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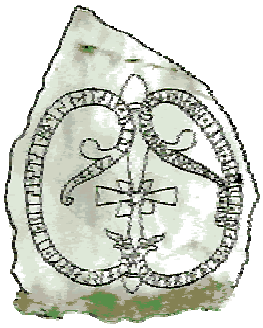
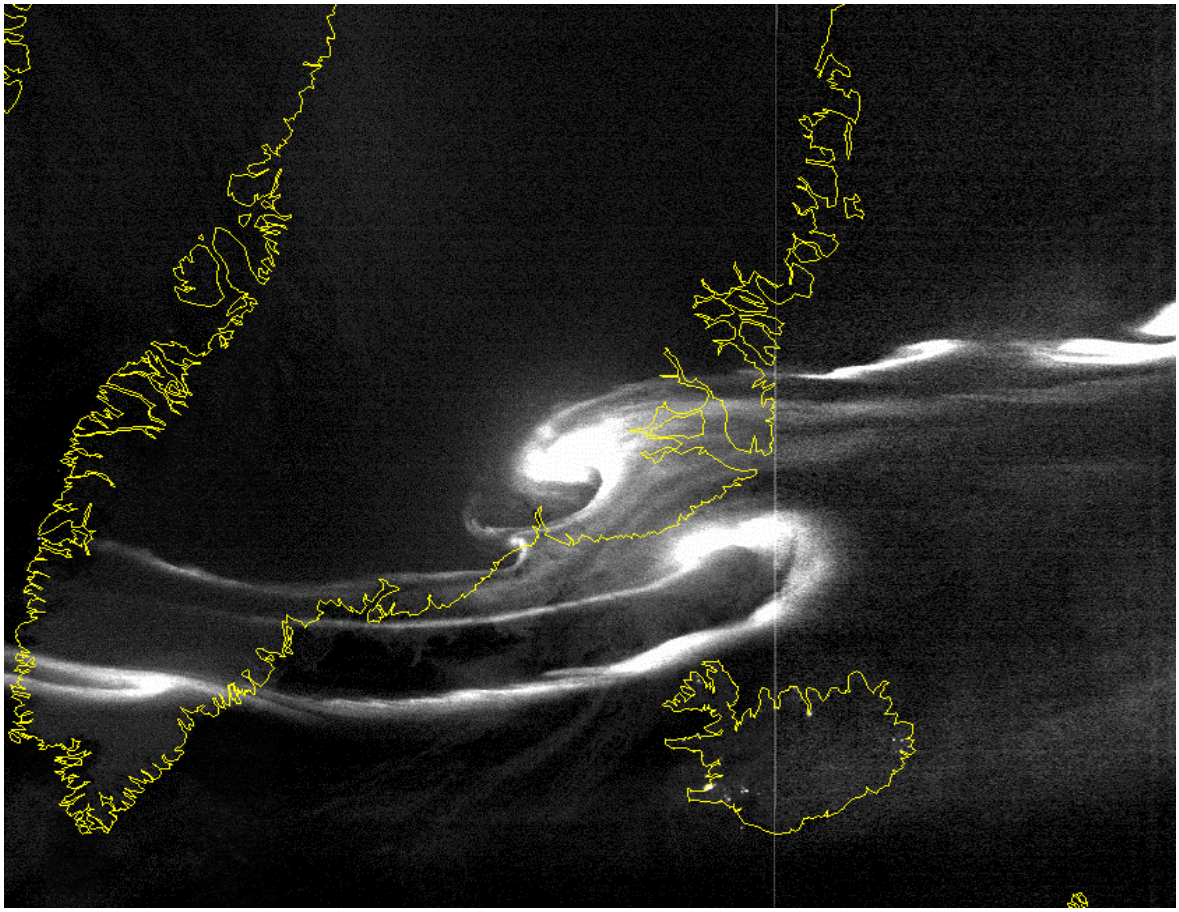
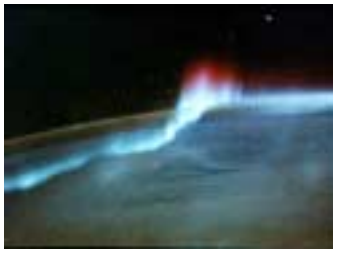
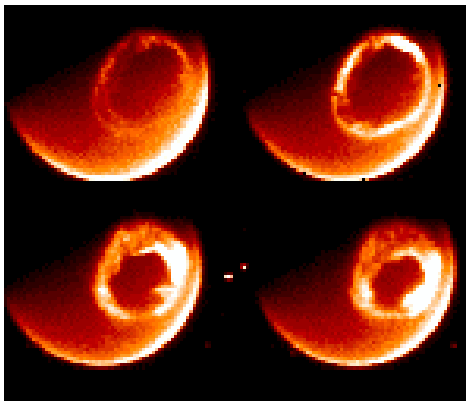


