

# Performance Based Learning and Assessment Task

## *Ancient Aqueduct Analysis Project*

### **I. ASSESSMENT TASK OVERVIEW AND PURPOSE:**

The students are instructed to: research roman aqueduct systems, analyze different aspects of their construction, reflect on the efficiency of the time period technology, and sketch a model drawing. Then, students will create a model aqueduct in GeoGebra while calculating some basic geometric concepts.

### **II. UNIT AUTHOR:**

Ashley Hoffman, Hampton City Schools

### **III. COURSE:**

Geometry

### **IV. CONTENT STRAND:**

Geometry: G2, G3, G5

### **V. OBJECTIVES:**

The student will be able to: 1)Peer discuss and analyze an article on roman aqueduct systems, 2)Make connections to aqueduct systems and basic geometric concepts, 3)Reflect on roman aqueduct systems and make improvements/changes, 4)Sketch a basic aqueduct system, 5)Apply knowledge of GeoGebra to construct a basic aqueduct system in the program

### **VI. REFERENCE/RESOURCE MATERIALS:**

Graphing Calculator, computer (online) access, worksheets, pencil, straight edge

### **VII. PRIMARY ASSESSMENT STRATEGIES:**

The project includes two assessment components. The first is self-evaluation by the student using the checklist; the second is evaluation by the teacher using the checklist and rubric. The assessment checklist evaluates the student's analysis and understanding of ancient aqueduct systems and the recognition of geometric concepts in aqueduct structures. The assessment checklist also evaluates the student's ability to accurately create a realistic aqueduct system, both in sketch and through the use of GeoGebra.

### **VIII. EVALUATION CRITERIA:**

Assessment checklist for Activities 1 – 4, and the corresponding rubrics. Also included are benchmarks of what students are expected to produce

### **IX. INSTRUCTIONAL TIME:**

Two ninety-minute class periods

# Ancient Aqueducts Analysis Project

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## **Strand**

Geometry

## **Mathematical Objectives**

Students will be able to: Make connections to aqueduct systems and basic geometric concepts,

## **Related SOL**

G2 (Solving practical problems with parallel lines;G3: Using formulas to find distance, midpoint, and slope),G4 (Constructing congruent line segments and angles, bisecting segments and angles, and perpendiculars)

## **NCTM Standards**

- 1)Precisely describe, classify, and understand relationships among types of two- and three-dimensional objects using their defining properties
- 2)Understand relationships among the angles, side lengths, perimeters, areas and volumes of similar objects
- 3)Recognize and apply geometric ideas and relationships in areas outside the mathematics classroom, such as art, science, and everyday life.
- 4)Apply and adapt a variety of appropriate strategies to solve problems
- 5)Communicate mathematical thinking coherently and clearly to peers, teachers, and others

## **Materials/Resources**

Graphing Calculator, computer (online) access, worksheets, pencil, straight edge

## **Assumption of Prior Knowledge**

Students will: 1)have a basic understanding of using GeoGebra, 2)understand and calculate slope, distance, and area, 3)understand concepts of parallel and perpendicular lines and segments

## **Introduction: Setting up the Mathematical Task**

The teacher will ask “How often can we describe real world structures with geometric concepts?” Students will respond. Teacher will ask for examples. The teacher will then give a short presentation (PowerPoint, ActivInspire, etc.) to show real world scenarios (some may have already been brought up by the students). The class will describe different geometric concepts found in each photo, drawing, or written scenario. It is important for the teacher to introduce any geometric concepts not brought up by the students in each scenario.

Students will then be given the project packet, which includes the directions, checklist, and rubric. The teacher will give explanation of the overall project, including which parts are to be

completed individually and which require a partner. The teacher will spend time discussing the rubric and grading scale, as well as taking questions from the class.

The teacher will need to monitor individual student progress, as well as become available to assist throughout the project. Teachers should take note of which sections are most difficult for students, to be used for future reference.

Computer access is necessary for many sections of the project. If able, the teacher should acquire use of a laptop cart or computer lab for the entirety of the project. The students will begin reading the assigned post individually. Students should be instructed to make conscious reflections to what is being read. Then, students will team up to complete the worksheet using a Think/Pair/Share method. Students will go back to individual work to handwrite or type their reflection on ancient aqueducts. Afterwards, students will recreate their sketch aqueduct in GeoGebra.

## **Student Exploration**

Students should be encouraged to use notes, textbook, and online resources to research any aspects that confuse them. Words like “parallel, perpendicular, slope, and congruent” should be circulated through conversation. The teacher should prompt students to think back and reflect on the class assignment at the beginning of the project. The teacher should help students use those scenarios and apply them to the aqueduct.

Students should give equal amounts of effort during the team section. Students should be encouraged to think outside of the box (beyond basic geometric concepts) and to give evidence to defend their findings.

## **Student/Teacher Actions**

Students will be reading individually, then talking in teams (pairs, groups of 2) to answer the worksheet. Students will be writing individual reflections. Students will be using the computer to read and research concepts online. Students should not be using GeoGebra until all other sections have been completed.

Students will have control over their aqueducts but must keep to realistic designs and measurements.

Teachers should walk the room, openly assisting and making suggestions when needed. This will also help with monitoring computer use. Teachers should be prompting geometric thinking and encouraging exploring more than just basic concepts. Teachers should be asking students to justify their decisions or give an alternative to their first solution or decision. In some cases, the teacher will need to give an example or help guide the student into an alternative way of thinking. This may be especially so during the GeoGebra section.

## **Monitoring Student Responses**

Teachers should be monitoring all student progress throughout the project. Students will communicate their responses through grammatically correct sentences of the worksheet and reflection. Students will also communicate their understanding through appropriate aqueduct constructions justified with correct geometric calculations.

Students will need to speak clearly and with accurate understanding of geometric concepts to work in a team to create written responses. When unsure, students should be comfortable to ask for assistance by the teacher.

The class should take the time to post a collage of GeoGebra printouts of finished aqueduct systems on an available wall or bulletin board.

## **Assessment Lists and Benchmarks**

Students will be required to complete the project shown below. The project packet includes the directions, assessment list, and rubric. Students will be required to complete the accompanying worksheet and write a one-paragraph reflection.

Students will self-evaluate their progress throughout the project, as well as receive a grade from the teacher. Both will use the same rubric. Benchmarks are included to provide appropriate student responses. Some responses will vary based on the student.

## **Ancient Aqueducts Analysis Project**

**Teacher: Hoffman  
Geometry**

**Student Name: \_\_\_\_\_ Class:**

Our research project will explore the need and creation of ancient aqueducts, communicate the advantages and disadvantages of certain aqueduct construction, apply our geometric understanding to these structures, and allow you to create a model version.

Please follow the directions carefully. Use the provided checklist to correctly complete each activity. As you complete an activity, self grade your performance on the activity.

