A Little Light Work

ID: 8547

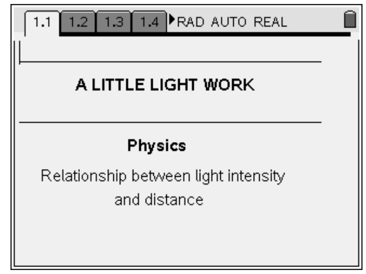
Name ____________________

Class ____________________

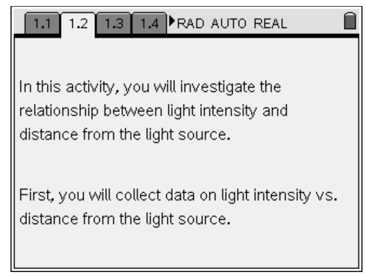
In this activity, you will explore the following:

- *the relationship between light intensity and distance*
- *how to make a mathematical model of a physical phenomenon*

Open the file **PhyAct02_light_intensity_EN.tns** on your handheld or computer and follow along with your teacher for the first two pages. Move to page 1.2 and wait for further instructions from your teacher.

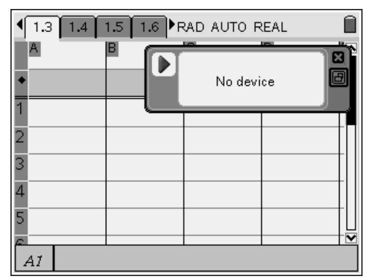


The intensity (brightness) of light decreases as you move farther from the light source. This occurs because light waves travel outward in all directions from their source. The expanding wave fronts form a sphere of increasing radius. Because the amount of light energy is fixed, the amount of energy in any given area on the surface of the sphere decreases as the sphere's radius increases. In this activity, you will determine the mathematical relationship between the intensity of light and the distance from its source.



Part 1 – Using a regression to quantify the intensity-distance relationship

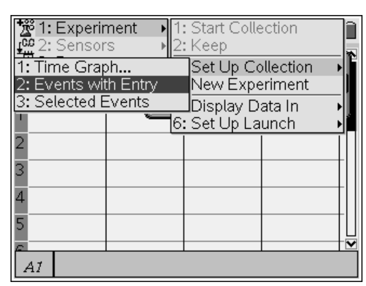
Step 1: Place the meter stick on the floor or another flat, level surface. Place the flashlight at the zero end of the meter stick, with the bulb pointing down the meter stick (so that the light shines down the length of the meter stick when you turn the flashlight on). Connect a Vernier Light Sensor to an EasyLink interface (if using a handheld) or a Go!Link interface (if using a computer). Your teacher will tell you which setting on the back of the Light Sensor to use (0-6000, 0-600, or 0-150,000).



Step 2: Move to page 1.3, which contains an empty *Lists & Spreadsheet* application. Insert a new data collection box by pressing ctrl D. Connect the EasyLink or Go!Link interface to your handheld or computer. Data should appear in the data collection box.

Step 3: With the flashlight turned off, place the Light Sensor at the 0.05 m (5 cm) mark on the meter stick. (You may need to hold it in place gently.) Wait for the light intensity reading to stabilize, and then zero the sensor (**Menu > Sensors > Zero**).

Step 4: For this experiment, you will need to collect data on intensity and distance at specific points. To set up the TI-Nspire to collect data in this way, select **Events with Entry** from the **Experiment** menu (**Menu > Experiment > Set Up Collection > Events with Entry**). Click the "play" button (►) to begin the experiment.



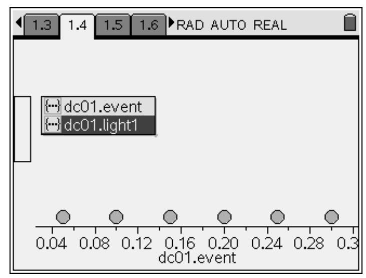
Step 5: Turn on the flashlight. Wait until the intensity reading has stabilized, and then click the button in the lower right corner of the data collection box. A dialog box should appear. Enter 0.05 in the box, and then click OK.

Step 6: Move the Light Sensor to the 0.10 m (10 cm) mark. Wait until the intensity reading has stabilized, and then click the button in the lower right corner of the data collection box. A dialog box should appear. Enter 0.10 in the box, and then click OK.

Step 7: Repeat step 6 four more times, moving the light sensor 0.05 m farther from the flashlight each time. Note: Make sure you keep the Light Sensor in exactly the same orientation relative to the flashlight at all times. Do not raise, lower, or tilt the sensor, or your data will not be accurate.

Q1. Briefly describe how intensity changes as distance increases. Does the change appear to be linear (that is, do uniform increases in distance produce uniform change in intensity)? Justify your answer.