THE NORTHERN LIGHTS







A Grade 7-8 guide to understanding the Aurora Borealis through math, geometry and reading activities.

This series of activities will help students understand how the Northern Lights work, what causes them, and how to observe them.

Through a series of math and reading activities, students will learn:

- How aurora are described by scientists and by other students (Reading)
- The geographic locations of aurora based on satellite data (Geography)
- How aurora appear in the sky at different geographic latitudes (Geometry)
- The height of aurora above the ground (Geometry - parallax)
- How to predict when they will appear (Mathematics)
- What Norse Mythology had to say about aurora (symbolic code translation)

This booklet was created by the NASA, IMAGE satellite program's Education and Public Outreach Project.

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For more classroom activities about aurora and space weather, visit the IMAGE website at:

http://image.gsfc.nasa.gov/poetry

The cover shows a view from the NPOESS satellite looking down at an aurora over Greenland. *(http://npoesslib.ipo.noaa.gov/S_sess.htm).* Viking rune inscription (http://www.commersen.se/vikingar/vardag/runor.html). The three smaller images at the bottom of the page are: (Left) an aurora borealis viewed from the Space Shuttle; (middle) portion of the auroral oval over North America viewed by the DMSP satellite showing city lights; (right) the auroral oval viewed over the Arctic region on July 15, 2000 by the IMAGE satellite.

Activity 4 Estimating Heights with a Clinometer

A clinometer is a simple-to-make instrument which lets you estimate the height of an object (building, tree, flag pole) by using the properties of a right-triangle.

Objectives:

Students will apply direct measurement of angles and length to determine height using the tangent ratio and the clinometer (a measuring tool).

Benchmarks:

6-8 Models are often used to think about processes that happen too slowly, too quickly or on too small a scale to observe directly, or that are too vast to be changed deliberately.

9-12 Find answers to problems by substituting numerical values in simple algebraic formulas.

9-12 Make and interpret scale drawings

Materials for the lesson:

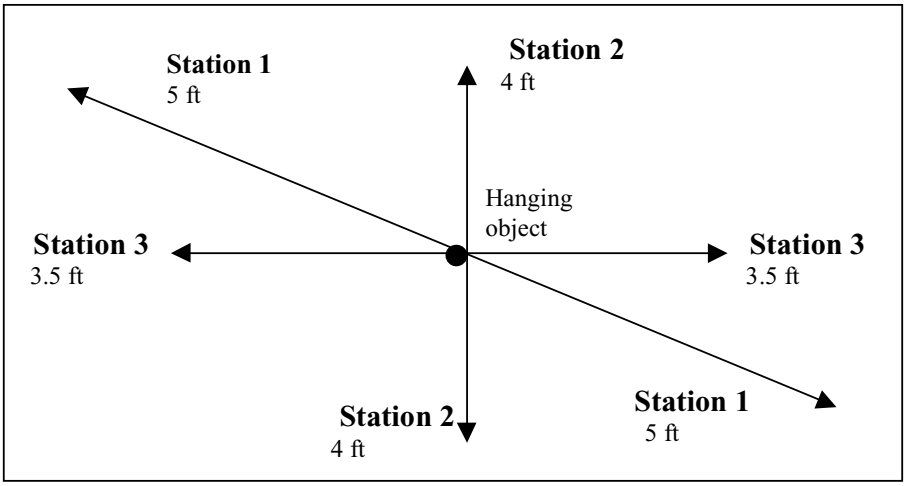
Rulers or yardsticks
An object to hang
A big X to hang under the object
Clinometers
Calculators – degree mode
Tangent table (optional if calculator is not available)
Graph paper or drawing paper
Student worksheet
Student Clinometer Activity Sheet
Teacher Demonstration Examples (Transparency)
Teachers scaled drawing
Ladder for the teacher
Roll of yarn
Scissors
Station marking items (paper taped to the floor indicating use this point here)
Ducked Tape

Extension: Have students measure the height of a tree or flagpole using the clinometer.

Procedure:

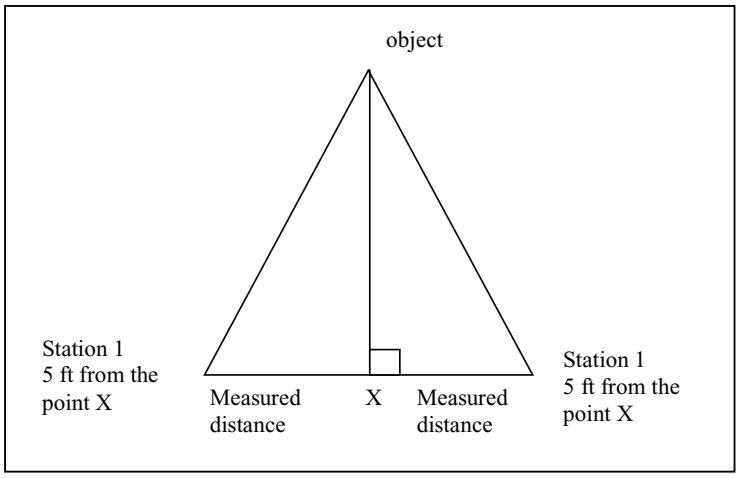
Step 1: Hang an object high from the center of the classroom. A big X can be taped to the floor so that the object hanging from it is directly under it. Based on the number of students in the class, locate enough stations so that each group will make at least two measurements from opposite sides of the room. Students will measure the distance out from the point right under the object, or the teacher could have already located the corresponding points. This is teacher discretion. In either case, vary the length of the distance for each station from where the student will stand to measure with the clinometer and the object. For instance, Station 1 is located five feet out from the point directly under the object while Station 3 is located 3.5 feet away from the point beneath the hanging object.

See the following figure for an example of the station set up. Note: groups may share a station since they could be on opposite sides of the room measuring.



Students completing Station 1 need to measure out five feet in both directions from the hanging object towards opposite sides of the room. The teacher may opt to tape yarn in lines through the point directly under the hanging object. This will provide the students with a direction guide.

Students will need to measure the distance to a point designated a certain distance from the location under the object. **Reminder**, a big X can be taped to the floor so that the object hanging from it is directly under it. Therefore, the triangle for Station 1 would be drawn as follows:



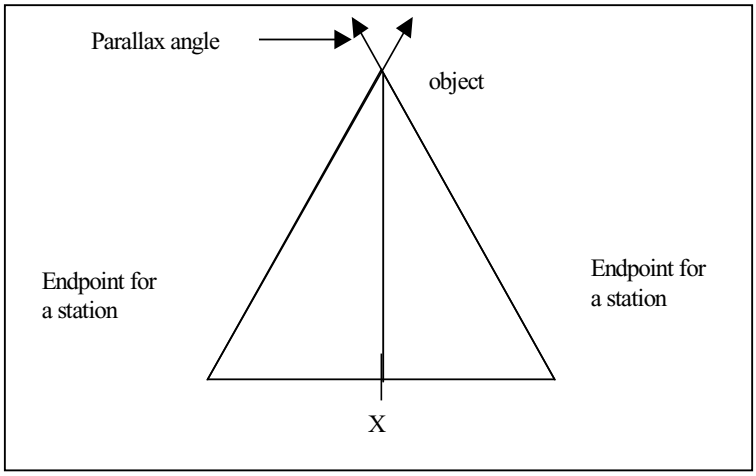
Students would have to determine the appropriate scale based on the individual classrooms.

Step 2: The teacher will have to prepare a scale drawing for one of the stations to use for discussion purposes in Step 8. Use the above diagram as a model based on your classroom.

Step 3: Using the Clinometer Instructions, students construct the clinometer. Another option is for the teachers to have the clinometers already constructed or to use store bought clinometers. The actual construction provides a hands on component prior to the actual measuring activity.
Step 4: Teacher guides the students through the teacher directed activity (see Teacher Demonstration Examples and Student Worksheet). This provides students with exposure to the process they will perform when determining the height of the object in the room. Teacher may opt to demonstrate location and clinometer as a visual model while completing the examples.
Step 5: Assign student groups to the stations that they will measure. Provide time for the students to complete their measurements, calculate the height, and check for reasonableness of their answer. Students record their answers on the Student Clinometer Activity Sheet. Teacher monitors measurements and calculations.
Step 6: The whole group discusses the possible answer as to how high the object is hanging and a what a possible scale diagram might look like from one of the stations.

Average the answers from each station.

Step 7: Select a station to be used as an example. The students from the group that used that station will be the helpers. Students use the yarn to go from the opposite endpoints of the station to each other to construct the base of the triangle. Students hold the endpoints. Another student gives the teacher, who is up on the ladder, two separate pieces of yarn while the students at the endpoints are given the other ends. Students duct tape the yarn to the floor. As a final step, the teacher uses another piece of string to construct the height of the triangle. The teacher duct tapes the yarn to the object, climbs down the ladder, removes the ladder, and duct tapes the other end of the 'height' yarn to the floor. What this step is doing, essentially, is to construct a visual model of the triangle that they will draw. (See diagram)



This is how the yarn should appear to the students when the teacher is on the ladder and students are holding the base vertices of the triangle.

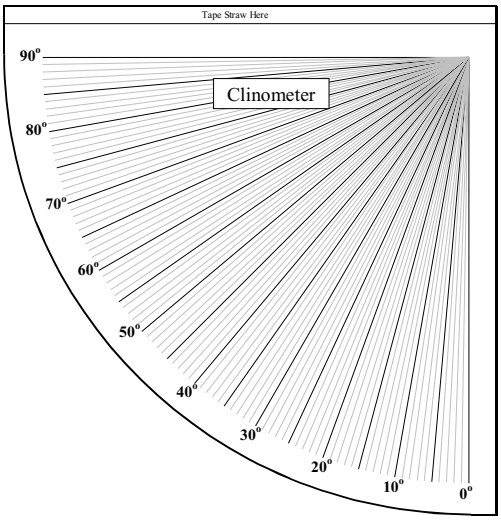
The teacher holds the yarn up near the object and the student groups hold the other ends in opposite endpoints of a station.. The triangle should be evident. The teacher can then extend the ends of the yarn to demonstrate the Parallax angle, and the property of vertical angles in a visible format.

Step 8: Using a piece of graph paper, students construct a scale drawing of the stations that they used to determine the height of the hanging object. Refer to Step 9 on the Student Clinometer Activity Sheet.
Step 9: Students share their scaled drawings.
Step 10: Teacher leads students in a discussion about how the scientists would use this method to determine the height of an aurora.

