Two Trees for Hawaiʻiloa

How can we use ratios and proportions to measure trees that could be suitable for a canoe?

HAWAIʻI DOE STANDARD BENCHMARK

Math 4: Measurement: FLUENCY WITH MEASUREMENT
Measurement Formulas

- **MA.8.4.3** Use ratios and proportions to solve measurement problems.

KEY CONCEPTS

- Box-and-whisker plots provide a way to analyze the distribution of data.
- Marine data collected from Kahoʻolawe in 1998 provides a baseline for seeing how the distribution of marine species at different sites changes over time.

ACTIVITY AT A GLANCE

Students practice using the Pythagorean theorem to estimate the height of trees to determine if they have trees suitable for a fishing canoe on or near their campus.

TIME

2 class periods

SKILLS

estimating, measuring, using ratios, applying mathematical theorem

ASSESSMENT

<u>Students</u>:

- Use ratios and proportions to determine an unknown measurement when given a known measurement.

MATERIALS

<u>Provided</u>:

✓ Student Data Sheet
✓ Student Reading

<u>Needed</u>:

✓ Ruler, tape measure, notepad, and pencil (one for each group of 4 students)

VOCABULARY

ratio – pairs of numbers used to make comparisons

ADVANCE PREPARATION

- ☐ Make a copy of the Student Reading and Data Sheet for each student.
- ☐ Check the school campus or nearby areas to find tall trees that students can observe for this activity.
- ☐ Check out the Polynesian Voyaging Society's Web site for photographs of the Hawaiʻiloa canoe:

http://pvs.kcc.hawaii.edu/onlinevisuals.html

Teaching Suggestions

1. **Introduce students to the focus question for this lesson and to the standards they are working on.**

2. **Distribute the Student Reading and review it with the class.**
   - Discuss the challenge of finding trees large enough for Hawaiʻiloa in Hawaiian forests.
   - Ask students how you could estimate the height of a tall tree if you were searching for trees suitable for a canoe.

3. **Pose the challenge on the Student Reading – to estimate the height and measure the circumference of nearby trees to determine if any are suitable for a fishing canoe.**
   - Introduce the idea of using rations and proportions and discuss how to apply this to solving the challenge.
   - Review the steps involved in estimating the height of a tree.

4. **Divide the class into teams of four students and prepare to go out and measure trees (or assign this as homework for teams to complete).**

5. **Distribute the Student Data Sheet.**
   - Ask students to calculate the tree height using ratios and proportions.

6. **Have teams share their results.**
   - Use the questions provided on the Student Data Sheet to discuss students' conclusions.

Adaptation / Extension

Have students create a box-and-whisker plot using the data from one of the trees used for Hawaiʻiloa.

Review the different methods for estimating tree height at the following Web site and have students try different methods, including making and using a clinometer to see if they consistent measurements. Measuring Tree Height. Retrieved on November 19, 2008, from: http://web.archive.org/web/20030426171031/http://cgee.hamline.edu/Fall/height.html

References

Finney, Ben. *Sailing in the Wake of the Ancestors*. Honolulu: Bishop Museum Press, 2003. p. 17-21.

Texas Tree Trails: A Geographic Guide to Texas' Significant Trees. Retrieved on November 19, 2008, from: http://texastreetrails.org/ttt_measurement.html

TWO TREES FOR HAWAIʻILOA
STUDENT READING

Imagine that you are a master canoe builder living in modern times. You have been asked to construct a voyaging canoe, using only traditional materials. How would you go about finding and collecting these materials?

This challenge was posed to a group of canoe builders in the late 1980s. The purpose of their project was to recover ancient knowledge and skills connected to traditional Hawaiian canoe-building.

Their first task was to find koa logs that could be used for the hull of the canoe. Their search proved unsuccessful. They discovered that the koa forests had been depleted and the koa that were growing in the Hawaiian forests were not large enough to be used for a voyaging canoe.