All research components must be organized in your research folder. Be sure to include the directions (this sheet), your checklist, and rubric in the folder as well.

### **Section One: Research**

1) Read Peter Aicher's post on Watering Ancient Rome:  
<http://www.pbs.org/wgbh/nova/ancient/roman-aqueducts.html>

2) Find a partner to complete the worksheet *Watering Ancient Rome: Response*.

3) Type or hand-write a one-paragraph reflection on something you feel could have improved ancient aqueduct systems. Keep in mind the technology available at the time.

### Section Two: Recreation

4) Open GeoGebra on your laptop. Complete the following steps.

A) Create and modify your aqueduct sketch from the *Watering Ancient Rome: Response* worksheet.

B) Show the beginning of the aqueduct and its water source.

C) Show an appropriate syphon or depository area for water purification OR use an appropriate aqueduct model that purifies without this structure.

D) Show the ending of the aqueduct and the city.

E) Calculate the following:

\* The slope of the top and bottom of the aqueduct lines to show parallel lines.

\* The distance from the beginning of the aqueduct to its end. (You may find the straightest path, or average distance)

\* The area of the depository section (if created).

## **Aqueduct Research Project: Checklist**

Teacher: Hoffman  
Geometry

Student Name: \_\_\_\_\_ Class: \_\_\_\_\_

Number	Element	Point Value	Earned Assessment	
			Self-Graded	Teacher Grade
1	Read the article post <i>Watering Ancient Rome</i>	-		
2	Complete the <i>Response</i> worksheet	15		
2a	The need for aqueducts	3		
2b	Advantages/disadvantages of tunnel aqueducts	3		
2c	Water purification	3		
2d	Identifying geometric concepts	3		
2e	Sketch original aqueduct system	3		
3	Improving Aqueduct Reflection	10		

<b>3a</b>	One paragraph response	2		
<b>3b</b>	Addressing the prompt question	2		
<b>3c</b>	Technology for the time period	2		
<b>3d</b>	Improvement to the aqueducts	2		
<b>3e</b>	Appropriate grammar and language	2		
<b>4</b>	GeoGebra Aqueduct Model	25		
<b>4a</b>	Create and modify sketch	5		
<b>4b</b>	Beginning (of aqueduct) and water source	5		
<b>4c</b>	Water purification	5		
<b>4d</b>	Ending (of aqueduct) and city	5		
<b>4e</b>	Geometric Calculations	5		

### Ask Yourself:

Does my research folder include this checklist and the rubric?

Does my research folder include the directions page?

Does my research folder include the *Watering Ancient Rome: Response* worksheet?

Does my research folder include my Improving Aqueduct Reflection?

Does my research folder include a print out of my GeoGebra Aqueduct Model?

Did I email Miss Hoffman my GeoGebra Aqueduct Model?

### Category Descriptions

**Please read over all descriptions as you work through the directions and checklist. When unsure of a description, raise your hand for Miss Hoffman to clarify. Do not assume, do not ask a classmate.**

#	Element	0	1 – 2	3
<b>1</b>	Read the article post <i>Watering Ancient Rome</i>	-	-	-
<b>2</b>	Completed the <i>Response</i> worksheet	15 total possible points: based on questions 2a – 2e		
<b>2a</b>	The need for aqueducts	Does not accurately respond	Accurately responds with some evidence	Accurately responds with adequate evidence

<b>2b</b>	Advantages/disadvantages of tunnel aqueducts	Does not list any appropriate viewpoints	Lists some appropriate viewpoints	Lists 4 appropriate viewpoints
<b>2c</b>	Water purification	Does not correctly describe any methods	Correctly describes one method	Correctly describes two methods
<b>2d</b>	Identifying geometric concepts	Does not correctly identify geometric concepts	Correctly identifies 1-2 geometric concepts	Correctly identifies 3 or more geometric concepts
<b>2e</b>	Sketch original aqueduct system	Does not create a realistic model or does not use labels	Creates a mostly realistic model with labels	Creates a realistic model with labels
	<b>Element</b>	<b>0</b>	<b>1</b>	<b>2</b>
<b>3</b>	Improving Aqueduct Reflection	10 total possible points: based on components 3a – 3e		
<b>3a</b>	One paragraph response	Does not create a full paragraph (<4 sentences)	Creates an almost full paragraph (4 sentences)	Creates a full paragraph (5-7 sentences)
<b>3b</b>	Addressing the prompt question	Does not address the prompt question	-	Addresses the prompt question
<b>3c</b>	Technology for the time period	Uses technology too advanced for or around the time period	Uses time-period technology within a small range of years	Accurately uses time-period technology
<b>3d</b>	Improvement to the aqueducts	Does not describe an improvement or realistic improvement	Describes a mostly realistic improvement	Describes a realistic improvement
<b>3e</b>	Appropriate grammar and language	Many grammatical or language errors (+3)	Few grammatical or language errors	No grammatical or language errors

	<b>Element</b>	<b>0</b>	<b>1 – 3</b>	<b>4 - 5</b>
<b>4</b>	GeoGebra Aqueduct Model	25 total possible points: based on tasks 4a – 4e		
<b>4a</b>	Create and modify sketch	Does not create an aqueduct system	Creates aqueduct system	Uses sketch design (may modify); creates aqueduct system



<b>4b</b>	Beginning (of aqueduct) and water source	Does not create an aqueduct system	Shows beginning of aqueduct	Shows beginning and water source
<b>4c</b>	Water purification	Does not show a purification method	Shows a mostly correct method	Shows a correct method to purification
<b>4d</b>	Ending (of aqueduct) and city	Does not create an aqueduct system	Shows ending of aqueduct	Shows ending and city
<b>4e</b>	Geometric Calculations	Does not calculate or correctly calculate necessary tasks	Correctly calculates most necessary tasks	Correctly calculates all necessary tasks

### ***Watering Ancient Rome*** Response Worksheet

Teacher: **Hoffman**  
**Geometry**

Student Name: \_\_\_\_\_ Class:

Discuss each question with your partner. Separately, record your discussion responses.

A) Why were aqueducts necessary in ancient Rome?

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B) List one advantage and disadvantage of tunnel aqueducts from the article. Then, list a second advantage and disadvantage not mentioned in the article.

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C) Describe two different ways that the Romans would purify (clean) the water.