CLINOMETER INSTRUCTIONS

Materials to build a clinometer (one for each group of students):

- Copy of the clinometer diagram
- Straw
- Scissors
- Tape
- 13 centimeters of string
- coin or weight
- tagboard or cardboard
- one hole punch

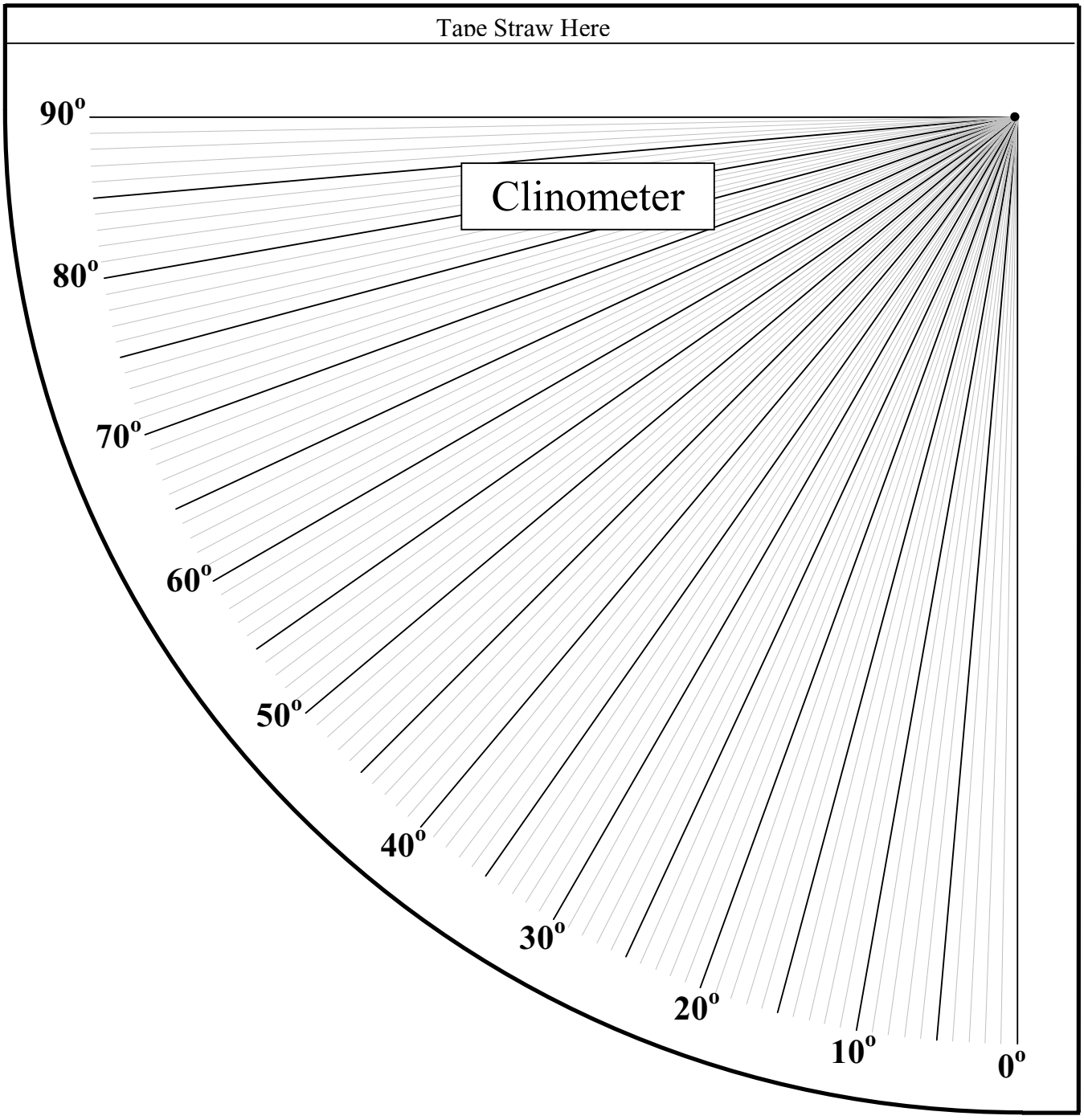


Instructions:

1. Mount a copy of the clinometer onto tagboard or cardboard. Cut out the clinometer.
2. Use a one hole punch or a push pin to poke a hole in the small circle in the upper right hand corner of the clinometer.
3. Put the piece of string through the hole in the clinometer. Allow about two or three centimeters of string on the backside of the clinometer. Tape the string securely to the back of the clinometer. Let the string on the other side dangle freely.
4. Tape a penny, nickel, or other coin to the end of the freely swinging piece of string. This will serve as a weight and act as a plumb line.
5. Lay the straw across the top of the clinometer. Cut off the excess straw. Tape the straw securely to the clinometer.

When using the clinometer, sight the top of the object through the straw. The plumb line remains perpendicular to the ground, and able to move freely, as the clinometer is moved to sight the object. The angle can be determined based on the string's location.

Sight from this end

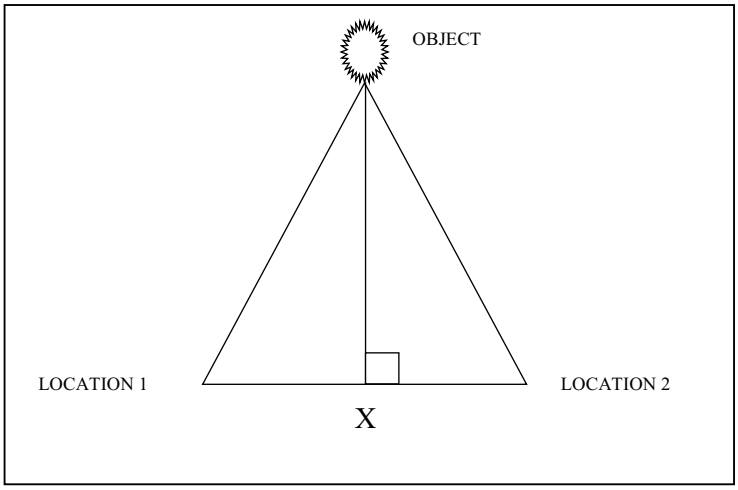


Teacher Demonstration Examples (Transparencies)

Student One is standing at Location 1

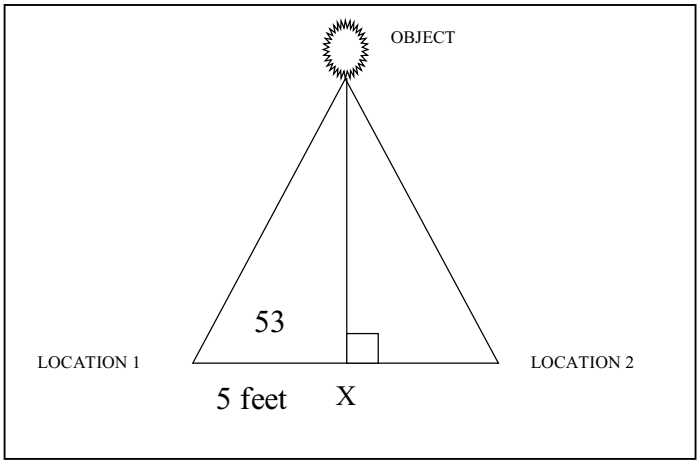
Student Two is standing at Location 2.

The goal is to determine how high the object is above the X. A diagram is provided.



PROBLEM 1:

Student One uses a clinometer and measures the angle to be 53 degrees. He measures the length from Location 1 to the X to be 5 feet. How high is the object based on his measurements?



