CBL Laboratory for the Investigation of the Variation of
Light Intensity with Distance from the Light Source

By Austin Raabe

Revision 0

NOTE! In this document I have included explanatory information in italic type. You should omit the italic text to produce a procedure for your students. If you find errors, please email me.

This lab procedure was designed to be performed using the apparatus (see Appendix) described the file Light Intensity Apparatus *on the website. Check for revision updates.*

INTRODUCTION

Who cares how light intensity varies with distance? A partial list includes: light bulb producers, flashlight producers, traffic engineers, astronomers, the armed forces, automobile manufacturers, airplane manufacturers, and safety engineers. A better question may be "who doesn't care"?

You might ask the question some night, if two cars are approaching me and the second car's lights appear to me to be half as bright as the first car, does that mean the second car is twice the distance behind the first? Can I pass the slow car in front of me as soon as the first car approaching me goes by? The correct answer to this question depends upon your understanding of the relationship between light intensity and distance.

OBJECTIVE

To collect light intensity vs. distance data and determine the mathematical relationship between the variables.

You might ask the students which is the dependent and which the independent variable.

SAFETY

Your teacher will inform you as to the necessity of wearing safety goggles.

MATERIALS

- Light intensity apparatus.
- TI 83Plus calculator
- CBL

If you have other calculators or the CBL2 or LabPro, you will have to make some modifications in the procedure.

PROCEDURE

If you have the time, show the students the apparatus and have them come up with a procedure. If they are not familiar with the CBL you may have to provide them with that part of the procedure.

1. Read the procedure and then prepare a table to record your data.
2. Plug the light sensor into CH1 and connect the CBL to the calculator.
3. Turn on both the calculator and the CBL.
4. Press APPS on the calculator and start the ChemBio application.
   You can use other application such as PHYSICS or PHYSCI but you may have to make minor modifications in the calculator setup procedure.
5. Press ENTER when you see the "VERNIER SOFTWARE" screen.
6. Select #1, "SET UP PRPBES".
7. Type 1 for "ENTER NUMBER OF PROBES:" and then press ENTER.
8. Type 7 "MORE PROBES" and then type 3 for the "LIGHT" sensor.
9. Type 1 for the "ENTER CHANNEL NUMBER:" and then presenter.

10. Type 2 for “COLLECT DATA”.
11. Type 1 for “MONITOR INPUT”.
    When you find where to position the sensor, in the future you might collect data by using “TRIGGER PROMPT”.
12. Turn the light on and then adjust the position of the light sensor until the reading on the calculator is between 0.85 and 0.90. Record the light intensity, the position of the light filament, and the position of the end of the paper collar on the light sensor nearest the light filament. Be sure not to change the position of the wood slider holding the light bulb for subsequent readings.
13. Move the sensor slider until the new position is 1cm farther from the light bulb and then record the position of the sensor and the light intensity.
14. Repeat step 13 until you have a total of 6 data pairs.
15. Reposition the sensor slider to the original position and then record another set of data.
16. Press + and then type 7 to “QUIT”.
17. Turn off both the calculator and the CBL interface.

<u>DATA TREAMENT</u>

There are several ways that your students might investigate the relationship of the variables. I have made suggestions below as to how to proceed as to how to proceed. You might consider having your students first perform Experiment #5 “Find the Relationship: An Exercise in Graphical Analysis” in <u>Chemistry with CBL</u> *by D. Holmquist, J. Randall, and D. Volz, which is available from Vernier.*

1. Obtain three pieces of graph paper.
2. On the first piece of graph paper plot the distance between the light sensor and the light filament on the x-axis and plot the light intensity on the y-axis.
3. On the second piece of graph paper plot values obtained by dividing ‘1” by the distance between the light sensor and the light filament on the x-axis, and plot the light intensity on the y-axis.
4. On the third piece of graph paper plot values obtained by dividing ‘1” by the “square” of the distance between the light sensor and the light filament on the x-axis, and plot the light intensity on the y-axis.
5. Press STAT on your calculator and then edit.
6. In list L_1 record the distance between the light sensor and the light filament.
7. In list L_2 record the corresponding light intensity values.
8. In list L_3 record $1/L_1$ values.
9. In list L_4 record $1/(L_1)^2$ values.
10. Be sure the DiagnosticOn is active in the CATALOG.
11. Press STAT, cursor over to CALC, and then cursor down to LinReg and press ENTER.
12. Key in L_1,L_2 and press ENTER. Record the statistics.
13. Repeat step 11 and then key in L_3,L_2 and press ENTER. Record the statistics.
14. Repeat step 11 and then key in L_4,L_2 and press ENTER. Record the statistics.
15. Press STAT, cursor to CALC, and then cursor down to PwrReg and press ENTER. Record the statistics.

