**Unit 4: Investigation 8 (1 Day)**

**Indirect Measurement**

**Common Core State Standards**

* G-SRT 5 Use congruence and similarity criteria for triangles to solve problems and to prove relationships in geometric figures.
* G-SRT 8Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.

**Overview**

In preparation for the performance task students will analyze how various indirect measurement tools are based on similar triangles and trigonometric ratios. **Note:** This investigation is not needed prior to the End-of-Unit Assessment and may be given later in the year if the performance task is delayed until the weather improves. If the performance task is not given, then this becomes an optional activity.

**Assessment Activities**

**Evidence of Success: What Will Students Be Able to Do?**

* Explain how an indirect measurement tool works
* Use an indirect measurement tool to determine the length of an inaccessible object.

**Assessment Strategies: How Will They Show What They Know?**

* **Exit slip:** There is no exit slip for this activity. Rather the Performance task will be used to assess what students have learned.
* **Journal entry** will have students explain how similar triangles are used in indirect measurement.

**Launch Notes**

Introduce the topic of indirect measurement with this 4 minute video [www.youtube.com/watch?v=aMiKNToaQ0k](http://www.youtube.com/watch?v=aMiKNToaQ0k). It shows how similar triangles created by the sun’s rays allowed Thales to measure the heights of the pyramids in Egypt. In this Investigation we will be examining tools that are used to measure tall objects indirectly. They have the advantage of Thales’s method in that they work even when the sun is not shining!

**Teaching Strategies**

**Activity 4.8.1 Indirect Measurement Tools**introduces students to two home made tools for indirectly measuring the height of a tall object. You may want to make examples of these to demonstrate to the class or even have students experiment using them. Instructions for making the tools are listed below. The focus of the activity, however, is on having students explain how they work. Both are based on similar triangles. One drawback they both share is that they work only when the observer is at a certain distance from the object being measured. This shortcoming is overcome with the clinometer, which students will construct in the next activity.

In **Activity 4.8.2 Making a Clinometer** students make the tool they will use for the Performance Task. A clinometer measures the angle of elevation of a tall object, which the user sites through a straw. Attached to the straw are a protractor and a string with a weight tied at one end so that the plumb line thus formed will give a reading from the protractor. Student will need to understand that the acute angle read from the protractor is the complement of the angle of elevation.

Discuss various methods students can use to measure horizontal distances. If your school has one, you may want to demonstrate a measurement wheel. Alternatively, students may count the number of paces they use to get from one point to another, but first they need to determine the length of their pace. A pedometer is an instrument that measures the distance a person walks. Some students may have pedometer apps on their phones.

**Journal Prompt:** Explain how similar triangles are used in one or more of the indirect measurement techniques you have seen. Look for students to explain why a pair of triangles are similar and that corresponding sides of similar triangles are proportional.

**Closure Notes**

If practical, have students go outside to use the clinometer. Otherwise discuss how it is used, and begin to prepare students for the Performance Task.

**Vocabulary**

clinometer

cross staff

indirect measurement

scope

**Resources and Materials**

For constructing the clinometer: protractor, straw, tape, string, scissors, weight to place at end of string

Video for launch: [www.youtube.com/watch?v=aMiKNToaQ0k](http://www.youtube.com/watch?v=aMiKNToaQ0k).

Activity 4.8.1 Indirect Measurement Tools

Activity 4.8.2 Making a Clinometer

**Instructions for Constructing Tools**

**Cross staff**

Materials: Popsicle sticks or dowel pieces, hot glue gun, ruler, protractor.

Construct the cross staff modeling the diagram on page 1 of **Activity 4.8.1**. The cross pieces should be constructed perpendicular to each other and so that the horizontal piece bisects the vertical piece. You may want to cut the vertical piece to make it shorter than the horizontal.

**Scope**

Materials: paper towel tube or toilet paper tube, string, hot glue gun, scissors, ruler, single-hole puncher

Construct a scope modeling the diagram on page 2 of **Activity 4.8.1**. Take a cardboard roll and 7 or 9 or pieces of string 2 inches long.

Step 1: Hot glue a piece of string across the diameter of one open end of the tube.

Step 2: Take the remaining 6 or 8 pieces of string and hot glue half of them above the diameter and half of them below so that all cords are parallel to each other and equally spaced.

Step 3: Using the other open end of the tube, trace the circumference of the tube on a piece of paper.

Step 4: Find the center of this circle by folding the circle in half twice.

Step 5: Punch a hole in the circle’s center with the hole-punch.

Step 6: Cut around the circle slightly larger than the constructed circle and hot glue it to the end of the tube to form the eyepiece for the scope.

**Clinometer**

Materials: protractor, straw, tape, string, scissors, weight to place at end of string (washer, heavy paper clip, of paper clamp as shown on in **Activity 4.8.2**)

Tape the diameter of the protractor to the straw.

Cut the string to a length of 12 to 15 inches.

Tape one end of the string to the straw opposite the center of the protractor.

Tie the other end of the string to the weight.