Mr. Young
MBF3C

Name: _____
Date: _____

TRIGONOMETRY ASSIGNMENT:

Estimating the Height of a Structure with a Clinometer in Virtual Reality

Background:

The clinometer is a tool used by plumbers, surveyors, miners, skiers, artillery gunners, sailors, foresters, and chiropractors to measure angles of elevation (and angles of depression) and to determine heights and slopes using gravity.

Purpose:

In this lab assignment you will work with a partner (or partners) to create and use a clinometer to estimate the heights of structures in a virtual, three-dimensional environment.

Learning Objective:

- To be able to calculate the height of a structure using trigonometric ratios
- To be able to use a clinometer
- To be able to reflect on the accuracy of a calculation and suggest improvements

Rubric:

	Level 1	Level 2	Level 3	Level 4
Thinking (5)	- shows little understanding or trigonometric ratios and the use of a clinometer	- shows partial understanding for trigonometric ratios and the use of a clinometer	- shows understanding for trigonometric ratios and the use of a clinometer	- shows deep understanding for trigonometric ratios and the use of a clinometer
Application (20) Measurements, Calculations & Conclusions (15) Clinometer (5)	- has difficulty in being able to independently: identify angles of elevation/depression, hypotenuse / opposite / adjacent sides of a right triangle, and calculate the height of the structure - Device is not attached	- is generally able to: identify angles of elevation/depression, hypotenuse / opposite / adjacent sides of a right triangle, and calculate the height of the structure - Device is not accurate, but attached	generally accurate when attempting to: identify angles of elevation/depression, hypotenuse / opposite / adjacent sides of a right triangle, and calculate the height of the structure, with few errors or omissions - Device is accurate, and attached	- very accurate when attempting to: identify angles of elevation/depression, hypotenuse / opposite / adjacent sides of a right triangle, and calculate the height of the structure, with no errors or omissions in - Device is accurate, and attached
Communication (15) Reflection (10) Diagram (5)	- unable to record and explain reasoning and procedures clearly and completely - diagrams are incomplete or incorrect and omit key information	- records and explains reasoning and procedures with partial clarity; may be incomplete - diagrams are partially complete and may contain errors or omissions	- records and explains reasoning and procedures clearly and completely - diagrams have few errors or omissions	- records and explains reasoning and procedures with precision and thoroughness - diagrams are neat, complete and have no errors

TOTAL: 40				

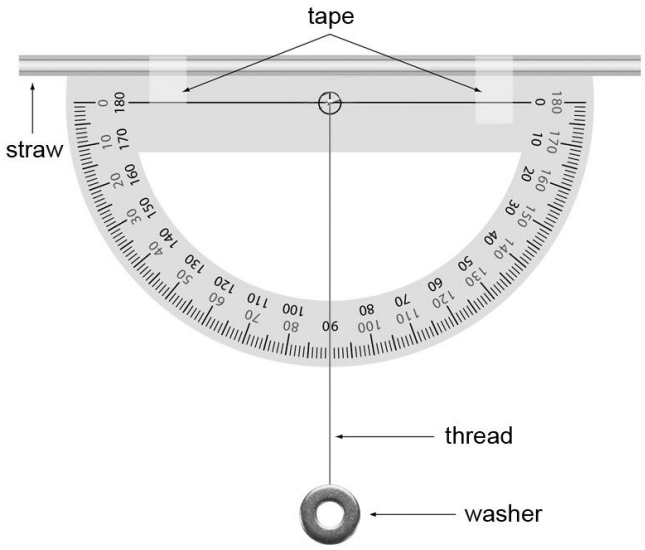
PART A: Building the Clinometer

Materials

- 1 cardboard index card
- 1 plastic protractor
- 1 plastic straw
- 1 15-cm length of thread
- 1 28-mm washer
- 1 metric ruler
- transparent packing tape
- scissors