Tan 53 = X / 5
(Tan 53) * 5 = X
6.64 feet = X

This is not the height. In order to finish calculating the height, it is necessary to add in the student's line of sight. The student measures his height from the floor to eye level and adds that amount back in to the height.

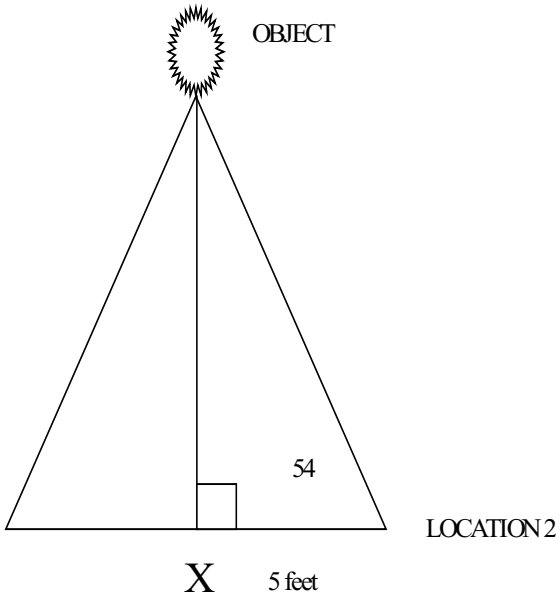
Student Ones' eye height is 4 feet.
The height is 6.64 feet + 4 feet = 10.64 feet.

What is 0.64 of a foot?
0.64 * 12 = 7.68 inches
Therefore, the height is approximately 10 feet 8 inches.

PROBLEM 2:

Student Two measures the distance from Location 2 to the X as 5 feet. Using the clinometer, she estimates the angle is 54 degrees. She is 4 and a half feet tall to her line of sight. How high is the object?

Tan 54 = X / 5
(Tan 54) * 5 feet = X
6.88 = X
Convert .88 to inches by using
.88 * 12 = 10.56 inches
Now add the two values together plus her height for the final height of the object.
6 feet + 10.5 inches + 4feet 5 inches = 10 feet and 15.5 inches
This simplifies to 11 feet 3 and half inches.



AVERAGE THE TWO ESTIMATED ANSWERS.

10 FEET 8 INCHES + 11 FEET 3.5 INCHES = 21 FEET 11.5 INCHES
= 263.5 INCHES

263.5 INCHES / 2 = 131.75 INCHES
= 10.97 FEET
= 10 FEET 11.6 INCHES

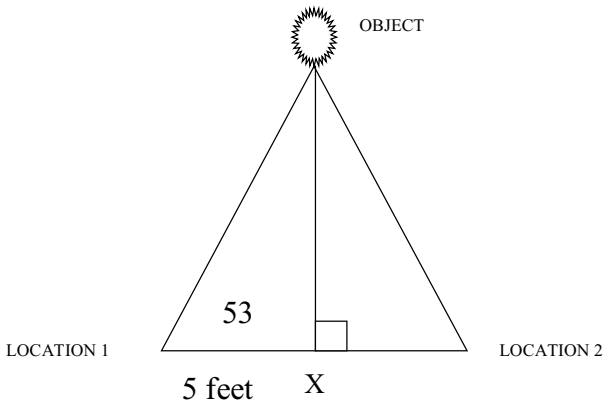
Student Worksheet

Name _____ **Date** _____

Problem 1:

Student One uses a clinometer and measures the angle to be 53 degrees. He measures the length from Location 1 to the X to be 5 feet. How high is the object based on his measurements?

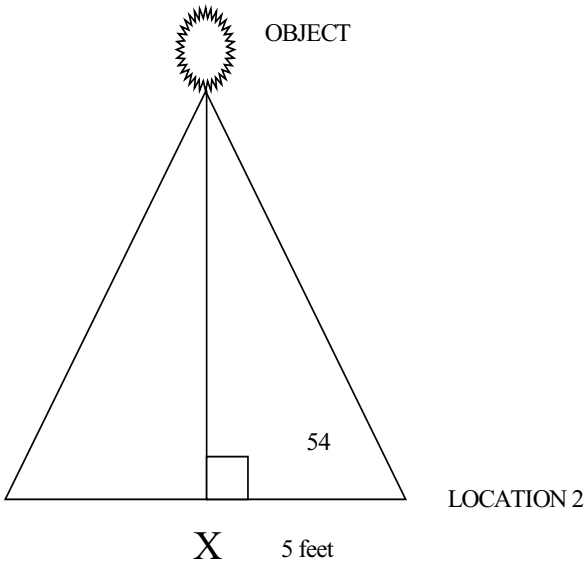
Show the calculations below.



Problem 2

Student Two measures the distance from Location 2 to the X as 5 feet. Using the clinometer, she estimates the angle is 54 degrees. She is 4 and a half feet tall to her line of sight. How high is the object?

Show the calculations below.



Average the two answers to obtain a closer estimate.

Student Clinometer Activity Sheet

SIGHTER_____
RECORDER_____
MEASURER_____
CALCULATOR_____

STEP 1: Decide which person will perform each of the above tasks.

STEP 2: Locate one of the station numbers that you were assigned.

STEP 3: Measure the distance in feet from the X to your station. Record the measurement in the table below.

STEP 4: Measure the eye level of the sighter from the floor to eye level. Record the data in the table below.

STEP 5: Use the clinometer to locate the top of the object. The measurer will need to determine the angle reading on the clinometer. Record the angle reading in the table.

STEP 6: Repeat the process above at the second assigned station recording the results in the table below.

STEP 7: Use the tangent ratio and the previous examples that were completed with teacher assistance to determine the height of the object.

Station Number	Clinometer Reading	Length to the X (in feet)	Sighting Students eye height

For each station fill in the following measurements for your calculations.
TAN (angle measure) = (the missing height) / (the length to the X)
TAN (_____) = (the missing height) / (_____)
TAN (_____) (_____) = (missing height)
Next add in the height of the sighter.
(missing height) + (height of the sighter) = (total height of the object)
The estimated total height of the object is _____ feet.

STEP 8: Average the results from all of the stations to obtain a closer estimate of the height of the hanging object.

STEP 9: Using a piece of graph paper, make a scale drawing of the two stations and the object.

Useful Web Resources

Exploratorium "Auroras:Paintings in the Sky"
http://www.exploratorium.edu/learning_studio/auroras/

Archive of aurora photos by Jan Curtis:
http://www.geo.mtu.edu/weather/aurora/images/aurora/jan.curtis/

Archive of aurora photos by Dick Hutchinson:
http://www.ptialaska.net/~hutch/aurora.html

Space Weather Today:
http://www.spaceweather.com/

IMAGE real-time aurora images from space:
http://image.gsfc.nasa.gov/poetry/today/intro.html
http://www.sec.noaa.gov/IMAGE/
http://sprg.ssl.berkeley.edu/image/

NOAA Auroral Activity monitor:
http://www.sec.noaa.gov/pmap/index.html

CANOPUS real-time auroral monitor:
http://www.dan.sp-agency.ca/www/rtoval.htm#TOPOFPAGE

Current solar activity report:
http://www.dxlc.com/solar/

Alaska Science Aurora page for kids:
http://www.alaskascience.com/aurora.htm

Human Impacts of Space Weather:
http://image.gsfc.nasa.gov/poetry/weather01.html

Ask the Space Scientist:
http://image.gsfc.nasa.gov/poetry/ask/askmag.html

More classroom activities:
http://image.gsfc.nasa.gov/poetry/activities.html

The Northern Lights Essay Competition:
http://image.gsfc.nasa.gov/poetry/alaska/alaska.html