Exploring Light Intensity

Part A: Making Conjectures: What happens to *light intensity* when you tint your windows?

1. What are the factors of window tint that may impact light intensity?

2. Generate a list of conjectures regarding the relationship between light intensity and window tint.

3. Sketch a graph of your conjecture about the relationship between the value of light intensity and the layers of window tint. Label the axes appropriately.

Part B: Collecting Data

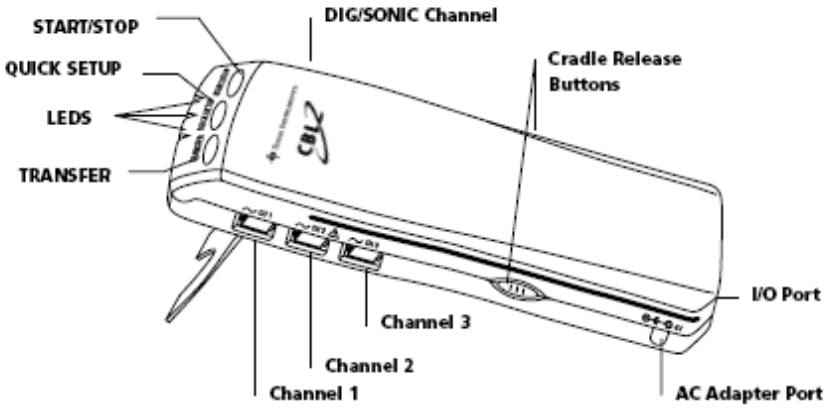


Figure 1. CBL 2 Features

- **About the Calculator-Based Laboratory 2™:**
  The Calculator-Based Laboratory 2™ (CBL2™) by Texas Instruments can be used to collect real-world data. In this activity, the CBL2™ will be used to collect light intensity values based on various amounts of window tint. The CBL2™ will report light intensity values in mW/cm^2 (That is, milleWatts per square centimeter -- this is the default setting). This setting will be detected once you plug the light sensor probe into the CBL2™ unit.

- **What you need to start:**

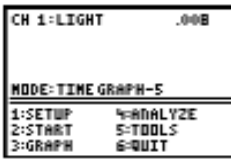
  - One CBL2™ per group
  - One light sensor
  - Graphing Calculator for each person
  - Suitable light source
  - 4-8 sheets of window tinting material

- **About the Light Source:**
  If possible, natural light should be used for this experiment. This light can be obtained from a window or outside in the shade (avoid direct sunlight). If indirect sunlight is not available, "night lights" that use Christmas-tree bulbs are the next best source – fluorescent lights and the lights from an overhead projector will not work, however a standard incandescent desk lamp will. The light intensity should be measured at a consistent distance from the light source.

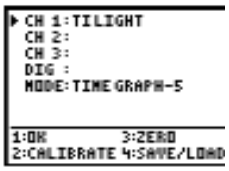
A. Once you have set up the calculator with the CBL2™ (See CBL2™ Cheat Sheet), plug the LIGHT Sensor into CH1 and connect the CBL2™ to the best calculator in the group. (TI-83 plus and TI-84 have the most memory and so will work more quickly and smoothly than earlier models).

B. Go to APPS key and load the DataMate application. (Note that a second beep will tell you when the download is complete.)

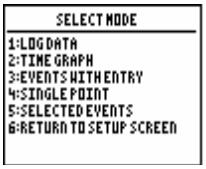
C. When the DataMate screen comes up, choose [1:SETUP]



D. You want to toggle down to [MODE:] and hit ENTER to change the mode.



E. Select [3:EVENTS WITH ENTRY]

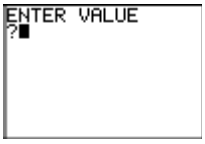


F. Select [1:OK]

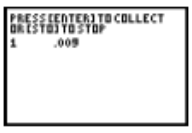
G. Select [2:START]

H. You should see a screen similar to the one on the right. Notice that the reading changes as you move the light probe. The number on the left represents the data point you would be reading (i.e., in the screen, you see a [1] because this will be the first data point you have stored). You are now ready to make a series of light measurements with the light probe.

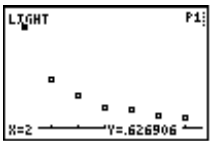
I. Wait for the reading to stabilize somewhat, and then take your first light measurement.
   a. Record the value on the table on the next page.
   b. Hit ENTER. You will see a screen like the one shown on the right.
   c. Enter [0] because you have no sheets of tint on the sensor.



