Measuring Altitude with Math and Invention

Duration	Age	Difficulty
45-60 min	13-14	Hard

#creativity#mathematics #invention #measuring

DESCRIPTION

This immersive STEAM activity transforms students into mathematicians, engineers, storytellers, and inclusive innovators. Learners will build a hands-on inclinometer to measure angles and use trigonometry to calculate the height of tall structures. Through collaborative design, historical context, and artistic reinterpretation, students will explore mathematics as a cultural and creative language. The experience concludes with a multimedia presentation combining graphs, narratives, and visual art, shared via digital platforms.

KEY COMPETENCES (EU)

- Mathematical Competence
- Digital Competence
- Learning to learn
- Social and civic competence
- Cultural awareness and expression
- Entrepreneurship competence

ACTIVITY OBJECTIVES

- **Apply trigonometric principles (tan(θ) = height / distance) in real-world measurement.**
- **Design, test, refine, and document an inclinometer prototype using engineering cycles.**
- **Contrast manual and digital angle measurements (e.g., app-based inclinometer tools).**
- **Create data visualizations (graphs, tables) and explore simulation tools.**
- **Present findings through infographics, posters, or narrated digital slideshows.**
- **Incorporate traditional knowledge, gender-inclusive role models, and global STEAM culture.**
- **Engage in peer critique using inclusive design and artistic storytelling principles.**

Funded by the European Union

MATERIALS

Scissors

Pencils and notebooks

Calculator

- 🟠 Provided by students
- 🩷 Provided by the teacher/institution
- 🟢 Downloadable Elements

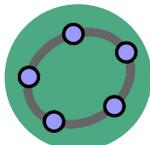**Protractors**

Straws

Tape

String

(Optional) access to google maps

Inclinometer construction guide

Trigonometry simulation links (GeoGebra or Desmos)

Poster or Multimedia storytelling templates (Canva, Google Slides, etc.)

Smartphone / computer (optional, for documentation and app comparison)

Cultural iconography pack

Measurement data table template

Role cards

PREVIOUS PREPARATION

- Teacher prints inclinometer guides, team role cards, cultural iconography sheets, and poster templates.
- Assign teams of 4 with rotating roles to ensure equity and to promote technical leadership by girls and underrepresented students.
- Show a video: "How Ancient People Measured with Triangles".
- Organize a short pre-activity discussion: "Which stereotypes exist around math and gender?" Debrief after reflection.
- Set Up an outdoor measurement zone or project images of tall objects if outdoor access is limited.

CONTEXTUALIZATION AND ADAPTATION

"Have you ever wondered how tall that flagpole is?" Humans have been measuring heights for centuries, from ancient pyramids to modern satellites. But you can estimate heights using only a triangle, your brain, and a bit of math!

Why does this matters:

- Civil engineers, architects, and conservationists use these techniques daily.
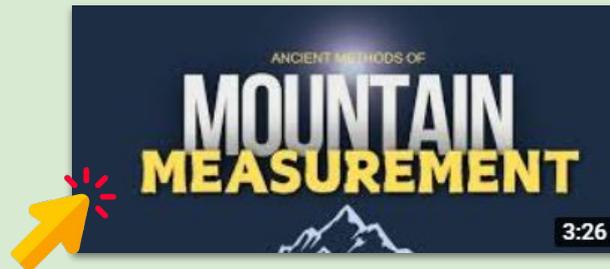- Cultures across time: Egyptians, Greeks, Chinese, measured the world with triangles.

$= \dfrac{height}{distance}$
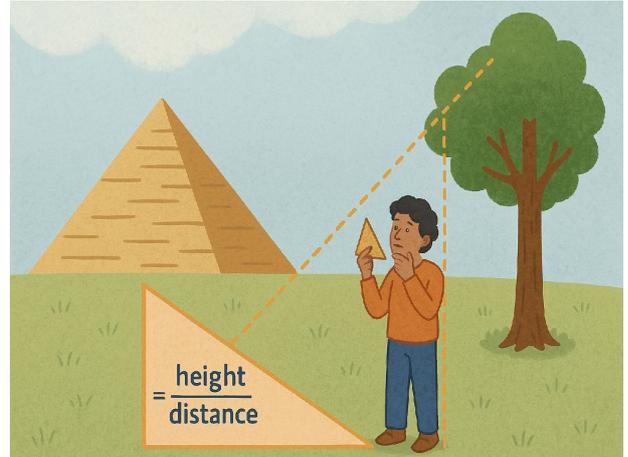
Classroom activity 💡

Historical hook: Learn from Hypatia and other early mathematicians. Your team will reimagine how ancient inventors might have used or built similar tools, then prototype your own!

