Score: / 25

Names: ____

Group #__________

Period #__________

Light Brightness, and Distance

You probably have noticed that a light appears to be brighter when you are close to it, and dimmer when you are farther away. If you are reading a book that is illuminated by a single light bulb, the amount of the light that strikes the page will increase as the page is brought closer to the light source. Using a Light Sensor, you can determine how the illumination varies with distance from the source and compare that result to a mathematical model.

Recall that **E** is illumination measured in lux (or lm/m^2), and it is a measure of how bright an object is when light is shined on it. In this lab, the Vernier Light Sensor will be the object that light is shining on. **P** is the luminous flux of the light source measured in lumens (lm), and it is a measure of how bright the light source itself is. The distance between the source and the object is **r**, which is normally measured in meters. This lab is set up so that we record the distance in cm. The illumination on the screen should decrease as distance increases, and that is what you will study today. In this experiment you will measure illumination at a variety of distances on a screen from a small source of light. By plotting E vs. r, you will observe graphically how illumination varies with distance. Then, by doing an inverse square curve fit, you will calculate the luminous flux of the source and compare it to a known value. Finally, you will explain how the results of this experiment support the model of light as a stream of particles.

OBJECTIVE

- Study the mathematical and graphical relationship between illumination and the distance from the light source.
- Calculate the luminous flux of the light source and compare it to a known value.

MATERIALS

Computer

Vernier Lab Pro computer interface

Logger *Pro* software

Light Sensor (placed securely in holder from Vernier OEK)

Light source (from Vernier Optics Expansion Kit)

INITIAL SETUP

1. Place the light source on the track so that the **back end of the holder** is at the 10 cm mark on the track. The light should be shining toward the larger numbers on the track.
2. Place the light sensor on the track facing the light source. The **arrow at the center of the holder** should be at the 20 cm mark on the track.
3. The sensor is now 10 cm away from the source. Call the teacher over to your table to verify your setup.
4. Plug in the Lab Pro, connect the Light Sensor to CH 1, and connect the Lab Pro to your computer with the USB cord.
5. Open Logger Pro. Click on file → open → *Physics with Vernier* → 29 Light Brightness Dist. The meter window will display illumination. There will also be a data table and graph displayed.
6. Calibrate the Light Sensor. Do this by making sure that the light source is off. Then move the light sensor until it touches the source, which is turned off. There should be no light getting into the sensor. Then click on Experiment → zero. Now you can move the sensor back to its starting position (20 cm).
7. Make the area between the source and the sensor as dark as possible. Turn down the lights to darken the room. A dark room is critical to obtaining good results. Also use the test dividers to provide extra shading if necessary. There must be no reflective surfaces behind or beside the bulb.

PROCEDURE

1. Turn on the light source. Notice the value of "Illumination" in the Logger Pro window. This value represents the illumination measured by the light sensor. What is your prediction for the relationship between illumination and the distance to a light source? In the prediction section below, explain what you expect to happen to the illumination as you move the light sensor away from the light source. After making your prediction, slowly move the sensor away from the source and observe how the Illumination value changes as you move it.

   Prediction:

   Observation:

2. After at least 5 minutes of qualitative observations in step 1, place the light sensor back at the 20 cm mark on the track. Click ▶ Collect to begin data collection. Be careful not to press the ■ Stop button until the very end of the experiment (step 6 below).

   Important Note: You must wait at least 5 minutes before making formal measurements to give the light source time to warm up.

3. Wait until the illumination value displayed on the screen stops changing in a single direction. Click Keep and wait a few seconds while the computer processes the data point. Then type the distance (in cm) between the sensor and the source when prompted and click OK to record the value of illumination. It should be 10 cm for your first data point. A point will be added to the data table and plotted on the graph.

4. Move the Light Sensor 2.0 cm farther away from the light source and repeat Step 3.

5. Repeat Step 4 moving the sensor in 2.0 cm increments until the Light Sensor is 28 cm from the light source. For the final data point, the light sensor should be the 38 cm mark on the track.

6. Click ■ Stop when you have finished collecting all the data. Place a screenshot of the data table in the data section of your lab report.

CALCULATIONS

1. Examine the graph of illumination *vs*. distance. To see it better, select **Analyze → Autoscale → Autoscale from zero**. This shape is a classic "invers square law," which is very important in physics. For example, many forces such as gravity and electricity follow inverse square laws also.

2. Fit a model to your data.

   a. Click the Curve Fit button, . Select inverse square from the list of curve fits displayed. You might have to scroll down a little to get to this option. Then click Try Fit.

   b. A best-fit curve will be displayed on the graph. The curve should closely match the data.

   c. Place a screenshot of your Illumination vs. Distance graph with the curve fit information in the data section of your lab report.

3. How well does the inverse square function fit your experimental data? Does your data approximately follow an inverse square function?

   (**hint**: The closer the correlation is to 1.00, the better the fit. A correlation of 0.940 or higher is good for this experiment.)

4. Recall the equation for illumination ($E = P/4\pi r^2$). Based on that equation and the data from your curve fit, solve for the luminous flux (in lumens) of the light source.

CONCLUSIONS

1. Ask the teacher for the theoretical value of the luminous flux for your light source, then calculate your percent error.

2. List two sources of error, which could help explain why your experimental value for P might not be the same as the theoretical value.

3. Explain how the results of this experiment support the model of light being a stream of particles emanating from a source.