Shedding Light Experiments

NAME _____

The following describes several different experiments that can be performed to measure the change in light intensity as the depth of water increases.

Experiment 1 – PlexiGlas®

Use a steady light source, such as the light from a window or from a flashlight. Connect a light sensor to a Calculator-Based Laboratory™ (CBL). Do not connect the CBL to a graphing calculator. To take a reading, press the MODE button on the CBL. You should see the word "Sampling" flash on and off. When you are not taking a reading, press MODE or ON to save power.

Take the following readings with the CBL:

- Take a reading with no light on the sensor (cover the sensor with your hand).
- Take a reading directly from the light source (with the sensor directly exposed to the light).
- To model incremental depths, layers of tinted Plexiglas will be used to represent layers of water. Add a layer of Plexiglas between the light source and the sensor. Determine the reading for a depth of 1. Then repeat this process, increasing the depth by 1 each time for as many layers as you can.

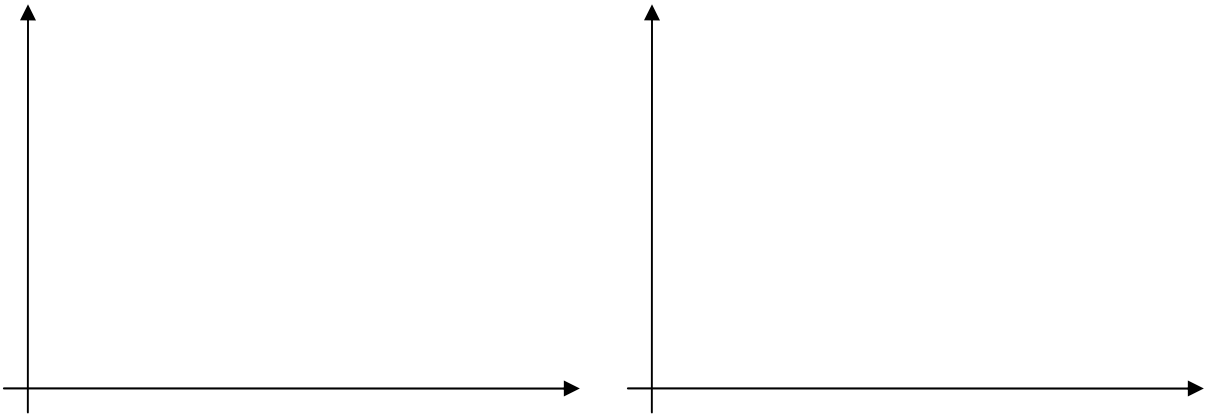
1. Record your data in the table below.

Depth d	Light Intensity $I(d)$	$I(d + 1) - I(d)$

2. Graph the light intensity as a function of depth. Do all the data points seem reasonable and follow a common curve? If not, are there data points you think should be removed? Explain how the graph compares to your conjecture from the previous lesson.

3. Using $I(d)$ to represent the light intensity at the current layer of Plexiglas, and $I(d + 1)$ to represent the light intensity at the next layer, calculate the difference in light intensity between consecutive layers of Plexiglas $I(d + 1) – I(d)$. Record the difference in the third column of the table above.

4. Plot $I(d + 1) – I(d)$ against the depth d. Also plot $I(d + 1) – I(d)$ against the light intensity $I(d)$. Explain why an equation of $I(d + 1) – I(d)$ vs. $I(d)$ may be easier to find than the other two.



5. Find an equation for $I(d + 1) - I(d)$ vs. $I(d)$. Solve your expression for $I(d + 1)$. The resulting equation for $I(d + 1)$ is a *recurrence relation*. Make sense of your equation by explaining what each part of the equation represents, why the numbers are the size they are, and why they have the sign they have.

6. Plot this recurrence relation on the same axes as the data in Question 4. What initial value should be used for the recurrence relation? How does the model fit the data? What explanation can you give for any deviation?

7. Find a general expression for $I(d)$ in terms of initial value $I(0)$. Begin by using your recurrence relation to write $I(1)$ in terms of $I(0)$. Express $I(2)$ using $I(1)$. Substitute your first expression for $I(1)$ to express $I(2)$ in terms of $I(0)$. Express $I(3)$ in terms of $I(2)$ and then in terms of $I(0)$.