Hearing of their situation, the Alaskan Tlingit tribe offered to donate two Sitka spruce logs. The canoe builders traveled to Alaska to meet with the Tlingit tribe. The trees they had selected were 200 feet tall and measured 7 feet in diameter at the base of the tree. The trees were over 400 years old.

An official tree-cutting ceremony was performed and the trees were felled and the logs shipped to Hawaiʻi. The construction of the Hawaiʻiloa canoe began in earnest in 1991 and was completed in 1993.

Numerous *kupuna* and volunteers led the efforts in the construction of the canoe and the donation of materials. Hawaiʻiloa's final dimensions are: Length = 57 ft, Beam=19 ft, Sails (2) = 240-420 sq. feet each.
To see photographs of Hawaiʻiloa, see the Polynesian Voyaging Society Web site: http://pvs.kcc.hawaii.edu/onlinevisuals.html

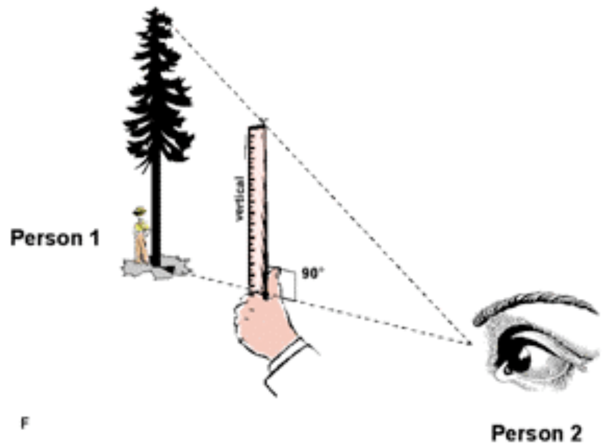
YOUR CHALLENGE:

Find out if you have trees that would be suitable for a smaller fishing canoe on your campus or in a nearby area. Decide how long and how wide your canoe should be, for example if your canoe was to be 15 feet long, the tree should be at least 15 feet high and 3 feet in circumference.

Method – Measuring Height

In teams of four students, have one student (Person 1) be the assistant, one be the estimator (Person 2), another be the Recorder with a notepad and pencil, and one be the Measurer with a tape measure.

First, carefully, have your measurer measure the distance from the ground to the eye level of Person 2. Record the measure (Call it C). This will be a correction because the eye of Person 2 will not be at the same ground level as the tree.

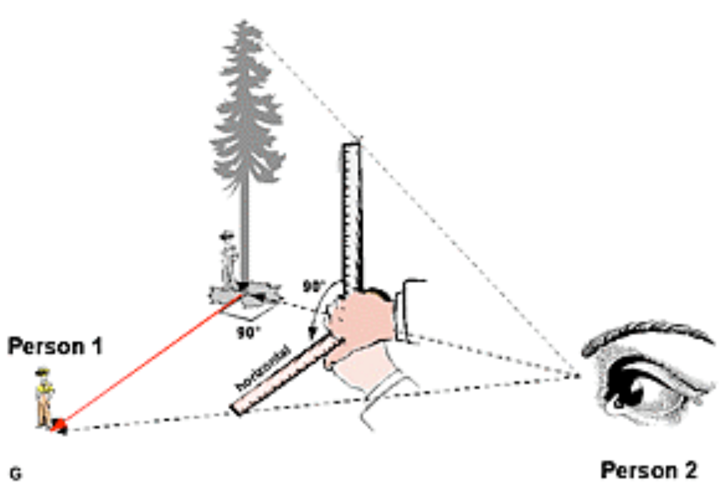


Have Person 1 stand near the trunk of the tree and Person 2 stand at a distance where both Person 1 and the top of the tree are visible. Person 2 holds a ruler upright (at right angle to the ground or parallel to the tree) at arms length and (carefully!) walks backward, holding the arm stiff until the top and bottom of the tree lines up with the top and bottom of the ruler. - F.

Still holding the ruler at arms length, Person 2 turns his/her wrist right or left so that the ruler is now horizontal, with one end sighting the base of the tree.

Person 2 must now move a distance C to the right.

