WAMC Lab Template

Math Concept(s): Indirect Measurement, Similar Triangles
Source / Text: CORD Geometry
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Attach the following documents:

- Lab Instructions
- Student Handout(s)
- Rubric and/or Assessment Tool

Short Description (Be sure to include where in your instruction this lab takes place):

Students will use indirect measurement to calculate the height of a flagpole or some other tall object using a mirror and a tape measure. Students will measure side lengths of two similar triangles, calculate the ratio of the corresponding sides, and use this ratio to calculate the height of the flagpole. This lesson will follow a lesson where students are introduced to the concept of similar triangles.

Lab Plan

Lab Title: Measuring the height of a flagpole

Prerequisite skills:

- Understanding of similar triangles
- Measurement with a tape measure

Lab objective: Students can use indirect measurement to find the height of a tall object.

Standards: *(Note SPECIFIC relationship to Science, Technology, and/or Engineering)*

Mathematics K–12 Learning Standards:

- G-SRT5: Use congruence and similarity criteria for triangles to solve problems and to prove relationships in geometric figures.

Standards for Mathematical Practice:

- Makes sense of problems and persevere in solving them
- Reason abstractly and quantitatively
- Use appropriate tools strategically
- Attend to precision

K-12 Learning Standards-ELA (Reading, Writing, Speaking & Listening):

- RST.9-10.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9-10.4 Determine meaning of symbols, key terms, or other domain specific words and phrases as they are used in specific technical context

- RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form and translate information expressed verbally or mathematically into words.
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- SL.9-10.4 Present information, findings, and supportive evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.
- L 9-10.6 Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

K-12 Science Standards

- HS-PS1-3 Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

Technology

- 1.2.1 Communicate and collaborate to learn with others.

Engineering

- HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Leadership/21st Century Skills:

21st Century Interdisciplinary themes (Check those that apply to the above activity.)

☐ Global Awareness ☐ Financial/Economic/Business/Entrepreneurial Literacy ☐ Civic Literacy
☐ Health/Safety Literacy ☐ Environmental Literacy

21st Century Skills (Check those that students will demonstrate in the above activity.)

LEARNING AND INNOVATION

Creativity and Innovation
☐ Think Creatively
☐ Work Creatively with Others
☒ Implement Innovations

Critical Thinking and Problem Solving
☐ Reason Effectively
☐ Use Systems Thinking
☐ Make Judgments and Decisions
☒ Solve Problems

Communication and Collaboration
☐ Communicate Clearly
☒ Collaborate with Others

INFORMATION, MEDIA & TECHNOLOGY SKILLS

Information Literacy
☒ Access and Evaluate Information
☒ Use and manage Information

Media Literacy
☐ Analyze Media
☐ Create Media Products

Information, Communications and Technology (ICT Literacy)
☐ Apply Technology Effectively

LIFE & CAREER SKILLS

Flexibility and Adaptability
☐ Adapt to Change
☐ Be Flexible

Initiative and Self-Direction
☐ Manage Goals and Time
☐ Work Independently
☐ Be Self-Directed Learners

Social and Cross-Cultural
☒ Interact Effectively with Others
☒ Work Effectively in Diverse Teams

Productivity and Accountability
☐ Manage Projects
☒ Produce Results

Leadership and Responsibility
☒ Guide and Lead Others
☒ Be Responsible to Others

Teacher Preparation: (What materials and set-up are required for this lab?)

Materials

- Each lab team (of 3-4 students) needs the following:
  - One tape measure (at least 25 ft.)
  - One mirror – Approximately 5x5 inches (shower mirrors or automobile mirrors work well)
  - One clipboard or writing surface

Set-Up Required:

- Identify 3-5 tall objects for students to measure

Lab Organization Strategies:

Leadership (Connect to 21st Century Skills selected):

- Lab teams of 3-4 students will be formed to complete the task. Each student will be assigned a specific role. One person on the lab team will be designated the team leader. It will be their responsibility to guide and lead others by ensuring the correct measurements are taken accurately.
- Other roles include someone to take measurements, someone to record measurements, and someone to stand and look for the top of the flag pole in the mirror. Each one of these roles is critical to the success of the project, requiring each student to be responsible to others.