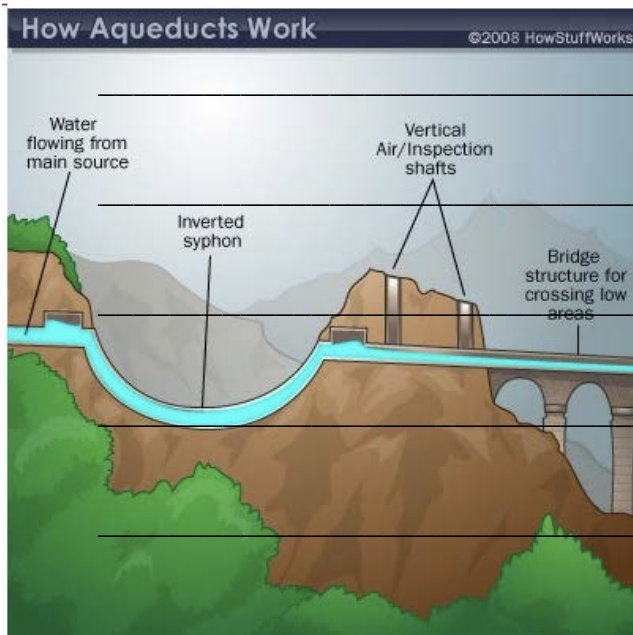
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D) Look at the diagram below. List as many geometric concepts as possible that are represented, with a minimum of 3 concepts. Use your notes, textbook, and geometry pacing-guide to help you. Describe where/how each concept is located in the diagram.



*An Aqueduct* (diagram). 2008. Retrieved July 16, 2014, from <http://science.howstuffworks.com/environmental/green-science/la-ancient-rome1.htm>

E) Sketch a model of your own ancient aqueduct system. Use the *Watering Ancient Rome* article and websites you research online for inspiration. Label different sections of your model (as seen in the diagram from question D).

## Student Benchmark

### *Watering Ancient Rome* Response Worksheet

Teacher: Hoffman  
Geometry

Student Name: Valerie S.

Class:

Discuss each question with your partner. Separately, record your discussion responses.

A) Why were aqueducts necessary in ancient Rome?

The aqueducts were necessary to bring fresh water to roman cities for bathing and drinking.

Without enough water, the city would not be able to support the population. To many outside

visitors, Rome was considered especially clean.

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B) List one advantage and disadvantage of tunnel aqueducts from the article. Then, list a second advantage and disadvantage not mentioned in the article.

Tunnels were less affected by nature, such as wind erosion and earthquakes. However, enemies

would often damage the aqueducts to hurt the Romans. An advantage, not mentioned in the

article, of using tunnels is to keep out manmade impurities, as well as to keep the water cold.

A disadvantage, not mentioned in the article, is that tunnels could be difficult to build and unseen

obstacles could appear to slow the construction process.

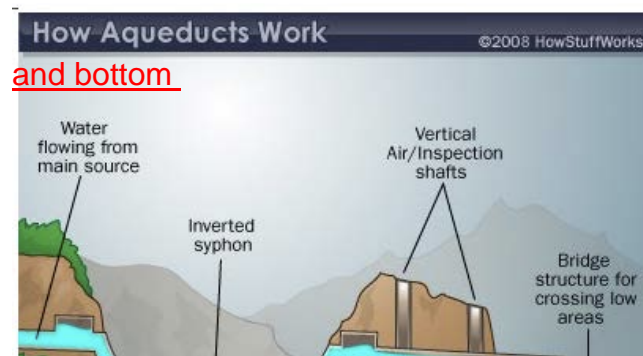
C) Describe two different ways that the Romans would purify (clean) the water.

One way to purify the water was to use a “settling basin”. This would slow the water down and

allow impurities to sink to the bottom. Another way to purify the water was to build the aqueduct in

a zigzag manner instead of a gentle straight slope. This would also cause the water to slow down.

D) Look at the diagram below. List as many geometric concepts as possible that are represented, with a minimum of 3 concepts. Use your notes, textbook, and geometry pacing-guide to help you. Describe where/how each concept is located in the diagram.



and bottom

Parallel line segments – between top sections of the aqueduct tunnels

the

syphon

syphon

Slope – of every linear segment

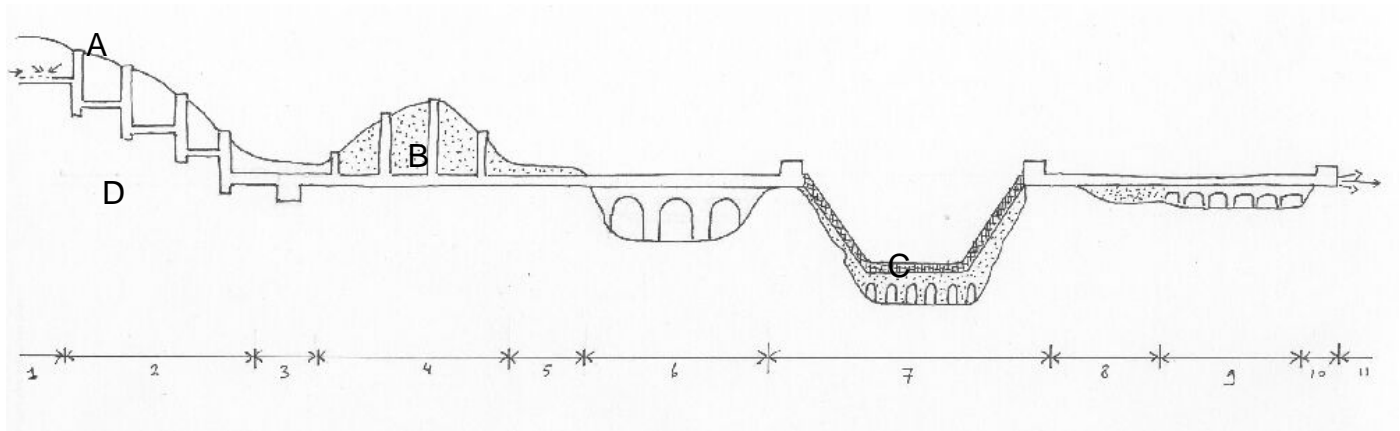
Distance – from the beginning to end of  
aqueduct

Parabolas – to represent the inverted

Area and volume – of the inverted

*An Aqueduct* (diagram). 2008. Retrieved July 16, 2014, from <http://science.howstuffworks.com/environmental/green-science/la-ancient-rome1.htm>

E) Sketch a model of your own ancient aqueduct system. Use the *Watering Ancient Rome* article and websites you research online for inspiration. Label different sections of your model (as seen in the diagram from question D).



A = water source  
city

B = tunnel

C = setting basin

D =

Photo Courtesy of: Wilke D. Schram (Professor of Utrecht University). (2004). *A Roman Aqueduct* (Sketch), Retrieved July 16, 2014, from: <http://www.romanaqueducts.info/introduction/>

## **Student Benchmark**

### **Improving Aqueduct Reflection**

**By: Valerie S.**

The aqueduct system was used to bring fresh, clean water to the cities of the Roman Empire. An issue that the people faced was water purities. An improvement to the system would be finding a way to alternate netting (such as those used for fishing), to help drain larger impurities. This could include larger pieces of dirt and rock, but also manmade items or byproducts. The netting would need to be smaller, so workers would have to produce netting with smaller gaps. Also, the nettings would need to be rigged at specific locations along the aqueduct. This would help the workers keep track of what areas needed to be monitored to clean the nettings. If the netting isn't cleared periodically, then the garbage could stop the water flow along the aqueduct.