Watch video 🎥 - **"Ancient Secrets: Measuring Mountains Before GPS and Satellites!"**
- ★ *Link: https://www.youtube.com/watch?v=JtvCBjMlRAc*

ANCIENT METHODS OF
MOUNTAIN MEASUREMENT
3:26

Classroom activity 💡 - **Pre-measurement Estimation Game**

Guess the height of tall objects, then measure and reflect: "Were we right? Why or why not?"

Note for the teacher 📝

- Ensure teams rotate leadership and technical roles.
- Choose visible, safe targets for measurement.
- Use printed diagrams or photos as alternatives if outdoor access is limited.

ACTIVITY

**Step 1: Warm-Up – design, build & Test your inclinometer**

Construct the inclinometer and test it on a known-height object.

How to Build Your Inclinometer (Step-by-step) (you also have the complementary document "inclinometer construction guide" in case further details are needed):

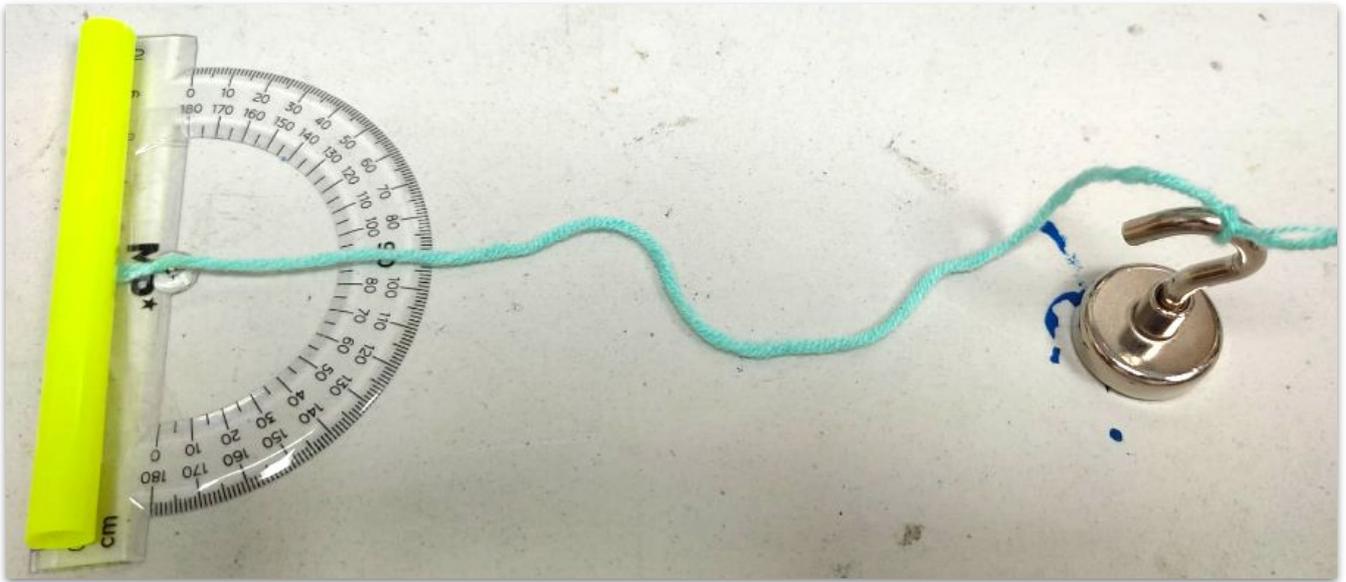1. Cut a straw in half and tape it securely along the straight edge of a protractor.
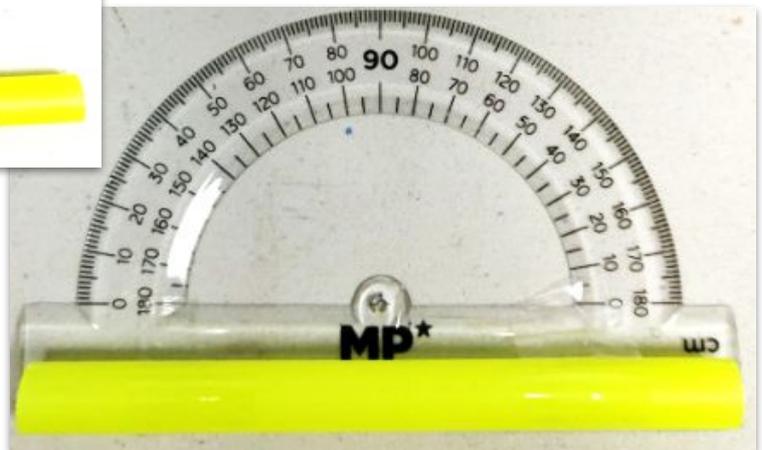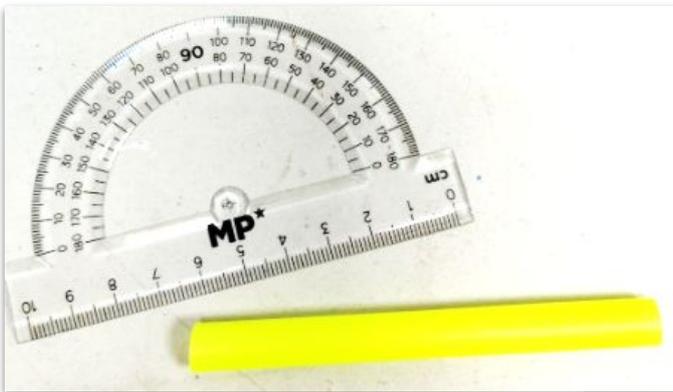
2. Tie a string through the center hole of the protractor (the 90° mark).
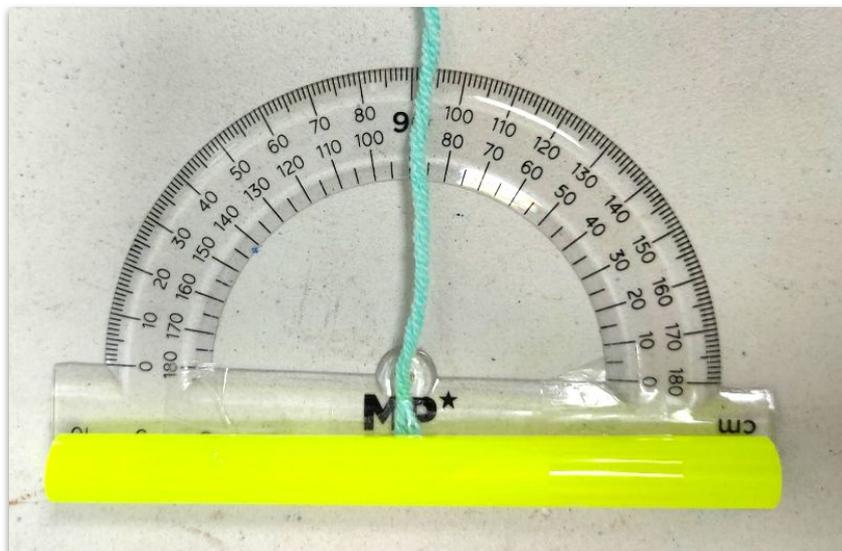
ACTIVITY

3.   Attach a small washer or nut to the end of the string so it hangs freely as a plumb line. In this example we used a weight tied to the string, but it can be anything, for example a rubber or a pencil sharpener


Step 2: Measure, record and compare

1.   Choose a target that you know how far away is it, for example, select a tree that is 15 meters away, or a building 100m away and that you **want to know it's height**. Something interesting to add in this part is that, if we are able to see a far mountain or tall building, we may know it's distance by using the **Google Map distance trace**.

