

3D Educational Resources

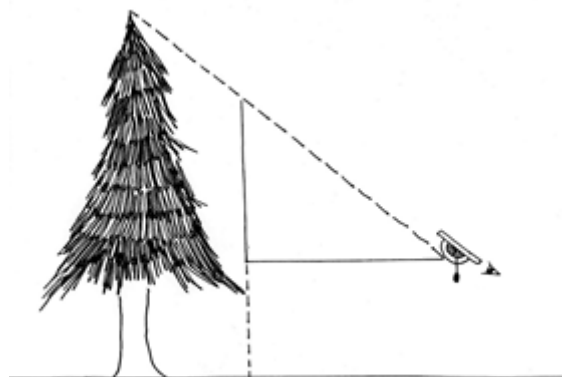
CLINOMETERS – HOW HIGH IS THAT? (ADVANCED METHOD)

Clinometers were used by early surveyors, explorers and scientists to quickly estimate the incline and height of any objects they encountered. While not as common these days, they are still a useful tool. Find out how you can use a clinometer to determine how tall something is in your everyday life!

ONTARIO CURRICULUM LINKS

Through this activity your students will learn about clinometers and use the principles of trigonometry (specifically the tangent function) to estimate the height of an object. This activity can be connected to multiple aspects of the Ontario school curriculum, our suggested links are:

- Grade 10: Mathematics: Academic and Applied (Trigonometry)



Grades

10 – 12

Age Range

14 – 17 years

MATERIALS

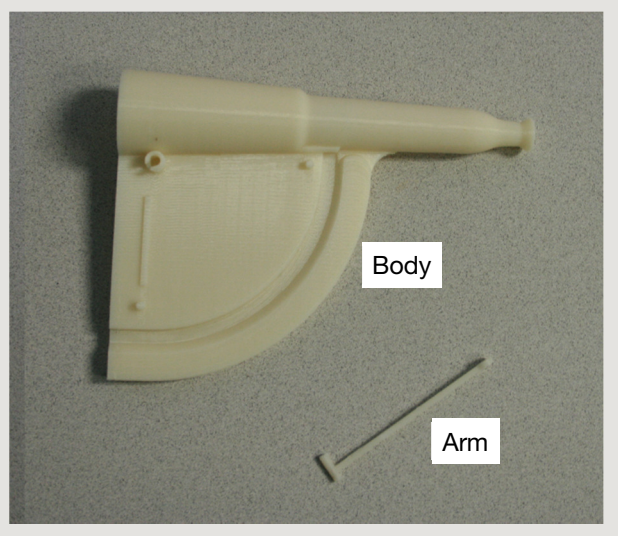
- | | |
|------------------|----------------------------------|
| 1 – Glue stick | 1 – 3D printout of clinometer |
| 1 – Tape measure | 1 – Printout of clinometer label |
| 1 – Calculator | |



