How High Is The Aurora?

Overview:

In the 1920s, Carl Stromer from Norway used a mathematical formula called triangulation to determine the height of the aurora. Students use triangulation to figure out the height of a tall object in their school using a simple hand-held instrument called a Height-O-Meter.

Objectives:

The student will:

- measure the height of objects;
- use triangulation to determine the height of an object;
- construct an instrument called a Height-O-Meter;
- measure in degrees, calculate averages and interpret data; and
- conclude that similar triangulation techniques were used by Carl Stromer to figure out the height of the aurora.

Materials:

- Scissors
- Paper fasteners
- Masking tape
- Writing paper
- Chalk
- Tape measures
- Calculators
- Meter stick
- TEMPLATE: "Height-O-Meter*"
- VISUAL AID: "Height-O-Meter Data Table"
- VISUAL AID: "Measuring the Aurora"
- VISUAL AID: "Triangulation"
- STUDENT INSTRUCTION SHEET A: "How to Build a Height-O-Meter"
- STUDENT INSTRUCTION SHEET B: "How to Use Your Height-O-Meter"
- STUDENT INFORMATION SHEET: "Tangent Chart"
- STUDENT WORKSHEET: "Data Table"

**from page 53 of Height-O-Meter by Cary I. Sneider*

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Preparation for Triangulation Activity

1. For hanging gymnasium lights, make a dot on the floor directly below the light, and then draw a circle at 6 meters around the dot. *(NOTE: For free standing light fixtures, draw a circle around a light in the gymnasium with chalk or masking tape, 6 meters from the base of the light. Students will stand on this line to measure the height of the light.)*

2. Measure the height of a light in the gymnasium and write the results on a piece of paper.

3. Copy one TEMPLATE: "Height-O-Meter" onto cardstock for each student.

4. Use regular paper to make copies of the following sheets for each student:
   - STUDENT INSTRUCTION SHEET A: "How to Build a Height-O-Meter"
   - STUDENT INSTRUCTION SHEET B: "How to Use Your Height-O-Meter"
   - STUDENT INFORMATION SHEET: "Tangent Chart"
   - STUDENT WORKSHEET: "Data Table"

5. Measure one meter up from the floor and tape a meter stick vertically to the wall with "0" touching the one-meter position. This will help students find eye levels. For more information, see STUDENT INSTRUCTION SHEET B**:** "How to Use Your Height-O-Meter."

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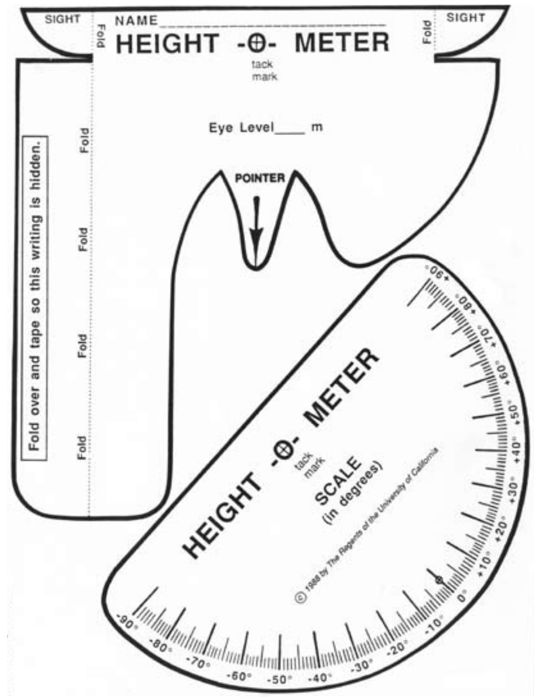


Activity Procedure:

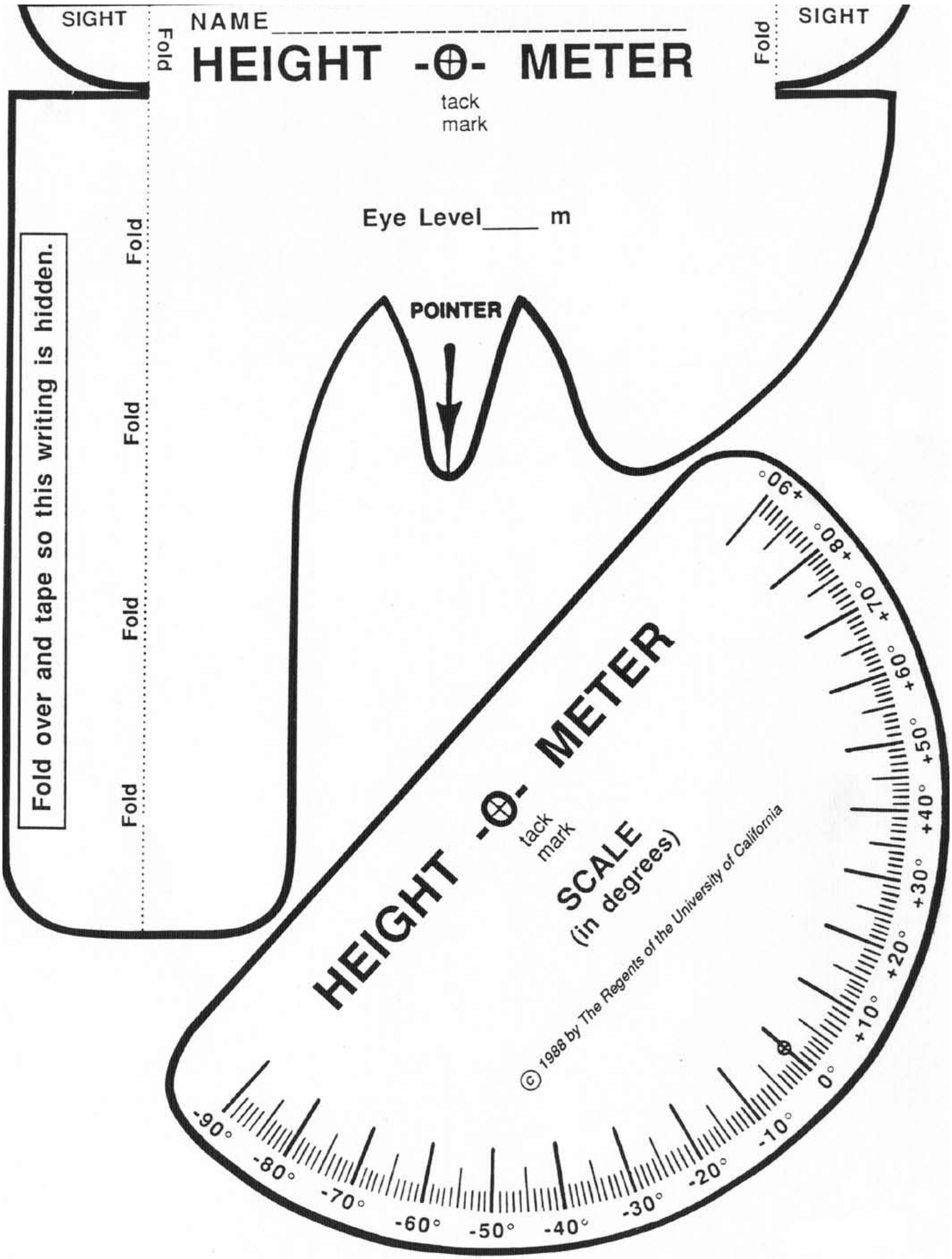
1. Show VISUAL AID: “Measuring the Aurora” and explain that scientist Carl Stromer, from Norway, used triangulation to measure the height of the aurora.
2. Ask students to build Height-O-Meters using STUDENT INSTRUCTION SHEET A: “How to Build a Height-O-Meter.”
3. Teach students to use Height-O-Meters using STUDENT INSTRUCTION SHEET B: “How to Use Your Height-O-Meter.”
4. Explain that Height-O-Meters can be used to find the height of an object.
5. Instruct students to use Height-O-Meters to measure the height of a light hanging from the gymnasium ceiling. Explain that they will compare their results with a measurement made by the teacher before class.
6. Explain that the Height-O-Meters measure angles that fall between eye level and directly overhead.
7. Distribute STUDENT WORKSHEET: “Data Table” to each student. Ask them to bring paper, a pencil, and their Height-O-Meter to the gymnasium.
8. In the gym ask students to stand with their toes along the circle drawn on the floor. Ask students to use Height-O-Meters to measure the top of the light three times. Students should record their measurements in the “Data Table” under the “Angle Using Height-O-Meter” column.
9. Back in the classroom, use VISUAL AID: “Height-O-Meter Data Table” to help students calculate the average of their three numbers. Ask them to state their results in degrees above eye level. Help students complete the remainder of the “Data Table” and the questions on the STUDENT WORKSHEET.
10. Compare student results to each other and to the actual height measurement taken earlier.
11. Conclude the lesson by showing VISUAL AID: “Triangulation (Stomer’s Experiment)” again. Explain that Carl Stromer used triangulation to find the height of the aurora in the same way that they used triangulation to find the height of the light in the gymnasium.

Answers to Student Worksheet:

1. answers should match teacher measurements *2. triangulation*

3. B. height = angle tangent x baseline distance

Template


SIGHT
SIGHT
NAME____________________
HEIGHT -⊖- METER
Fold
Fold
tack
mark
Eye Level____ m
POINTER
Fold over and tape so this writing is hidden.
Fold
Fold
Fold
Fold
HEIGHT -⊖- METER
tack
mark
SCALE
(in degrees)
© 1988 by The Regents of the University of California
+90°
+80°
+70°
+60°
+50°
+40°
+30°
+20°
+10°
0°
-10°
-20°
-30°
-40°
-50°
-60°
-70°
-80°
-90°

How to Build a Height-O-Meter

Materials:

- Height-O-Meter (on cardstock)
- Scissors
- Paper fastener

Activity Procedure:

1. Cut out the two pieces on the Height-O-Meter sheet along the dark heavy line.
2. Fold the two "sights" so they point straight up.
3. Fold the handle along the fold line.
4. Fill in your name at the top of the handle piece.
5. Attach the half-disk to the handle using a paper fastener. Work the fastener in a circle to enlarge the hole. Make sure the half-disk moves freely back and forth over the handle.

How to Use Your Height-O-Meter

Directions: Height-O-Meters are used to help find the height of an object. Following the instructions below, learn how to use your Height-O-Meter.

Materials:

- Height-O-Meter
- Meter stick taped to the wall with "0" on the meter stick 1 meter up from the floor

Activity Procedure:

1. Height-O-Meters measure the height of an object from eye level, rather than from the ground. Find eye level using the following steps:
   a. Stand next to the meter stick taped to the wall and note the number closest to your eye.
   b. Because the meter stick is taped 100 centimeters from the floor, add 100 centimeters to the number closest to your eye.
   c. Convert the sum to meters and round off to the nearest tenth of a meter. (For example, if the number closest to your eye is 19 centimeters, your eye level height is 119 centimeters, which converts to 1.2 meters.)
   d. Write your eye level on your Height-O-Meter.

2. Practice using your Height-O-Meter by finding the height of a poster on your classroom wall. Follow these steps:
   a. Hold the Height-O-Meter and sight along the top edges of the two sights so they both line up with the top of the poster.
   b. Use the thumb and forefinger of one hand to firmly press the half-disk against the handle piece.
   c. Now look at the scale on your Height-O-Meter. Read the number the arrow is pointing to in terms of degrees. The plus side of the scale indicates degrees above eye level and the minus side of the scale indicates degrees below eye level. (For example, if your arrow is pointing to 40, then the poster is 40 degrees above eye level.)