## Performance Based Learning and Assessment Task

### Right Triangles – Let's Make a Hypsometer Project

#### I. ASSESSMENT TASK OVERVIEW AND PURPOSE:

The students are instructed to: analyze and differentiate between the two methods of solving practical problems of right triangles, then peer examine their decisions and make corrections. Students will also create a hypsometer, which will then be applied to calculating real world heights at the school.

#### II. UNIT AUTHOR:

Ashley Hoffman, Hampton City Schools

#### III. COURSE:

Geometry

#### IV. CONTENT STRAND:

SOL: Geometry

- G8: Solve practical problems involving right triangles by using the Pythagorean theorem and its converse, properties of special right triangles, and right triangle trigonometry.

NCTM Standards: Geometry

- Create and critique inductive and deductive arguments concerning geometric ideas and relationships, such as congruence, similarity, and the Pythagorean relationship.
- Use trigonometric relationships to determine lengths and angle measures.
- Recognize and apply geometric ideas and relationships in areas outside the mathematics classroom, such as art, science, and everyday life.
- Apply and adapt a variety of appropriate strategies to solve problems
- Communicate mathematical thinking coherently and clearly to peers, teachers, and others.

#### V. OBJECTIVES:

The student will be able to:

- Analyze correct methods for solving practical problems of right triangles
- Calculate missing side lengths based on student analysis
- Peer discuss and correct the analysis



- Create a hypsometer
- Apply the hypsometer to solving real world practical problems

**VI. REFERENCE/RESOURCE MATERIALS:**

Graphing Calculator, computer (online) access, worksheets, pencil  
Protractor, straw, tape, string, heavy jewelry bead

**VII. PRIMARY ASSESSMENT STRATEGIES:**

The project includes two assessment components. The first is self-evaluation by the student using the checklist; the second is evaluation by the teacher using the checklist and rubric. The assessment checklist evaluates the student's analysis, understanding of right triangles, and the ability to apply knowledge to solve practical problems. The assessment checklist also evaluates the student's ability to accurately create and use a hypsometer to solve additional practical problems.

**VIII. EVALUATION CRITERIA:**

Assessment checklist for Activities 1 – 5, and the corresponding rubrics. Also included are benchmarks of what students are expected to produce.

**IX. INSTRUCTIONAL TIME:**

The project should take 1 – 2 class periods of 90 minutes each for Activities 1 – 4. An additional period will be required for the class to learn how a hypsometer is used and for students to discover the correct trigonometric function and set up for using the hypsometer. After the class agrees on the correct trigonometric function, groups will go outside to complete Activity 5.

# Right Triangles – Let's Make a Hypsometer Project

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## **Strand**

Geometry

## **Related SOL**

G8: Solve practical problems involving right triangles by using the Pythagorean theorem and its converses, properties of special right triangles, and right triangle trigonometry.

## **NCTM Standards**

- Create and critique inductive and deductive arguments concerning geometric ideas and relationships, such as congruence, similarity, and the Pythagorean relationship.
- Use trigonometric relationships to determine lengths and angle measures.
- Recognize and apply geometric ideas and relationships in areas outside the mathematics classroom, such as art, science, and everyday life.
- Apply and adapt a variety of appropriate strategies to solve problems
- Communicate mathematical thinking coherently and clearly to peers, teachers, and others.

**Materials/Resources**

Graphing Calculator, computer (online) access, worksheets, pencil, protractor, straw, tape, string, heavy jewelry bead

**Assumption of Prior Knowledge**

- Students have a solid understanding of the Pythagorean theorem and its converses
- Students have a solid understanding of trigonometric functions (SOHCAHTOA)
- Students can differentiate between the two methods listed above and when to use each
- Students will need to communicate their reasoning mathematically and written
- Students may have difficulty constructing the hypsometer, and will receive assistance from the teacher
- Students may be given assistance or an example when first using the hypsometer
- The relevant contexts that related to this project: recognizing mathematical concepts in the real world, applying geometric concepts to the real world, making connections to real world needs (example: the need for surveyors in construction)

## Introduction: Setting up the Mathematical Task

The teacher will ask “When should we differentiate our method to solving a problem?” Students will respond. Teacher will ask for examples. The teacher will then explain “We should always analyze our problem to figure out the best way to find the solution.” The teacher will ask for two methods used in solving right triangle problems. The teacher should receive the answers “the Pythagorean theorem” and “trigonometric functions”.

Students will then be given the project packet, which includes the directions, checklist, and rubric. The teacher will give explanation of the overall project, including which parts are to be completed individually and which require a partner. The teacher will spend time discussing the rubric and grading scale, as well as taking questions from the class.

The teacher will need to monitor individual student progress, as well as become available to assist throughout the project. Teachers should take note of which sections are most difficult for students, to be used for future reference.

Computer access is necessarily for one section of the project. If able, the teacher should acquire use of a laptop cart or computer lab for the entirety of the project.

The students will begin with the *Analyzing Right Triangles* worksheet individually. Each student will show a completed worksheet to the teacher before moving on to revise with a partner.

Students will go back to individual work to create a hypsometer. This section requires computer access and may pose difficulties for some students. The last portion of the project should be completed in a separate class period, outside, in small groups. Students will use the hypsometers to find real world heights.

## Student Exploration

Students should be encouraged to use notes, textbook, and online resources to research any aspects that confuse them. Words like “angles, lengths, hypotenuse, sine, cosine, and tangent” should be circulated through conversation. The teacher should prompt students to always create a diagram. The teacher should help students identify what is given to set up the diagrams properly, if needed.

Students should give equal amounts of effort during the team section. Students should be encouraged to collaborate appropriately and to give evidence to defend their findings.

## Student/Teacher Actions

Students will be calculating word problems individually, then talking in pairs to analyze the worksheet. Students will have constraints to build individual hypsometers. Students will be working in groups of three to complete the real world portion of the project.

Teachers should walk the room, openly assisting and making suggestions when needed. This will also help with monitoring computer use. Teachers should be prompting geometric thinking and encouraging finding the best method. Teachers should be asking students to justify their decisions.

### **Monitoring Student Responses**

Teachers should be monitoring all student progress throughout the project. Students will communicate their responses through grammatically correct sentences and mathematically correct diagrams and calculations on the worksheet.

Students will need to speak clearly and with accurate understanding of geometric concepts to work in a team to create written responses. When unsure, students should be comfortable to ask for assistance by the teacher.

The class should take the time to compare group findings from the real world portion of the project. The class should then explore why calculations may differ and how this affects calculations made by engineers and surveyors.

### **Assessment Lists and Benchmarks**

Students will be required to complete the project shown below. The project packet includes the directions, assessment list, and rubric. Students will be required to complete the accompanying worksheets.

Students will self-evaluate their progress throughout the project, as well as receive a grade from the teacher. Both will use the same rubric. Benchmarks are included to provide appropriate student responses. Some responses will vary based on the student.

## Right Triangles – Let's Make a Hypsometer Project

Teacher: Hoffman  
Geometry

Student Name: \_\_\_\_\_ Class: \_\_\_\_\_

Our project will explore the two methods we use to solve practical problems including right triangles; using the Pythagorean theorem vs. using trigonometric functions. After analyzing and answering several questions, we will be creating a hypsometer, which allows for the solving of real world right triangle scenarios.

Please follow the directions carefully. Use the provided checklist to correctly complete each activity. As you complete an activity, self grade your performance on the activity.

All project components must be organized in your project folder. Be sure to include the directions (this sheet), your checklist, and rubric in the folder as well.

### Section One: Analyzing Right Triangles

- 1) Complete the *Analyzing Right Triangles* worksheet.
- 2) Show the teacher your completed worksheet. (Bring your checklist)
- 3) Find a partner with whom to check and discuss answers with. Make corrections as you see fit.

### Section Two: Hypsometer Construction

- 4) Read the given webpage on designing and creating a hypsometer.

Materials we will use: protractor, straw, tape, string, and a heavy jewelry bead

A) Read the article *How to Make a Hypsometer* by Spaceman Spiff

<http://www.instructables.com/id/How-to-make-a-tool-to-measure-angles/?ALLSTEPS>

- B) Gather the required materials from the material station.
- C) Build your own hypsometer based on the webpage instructions.
- D) Show your construction to the teacher. (Bring your checklist)

\* At this point, corrections/adjustments may need to be done on the hypsometer, which will affect your grade on the hypsometer construction.

### Section Three: Real World Application

5) Find two partners with whom to complete the *Real World Application* worksheet.

\* This activity will take place outside. Materials we will use: hypsometer, graphing calculator. Don't forget the worksheets and pencils!

## **Right Triangles – Let's Make a Hypsometer Project: Checklist**

Teacher: Hoffman  
Geometry

Student Name: \_\_\_\_\_ Class: \_\_\_\_\_

Number	Element	Point Value	Earned Assessment	
			Self-Graded	Teacher Grade
<b>1</b>	Complete the <i>Analyzing Right Triangles</i> worksheet	15		
<b>1a</b>	Right Triangle Diagram	3		
<b>1b</b>	Right Triangle Diagram	3		
<b>1c</b>	Right Triangle Scenario	3		
<b>1d</b>	Right Triangle Scenario	3		
<b>1e</b>	Right Triangle Scenario	3		
<b>2</b>	Show your completed <i>Analyzing Right Triangles</i> worksheet to the teacher (bring this list)	2		
<b>3</b>	Check and modify answers to <i>Analyzing Right Triangles</i> worksheet with a partner	2		
<b>4</b>	Hypsometer Construction	16		
<b>4a</b>	Read the article <i>How to Make a Hypsometer</i>	-		
<b>4b</b>	Gather appropriate materials	2		
<b>4c</b>	Build hypsometer	14		
<b>4d</b>	Show your constructed hypsometer to the teacher (bring this list)	2		
<b>5</b>	Complete the <i>Real World Application</i> worksheet	25		
<b>4a</b>	Height of a tree	5		
<b>4b</b>	Height of the flag pole	5		
<b>4c</b>	Height of the school	5		

<b>4d</b>	Height of the basketball hoop	5		
<b>4e</b>	Height of the gymnasium	5		

### Ask Yourself:

Does my project folder include this checklist and the rubric?

Does my project folder include the directions page?

Does my project folder include the *Analyzing Right Triangles* and *Real World Application* worksheet?

Do those worksheets include diagrams where needed? Is all of my work shown?

Is my hypsometer included in the project folder?

### Category Descriptions

**Please read over all descriptions as you work through the directions and checklist. When unsure of a description, raise your hand for Miss Hoffman to clarify. Do not assume, do not ask a classmate.**

#	Element	0	1 – 2	3
<b>1</b>	Complete the <i>Analyzing Right Triangles</i> worksheet	15 total possible points: based on questions 1a – 1e		
<b>1a</b> - <b>1b</b>	Right Triangle Diagram	Does not find the missing side length, does not use the correct method	Does not find the missing side length, does use the correct method	Correctly finds the missing side length using the correct method
<b>1c</b> - <b>1e</b>	Right Triangle Scenario	Does not find the missing side length, does not correctly draw the diagram or use the correct method	Does not find the missing side length, does correctly draw a diagram and use the correct method	Correctly draws a diagram, and finds the missing side length using the correct method
	<b>Element</b>	<b>0</b>	<b>1</b>	<b>2</b>
<b>2</b>	Show your completed <i>Analyzing Right Triangles</i> worksheet to the teacher (bring the checklist)	Does not show teacher a completed worksheet	Shows a completed worksheet	Shows a completed worksheet, and brings up checklist to be marked



<b>3</b>	Check and modify answers to <i>Analyzing Right Triangles</i> worksheet with a partner	Does not write name on partner's worksheet and does not check and modify worksheet	Checks and modifies worksheet with partner	Writes name on partner's worksheet for review; checks and modifies worksheet
	<b>Element</b>			
<b>4</b>	Hypsometer Construction	16 total possible points: based on components 4a – 4d 4b: total possible = 2 points 4c: total possible = 14 points 4d: total possible = 2 points		
<b>4a</b>	Read the article <i>How to Make a Hypsometer</i>	-	-	-
<b>4b</b>	Gather appropriate materials	0 points: does not gather	1 point: gathers some but not all materials	2 points: gathers all material at one time
<b>4c</b>	Build hypsometer	0 points: Does not build a correct hypsometer, several modifications, does not look neat and sturdy	10 points: Mostly builds a correct hypsometer, may need some modification, looks mostly neat and sturdy	14 points: Correctly builds hypsometer; no modifications needed, looks neat and sturdy
<b>4d</b>	Show your constructed hypsometer to the teacher (bring this list)	0 points: does not show teacher hypsometer	-	2 points: shows teacher hypsometer

	<b>Element</b>	<b>0</b>	<b>1 - 3</b>	<b>4 - 5</b>
<b>5</b>	Complete the <i>Real World Application</i> worksheet	25 total possible points: based on tasks 4a – 4e Every question follows the same grading		
<b>5a</b> <b>5b</b> <b>5c</b> <b>5d</b> <b>5e</b>	Height of a tree Height of the flagpole Height of the school Height of the basketball Height of the gymnasium	Does not draw a diagram, show calculations, or find the correct answer	Draws a diagram, shows all calculations, does not find the correct answer	Correctly draws a diagram, shows all calculations, finds correct answer

## ***Analyzing Right Triangles Worksheet***

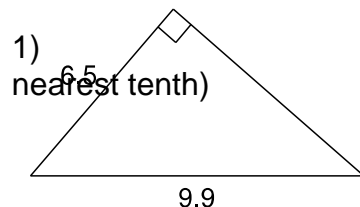
Teacher: Hoffman  
Geometry

Student Name: \_\_\_\_\_ Class: \_\_\_\_\_

All questions require the use of the Pythagorean theorem or SOHCAHTOA to find a missing side length. Analyze each diagram or scenario to determine which method to use. State the given method.