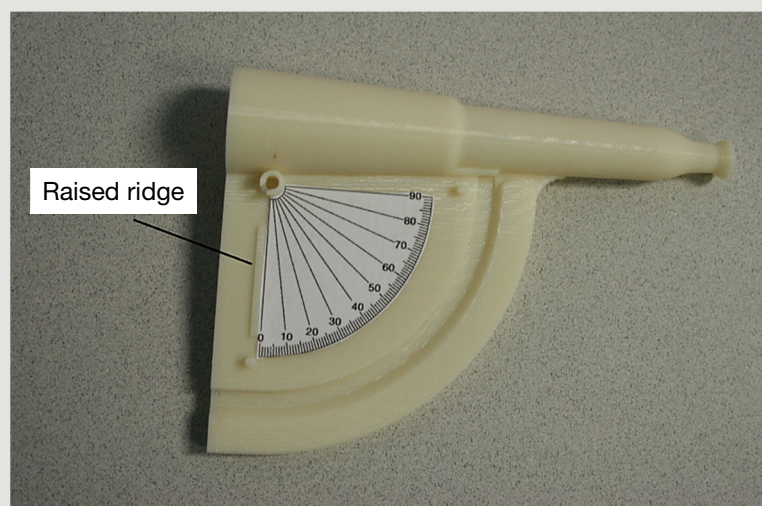
INSTRUCTIONS

Constructing the clinometer

1. The following naming convention will be used in these instructions:

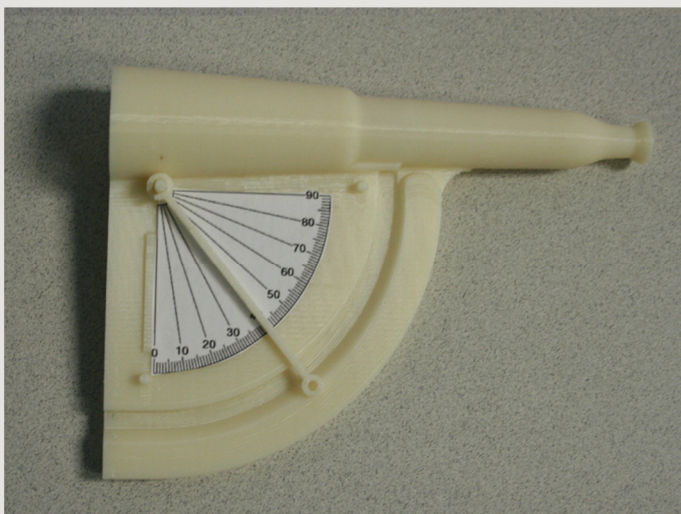


2. Paste the clinometer label on to the body of clinometer with the glue stick. Place the label so that the edge of the "0" line is flat against the raised ridge and the round cut-out portion at the top of the label is flush against the hole (see image below). This ensures that the measurements are accurate.

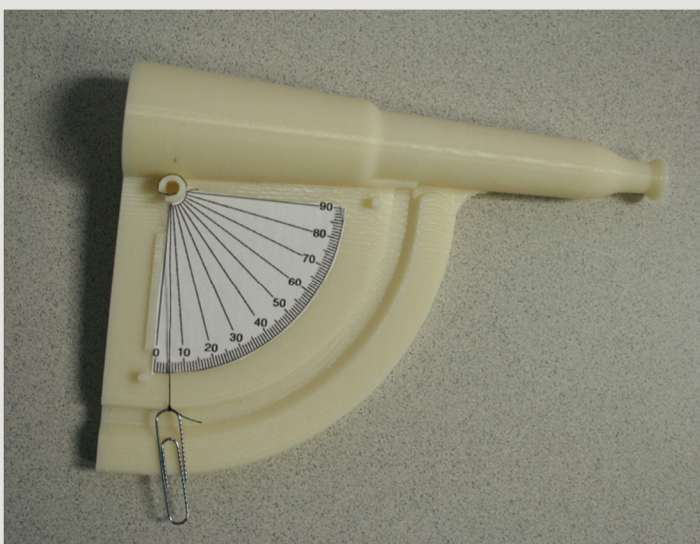




3. Insert the arm of the clinometer into the hole found on in the body of the clinometer. Make sure that the shorter end goes in first. If the arm does not move freely you might have put it in backwards.



Note: If you do not wish to use the arm (or if the arm breaks), an alternate way to do step 3 is to tie a piece of thread around the rim of the hole on the body of the clinometer and, on the other end of the thread, attach a weight (such as a paper clip or washer).

