Light at the End of the Tunnel

Math / Physics
Middle / High
Parametric Equations / Data Collection

Introduction: Have you ever noticed when walking along the side of the road or driving at night, that as the head lights of an approaching vehicle get closer, the light becomes increasingly more uncomfortable? Why is this? The standard answer is because the lights get brighter. However, a better way of discussing light is to say that as a light source gets closer to an observer, the light becomes more intense to that observer. The term "brightness" can be confused with relative brightness and absolute brightness. Intensity, however, by definition, is a function of the characteristics of the light source and the distance from the observer. Mathematically the equation is:

$$I = \frac{I_o}{d^2}$$

where I is the light intensity, Io is the original intensity (a constant based on the properties of the light source), and d is the distance form the light to the observer.

In this activity, you will use a motion probe and a light probe with your EA-100 Data Analyzer to derive a model of the inverse square relation of light intensity to distance.

Objectives: Students will be able to…

1. Collect data by following an experimental procedure.
2. Input data in a graphing calculator.
3. Compare results.
4. Draw conclusions.
5. Determine the governing math model
6. Discuss applications of results.

Related Key Words:

intensity	inverse relation	brightness
dispersion	light spectrum	monochrome light
Laser	in phase light	

Materials:
Incandescent light source (lamp with 100-watt bulb or more)
CASIO CFX9850-Ga Plus or CFX9850-G COLOR GRAPHING CACLAULTOR
CASIO EA-100 CASIO Data Collector (CDA)
Light Probe (Included with the CDA)
Link Cord (Included with the CDA)
Vernier Motion Detector

Purpose: We are going to use the EA-100 to measure the relative light intensity of our lamp and the motion detector to measure the distance from the lamp.

STEP 1— The lamp should be placed next to a wall or some other large flat surface to reflect the sonic signal from the motion detector.

STEP 2— Plug the light probe into the EA-100 in Channel One (CH1) on the top of the EA-100. Plug in the motion detector into the sonic (SONIC) port, on the right side of the EA-100. Using tape or rubber bands, secure the light probe to the side or top of the EA-100 so that they are both facing the same direction.

STEP 3— Turn on the EA-100 by pushing the red button labeled ON/OFF

STEP 4— Set up the EA-100 to collect data. With the data collector on, push the [SHIFT] key followed by the [MODE] key for SET UP. The tome interval for data collection will be 1.00. Press the [DataLOG] for NEXT until this option appears on the screen. Press [TRIGGER] key for ENTER to save the setting. Input the number data points to be collected at 20. Press the [DataLOG] for NEXT until this option appears on the screen. Press [TRIGGER] key for ENTER to save the setting. Time will be measured in the absolute mode, 1 (running clock). Press the [DataLOG] for NEXT until this option appears on the screen. Press [TRIGGER] key for ENTER to save the setting.

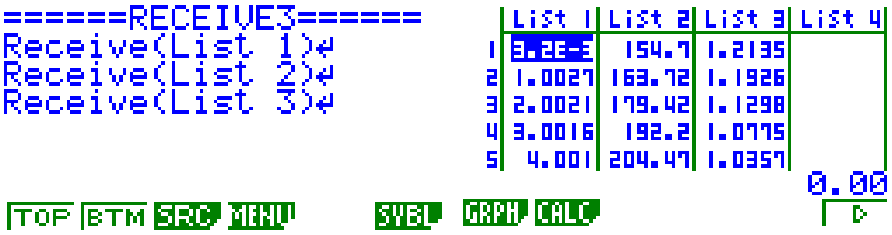
STEP 5— The EA-100 should now have the word "READY" show along the left side of the display and the motion detector should be clicking at one-second intervals. Turn on the lamp and dim the rest of the lights in the room.

STEP 6— A student should position themselves in front of the lamp with the probes facing the light. The EA-100 should be displaying the light probe reading. If it is indicating the distance, press the [CH-View] button once to display the light probe reading.

STEP 7— The student should move to a distance where the light probe reading is as near 100 as possible. This will be their starting position.

STEP 8— The student presses the [TRIGGER] to begin the data collection. At the same time, s/he will begin to walk toward the lamp, stopping when the data collection is complete. It may take a few attempts to determine the correct rate at which the student needs walk. Experiment with the procedure until you are confident of your timing.

STEP 9— Now get out your Casio CFX-9850G color-graphing calculator. Using the data link cord, connect the calculator and the EA-100. Using the RECIEVE3 program, transfer the data from the EA-100 to the STAT menu of the calculator.



This program will transfer three lists of data from the EA-100 to your calculator. List 1 will be the time data, List 2 will be the light probe data, and List 3 will be the distance data.

STEP 10— The data can now be graphed and analyzed. The important graph will be the graph of light intensity and distance, List 2 and List 3. After going into the STAT menu from the MAIN MENU, select [F1] for GRPH, then [F6] for SET. Scrolling down to Xlist, select [F2] for List2, then scroll again to Ylist and select [F3] for List3. [EXE] to save the changes, then [F1] for GPH1 to graph the data.

STEP 11— Now you must decide which regression equation is correct for the data and for the concept being studied. For different best-fit curves try linear (X), quadratic (X^2), logarithmic (Log), exponential (Exp), and power (Pwr). Study each of the equations carefully after each selection, taking note of their form.

Joseph K. Schumaker of CASIO Inc. developed this activity.

Questions and Problems:

Level 1: Answer the following questions in complete, well-structured sentences.

1. Describe the graph of the data of the intensity verses the distance.
2. Explain why the rest of the lights in the room needed to dimmed. What might happen if they are not dimmed?
3. Why isn't laser light used for this lab? Include in your explanation the terms "monochromatic" and "in phase."
4. What does the acronym LASER stand mean?
5. How does the relation of light intensity and distance related to our solar system? What does this mean for a manned mission to Mars? Saturn?

Extension:

Have students repeat the experiment with different colored filters over the light, or with bulbs of different wattage. They could also compare incandescent with florescent light.