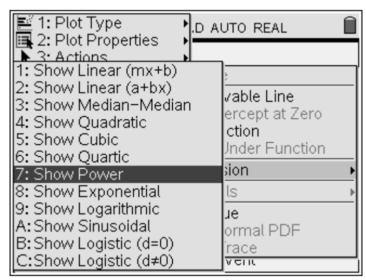
Step 8: Page 1.4 contains a blank *Data & Statistics* application. Use this application to create a scatter plot of the data in the spreadsheet on page 1.3. Use distance as your *x*-values and intensity as your *y*-values.



Q2. Describe the shape of the graph of intensity vs. distance.

Q3. What types of mathematical functions produce graphs with shapes like this?

Step 9: Use the **Power Regression** tool (**Menu > Analyze > Regression > Show Power**) to carry out a power regression on the data. A best-fit curve for the data, and its equation, should appear on the screen.



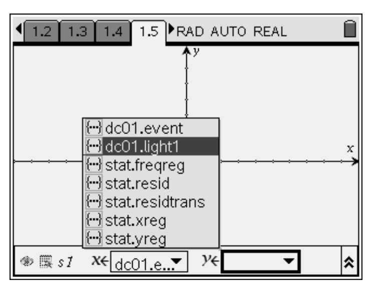
Q4. Write the equation that best fits the data on your answer sheet. Round the calculated values to three significant figures.

Q5. Why do you think relationships like these are called "inverse-square laws"?

Q6. Does the graph of the regression equation appear to fit the data well?

Part 2 – Building your own model for the relationship

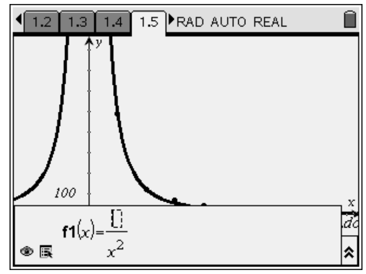
Step 1: Move to page 1.5, which contains an empty *Graphs & Geometry* application. Make a scatter plot of intensity vs. distance on this page. Use the **Trace** tool to determine and mark the coordinates of the leftmost point.



As you established in problem 1, intensity and distance are related by an inverse-square law. That is, the equation relating intensity (*I*) and distance (*d*) takes the form $I = \frac{k}{d^2}$, where *k* is a constant.

Q7. Use substitution to find the value of *k* that makes the equation above true for the leftmost point on the graph. Show your work.

Step 2: Change the graph on page 1.5 to a **Function** graph. Graph the function you calculated above. Modify the value of *k* as needed to obtain the best fit to the data.

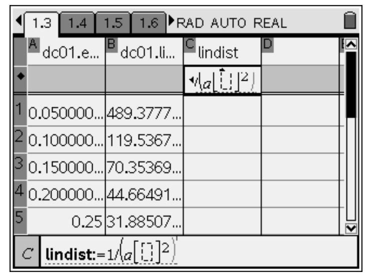


Q8. What value of *k* makes the curve fit the data best?

Q9. How does this value of *k* compare to the value of *a* you calculated in problem 1?

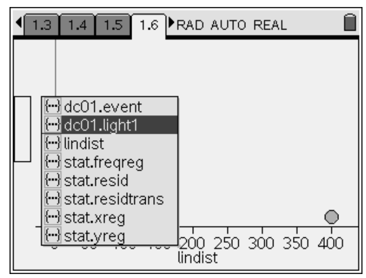
Part 3 – Another confirmation of the inverse-square relationship

Step 1: Another way to confirm that intensity and distance are related by an inverse-square law is to plot intensity vs. $\frac{1}{d^2}$. Such a plot should be a straight line because intensity is directly related to $\frac{1}{d^2}$.



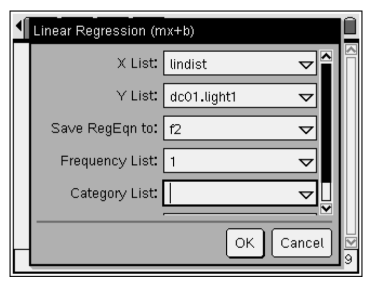
Move back to page 1.3. In Column C, define a new variable, **lindist**, that is equal to $\frac{1}{d^2}$.

Step 2: Move to page 1.6 and create a scatter plot of the data you have just calculated. Use **lindist** for your *x*-values and intensity for your *y*-values.



Q10. Describe the shape of the graph.

Step 3: Next, use the *Calculator* application on page 1.7 to calculate a linear regression for intensity vs. $\frac{1}{d^2}$. From the **Stat Calculations** menu, choose **Linear Regression (mx + b)**. Select **lindist** for the *X List* and intensity for the *Y List*.



Q11. Does the r^2 value for the linear regression support the statement that intensity is directly related to $\frac{1}{d^2}$? Explain your answer.

Q12. Use each of the three equations relating *I* and *d* that you found in this activity to calculate the intensity of this light at a distance of 0.35 m from the source. Show your work.

Q13. How could you test your calculations from question 12 to determine which value is most accurate?

Q14. Using the equation for the surface area of a sphere, explain why the relationship between intensity and distance follows an inverse-square law.