RESULTS and CONCLUSIONS

This is an opportunity to discuss this example of real science with your students. Scientist collect data and then try to understand what the data mean, that is, they try to understand the relationship of the variables. As is apparent from the various methods of analyzing the data as suggested above, some methods of data analysis do not yield unequivocal results.

1. What is the relationship between distance and light intensity? Defend your decision using the graphical and statistical results found above.
2. What is the true (i.e. accepted) relationship?
3. Suggest some reasons why the data do not conform more closely to the true relationship.
4. Suggest ways to modify the lab procedure to produce data the better conforms to the true relationship, that is, how would you improve the experiment?
   You might consider awarding extra credit points for students who are willing to perform the experiment again incorporating their suggestions.

APPENDIX

An Inexpensive Optical Bench for TI Light Sensor Experiments
By Austin Raabe
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INTRODUCTION

In the past, I tried to demonstrate the inverse square law by having my students perform experiments described in Texas Instrument's Experiment Workbook, Vernier's Physical Science with CBL(by D. L. Volz and S. Sapatka), and Vernier's Physics with CBL(by J. Gastineau, K. Appel, C. Bakken, R. Sorensen, and D. Vernier). I found the apparatus described to be difficult to use and the results unsatisfactory. In an attempt to improve the experimental practice and results, I devised the inexpensive optical bench described below. Although the data I have obtained are more reproducible and more closely approximate the inverse square model, because I have a limited number of light probes to experiment with, I cannot predict with certainty that you will achieve comparable results. I did find that several of the construction and procedural details are critical. These items will be noted below.

Construction of the apparatus requires inexpensive and readily available tools and materials. The design is similar to the apparatus displayed at http://www.omni-optical.com/l-optics/sl205.htm but avoids the specialized metallic fixtures. Figures 1 and 2 show the side and overhead views of the apparatus.

Figure 1

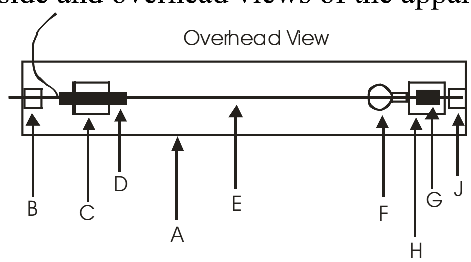


Figure 2

A. Base
B. Left meter stick support
C. Light sensor slider
D. Light sensor
E. Meter stick
F. Flashlight bulb
G. Battery holder
H. Light bulb slider
J. Right meter stick support

MATERIALS LIST

1. Wood 2"X 4". Length depends upon how many apparatus you are making. Home Depot, 8' length =$2.04
2. Wood 1"X 4". Length depends upon how many apparatus you are making. Home Depot, One 8' length =$2.19
3. Wood 2"X 2". Length depends upon how many apparatus you are making. Home Depot, One 8' length =$1.97
4. Flashlight bulb (F), 2.47V, unfocused. Radio Shack, #272-1132, $1.49/2
5. Light bulb base. Radio Shack, #272-0357, $1.59
6. AA battery holder(G). Radio Shack, #270-0408, $1.49
7. Screws for Light bulb base and battery holder. Flat Phillips 4X3/4 Wood
8. Two AA batteries.
9. Electrical tape.
10. Black construction paper.
11. Meter or yard stick. Note! Check the thickness of the meter or yard stick **before** cutting the wood.

TOOLS LIST

1. Saw. Either hand, or preferably, a chop or miter saw.
2. Drill.
3. Screw drivers.
4. Drill bit 1/8".
5. Drill bit 5/8".