Now Person 2 instructs Person 1 to move away from the trunk in the direction the ruler is pointed (at a 90 degree angle) until s/he is standing in line with where the end of the ruler points (G).



Person 1 is now standing the same distance from the trunk as the tree is tall. Have your Measurer measure this distance, in feet and have the Recorder record the distance.

Method – Measuring Circumference

Note: Calculate the diameter of the tree by using the relationship

Diameter equals circumference divided by pi (3.14).

Use your tape measure to find the circumference of the tree (the distance around its trunk). Foresters typically measure the circumference of the tree at 4.5 feet above the ground. If the tree forks below this point, measure the circumference below the fork. Also measure the circumference at the ground level. Record these two measures.

Adapted from: Texas Tree Trails: A Geographic Guide to Texas' Significant Trees. Retrieved on November 19, 2008, from: http://texastreetrails.org/ttt_measurement.html. Reprint permission requested; for field test use only.

TWO TREES FOR HAWAIʻILOA
STUDENT DATA SHEET

NAME:______________________________ **DATE:**___________________

Tree Circumference
Record your measurements for the tree circumference.

Tree Height
What is your estimation of the tree's height?

Note: Tree height estimations are based on the geometric comparisons of the sides of similar triangles.

The distance from the tree to the new position of Person 1 is the height of the tree. This is because the upright right triangle formed by the observer with the ruler and the top of the tree is equal to the horizontal triangle formed by the observer with the ruler and the new position of Person 1.

Conclusions
Explain how you have used ratios and proportions to determine the height of the tree.

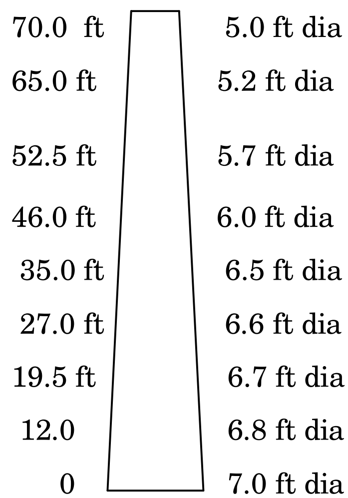
How does your circumference compare to one of the trees that were used for Hawaiʻiloa, which were 7.0 ft at the base?

Is your tree suitable for a fishing canoe? Explain your answer.

STUDENT DATA SHEET
EXTENDED ACTIVITY

NAME:________________________________ DATE:____________________

Estimated diameters at different positions on the Sitka spruce log used for Hawaiʻiloa



The estimated measure of the diameters of one of the Sitka spruce logs used for Hawaiʻiloa, taken at different distances from the base were:

6.7 ft, 5.0 ft, 7.0 ft, 6.5 ft, 5.2 ft, 6.8 ft, 5.7, 6.6 ft, 6.0 ft.

1. **Find the median measure.** The median is the middle measure when all the readings are listed from smallest to largest. There are nine measures. **Rewrite the measures below from smallest to largest.**

End 1		Q1		M Q2		Q3		End 2

⇧ This is the middle measure—it is the median.

2. Find the end points, the first quartile, the median, and the third quartile.

b. End 1 is one end of the range:____________
c. Q1 is the first quartile:__________________
d. M is the median:_______________________
e. Q2 is the second quartile:________________
f. Q3 is the third quartile:__________________
g. End 2 is the other end of the range:________

3. Fill in the five points of the distribution that you can use to draw a box-and-whisker plot.

1. The ends of the box are the First Quartile (________) and Third Quartile. (______________).

2. The line in the box is the Median or Second Quartile (_____________).

3. The lower whisker starts at Endpoint 1 (_______________) and ends at the First Quartile (_________________).

4. The upper whisker starts at the Third Quartile (______________) and ends at Endpoint 2 (_____________________).

4. Draw the box-and-whiskers plot for the tree circumferences on the line below.

4 5 6 7 8

5. The box-and-whisker plot is a visual presentation of the distribution of the data. What can you conclude from your plot of the data?