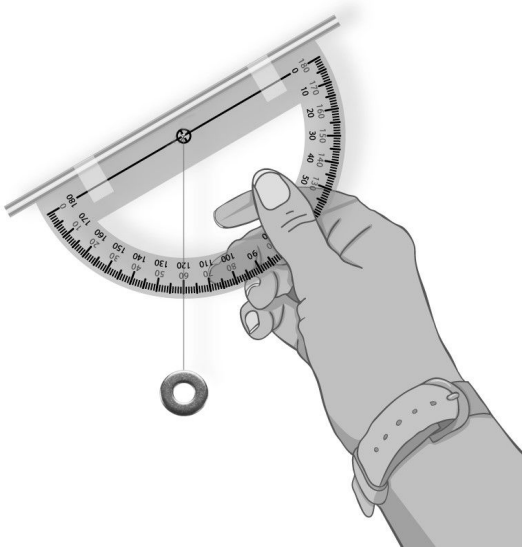
Assembly Instructions

An assembled clinometer is shown below. Use the illustration as a guide while following the steps outlined.



Step 1: Measure and mark a line 5mm in from the long end of the index card. Place the protractor on top of the index card so that this line and the baseline of the protractor overlap. Using the transparent packing tape, attach the protractor to the index card and cut away the excess cardboard to leave a rounded semi-circular shape.

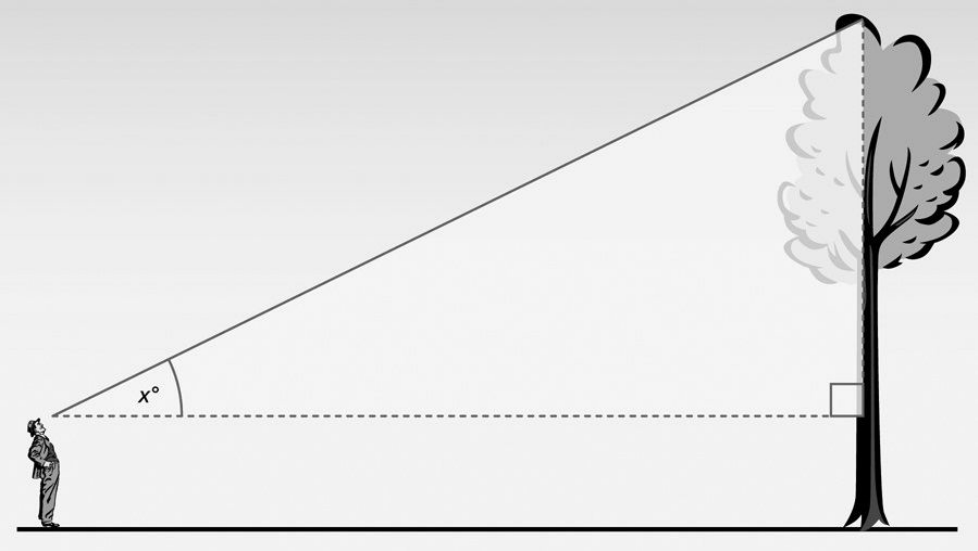
Step 2: Using the scissors, make a hole through the protractor and the index card at the origin of the protractor. Put one end of the thread through the hole and tie it. Tie the washer to the other end.



Step 3: Line up the middle of the straw with the origin of the protractor and tape it down so that the baseline of the protractor runs down the centre line of the straw.

Now you have your clinometer!

PART B: Analysis



1. **What angle on the clinometer does the string pass through when the straw is parallel to the ground?**

2. **When using the clinometer to look up, if the string passes through 60° then what would be the measure of angle *x* in the diagram above?**

3. **After calculating the measure of x in the diagram above, what parts of the triangle will you know (Hypotenuse, Opposite Side, Adjacent Side, Right Angle, Reference Angle)?**