Write a brief explanation of why you chose your method (1 – 4 sentences). Then show all work to calculate the missing side length. If units are given, use those, if not simply write “units” to describe the measurement.

For questions #1 and #2, use the diagram of the given right triangle to solve for the missing side.



What is the length of the missing side? (Round to the

\_\_\_\_\_

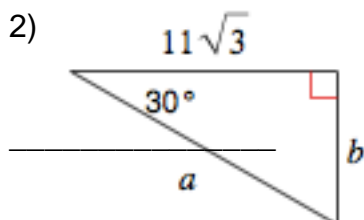
Method: \_\_\_\_\_

Answer:

Explanation:

Calculations:

2)



What is the length of  $a$ ? (Write in simplified radical form)

Method: \_\_\_\_\_

Answer:

Explanation:

Calculations:

For questions #3 – #5, draw and label the diagram of a right triangle for each scenario. Then solve for the missing side.

3) The diagonal of a TV screen is 32 inches. The screen is 16 inches wide. How high is the screen? Write your answer in simplified radical form.

Method: \_\_\_\_\_  
\_\_\_\_\_

Diagram:

Answer:

Explanation:

Calculations:

4) A ladder 24 feet long leans against a firehouse and makes an angle of  $71^\circ$  with the ground. How high up the wall does the beam reach to the nearest foot?

Method: \_\_\_\_\_  
\_\_\_\_\_

Diagram:

Answer:

Explanation:

Calculations:

5) When an airbus travelling to Japan had flown 2,800 feet from the airport where it had taken off, it had covered a horizontal distance of 1,995 feet. What is the angle at which the plane rose from the ground to the nearest degree?

Method: \_\_\_\_\_  
\_\_\_\_\_

Diagram:

Answer:

Explanation:

Calculations:

Partner Name: \_\_\_\_\_

Which questions were modified? \_\_\_\_\_

***Real World Application Worksheet***

Teacher: Hoffman

Class: Geometry

**Student A: Name:** \_\_\_\_\_  
\_\_\_\_\_ in.

**Height:** \_\_\_\_\_ ft. ;

**Student B: Name:** \_\_\_\_\_  
\_\_\_\_\_ in.

**Height:** \_\_\_\_\_ ft. ;

**Student C: Name:** \_\_\_\_\_  
\_\_\_\_\_ in.

**Height:** \_\_\_\_\_ ft. ;

All questions require the use of your hypsometer. Take turns using the hypsometer, which will change the height used in calculations.

Be consistent with measurements of each object!

1) Height of a tree:

Diagram:

Student A or B or C (circle one)

Student Height: \_\_\_\_\_

Distance from object to student: \_\_\_\_\_

Angle Measure: \_\_\_\_\_

Discovered Height from calculations: \_\_\_\_\_

Calculations:

**ANSWER:** The height of the tree is \_\_\_\_\_.

Explain how you came to this answer (explain how you set up your diagram and calculated the answer).

2) Height of the flagpole:

Diagram:

Student A or B or C (circle one)

Student Height: \_\_\_\_\_

Distance from object to student: \_\_\_\_\_

Angle Measure: \_\_\_\_\_

Discovered Height from calculations: \_\_\_\_\_

Calculations:

**ANSWER**: The height of the flagpole is \_\_\_\_\_.

Explain how you came to this answer (explain how you set up your diagram and calculated the answer).

3) Height of the school:

Diagram:

Student A or B or C (circle one)

Student Height: \_\_\_\_\_

Distance from object to student: \_\_\_\_\_

Angle Measure: \_\_\_\_\_

Discovered Height from calculations: \_\_\_\_\_

Calculations:

**ANSWER:** The height of the school is \_\_\_\_\_.

Explain how you came to this answer (explain how you set up your diagram and calculated the answer).

4) Height of the basketball hoop:

Diagram:

Student A or B or C (circle one)

Student Height: \_\_\_\_\_

Distance from object to student: \_\_\_\_\_

Angle Measure: \_\_\_\_\_

Discovered Height from calculations: \_\_\_\_\_

Calculations:



**ANSWER:** The height of the basketball hoop is \_\_\_\_\_.

Explain how you came to this answer (explain how you set up your diagram and calculated the answer).

5) Height of the gymnasium:

Diagram:

Student A or B or C (circle one)

Student Height: \_\_\_\_\_

Distance from object to student: \_\_\_\_\_

Angle Measure: \_\_\_\_\_

Discovered Height from calculations: \_\_\_\_\_

Calculations:

**ANSWER:** The height of the gymnasium is \_\_\_\_\_.

Explain how you came to this answer (explain how you set up your diagram and calculated the answer).

## Student Benchmark

### Analyzing Right Triangles Worksheet

Teacher: Hoffman  
Geometry

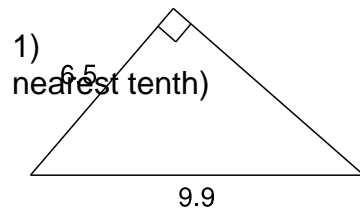
Student Name: Valerie S.

Class:

All questions require the use of the Pythagorean theorem or SOHCAHTOA to find a missing side length. Analyze each diagram or scenario to determine which method to use. State the given method.

Write a brief explanation of why you chose your method (1 – 4 sentences). Then show all work to calculate the missing side length. If units are given, use those, if not simply write “units” to describe the measurement.

For questions #1 and #2, use the diagram of the given right triangle to solve for the missing side.