CONSTRUCTION PROCEDURE

1. Cut the base (A) from 1"X 4" wood. The length is not critical.
2. Cut two 2" pieces (B and J) from the 2"X 2" wood. Note! Although the wood is sold as 2"X 2", it is actually 1 3/8" X 1 3/8".
3. Measure both pieces as shown below in Figure 3 and cut the notch cut with a saw. The width of the notch depends upon the thickness of your meter stick. My meter stick from Frey Scientific, required a 5/16" width.

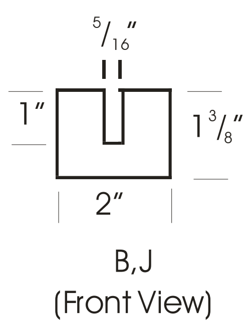


Figure 3

4. The hole drilled at "K" in Figure 4 with a 1/8" drill bit is optional. A bolt or nail inserted through the hole acts as a stop for the meter stick and helps to hold it in position.

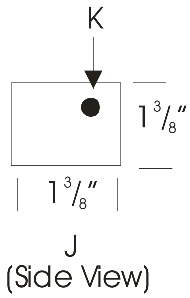


Figure 4

5. Cut two 2" pieces from the 2"X 4" wood. Cut the notch in both pieces as shown below in Figure 5.

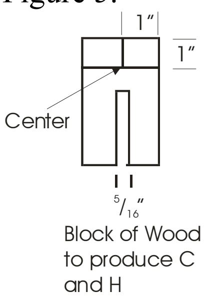


Figure 5

6. Align the notches of the two pieces and at the center point indicated, drill a 1/8" hole through the front piece and partially through the back piece. This process ensures that the light sensor and the light bulb are aligned.
7. Take the front piece and drill a 5/8" hole through the wood. Do this on a drill press or carefully position the hand drill to ensure the hole is straight. The front piece should resemble Figure 6.

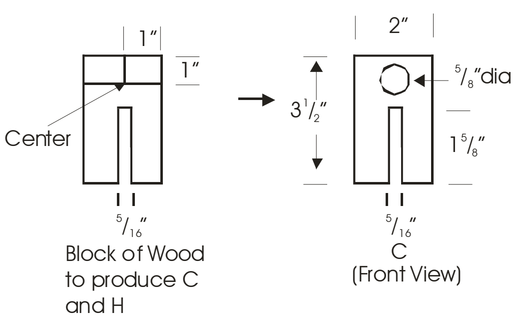
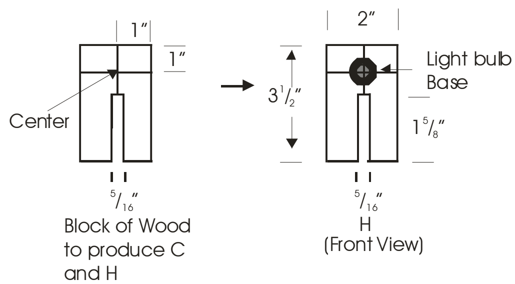
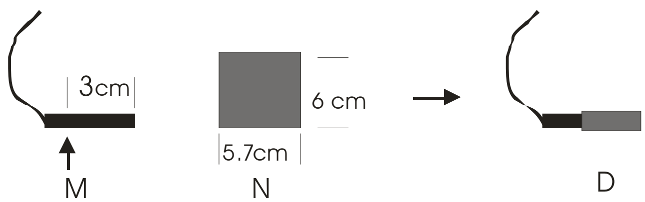


Figure 6

8. Take the back piece and draw two lines through the center of the 1/8" hole so that the flashlight bulb holder will be centered. Center the bulb holder and attach with the #6X ½" metal screws as shown below.



9. To exclude extraneous light from the light sensor, form a tube from black construction paper and slip it over the front of the taper as shown and described below.



Place a mark (M) on the light sensor exactly 3cm from the end. Cut a piece of black construction paper (N) exactly 5.7 cm long and about 6 cm wide and then wrap the paper around the sensor so that the edge is at "M". The reason that the paper is 5.7 cm long is because the sensor element is 0.3 cm from the end, hence the end of the paper nearest the bulb is exactly 3 cm from the sensing element. If the light bulb's heating element is positioned at 0.0 cm on the meter stick and the end of the paper tube is at the 1.0 cm on the meter stick, the distance from the light bulb's heating element to the probe's sensing element is exactly 4.0 cm. Thus, for this data point you would use 4.0 cm in your intensity vs. distance calculations.