3. Practice measuring the angle of different objects in the room.

Tangent Chart

Angle	Tangent	Angle	Tangent	Angle	Tangent	Angle	Tangent
0°	.0000	23°	.4245	46°	1.0355	69°	2.6051
1°	.0175	24°	.4452	47°	1.0724	70°	2.7475
2°	.0349	25°	.4663	48°	1.1106	71°	2.9042
3°	.0524	26°	.4877	49°	1.1504	72°	3.0777
4°	.0699	27°	.5095	50°	1.1918	73°	3.2709
5°	.0875	28°	.5317	51°	1.2349	74°	3.4874
6°	.1051	29°	.5543	52°	1.2799	75°	3.7321
7°	.1228	30°	.5774	53°	1.3270	76°	4.0108
8°	.1405	31°	.6009	54°	1.3764	77°	4.3315
9°	.1584	32°	.6249	55°	1.4281	78°	4.7046
10°	.1763	33°	.6494	56°	1.4826	79°	5.1446
11°	.1944	34°	.6745	57°	1.5399	80°	5.6713
12°	.2126	35°	.7002	58°	1.6003	81°	6.3138
13°	.2309	36°	.7265	59°	1.6643	82°	7.1154
14°	.2493	37°	.7536	60°	1.7321	83°	8.1443
15°	.2679	38°	.7813	61°	1.8040	84°	9.5144
16°	.2867	39°	.8098	62°	1.8807	85°	11.430
17°	.3057	40°	.8391	63°	1.9626	86°	14.301
18°	.3249	41°	.8693	64°	2.0503	87°	19.081
19°	.3443	42°	.9004	65°	2.1445	88°	28.636
20°	.3640	43°	.9325	66°	2.2460	89°	57.290
21°	.3839	44°	.9657	67°	2.3559	90°	—
22°	.4040	45°	1.0000	68°	2.4751		

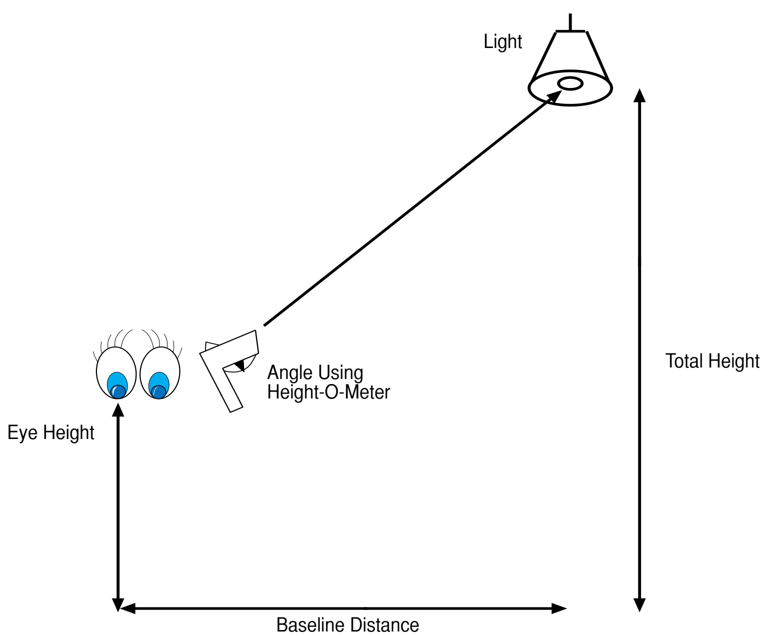
Name:______________________ **Student Worksheet**

Data Table

1. Use collected data and the STUDENT INFORMATION SHEET: “Tangent Chart” to complete the table below. You may use a calculator.

Height-O-Meter Data

	Eye Height	Baseline Distance	Angle Using Height-O-Meter	Tangent of Angle (from chart)	Height (tangent x baseline)	Total Height (height + eye height)
Trial #1		**6 meters**				
Trial #2		**6 meters**				
Trial #3		**6 meters**				
		Average Height = (Total #1 + Total #2 + Total #3) ÷ 3				



2. Scientists use a method called__________________ to figure out the height of the aurora.

3. Using triangulation, what mathematical formula would you use to find the height of an object?

   A. height = $\pi^2 + 2$ B. height = angle tangent x baseline distance

   C. height - mc^2 D. height = perimeter x radius