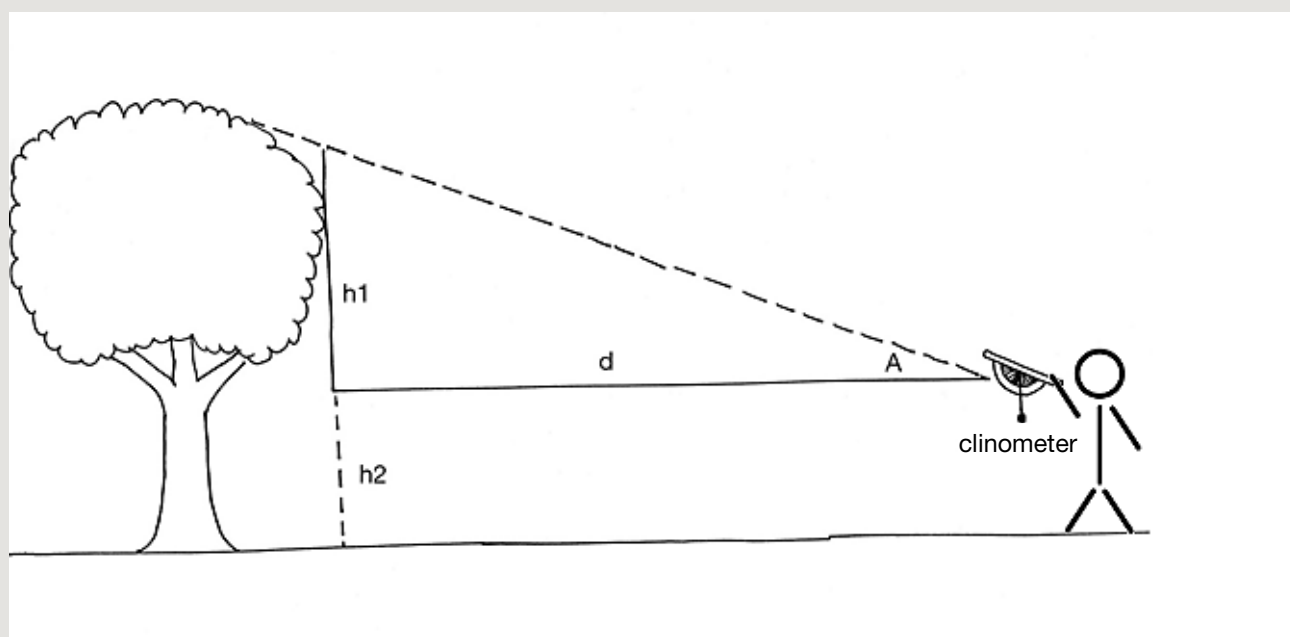




4. As you tilt the clinometer the arm of the clinometer will point down. The number that it points to represents the angle that the clinometer is tilted above the horizon. Try it out! Make sure to hold the clinometer in a way so that the arm does not drag along the surface of the main body.

Measuring height

1. Pick a nearby object that you wish to measure the height and stand a certain distance from that object.
2. Look through the clinometer so that the top of the object that you wish to measure the height of is in the centre of the view piece.



3. Record the angle that the arm of the clinometer indicates (A in the image above). If you're having problem reading the angle, hold the arm against the label once it stops moving.
4. Measure the distance between yourself and the object (d in the image above).
5. Determine the height of the object above the level of the clinometer (h1 in the image above), use the following equation:

$$\text{Height (h1)} = \text{Distance between person and object (d)} \times \tan(\text{angle A})$$

Can you explain why this equation works?



6. This height that you determined is not the actual height of the object. To get the actual height you need to add the distance from the ground to whatever level the clinometer was at when the measurement was made (h_2 in the image).