Cooperative Learning:

- The process of taking measurements cannot easily be done alone. Students need to collaborate with others in their group to be successful with this project. Specific roles will be assigned to students ahead of time.

Expectations:

- Students will use the measurements they've taken and apply their knowledge of similar triangles to calculate the height of the flagpole.
- Students will confirm their calculations produced reasonable results by comparing their calculated results with their estimated results.
- Students will suggest ways of modifying the lab procedures to produce more accurate results. If the calculated results are not consistent with their estimated results, this step should include an explanation about why the results are different.

Timeline:

- All students will complete the data collection within a 50-minute class period.
- Most students will complete the calculations and answer all the lab prompts by the end of the class period. Students needing additional time will be given until the next day to answer the prompts.

Post Lab Follow-Up/Conclusions:

Discuss real world application of learning from lab

- It is often not practical to measure the height of tall objects. Here are a few specific examples of why measuring the height of something might be important:

- When replacing the rope of a flagpole, the height is needed to determine the length of the rope.
- When cutting down a tree, the height of the tree is important to ensure that the tree doesn't damage buildings or other objects as it falls.
- Near an airport, it would be important to know that power poles, trees, or other tall objects won't interfere with a flight path during takeoff and landing.

Career Applications

- Surveying
- Construction
- Tree Service

Optional or Extension Activities

- Try different mirror placements (either closer or farther away from the flagpole) and compare results.
- Try different observers (of varying heights) and compare results.
- The measurements could be used to calculate the measures of the angles in the similar triangles using the inverse trigonometric functions.

Indirect Measurement Lab Assessment Criteria (50 points total)

Item	Points Possible	Grading
Teamwork	20 points	This score is primarily based on observations made by the teacher during the lab. Have a class roster on a clipboard or some other means to track when students are not engaged. This score may also be influenced by responses to Lab Prompt #5 by other members of the lab team. • 20 points: The student was consistently engaged and fulfilling their assigned lab role. • 15 points: There were 2 incidents where the student was not engaged and needed to be reminded of the task at hand by either the teacher or by other students in the lab team (give one warning deducting points). • 10 points: There were 3 incidents where the student was not engaged and needed to be reminded of the task at hand by either the teacher or by other students in the lab team (the student is given one warning before points are deducted) • 5 points: The student was seldom engaged, required frequent reminders to stay focused on the task at hand, and contributed minimally to the team effort. Some of the specific tasks assigned to the student needed to be completed by other students in the lab group. • 0 points: The student was never engaged. The tasks assigned to the student were either left incomplete or needed to be completed by others in their lab group.
Lab Procedures / Lab Data	5 points	Give one point for each of the following: • Writing down the estimated height in part B of the Lab Procedures • Providing a description, including the location of the object being measured • The distance from the base of the object to the mirror • The distance from the base of the mirror to the feet of the observer • The height of the observer If units of measurement are omitted from two or more of the above items, deduct two points.
Lab Prompts	25 points	Prompt #1 (5 points): • Correct responses include: $\frac{b}{a}=\frac{p}{h}$, $\frac{a}{b}=\frac{h}{p}$, $\frac{b}{p}=\frac{a}{h}$, or $\frac{p}{b}=\frac{h}{a}$. Either of the first pair proportions are the preferred response

		for this lab since the ratios represent corresponding sides of the similar triangles. The second pair of proportions are also true and should be given full credit since they represent either tangent or cotangent of the corresponding angles at the mirror. Prompt #2 (5 points): • Answers will vary, but the result should be $h = \frac{ap}{b}$ using the values the lab team measured for a, b, and p. • Partial credit may be given if work is shown. • Deduct one point if no units are provided in the final answer. Prompts #3-5 (5 points each): • Answers will vary. Give full credit if the student provided a well-reasoned response. If there are flaws in the reasoning, give partial credit based on effort demonstrated. The response to prompt #5 may be used to influence the teamwork score for other members of the lab team.

