
Twinkle, Twinkle Little Star, How I Wonder How Far Away You Are

Background

The Father of Ancient Astronomy, Hipparchus of Rhodes (circa 180-125 B.C.) was one of the first astronomers of note. He was a mathematician, as well as an astronomer and calculated the length of the year to within 6.5 minutes. He also made a catalog of about 850 stars visible to the naked eye. This catalog was developed without the use of telescopes or lenses, which had not yet been discovered. He listed stars by location and brightness. Location was based on a system similar to longitude and latitude used to describe a position on Earth's surface. Brightness, or magnitude, was measured by the eye with the aid of a brass disk with six holes of different sizes made by Hipparchus. The holes were labeled one, the largest, to six, the smallest. He would hold his disk up and sight a star through the hole that was a "best fit" and thereby establish the magnitude of the star or planet. The brightest was a one, the dimmest was a six. What Hipparchus didn't know was that the stars and other celestial bodies are not the same distance away. Today's astronomers use the terms apparent and absolute magnitude to describe brightness.

Apparent magnitude describes how bright a star (or planet) appears to be. No consideration is given to how far away from you the star is. For example the sun would measure very highly (-26) since it is only 93 megamiles away from us, using apparent magnitude.

Absolute magnitude, on the other hand, is how bright a star would be if all stars were the same distance away. Stars only have this since planets do not give off light and would be impossible to see at any interstellar distance. Our sun's absolute magnitude is only a 5.

You may have wondered how we know and can prove well enough to say how other galaxies are a particular distance away, such as the Andromeda galaxy which is 2 million light years from Earth. The breakthrough came in the 1920's. An American astronomer Edwin Hubble (1889-1953) used a type of variable star called a Cepheid variable. A Cepheid variable is a variable that has a regular time period from its brightest to its dimmest points. In other words, it brightens and dims with a regular pattern. The period of the variation is directly related to the brightness of the star. So, if you can measure the period, you know how bright that star is. If you know how bright a star is and can compare that to how bright it should be, you can determine the distance to that star. Using

this information, Hubble proved that there were other galaxies outside of our own.

Problem Statement

We are going to use the EA100 to do a simulation measuring a star's brightness and show exactly what the mathematical relationship is between distance and brightness. Our "star" will be a incandescent light bulb. Our distance will be measured using a meter stick. The EA100 will measure the relative intensity of the "star" at different distances.

Hypothesis

What do you think the relationship between light intensity and distance is? What's your hypothesis?

Equipment

Casio EA100 Data Analyzer and light probe
Casio CFX-9850G Color Graphing Calculator+

meter stick
incandescent light bulb with plug in
paper and pencil
graph paper

Procedure

1. Turn on your "star" and place it approximately one meter from the receiving end of the light probe.

2. Plug the light probe into the EA100 in Channel One (CH1) on the top of the EA100.

3. Turn on the EA100 by pushing the red button labeled ON/OFF.

4. Press the MODE button changing the EA100 to MULTIMETER MODE. The word "MULTIMETER" will appear in the lower left of the EA100 view screen.

5. Read the value and note it with the corresponding distance on a data table that you construct on page 3. Measure to the nearest centimeter on your meter stick.

6. Relocate the receiving end of the light probe to a point closer to the "star" and note the new value and distance.

7. Repeat this procedure (steps 5 through 6) until you have at least five(5) intensity values and five (5) corresponding distances.

8. With the values you have measured in mind, using your graph paper, construct a graph with the luminosity values on the y axis and the distance measurement on the x axis.

9. Now get out your trusty Casio CFX-9850G color graphing calculator. Turn it on and choose "STAT" from the main menu. Enter the measured distances in List 1 and the corresponding light intensity values in List 2.

10. Press F1 (GRPH). Press F1 (GPH1) again and your graph should display. If not, hit EXIT and then hit SEL. this is where you turn graphs on and off. Check to make sure Graph 1 is on and the other two are off. If that is OK, then hit EXIT again and press SET. Here you can select the type of graph (you want scatter), which list is which coordinate (you want Xlist as List 1 and Ylist as List 2), mark type (pick your own), and graph color (let your conscience be your guide). Press EXIT and you are back to your list, ready to regraph. If you are still having problems, press SHIFT and F3 (V-WIN). This will let you view the window and see what your minimums (0 for this graph), maximums (look at your data and decide) and scale should be (here again, use your judgment). Hit EXIT to go back to your list and you know what to do now.

11. Compare the graph you did manually and the graph on your calculator. Print your graph using a computer. The instructor will help you with this operation.

Data

Construct your data table on a separate sheet of paper.

Results

State your interpretation of your graphical data.

Conclusions

Relate your conclusions to your hypothesis in a narrative.