What is the length of the missing side? (Round to the

Method: Pythagorean theorem

Answer: 7.5 units

Explanation:

I chose this method because the triangle  
=  $9.9^2$

98.01  
gives two side lengths, a leg and the hypotenuse.  
42.25

55.76

Calculations:

$$a^2 + b^2 = c^2, \text{ then } 6.5^2 + b^2$$

$$42.25 + b^2 =$$

$$\underline{-42.25} \quad =$$

$$b^2 =$$

$$\sqrt{55.76}$$

7.46726

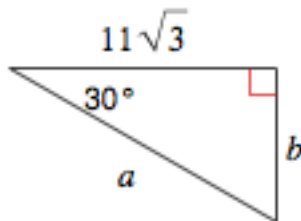
7.5

b =

b =

b ≈

2)



What is the length of  $a$ ? (Write in simplified radical form)

Method: SOHCAHTOA

Answer: 22 units

Explanation:

I chose this method because the triangle gives one

$$\frac{\sqrt{3}}{2} = \frac{11\sqrt{3}}{a}$$

side length and two angles. I chose cosine because

I am given the side adjacent and am looking for the

$$a = \frac{2}{\sqrt{3}} \times 11\sqrt{3}$$

hypotenuse.

Calculations:

$$\cos(30^\circ) = \frac{11\sqrt{3}}{a} \text{ then}$$

$$\text{then } a \frac{\sqrt{3}}{2} = 11\sqrt{3} \text{ then}$$

$$\text{then } a = 22$$

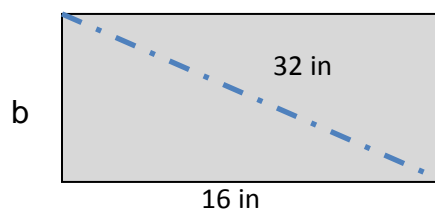
For questions #3 – #5, draw and label the diagram of a right triangle for each scenario. Then solve for the missing side.

3) The diagonal of a TV screen is 32 inches. The screen is 16 inches wide. How high is the screen? Write your answer in simplified radical form.

Method: Pythagorean theorem

Diagram:

Answer:  $16\sqrt{3}$  inches



Explanation:

Calculations:

I chose this method because the TV gives the  
 $+ b^2 = 32^2$

1,024  
width(leg) and the diagonal (hypotenuse).  
 256

768

$$\sqrt{768}$$

$$b = \sqrt{256} \times \sqrt{3}$$

$$b = 16\sqrt{3}$$

$$a^2 + b^2 = c^2, \text{ then } 16^2$$

$$256 + b^2 =$$

$$-256 \quad -$$

$$b^2 =$$

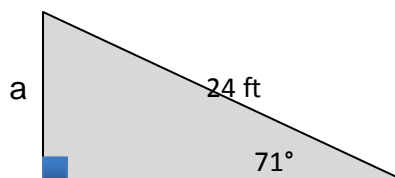
$$b =$$

4) A ladder 24 feet long leans against a firehouse and makes an angle of  $71^\circ$  with the ground. How high up the wall does the beam reach to the nearest foot?

Method: SOHCAHTOA

Diagram:

Answer: 23 feet



Explanation:

Calculations:

I chose this method because the triangle gives one side length and two angles. I chose sine because I am given the hypotenuse and am looking for the side opposite.

$$\sin(71^\circ) = \frac{a}{24}$$

$$0.945518 = \frac{a}{24}$$

$$24 \times 0.945518 = \frac{a}{24} \times 24$$

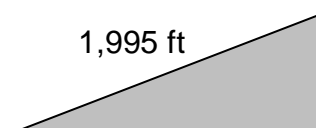
$$a = 22.692432 \approx 23$$

5) When an airbus travelling to Japan had flown 2,800 feet from the airport where it had taken off, it had covered a horizontal distance of 1,995 feet. What is the angle at which the plane rose from the ground to the nearest degree?

Method: SOHCAHTOA

Diagram:

Answer:  $45^\circ$



a  
2,800 ft

Explanation:

I chose this method because the triangle gives  
two side lengths, and am looking for an angle.  
I chose the inverse of cosine because I am given  
45°  
one side adjacent and one side the hypotenuse.

Calculations:

$$\cos^{-1}(a) = \frac{1,995}{2,800}$$

$$\cos^{-1}(a) = 0.7125$$

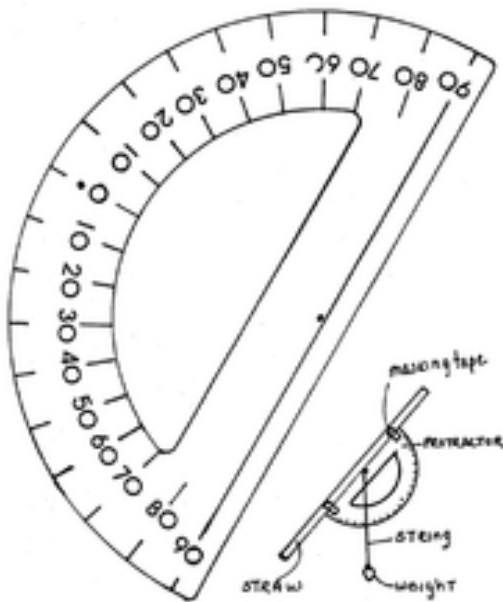
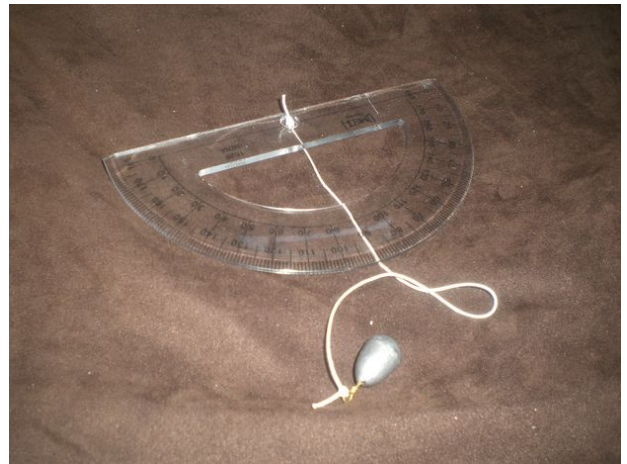
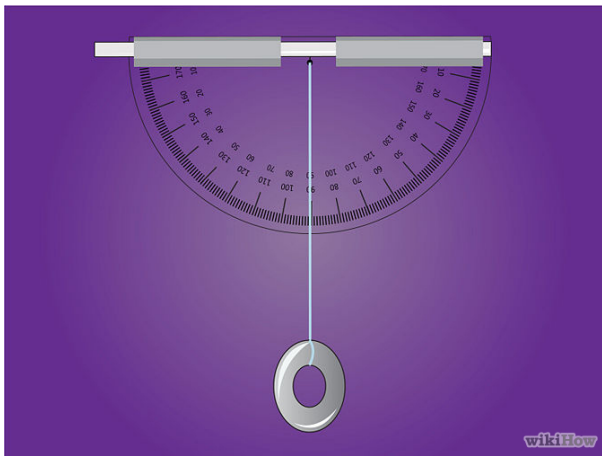
$$a = 44.561312 \approx$$

Partner Name: Susie Q

Which questions were modified? None

**Student Benchmark**

**Possible Hypsometer Constructions**



Photos Courtesy of:

[Untitled computer drawing of clinometer]. Retrieved July 16, 2014, from:  
<http://www.wikihow.com/Make-a-Clinometer>

Spaceman Spiff (unknown). (Year unknown). [Untitled photograph of hypsometer],  
 Retrieved July 16, 2014, from <http://www.instructables.com/id/How-to-make-a-tool-to-measure-angles/>

David C. Housel and Doreen K.M. Housel (unknown). (2011). [Untitled drawing of protractor and setup], Retrieved July 16<sup>th</sup>, 2014, from  
<http://wikieducator.org/File:P197.png>

## Student Benchmark

### *Real World Application Worksheet*

Teacher: Hoffman

Class: Geometry

Student A: Name: Mark W.

