

## How Bright is the Light?

You may have noticed that a light appears to be brighter when you are close to it, and dimmer when you are farther away. In this experiment, you will use a Light Sensor to measure light intensity as you study the relationship between light intensity and distance.

### OBJECTIVES

In this experiment, you will

- use a TI Graphing Calculator, a LabPro or CBL 2 interface, and a Light sensor to measure light intensity.
- graph and analyze data.
- make conclusions about the relationship between light intensity and distance.

### MATERIALS

LabPro or CBL 2 interface  
TI Graphing Calculator  
**DATAMATE** program  
Light Sensor

meter stick  
light source (lamp or flashlight)  
masking tape  
box

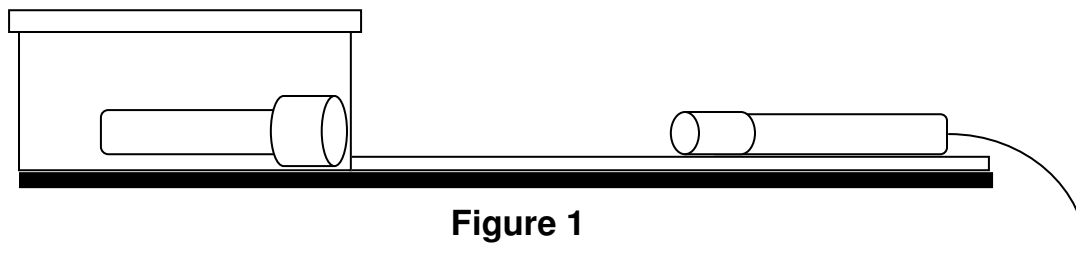


Figure 1

### PROCEDURE

1. Set up the equipment.
  - a. Tape a meter stick to your table top.
  - b. Place a box, with a small hole in the end, at the 0-cm mark of the meter stick as shown in Figure 1.
  - c. Place a light source into the box. The bulb should be at the small hole.
  - d. Tape the lamp in position to keep it from moving during the experiment. Cover the box with its lid.
  - e. Place your Light Sensor on the meter stick and line up the box's small hole with the Light Sensor.

2. Prepare the Light Sensor for data collection.
  - a. Connect the Light Sensor to Channel 1 of the LabPro or CBL 2 unit.
  - b. Use the link cable to connect the TI Graphing Calculator to the interface. Firmly press in the cable ends.
  
3. Turn on the calculator and start the **DATAMATE** program.
  - a. Check the **[APPS]** menu to see if your calculator already has the **DATAMATE** application. The applications are listed in alphabetical order.
  - b. If not, then follow these steps to install it:
    - i. Prepare your calculator to receive the application by pressing **[2nd ] [LINK]**
    - ii. When the calculator says “**Waiting...**” press the **TRANSFER** button on the LabPro or CBL 2 unit.
    - iii. When the screen displays “**Done**”, exit to the home screen by pressing **[2nd ] [QUIT]**
  - c. To run the application, while in the **[APPS]** menu, select the **DATAMATE** application and press **[ENTER]**
  
4. Set up the calculator and interface for the Light Sensor.
  - a. Select **SETUP** from the main screen
  - b. If the calculator displays **TI LIGHT PROBE** in **CH 1**, proceed directly to Step 5. If it does not, continue with this step to set up your sensor manually.
  - c. Press **[ENTER]** to select **CH 1**.
  - d. Press **[7]** to see more options.
  - e. Choose **LIGHT** from the **SELECT SENSOR** list.
  - f. Chose **LIGHT 600 (LX)** from the **LIGHT** list.
  - g. It may take a few seconds while “**SETTING UP CHANNEL**”
  
5. Set up the calculator and the interface for the appropriate data collection mode.
  - a. Press **[up curser]** once to select **MODE** and press **[ENTER]**.
  - b. Select **EVENTS WITH ENTRY** from the **SELECT MODE** menu to collect light data as a function of distance. In this mode you will trigger the interface to record the light intensity for each position you choose.
  - c. Select **OK** to return to the main screen.

6. Collect the data.
  - a. Select **START** to prepare for data collection.

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**WAIT FOR INSTRUCTIONS FROM YOUR INSTRUCTOR BEFORE PROCEEDING**

**THE REMAINING PART OF THE LAB MUST BE COMPLETED**

**WITH THE CLASSROOM LIGHTS OUT**

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- .....
- b. Position the end of the Light Sensor at the 10-cm line and turn on the light source. Wait 5 seconds then press **[ENTER]**. This stores the y-value (light intensity) in **L<sub>2</sub>**
    - c. The calculator will now prompt you to **ENTER VALUE**. Enter "10" (for 10 cm), then press **[ENTER]** to store this light intensity-distance data pair. This stores the x-value (distance) in **L<sub>1</sub>**
    - d. Move the light sensor to the 15-cm line. Wait five seconds, then press **[ENTER]**. Enter "15" (for 15 cm), then press **[ENTER]** to store this light intensity-distance data pair.
    - e. Repeat this procedure at 5-cm intervals through 80 cm.
    - f. Press **[STO]** to stop data collection.
    - g. Turn off the light source.
  7. Examine the data pairs on the displayed graph. As you move the cursor right or left, the distance (**X**) and light intensity (**Y**) values of each data point are displayed below the graph. Record these values in the data table provided on the next page.
  8. Quit the program and go to the **[STAT] [EDIT]** menu. Your data is stored in **L<sub>1</sub>** (distance) and **L<sub>2</sub>** (light intensity). Create a new named list **INTEN** Save the data in L2 in **L<sub>1</sub>INTEN** by highlighting **L<sub>1</sub>INTEN** and typing **L<sub>2</sub>** then **[ENTER]** .