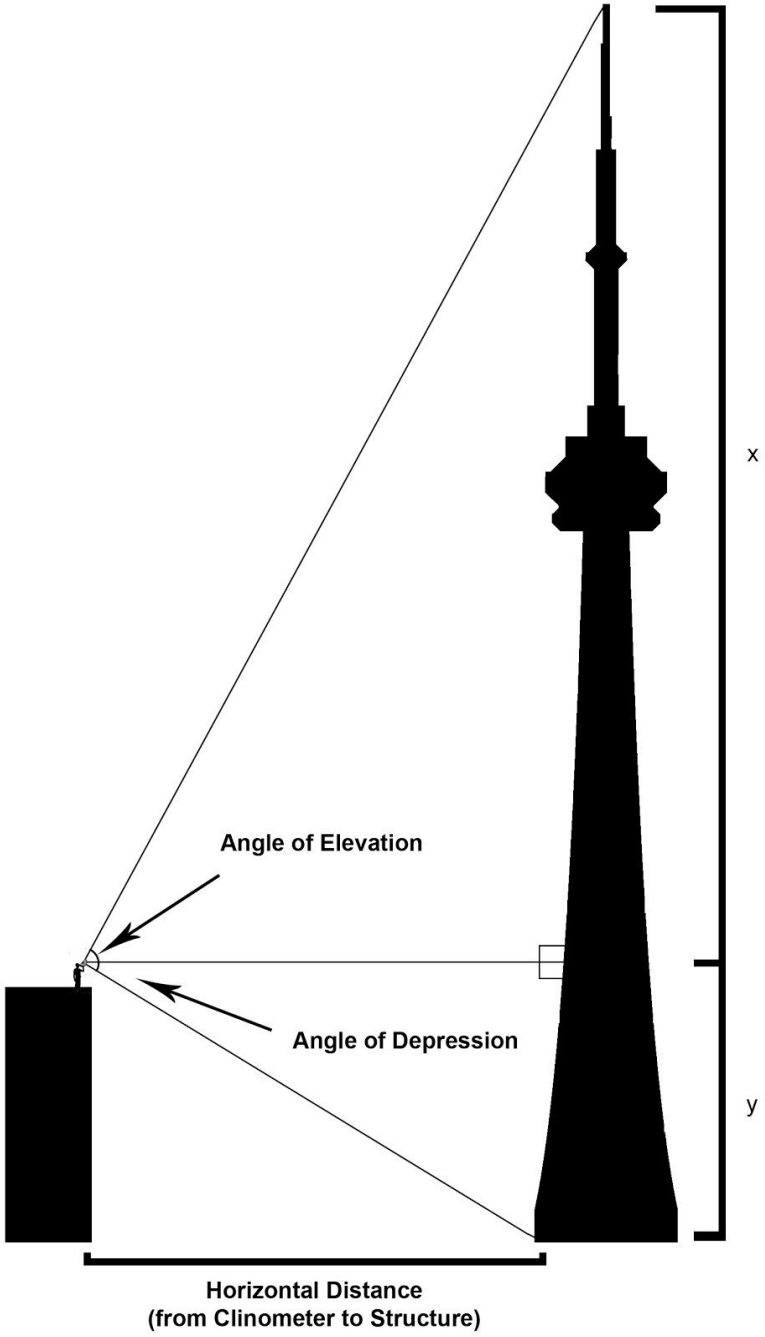
4. **What trigonometric ratio(s) would you need to use to solve for the height of the tree in the diagram above?**

5. **What other measurement do you need to know in order to determine the height of the tree in the diagram above?**

PART C: Application

Using your clinometer, some virtual reality equipment and Google Earth, you and your partner(s) will apply your knowledge of trigonometry to estimate the height of the tallest point of one of the following famous structures:

- One World Trade Centre
- Empire State Building
- Statue of Liberty
- Willis Tower (a.k.a. Sears Tower)
- Space Needle
- MGM Grand Hotel
- London Eye
- Elizabeth Tower (a.k.a. Big Ben)
- Eiffel Tower
- Cathedrale Notre-Dame de Paris
- Cattedrale di Santa Maria del Fiore
- Leaning Tower of Pisa



Once you have selected a structure, you and your partner(s) will have the opportunity to visit that structure in a virtual reality environment using Google Earth.