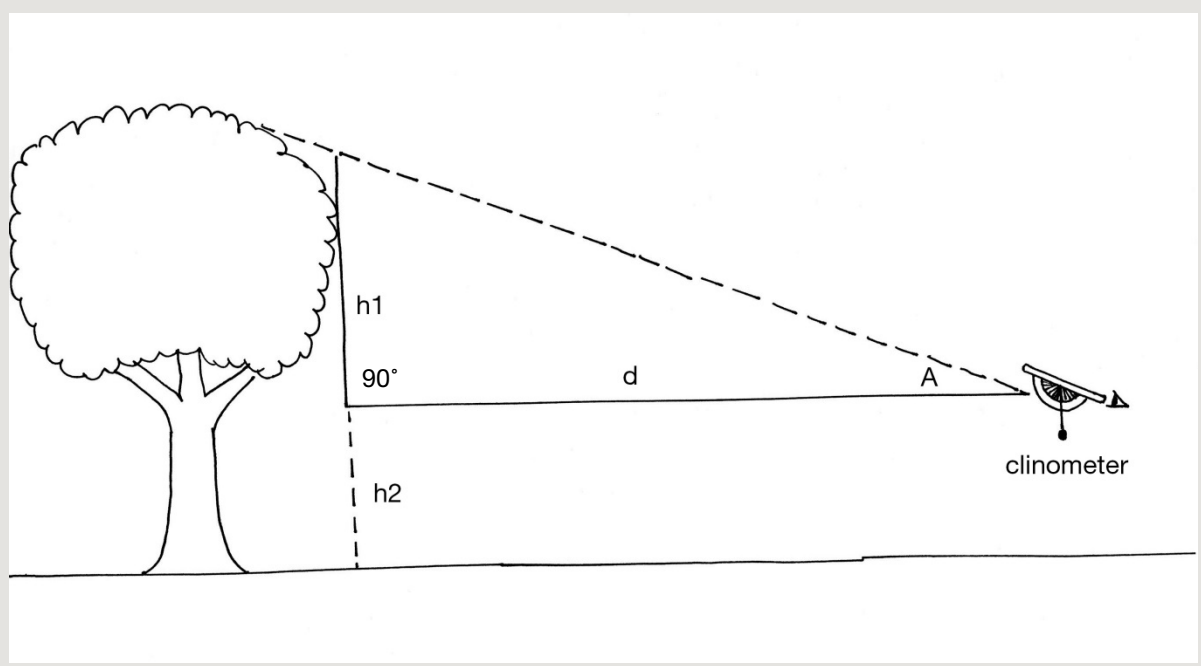
Try this! The original function of the clinometer from which the 3D model was scanned from was to measure the cloud base height (the height of the bottom of a cloud). You can still try this out. The only addition piece of equipment that you need is a very powerful light (like a handheld spotlight) and a second person.

Wait until evening and then have the second person stand beneath some clouds and shine the light straight up in the air. You should see a bright spot where the light is hitting the bottom of the cloud. Now use the previous instructions to determine the height of the bright spot. Because of how high the clouds are you probably need to be standing 100 m or so away from the second person.



SCIENTIFIC EXPLANATION

Trigonometry is the basis of how the clinometer works. When measuring the height of something (such as a tree) a right angle triangle is formed by the distance between the clinometer and the tree (d), the height of the tree above the clinometer (h1) and the diagonal line between the top of the tree and the clinometer (see diagram below).



In a right-angled triangle, the tangent of one of the non-90° angles is equal to the ratio of the length of the side of the triangle opposite to the angle to the length of the side of the triangle adjacent to the angle:

$$\tan(\text{angle}) = \text{Opposite Length} \div \text{Adjacent Length}$$

If we substitute the labels that we used in the diagram above, we have:

$$\tan(\text{angle } A) = h1 \div d$$



This can be rearranged to:

$$h_1 = d \times \tan(\text{angle } A)$$

We can measure d . The clinometer measures angle A . With these two variables known, h_1 can be calculated.

As indicated in the instructions, h_1 is not the actual height of the object, it is the distance between the level of the clinometer when it made its measurement and the top of the object. To get the actual height of the object, you'll need to add h_2 , the distance between the ground and the level of the clinometer.

Ingenium – Canada's Museums of Science and Innovation has more than 110 000 artifacts in its collection, including many ones related to clinometers. You can explore other objects in the collection at: ingeniumcanada.org/ingenium/collection-research/collection.php.