J. Lay one sheet of tint over the sensor. Make sure the sensor is in the same position (with respect to the light source) as the first reading. When the reading is pretty stable,
   a. Record the value on the table on the next page.
   b. Hit ENTER. You will see a screen like the one shown on the right.
   c. Enter [1] for 1 layer of tint, when asked to enter a value



K. Repeat this process until you have 9 readings. Then hit STO>. Your screen should look something like this.



Each member of the group should fill out the table.

# of layers	Light intensity (mW/cm^2)
0	
1	
2	
3	
4	
5	
6	
7	
8	

4. On separate paper, construct an accurate graph of your data. Remember to label the axes appropriately.

5. How does your graph compare to your original conjectured graph? (E.g., what are appropriate input and output values that can be expected?)

6. Summarize your findings. Consider the following questions:
    - How is light intensity related to the amount of tint used?
    - Is the rate-of-change increasing, decreasing, or constant?
    - Do you have any data that is inconsistent with your findings?
    - How does this graph differ from a graph exhibiting linear behavior?

Part C: Data Analysis and Modeling

If you do not regularly use or teach exponential functions or want to review some of the foundational concepts of exponential functions, complete this section. If you have considerable expertise using exponential functions, go on to Part D.

1. Enter the data from the table into the `[LIST]` on your calculator.

2. Perform an exponential regression on the data. (Recall, you need to toggle right to `[CALC]` and choose `[0:ExpReg]`)

3. Write the function that models the data.

4. What is the *initial value*? What does it mean in the context of the problem?

5. What is the *Growth/Decay Factor*? What does it mean in the context of the problem?

6. What does the exponent represent in this problem?

7. Based on the data, what percent of light is blocked by each layer of tinted material? Explain your reasoning.

You should now proceed to Part E.

Part D: Comparing Models

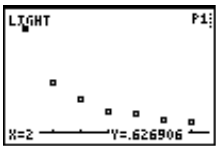
If you have considerable expertise using exponential functions, then complete this section. If you do not regularly use or teach exponential functions or want to review some of the foundational concepts of exponential functions, go on to Section E.

How you proceed in this section will depend on whether or not you collected the data with the CBL2™ attached to your calculator.

7. If you did not have your calculator attached to the CBL2™ , follow these instructions:
   a) Enter the data from the table into the [LIST] on your calculator.
   b) Perform an exponential regression on the data. (Recall, you need to toggle right to [CALC] and choose [0:ExpReg])
   c) Write the function that models the data.

8. If you did have the CBL2™ connected to your calculator, follow these instructions:

   a) From the screen with the graph, ENTER will take you out of the graph and into the "Graphing Menu"

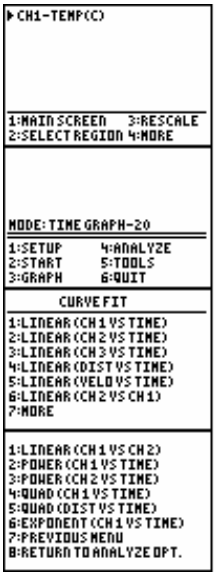


   b) Hit [1] to return to main screen

   c) On the main menu, choose {4:ANALYZE]

   d) Under ANALYZE OPTIONS choose [2:CURVE FIT]

   e) Under CURVE FIT, choose [7:MORE] then [6:EXPONENT]followed by ENTER



   f) Write the function that models the data.

9. Compare the two functions – the one generated in (7) and the one generated in (8). Are these functions the same or different? Offer a mathematical justification for your answer.

10. Based on the data, what percent of light is blocked by each layer of tinted material? Explain your reasoning using both functions.

Part E: Extension

11. If each sheet of window tinting blocks 15% of the light, what is the smallest number of layers of window tinting needed to block at least 50% of the light?

12. What if you can buy layers of window tint that are 30 times darker than the tint you used in the light experiment. How does this situation alter your function developed earlier? How will the light intensity be changed as a result of the increased amount of tint? How does this value compare to the graph of your data? Is it possible to completely block all light using tinted squares? Explain.

13. What if you can buy layers of window tint that are 2.5 times darker than the tint used in the light experiment. How does this situation alter your function developed in your experiment? How will the light intensity be changed as a result of the increased amount of tint? How does this value compare to the graph of your data?