We will explain how to use it using the 3D visuals as it's more fun to work with this way, and also is easier to take awareness of where we are standing physically: https://www.google.com/maps
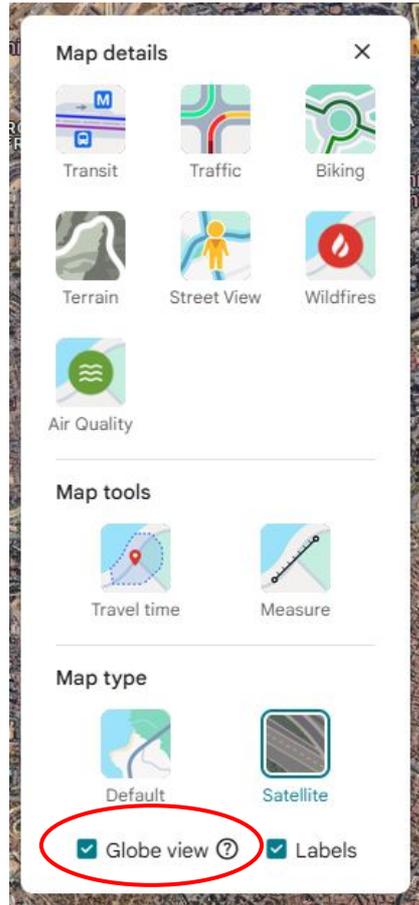
First, select the "terrain" option in the bottom left corner, then pinch in where it says more
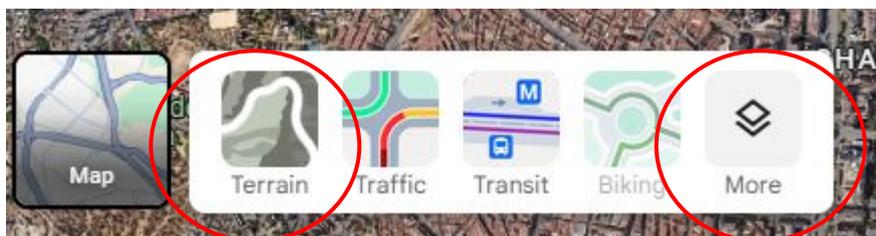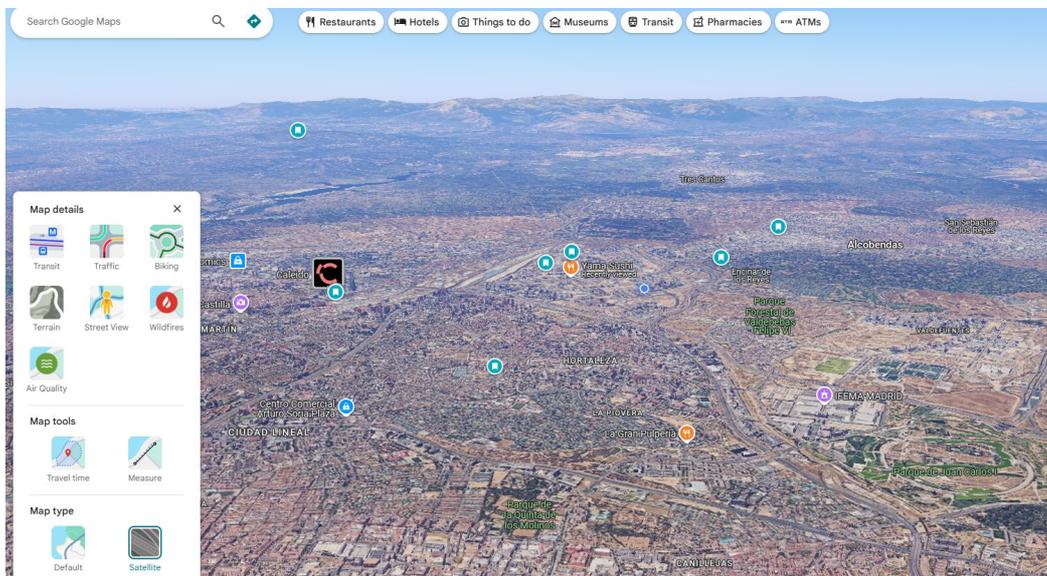
ACTIVITY

Then, select "globe view":

Now you may be able to press at the same time: **Ctrl + left click** and move the image in different directions, as shown in the picture below for example:
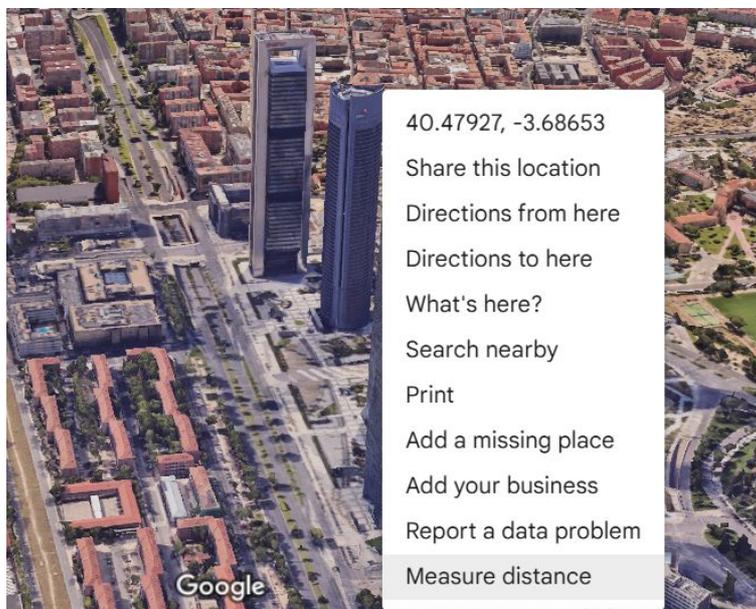
ACTIVITY

We will now show an example of how to measure the distance between us and a tall building/mountain that we are able to see from the distance and want to know it's height.
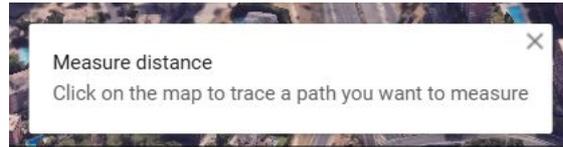

Now you must click right on your mouse on the building that you need the distance to, and select "measure distance":
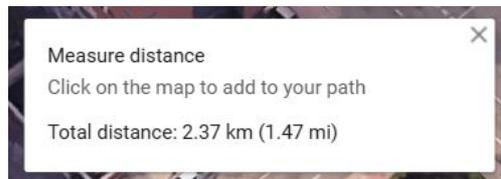
ACTIVITY

This massage will appear:

And now select your location. Finally the total distance between your position and the objects whom's height you want to measure will appear at the bottom:


As this measurement depends a lot on where you are choosing the exact locations of the sites, we recommend doing this proces 3-4 times and then calculate the average between those measurements.

Step 2: Measure, Record and Compare

Now we will use our inclinometer to determine the **angle of elevation from our viewpoint** to the top of the building or object.