One partner will wear the VR equipment, while the other(s) will use the clinometer and a chromebook with Google Maps to record the appropriate measurements.

You will then draw a diagram and perform the necessary calculations to determine the height of your chosen structure, and answer questions about your findings.

The members of our group are:

_____

_____

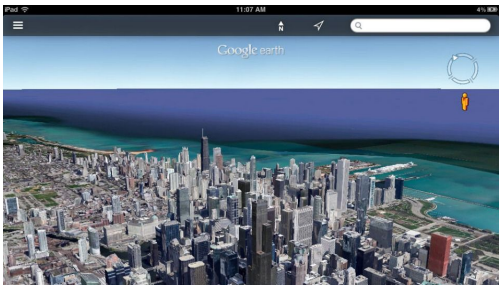
_____

… and we will be calculating the height of:

_____

Procedures

Step 1: Find a suitable place to view the top and the base of the structure. Note that the Google Earth environment does not allow you to stand directly on the ground. Therefore, to calculate the height of your structure, you will need to position yourself somewhere nearby and use the clinometer to calculate both the angle of depression and the angle of elevation.



Step 2: The person wearing the VR equipment should align their line of sight with the top of the structure, while the other group member(s) place the clinometer against that person's head and take necessary measurements to calculate the Angle of Elevation. Group members should then switch positions and calculate the Angle of Depression using the same method.

For a tutorial on how to do this, visit: https://youtu.be/rVNhDZOwVU8

Step 3:

Using a chromebook and Google Maps, calculate the approximate distance (in meters) between the place where you were standing and the base of the structure.

For a tutorial on how to do this, visit: https://youtu.be/kA-oNVdw2WM

Step 4: Now that you have the necessary information, draw a diagram similar to the one of the CN Tower on the previous page. There is a space provided for you on the next page, however, you may choose do this by hand on a separate sheet of paper, or create one using software. Be sure to include all known measurements and variables (h, x, y, etc.) for the heights you do not know but still need to calculate.

Step 5: Determine which trigonometric ratio to use (Sine, Cosine, or Tangent), input your measurements and perform the necessary calculations to determine the height of your structure. Again, you may use the space provided on the next page, or submit your calculations on another page. Be sure to show ALL of your steps.

$$\text{Sine: } \sin(x) = \frac{Opposite}{Hypotenuse}$$

$$\text{Cosine: } \cos(x) = \frac{Adjacent}{Hypotenuse}$$

$$\text{Tangent: } \tan(x) = \frac{Opposite}{Adjacent}$$

Step 6: Write a final "therefore" statement to restate your final calculation for the height of your structure. Make sure that the height is given in meters.

MEASUREMENTS	
Angle of Elevation	**Angle of Depression**
The clinometer reads _____ degrees, so the Angle of Elevation is _____ degrees. Calculations:	The clinometer reads _____ degrees, so the Angle of Depression is _____ degrees. Calculations:
Horizontal Distance (from the Clinometer to the Structure)	
Google Maps calculates the horizontal distance from where we are standing to the structure as _____ meters.	

DIAGRAM

CALCULATIONS

CONCLUSION

PART D: Reflection

1. **Using the internet, research the actual height of the structure you chose. Please record the height (in metres) in the box below:**

2. **How far off was the height you calculated using the clinometer to the actual height of the structure? Show your calculations in the box below:**

3. **Rate the accuracy of your results on a scale from 1 to 10 (with 1 being the least accurate and 10 meaning you calculated the exact height of the structure).**

1 2 3 4 5 6 7 8 9 10

4. **List 3 things that affected the accuracy of your results and explain why or how they did.**

5. **This assignment was designed to help you represent figures arising from real-world applications and solve problems involving trigonometry. Do you believe this activity supported this learning objective? Why or why not?**