Name_____ Date_____

Indirect Measurement Lab

Description

In this lab, we will use indirect measurement to calculate the height of a flagpole or some other tall object which cannot easily be measured directly.

Lab Teams

Form teams of 3-4 students and assign one person to each of the roles listed below. Record the name of the person in each role.

Role	Description	Name
Team Leader	• Ensures lab procedures are followed and that the correct measurements are taken accurately • Assumes the role of *recorder* for lab teams of three students	
Recorder	• Records all lab data on the data sheet • Assists with the measurement process	
Measurer	• Takes the required measurements using the tape measure and reports them to the recorder	
Observer	• Stands away from the object until they can see the top of the object in the mirror (this is the person pictured in the diagram)	

Lab Procedure

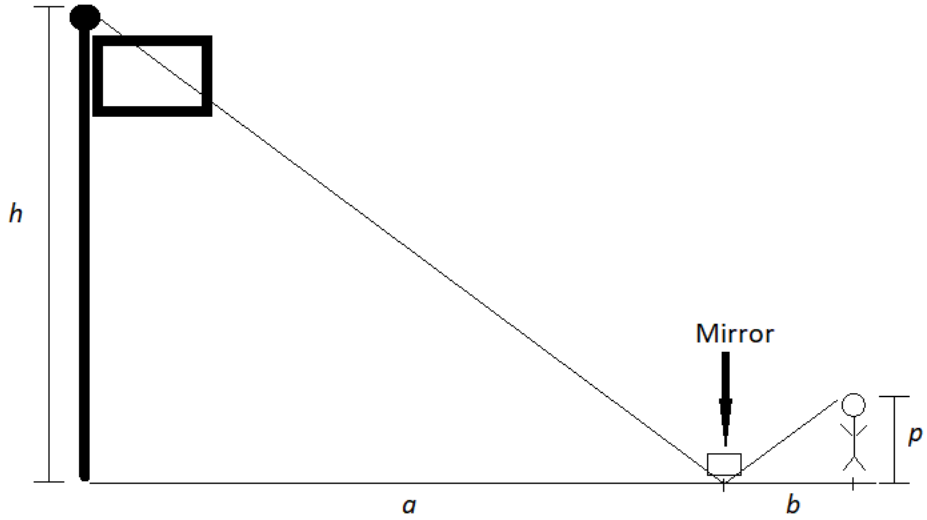
A. Identify the object to measure and record the description and location of the object.
B. Estimate the height of the object and write it down in the space provided below.

Estimated Height_____

C. Place the mirror on the ground several feet away from the flagpole.
D. Have the observer stand on the other side of the mirror until they can see the top of the flagpole in the mirror. If needed, adjust the position of the mirror (see diagram).
E. Measure and record the distance from the base of the object to the mirror (a in the diagram).
F. Measure and record the distance from the mirror to the feet of the observer (b in the diagram).
G. Measure and record the height of the observer (p in the diagram).

Name_____ Date_____

Lab Data



Description	Data
Object Measured (description and location)	
Distance from the base of the object to the mirror (a in the diagram)	
Distance from the mirror to the observer's feet (b in the diagram)	
Height of the observer (p in the diagram)	

Name_____ Date_____

Lab Prompts

1. Using the variables a, b, p, and h, setup a proportion for the sides of the two similar triangles.	2. Use your lab data to substitute the values of a, b, and p in your proportion to solve for h, the height of the object.
3. How does the height you calculated in #2 compare to the height you estimated in step B of the lab procedures? If the calculated results are different from your estimated results, provide an explanation as to why.	
4. If you repeated this experiment, are there changes to lab procedures you could implement to improve the accuracy of your results?	
5. Describe your role in your lab group and how well your lab group functioned as a team.	