8. Write a short summary that explains (i) how light intensity relates to the number of layers of Plexiglas (depth), and (ii) how could you use the data to test if a function similar to the light intensity function would model the data?

Experiment 2 – Column of Water

Like Experiment 1, this experiment models light through a depth of water, but it uses a column of water instead of layers of PlexiGlas®.

At the bottom of a tube, place a light sensor connected to the CBL. Do not connect the CBL to a graphing calculator. Before recording any light intensity readings, choose a method you will use to record the readings given by the CBL. You will need to decide what reading to record. Some possibilities are to note the maximum, minimum, average or most frequent reading. Place a light source at the top of the tube.

Take the following readings with the CBL:

- Take a reading with no water in the tube and no light in the tube (cover the top).
- Take a reading with no water but with your light source.
- Add a fixed amount of water of your choosing. Repeat to gather readings until the top of the tube is reached. You will want to gather about ten readings. Your light source may initially overwhelm the sensor. The first few readings may therefore be questionable.

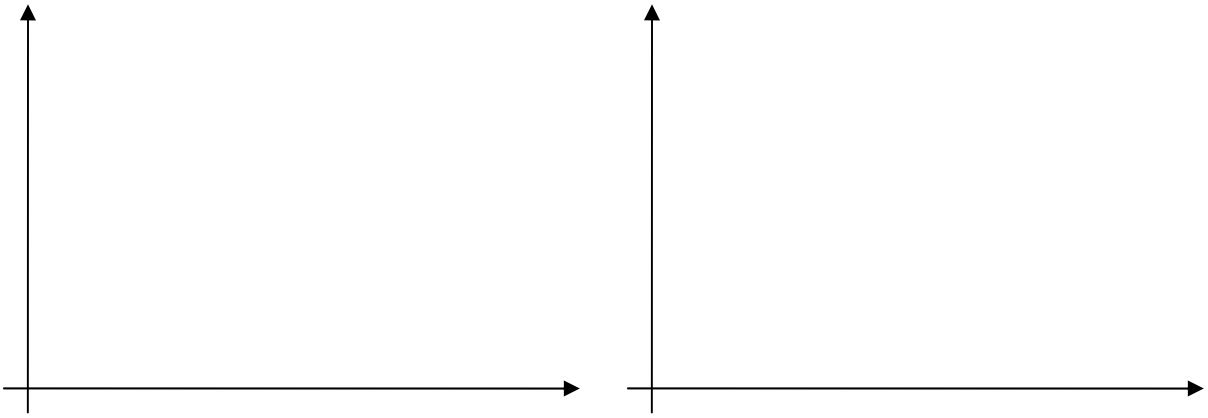
9. Record your data in the table below.

Depth d	Light Intensity $I(d)$	$I(d + 1) - I(d)$

10. Graph the light intensity as a function of depth. Do all the data points seem reasonable and follow a common curve? If not, are there data points you think should be removed? Explain how the graph compares to your conjecture from the previous lesson.

11. Using $I(d)$ to represent the light intensity at the current depth of water, and $I(d + 1)$ to represent the light intensity at the next layer, calculate the difference in light intensity between consecutive layers of Plexiglas $I(d + 1) – I(d)$. Record the difference in the third column of the table above.

12. Plot $I(d + 1) – I(d)$ against the depth d. Also plot $I(d + 1) – I(d)$ against the light intensity $I(d)$. Explain why an equation of $I(d + 1) – I(d)$ vs. $I(d)$ may be easier to find than the other two.



13. Find an equation for $I(d + 1) - I(d)$ vs. $I(d)$. Solve your expression for $I(d + 1)$. The resulting equation for $I(d + 1)$ is a *recurrence relation*. Make sense of your equation by explaining what each part of the equation represents, why the numbers are the size they are, and why they have the sign they have.

14. Plot this recurrence relation on the same axes as the data in Question 4. What initial value should be used for the recurrence relation? How does the model fit the data? What explanation can you give for any deviation?

