Measuring the Height of Gamow Tower

Big Idea

Science involves using creativity and imagination to figure things out. In Astronomy we often have to measure things we can't touch because they are so far away. Whenever you measure something it is important to understand the how accurate the measurement is.

Learning Goals

- Measure the size of something (Gamow Tower) you cannot touch.
  ****Use creativity in devising your own method to do this****
- Learn how to estimate the accuracy of your measurement.

IMPORTANT NOTE: Many labs are like cookbooks –they tell you what to do. That is not the way real science works. *Real science* (as opposed to boring classroom science) is all about using your imagination.

TA's and LA's: When results from many groups are combined this activity generates an *excellent* data set for discussing experimental error and standard deviation. It is much better to show these graphically, first, rather than introducing them with formulas. The professor, you, or both, can ask questions such as:

1. **Why doesn't everyone get the same answer?**
2. **What's the best estimate of Gamow's height? (the mean)**
3. **How can we describe how wide the distribution is? (standard deviation)**
4. **What is the typical measurement error? (standard deviation). In 3 and 4 a practical definition of standard deviation is "the limits between which 2/3 of the measurements fall if errors are random.**
5. **What are "outliers?" (We virtually always get a group or two to contribute them to the distribution!**

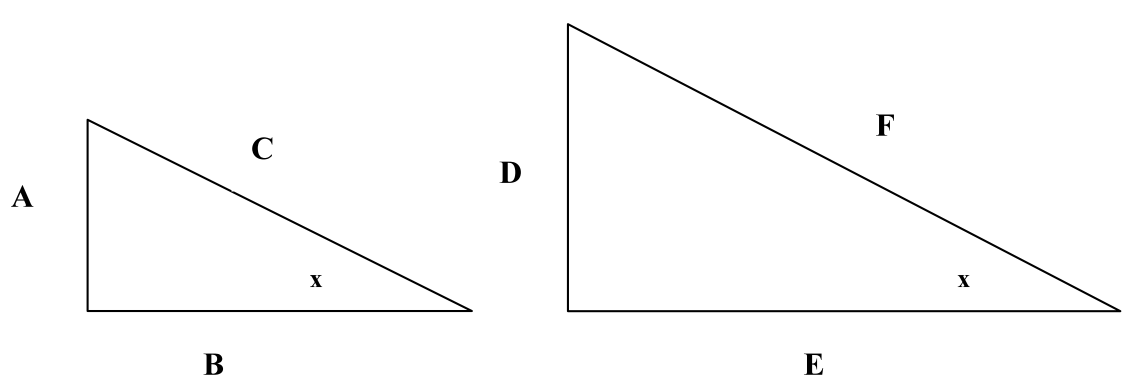
Activity:

Learning Goal I: Measure the size of something (Gamow Tower) you cannot touch (use creativity here).

Notes:

Experimentation: "Gamow Tower"

- Part 1: Measure the height of Gamow Tower using a meter stick and a large cardboard triangle whose sides are in a ratio of 2 or 1.
  - Use creativity in devising your own method to do this.
  - **HINT:** The following two triangles are *similar* and the sides are in the ratio of 2 to 1. Triangles are similar if the *corresponding angles are equal,* and that's true here. So the ratios of any two sides in the first triangle are equal to the ratios of the corresponding sides in the second triangle. If A=1" how large is B? B=2" If D = 50 feet, how large is E? **Write your answer here and show it to your TA or LA:** __________



Mathematically, A/B = D/E.

- You could also use trigonometry if you measured the angle x. The ratios A/C and B/C are called the *sine* and *cosine* of the angle x, and A/B is the *tangent*. So you could measure one side, and an angle (if you had a protractor) and figure out the other side. But you don't need to, because we've already told you the sides are in a ratio of 2 to 1.

Notes and Observations:

Sketch your method of measuring the tower here:
Show the drawing to your TA or LA BEFORE you do your measurements!

Question(s):

I.1) What is the height of Gamow? ______________________________
(units)

Learning Goal II: Learn how to estimate the accuracy of your measurement.

Notes:

Question(s):

II.1) What do you think is the accuracy of your measurement? Think about this carefully, please.

II.2) How did you estimate your uncertainty?

Hint:
Part of a **scientific attitude** means understanding data and the errors that come with it. When someone makes a claim, you *always* should ask, "What data or evidence supports that claim?" *and* "How good is that data?" So, how accurate is *your* data?!

II.3) If you compared your measurement of the height of Gamow Tower to the measurement of another group, how different would you expect them to be?
Answer: *Same as the answer to question II.1 (their uncertainty)*

II.4) How does that compare to your estimate of uncertainty?
Answer: *They should be comparable*

Discussion Question:

How do astronomers use geometry and trigonometry to measure distances? *See page 51 of The Cosmic Perspective 3rd edition.
Answer: *parallax. A long skinny triangle where you know one angle and one side, and can deduce the missing side. The side you know is the earth's orbital radius.*

Notes from the final discussion: