Trig-o-nom-e-tree!

Using clinometers and trig ratios to measure unknown heights

Grade Level	10th – 12th Grade	**Time Frame**	4-5 class period(s)
Subject	Mathematics	**Duration**	250 minutes
Course	Geometry, Precalculus		

Essential Question

How can you determine the height of an object without actually measuring it?

Summary

In this lesson, students will learn how to use a clinometer and trigonometric ratios to solve problems involving right triangles.

Snapshot

Engage

Students will brainstorm ideas for how to determine the height of a tree without measuring it.

Explore

Students will build a clinometer and discuss the mathematics involved with its use.

Explain

Students will learn about trigonometric ratios and connect them to prior knowledge of special right triangles.

Extend

Students will apply their knowledge of trigonometric ratios and clinometers to determine the heights of some objects around the school.

Evaluate

Students will reflect on what they learned using the What? So What? Now What? strategy. As an additional option, they will create a presentation that explains the process they used to determine the heights of objects around the school.

Standards

Oklahoma Academic Standards for Mathematics (Grades 9, 10, 11, 12)

G.RT.1.2: Verify and apply properties of right triangles, including properties of 45-45-90 and 30-60-90 triangles, to solve problems using algebraic and logical reasoning.
G.RT.1.3: Use the definition of the trigonometric functions to determine the sine, cosine, and tangent ratio of an acute angle in a right triangle. Apply the inverse trigonometric functions to find the measure of an acute angle in right triangles.
G.RT.1.4: Apply the trigonometric functions as ratios (sine, cosine, and tangent) to find side lengths in right triangles in real-world and mathematical problems.

Attachments

- Clinometer-Cutout.pdf
- Record-Sheet.docx
- Record-Sheet.pdf
- Right-Triangle-Problems.docx
- Right-Triangle-Problems.pdf

Materials

- Cardstock printed with protractors
- Straws
- Tape
- String
- Washers or paper clips
- Tape measures
- Worksheets to record measurements
- Worksheets of trig ratio word problems
- Calculators

Engage

Assign students to work in pairs.

Using the Think-Pair-Share strategy, give students thirty seconds to think about the following question: How can you determine the height of a tree or a building without actually measuring it?Ask students to discuss their thinking with their partner.Have groups share out by writing their answers on the board. Discuss the merits and shortcomings of each solution.

Why Discuss?

By discussing the merits and shortcomings, students will be able to engage in quality problem solving. They hear their thinking in contrast to their peers. As students move forward in the lesson, they will be able to use their initial hypotheses to guide their inquiry.