15. Find a general expression for $I(d)$ in terms of initial value $I(0)$. Begin by using your recurrence relation to write $I(1)$ in terms of $I(0)$. Express $I(2)$ using $I(1)$. Substitute your first expression for $I(1)$ to express $I(2)$ in terms of $I(0)$. Express $I(3)$ in terms of $I(2)$ and then in terms of $I(0)$.

16. Write a short summary that explains (i) how light intensity relates to the depth of the water, and (ii) how could you use the data to test if a function similar to the light intensity function would model the data?

Experiment 3 – Simulated Dive Online

Using the Simulated Dive online activity, collect data for at least ten different depths.

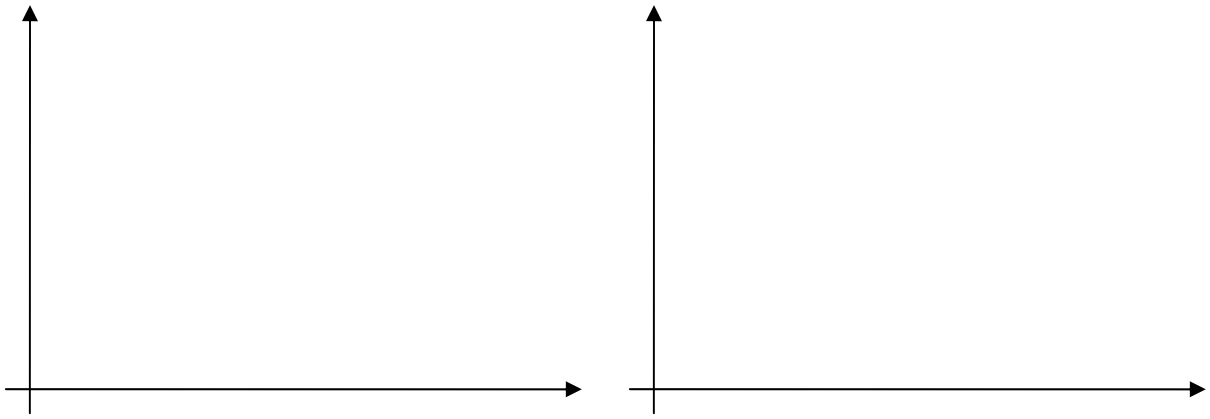
17. Record your data in the table below.

Depth d	Light Intensity $I(d)$	$I(d + 1) – I(d)$

18. Graph the light intensity as a function of depth. Do all the data points seem reasonable and follow a common curve? If not, are there data points you think should be removed? Explain how the graph compares to your conjecture from the previous lesson.

19. Using $I(d)$ to represent the light intensity at the current depth of water, and $I(d + 1)$ to represent the light intensity at the next layer, calculate the difference in light intensity between consecutive layers of Plexiglas $I(d + 1) – I(d)$. Record the difference in the third column of the table above.

20. Plot $I(d + 1) - I(d)$ against the depth d. Also plot $I(d + 1) - I(d)$ against the light intensity $I(d)$. Explain why an equation of $I(d + 1) - I(d)$ vs. $I(d)$ may be easier to find than the other two.



21. Find an equation for $I(d + 1) - I(d)$ vs. $I(d)$. Solve your expression for $I(d + 1)$. The resulting equation for $I(d + 1)$ is a *recurrence relation*. Make sense of your equation by explaining what each part of the equation represents, why the numbers are the size they are, and why they have the sign they have.

22. Plot this recurrence relation on the same axes as the data in Question 4. What initial value should be used for the recurrence relation? How does the model fit the data? What explanation can you give for any deviation?

23. Find a general expression for $I(d)$ in terms of initial value $I(0)$. Begin by using your recurrence relation to write $I(1)$ in terms of $I(0)$. Express $I(2)$ using $I(1)$. Substitute your first expression for $I(1)$ to express $I(2)$ in terms of $I(0)$. Express $I(3)$ in terms of $I(2)$ and then in terms of $I(0)$.

24. Write a short summary that explains (i) how light intensity relates to the depth of the water, and (ii) how could you use the data to test if a function similar to the light intensity function would model the data?