**It is important to do this!!!! The next step will erase the information in L<sub>2</sub>!!!!!!**

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9. Go to the **[APPS]** menu, select the **DATAMATE** application and press **[ENTER]**. This will restart the program. You should not have to change any of the settings. It will "remember" them from the previous trial.
  10. Repeat Steps 6-7 with the light source **OFF** to get **BACKGROUND LIGHT INTENSITY** data. To accurately measure the intensity of light from sources other than the bulb at each interval, group members should again do the same tasks from the same positions.

**DATA**

Distance (cm)	Light Intensity	Background Intensity	Adjusted Intensity
10	_____	_____	_____
15	_____	_____	_____
20	_____	_____	_____
25	_____	_____	_____
30	_____	_____	_____
35	_____	_____	_____
40	_____	_____	_____
45	_____	_____	_____
50	_____	_____	_____
55	_____	_____	_____
60	_____	_____	_____
65	_____	_____	_____
70	_____	_____	_____
75	_____	_____	_____
80	_____	_____	_____

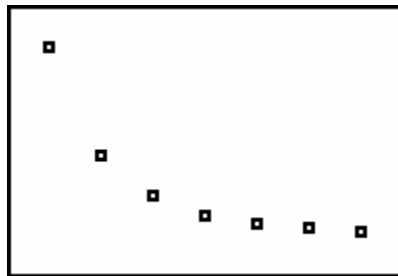
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**PROCESSING THE DATA**

1. Calculate the adjusted light intensity at each distance by subtracting the background intensity (Column 3) from the corresponding light intensity (Column 2). Record the results in Column 4 of the data table. You can have the calculator perform this step for you.  $L_2$  contains the background intensity and  $L_1$  **INTEN** contains the corresponding light intensity.
2. Graph your adjusted data. Plot the **DISTANCE** (in cm) on the horizontal axis and the **ADJUSTED LIGHT INTENSITY** on the vertical axis. If you do this on the calculator, sketch the graph below as well. Describe your graph. What type of association do you observe?



3. A light intensity curve showing an inverse square relationship looks like this:



*Light Intensity vs. Distance*

How well does your graph compare with this shape? Describe any differences?

4. If light intensity and distance fit on an inverse square relationship, doubling the distance would cause light intensity to be  $\frac{1}{4}$  as great. See how well your data agree by dividing the light intensity at 30cm by the light intensity at 15cm. Show your work below. How close is your value to 0.25 ( $\frac{1}{4}$ )? Does your data support an inverse square relationship for light intensity and distance?
5. If you would move the Light Sensor 5 times further away from the light, by what fraction would the light intensity change?
6. The formula for the inverse square relationship of **ADJUSTED INTENSITY** vs. **DISTANCE** is:

$$\lambda = \frac{k}{d^2} \text{ where } \lambda = \text{Intensity, } k = \text{constant, and } d = \text{distance from light source}$$

- (a) Use your data point for 10 cm to solve for the constant  $k$ . Show your work below:

(b) Use your formula from (a), with your calculation for  $k$  to predict the intensity at 20 cm, 30 cm, and 40 cm. Show your work below.

(c) Graph this equation and determine how well it fits the data. Remember, you want the STATPLOT to use the ADJUSTED INTENSITY. Show the graph for your group below.



(d) How close were your predictions to your actual answers? What might explain any differences?

7. **Transform the data** by squaring and inverting the distance. This represents  $1/d^2$ . Graph **ADJUSTED INTENSITY** vs.  $1/\text{DISTANCE}^2$ . Again, the calculator can do this, use a blank list and put  $1/L_1^2$  in the list.
8. Calculate the least-squares regression line of this relationship {the list with  $1/L_1^2$  is the explanatory (independent) variable, the list with the adjusted intensities is the response (dependent) variable}. Write it below and interpret the slope.
9. Interpret the correlation coefficient.

10. Interpret the coefficient of determination.

11. What do your answers to 9 and 10 suggest about this model?

12. Use the TI-83 to perform the following regressions. Write down your equations with the corresponding  $r$ - or  $R$ - squared and determine which one has the best fit.

- Quadratic                    \_\_\_\_\_     $R^2 =$  \_\_\_\_\_
- Exponential                \_\_\_\_\_     $r^2 =$  \_\_\_\_\_
- Power                        \_\_\_\_\_     $r^2 =$  \_\_\_\_\_

13. How does each fit compare to the inverse-square model?

14. Summarize the results of this experiment.