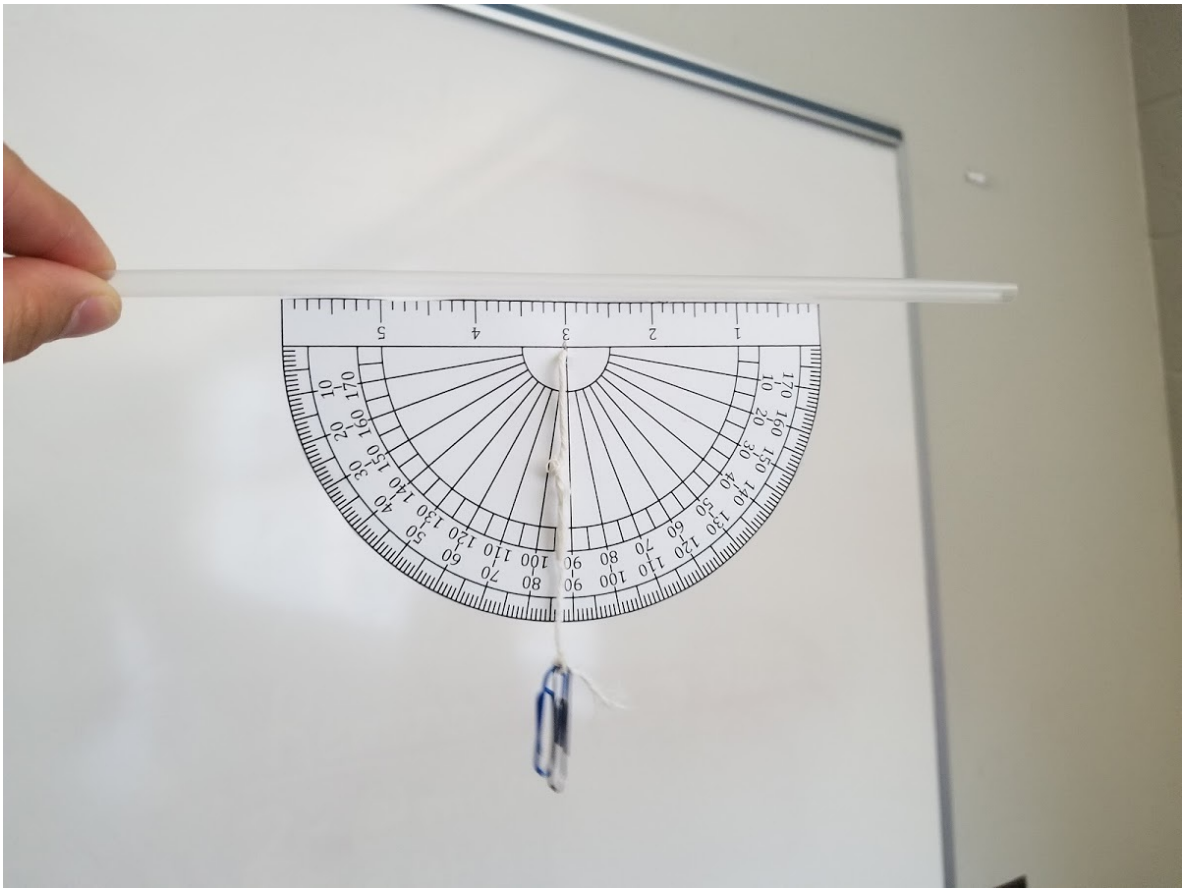
Explore

Students will work in pairs to build a clinometer.

What's A Clinometer?

This is a good opportunity to pause and poll your students to see if they have ever heard of a clinometer. If they have, ask them to share what they know. If they have not, take a moment to share with them that a clinometer is an instrument used to determine the height of something without directly measuring the height (going back to the essential question).

Before class, print copies of the Clinometer Cutout on card stock. Pass out a copy to each student and have them cut out the protractor that's printed on the page. Next, students will attach a straw along the base of the protractor with tape and cut it to fit the length of the base.Finally, students will place a small hole in the center of the base and secure a string in a knot through the hole and tie a washer to the other end of the string to keep the string taut.



A completed clinometer.

Discuss with students how the clinometer can be used to determine the heights of objects.

How To Use A Clinometer

Here is an instructional video for how to use a clinometer. Feel free to use this video as an instructional tool to further explain how to use their clinometers. Another suggestion is to have students theorize how to use their clinometers, try out their theories, and then see if they were correct!

Explain

Now is the time to present trig ratios and connect them to using the clinometer. Draw a right triangle on the board and label one angle THETA. Ask students to do the same on their papers. Ask students to recall SOHCAHTOA and, still working in pairs, define what it means. Call on three pairs to define SOH, CAH, and TOA. Have students write down the sine, cosine, and tangent ratios on their paper and label the sides of their triangle appropriately. You might want to model diagram this on the board if students struggle. Students might also discuss special right triangles and angle of depression or elevation from geometry. Give students two special right triangles 45-45-90 and 30-60-90. Connect this information back to the clinometer.

Here are some questions for students to consider:

- Where do you see right triangle connections in your clinometer?
- How does the clinometer help with measuring trig ratios?
- How can you use trig ratios to measure heights of objects?

Extend

Students will now extend their basic understanding of clinometers and trig ratios to further explore how the two connect to determine heights of objects.

Activity Options

If it's feasible to let your students explore heights of objects around the school, proceed with the directions for Option 1 below. Otherwise, have students complete the scenarios from the worksheet described in Option 2.

Option 1, **Exploring heights around the school:** Students will continue to work in pairs to determine the heights of different objects. Pass out copies of the Record Sheet for students to use to record their measurements. Have students perform these steps to get their measurements:

1. Find the angle of elevation from the student to the top of an object and the distance from the object to the student as they are standing looking through the clinometer at the object.
2. Record the height of the student using the clinometer from ground to eyes (the height of the clinometer). For the first two clinometer angles, students will walk toward the object or away from the object to the location where the clinometer registers 45 degrees for the first problem and 30 degrees for the second problem. They will repeat this process for three more objects at any clinometer angle and record their measurements.
3. Based on their knowledge of special right triangles, students should be able to find the height of the objects for the first two angles. Ask them to try to devise a way to find the other three objects' heights.

Option 2, **Worksheet:** Pass out copies of the Right Triangle Problems worksheet. The worksheet covers real-world scenarios where students can explore angles of elevation and depression.

Evaluate

Use the What? So What? Now What? instructional strategy to evaluate student understanding.

- **What?** What did you do in this lesson?
- **So what?** What mathematics did you use and why do you think it was important?
- **Now what?** What will you take away from this lesson?

Optional assignment: Ask students to create a PowerPoint or Google Slides presentation for the five objects in the experiment. Students will take a picture of the object and the person with the clinometer and overlay a right triangle labeling all relevant angles and sides. Students will also need to create slides showing how they used trig ratios to determine the heights of the objects.These presentations can be assessed holistically or using a rubric, depending on your preference.

Resources

- K20 Center. (n.d.). Think-pair-share. Strategies. Retrieved from https://learn.k20center.ou.edu/strategy/d9908066f654727934df7bf4f5064b49
- K20 Center. (n.d.). What? So what? Now what?. Strategies. Retrieved from https://learn.k20center.ou.edu/strategy/b30762a7557ba0b391f207f4c6002113