To do this, stand upright and look through the straw at the top of the object. Then, **record the angle indicated by the hanging string.**
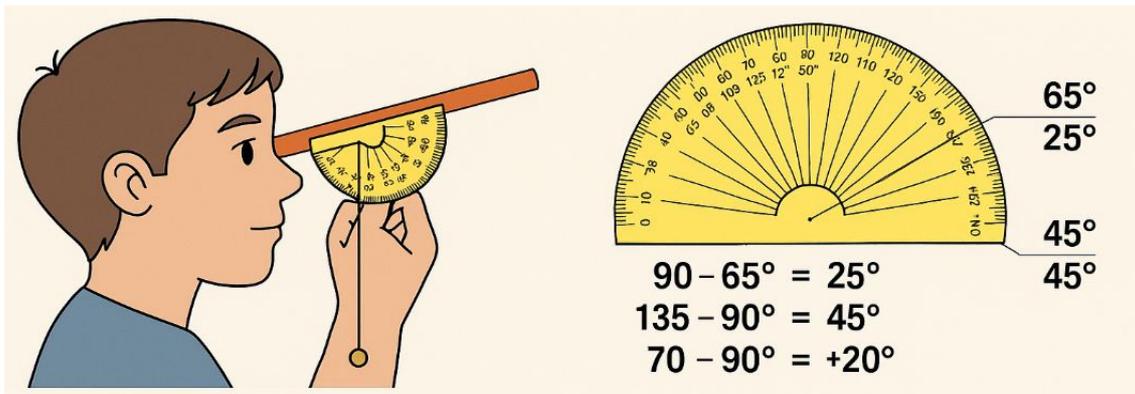
Use the protractor to measure the angle. Hold the inclinometer steady until the hanging string stops swinging. Then, find the angle by subtracting the point where the string crosses the edge from the midpoint of the protractor (90°). For example, if the string points to 65°, the angle of elevation is 90 − 65 = 25°. If it points to 135°, the angle is 135 − 90 = 45°.

The angle of elevation will always be less than 90°, since 90° represents a vertical line pointing straight up.

The result should always be a positive number. If your subtraction gives a negative value, simply remove the minus sign. For example, if you calculate 70 − 90 = -20°, the correct elevation angle is +20°.

Step 2: Measure, record and compare

Next, we will calculate the height of the selected object using trigonometry. If we recall some of our math knowledge, we know that in a right triangle, there are specific relationships between its sides and angles that allow us to calculate missing values.

To help us remember, here is a right triangle with its legs labeled, and one marked angle, the one we are interested in:
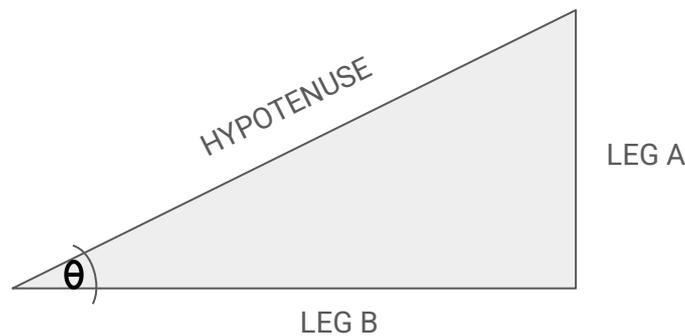
In this case, theta (θ) is the angle we measured using our inclinometer. Leg B represents the distance from us to the base of the object, and Leg A is the height of the object.

Based on what we know from trigonometry, we can use the following expression:

tan(θ) = opposite / adjacent, which in our case becomes:

tan(θ) = Leg A / Leg B

Now, if we replace the terms "Leg A" and "Leg B" with the actual values they represent:
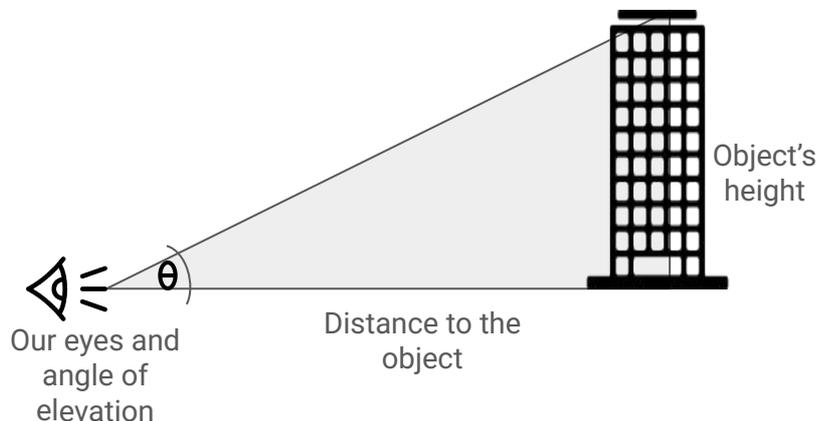
ACTIVITY

So now we may change the names on our mathematical expression for:

tan(θ) = Object's height / Distance to the object

We solve for the object's height and we got:

**Object's height = Distance to the object * tan(θ)**

Then, using this expression, you can calculate the height of your object. Record your results, and, if possible, look up the actual height of the object online. For example, well-known buildings or mountains likely have their measurements documented on the internet.