Height: 5'8" ft.

Student B: Name: Susie Q.

Height: 5'2" ft.

Student C: Name: Valerie S.

Height: 5'5" ft.

All questions require the use of your hypsometer. Take turns using the hypsometer, which will alternate the height used in calculations.

Be consistent with measurements of each object!

1) Height of a tree:

Student A or B or C (circle one)

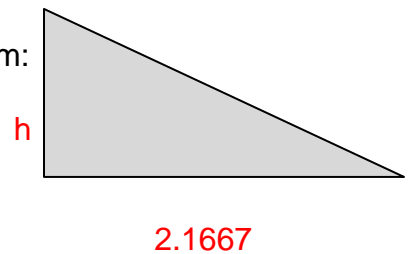
72°  
Student Height: 5'8 ft  
ft.

Distance from object to student: 2'2" ft. ≈ 2.1667 ft.

Angle Measure: 72°

Discovered Height from calculations: 6.6682 ft ≈ 6'6"

Diagram:



Calculations:

$$\begin{aligned}\tan(72^\circ) &= h / 2.1667 \\ 3.0776 &= h / 2.1667 \\ 3.0776 * 2.1667 &= h \\ h &= 6.6682 \text{ ft}\end{aligned}$$

**ANSWER:** The height of the tree is 12'2" ft

Explain how you came to this answer (explain how you set up your diagram and calculated the answer).

Every diagram is set up the same way. The angle measure was found by looking at the top of the object through the hypsometer. The bottom side of the triangle is the distance from the student to the object. We are looking for the height of the object from eye level. Thus, all calculations use the tangent function using adjacent and opposite sides.

Each problem calculates the tangent of the angle, and then solves for the missing height. After, the height is added to the student to find the actual distance from ground to top.

2) Height of the flagpole:

Student A or B or C (circle one)

$87^\circ$

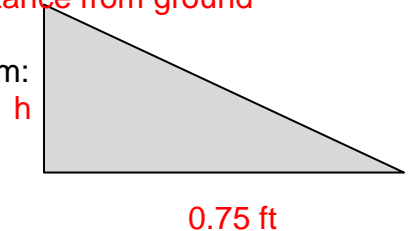
Student Height: 5'5" ft.

Distance from object to student: 9" = 0.75 ft.

Angle Measure:  $87^\circ$

Discovered Height from calculations: 14.2108 ft.  $\approx$  14'3"

Diagram:



Calculations:

$$\begin{aligned}\tan(87^\circ) &= h / 0.75 \\ 19.0811 &= h / 0.75 \\ 19.0811 * 0.75 &= h \\ h &= 14.2108 \text{ ft.}\end{aligned}$$

**ANSWER:** The height of the flagpole is 19'8" ft.

Explain how you came to this answer (explain how you set up your diagram and calculated the answer).



3) Height of the school:

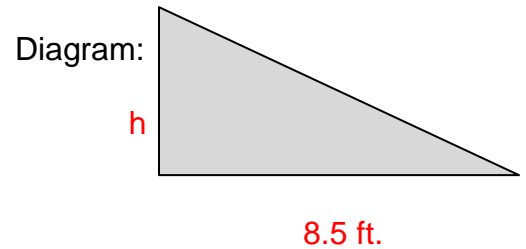
Student A or B or C (circle one)

$68^\circ$   
Student Height: 5'5" ft.

Distance from object to student: 8'6" ft = 8.5 ft.

Angle Measure: 68°

Discovered Height from calculations: 21.0384  $\approx$  ft 21'1" ft.



Calculations:

$$\begin{aligned}\tan(68^\circ) &= h / 8.5 \\ 2.4751 &= h / 8.5 \\ 2.4751 * 8.5 &= h \\ h &= 21.0384 \text{ ft.}\end{aligned}$$

**ANSWER:** The height of the school is 26'6" ft.

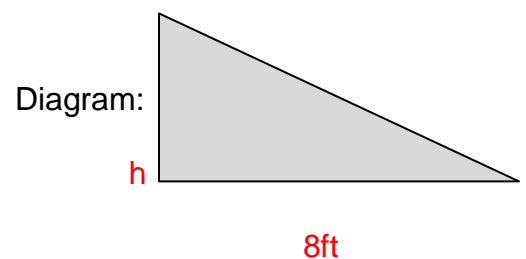
Explain how you came to this answer (explain how you set up your diagram and calculated the answer).

4) Height of the basketball hoop:

Student A or B or C (circle one)  
 $30^\circ$

Student Height: 5'2" ft.

Distance from object to student: 8ft



Angle Measure: 30°

Discovered Height from calculations: 4.6184 ft  $\approx$  4'8" ft

Calculations:

$$\begin{aligned}\tan(30^\circ) &= h / 8 \\ 0.5773 &= h / 8 \\ 0.5773 * 8 &= h \\ h &= 4.6184 \text{ ft.}\end{aligned}$$

**ANSWER**: The height of the basketball hoop is 10' ft.

Explain how you came to this answer (explain how you set up your diagram and calculated the answer).

5) Height of the gymnasium:

Student A or B or C (circle one)

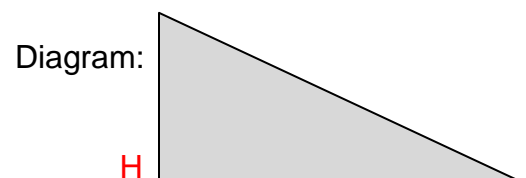
79°

Student Height: 5'8 ft.  
4.8333 ft

Distance from object to student: 4'10" ft.  $\approx$  4.8333 ft.

Angle Measure: 79°

Discovered Height from calculations: 24.8654 ft.  $\approx$  24'10" ft.



Calculations:

$$\begin{aligned}\tan(79^\circ) &= h / 4.8333 \\ 5.1446 &= h / 4.8333\end{aligned}$$

$$5.1446 * 4.8333 = h$$
$$h = 24.8654 \text{ ft.}$$

**ANSWER:** The height of the gymnasium is 30'6" ft.

Explain how you came to this answer (explain how you set up your diagram and calculated the answer).