on a slope, measure 4½ feet above the midpoint of the different ground levels.



## Wrap-Up Management Connection

### Forest Management

Why would it be important for a wildlife biologist to know how to count, measure and identify trees when managing a wildlife refuge? These skills are important for many reasons. Here a just a few examples:

- Bald eagles generally prefer large cottonwood trees along the Minnesota River. Biologist can measure tree diameter and height to determine if refuge trees are meeting the nesting requirements for Bald Eagles.

- Biologists may measure a variety of trees in a forest to estimate the wildlife food resources. Depending on the species, larger trees will often produce more food for many types of wildlife.

- Dead trees are an important food source for woodpeckers. These birds eat insects living under the bark of the dead and dying trees. Biologist might count the number of dead and dying trees in a forest to determine whether it is providing habitat requirements for woodpeckers.

- Measuring trees is also important to determine if there is adequate wildlife shelter. Some plants also need a shaded forest floor to grow.

# Winter Tree Math
# Inside Alternatives

**Measurement Hike**

Select the trees closest to the Visitor Center for measurement and mark them on the map. Assign each student team to just one tree.

- If a team's tree is visible from inside the Visitor Center, suggest they do their estimates from a window.
- Instruct students to alternate between quickly going outside to take one or two measurements with a brief warm up time inside the Visitor Center.
- Each student team should do all the math calculations back in the Visitor Center after they have collected all the measurements.

Compare the measurements they made with the measurements of the State Champion of the same species using the Minnesota's Native BIG Tree Registry list found in the equipment bin. Ask students to record the measurements of the State Champion in the second data box on their journal page. Leave the third box blank. Suggest to the teachers that they might complete the third data box with measurements taken from a schoolyard tree.

If there is still time available here are a few additional suggestions:

1. Go to the DNR BIG Tree Registry on the DNR website. With chaperone help, have each student team determine the point value for the tree they measured using the formula below.

   **Points= Circumference (in.) + the height (ft.) + ¼ the crown spread**

2. Focus on another type of tree measurement: age. Begin by watching a YouTube video on How to Use an Increment Borer
   https://www.youtube.com/watch?v=lVyBGmYWres.
   Narrate and demonstrate alongside the video using the real borer.

3. Pass out a tree cookie to each student (or student teams) and let them do a self-guided discovery of a tree cookie. Have them consider the following questions:

   - What do the darker and lighter colored rings represent?
   - Why are some rings wider than others?
   - How old was this tree?

Ask students to share their answers. Correct any misconceptions. Explain to students, if they do not already know, that the number of rings indicates the age of the tree when it was cut. The dark and light ring together is considered one year's growth. The light ring is wood produced during the summer growing season. The dark ring is wood produced during the fall growing season.

Ask students to count back to the year their tree was "born" (a young sapling. How old were they at that time? What important events were taking place in their lives then?

4. Ask a student to choose one of the champion trees from the Tree Guide and to tell the class the measurement of its circumference. Using a tape reel and choosing two volunteers, move into a large space with little to no obstacles (like the exhibit area) and have the class stand in a circle. Have the two volunteers pull out the tape reel to the measurement of the chosen tree circumference and wrap the tape around the whole class to see if they would all fit in the champion tree circumference.

Minnesota Valley National Wildlife Refuge

# Winter Tree Math… Refuge Tree Measurements

**Tree Name**_____ **Tree Tag Number**

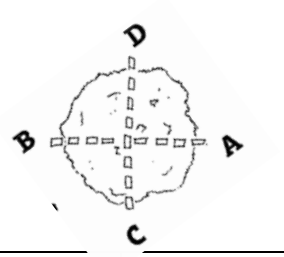
| | **Circumference** | **Tree Height** | **Crown Spread** |
|---|---|---|---|
| **Tree Estimates** Making a guess | How big around is your tree? _____in. | How tall is your tree? _____ft. | How wide is the top of your tree? _____ft. |

**Measuring Tree Circumference**

Measure 4 ½ feet from the base of your tree. Wrap the tape measure around tree

**Tree Circumference = _____nearest inch**

**Measuring Tree Crown Spread**



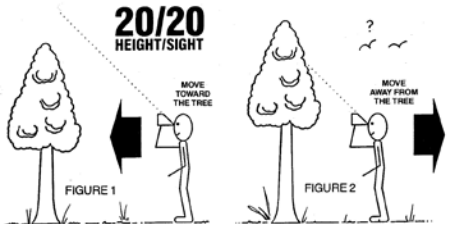

**1.** Students stand on opposites sides under the widest parts of the crown and make the following measurements:

- Distance from (A) to (B): _____ nearest foot
- Distance from (C) to (D): _____ nearest foot

**2.** Add the two measurements together. Find average by dividing your answer by 2.

| | **Distance A to B** | **+** | **Distance C to D** | **=** | **Total** | **½ total** | **Crown Spread** |
|---|---|---|---|---|---|---|---|
| **Crown Spread** Using Tape Reel | _____**ft.** (your measurement) | **+** | _____**ft.** (your measurement) | **=** | ____**ft.** | **½ total** | _____**ft.** |

**Measuring Tree Height**




**Step 1.** Stand up straight, measure from the ground up to your eye. Record your answer to the nearest foot.

**Step 2**. Hold gauge (by the handle) up to your eye. Level the gauge to the ground using bubble. Line up the top of the tree through both sight rings (holes). If tree is not in view, step closer; if too much tree in view, step back.

**Step 3.** When top of tree is in both sight rings and bubble is level, measure the distance from base of the tree to your toes.

**Step 4.** Add the two measurements together for the height of the tree. Record the data.

| **Tree Height** | **Height from the ground to your eyes** | **+** | **Distance from you to the tree** | **=** | **Tree Height** |
|---|---|---|---|---|---|
| Height Gauge | _____ (your measurement) | + | _____ (your measurement) | = | _____ft. (answer) |