Step 3: Analyze & Create (Art + History)

Analyze your results, how can your results be better? more measurements? better estimations of distance? Think about this in groups.

To conclude this activity, it's important to highlight that trigonometry plays a significant role in architecture across various cultures. For example, many Mayan symbols and structures reflect the use of trigonometric principles.
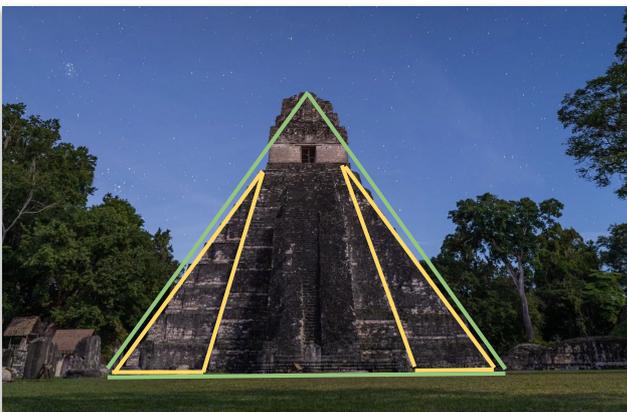
ACTIVITY

Now that you've built and used your inclinometer to measure the height of a real object using trigonometry, it's time to communicate your learning with the world!

Your team will create a poster or digital presentation (Canva, PowerPoint, handmade, etc.) that tells the story of your experiment and connects it with ancient wisdom and inclusive STEAM culture.

Explain Your Investigation

Briefly describe the object you measured.

Show your distance and angle data.

Present your final height calculation and what mathematical formulas you have used.

Include your inclinometer design (photo or drawing).

Connect with History

Investigate how one ancient culture (choose between Mayan, Egyptian, or Greek) used triangles to measure distances or build architectural structures.

Show how they may have used tools similar to your inclinometer or how they applied similar mathematical ideas.

Incorporate Artistic and Cultural Design

Add visual elements inspired by that culture (e.g., Mayan glyphs, Greek geometry, Egyptian papyrus).

Use them as decoration or as part of your data visuals. Use a minimum of 3 colors, 1 cultural symbol, and 1 visual structure (chart, map, or sketch) with labeled parts.

Promote Inclusive STEAM

Choose a gender-diverse figure in STEAM (past or present) related to math, engineering, or architecture.

Include a tribute: this can be a quote, a short bio, or an artistic drawing.

Reflect as a Team

Add a small paragraph or speech bubble per teammate reflecting on:

What was your role?

What stereotype did you challenge during the activity?

What did you learn from your mistakes or iterations?

CONCLUSION AND SHARING

- Host a classroom gallery or digital presentation session.
- How does accurate measurement help reduce material waste or environmental impact in construction?

REFLECTION PROMPTS:

- Which STEAM area did your team use the most? Why?
- How did your design reflect equity or inclusivity?
- What did your measurement say about your environment, team, and tools?
- How did ancient wisdom and modern tools complement each other?

EXTENSION IDEAS:

•Program a simple height calculator in Scratch.

•Invent a "STEAM role model trading card" based on someone your team researched.

•Redesign the activity as a family challenge using only household materials.

•Build a small exhibition: "Measuring the World Through Time" combining history, tools, and stories.

📣 **It's time to share your creation with the world!**

Take a photo or short video of your team's final poster or inclinometer in action and upload it using the official STEAMbrace hashtags:

#TriangleChallenge #STEAMbrace

Don't forget to take a photo of your experience and share it with us!

LinkedIn   Instagram   X

BIBLIOGRAPHY AND REFERENCES

- Trigonometry simulator: GeoGebra, Desmos, Women in STEM visual toolkit (She Can STEM, UNESCO)
- Inclusive learning design (CAST UDL Guidelines)
- Triangle Art + Architecture (Smithsonian Learning Lab)