

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 this page illuminated by a single light bulb, the amount of the light that strikes this page will increase as the page is brought closer to the light source. Using a Light Sensor, you can determine how the brightness of light varies with distance from the source and compare that result to a mathematical model.

There are several ways to measure the brightness of light. Since this experiment can be performed with any of several different light sensors, each of which measure slightly different quantities, we will just use the word *intensity* to describe the relative brightness of the light, although the term may not be strictly appropriate for your sensor. Regardless of the way light is measured, the same relative changes with distance are observed, and that is what you will study today. In this experiment you will measure light intensity at a variety of distances from a small source of light, and see how the intensity varies with distance.

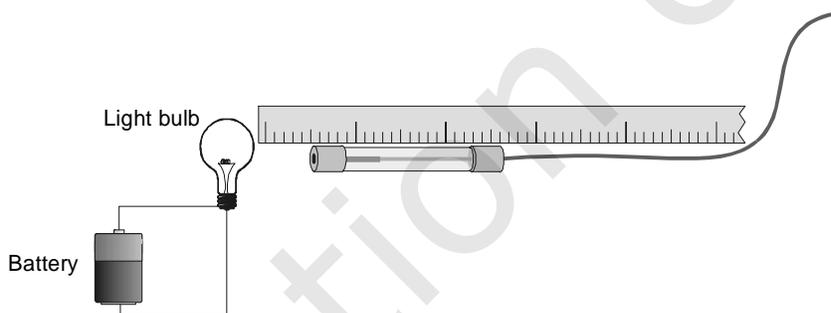


Figure 1

OBJECTIVE

- Determine the mathematical relationship between intensity and the distance from the light source.

MATERIALS

computer
Vernier computer interface
Logger Pro
Light Sensor

meter stick
or Vernier Dynamics System and Optics
Expansion Kit
clear glass light bulb (1.5 V penlight type)
battery (1.5 V)

PRELIMINARY QUESTIONS

- Suppose a small light source is placed at the center of two transparent spheres. One sphere has a radius R , and the other a radius $2R$. Energy in the form of light leaves the source at a rate P . That same power P passes through the surface of the inner sphere and reaches the outer sphere. Intensity is the power per unit area. What is the intensity at each sphere? Solve this problem by considering the following:

- How does the power passing through the inner sphere compare to the power reaching the outer sphere?
- How do the surface areas of the two spheres compare?
- In general, then, how will the intensity vary with distance from the source?

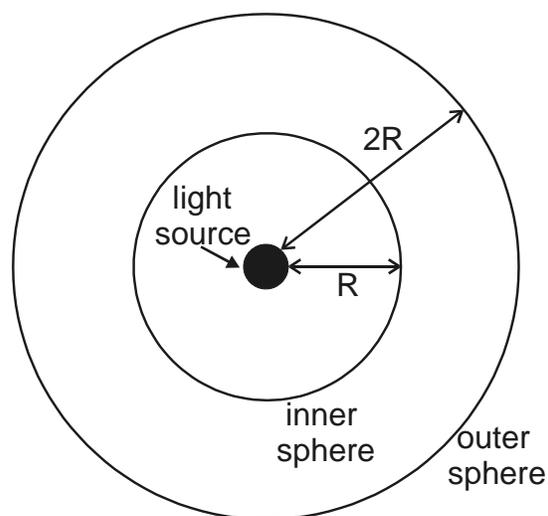


Figure 2

- Since most light bulbs that you use are not true point sources of light, how do you think the answer to Question 1 would change if a typical light bulb were used?

INITIAL SETUP

- Connect the Light Sensor to Channel 1 of the interface. If your sensor has a range switch, set it to the 600 lux range.
- Make sure that the filament axis of the light bulb is horizontal and pointing directly at the Light Sensor. This makes the light bulb look more like a point source of light as seen by the Light Sensor.
- The filament and Light Sensor should be at the same vertical height (Figure 1).
- Place the end of the filament (not the glass) at the 0.0 cm mark of the meter stick.
- Open the file “29 Light Brightness Dist” in the *Physics with Vernier* folder. The meter window will display light intensity.
- Turn down the lights to darken the room. A dark room is critical to obtaining good results. There must be no reflective surfaces behind or beside the bulb.

PROCEDURE

- Place the Light Sensor 2 cm from the light bulb filament and note the value of intensity in the Meter window. Make sure that the intensity changes as you move the sensor, otherwise you may need to switch to a less sensitive scale or use a less intense light source. Move the sensor away from the bulb and watch the displayed intensity values. What is your prediction for the relationship between intensity and the distance to a light source?
- Click to begin data collection. Place the Light Sensor 2 cm from the light bulb filament. **Important:** The distance must be measured carefully. Be sure you measure from the filament of the lamp to the sensor on the Light Sensor.

3. Wait for the intensity value displayed on the screen stops changing in a single direction. Click , then type the distance between the Light Sensor and the light source and click to record the value of intensity. A point will be plotted on the graph.
4. Move the Light Sensor 1 cm farther away from the light source and repeat Step 3.
5. Repeat Step 3 moving the sensor in 1 cm increments until the Light Sensor is 10 cm from the light source.
6. Click when you have finished collecting data. In your data table, record the intensity and distance data pairs displayed in the table (or, if directed by your instructor, print a copy of the table).

DATA TABLE

Distance (cm)	Intensity

ANALYSIS

1. Examine the graph of light intensity *vs.* distance. Does it appear to be consistent with the model you predicted in the Preliminary Questions? How can you tell?
2. Fit a model to your data.
 - a. Click the Curve Fit button, . Select inverse square from the list of curve fits displayed, then click .
 - b. A best-fit curve will be displayed on the graph. The curve should closely match the data.
3. How well does the power regression fit your experimental data? Do your data approximately follow an inverse square function? Does the equation agree with your model of light intensity using the concentric spheres?
4. List some reasons why your experimental setup might not match the relationship you predicted in the Preliminary Questions between intensity and distance.

EXTENSIONS

1. Confirm the relationship between intensity and distance by finding the linear plot of $I = k \cdot 1/d^2$. Use *Logger Pro* to verify the inverse square relationship between intensity and

distance. Enter the data, then create a modified column of data with the heading “Distance⁻²” to represent $1/d^2$. Graph intensity vs. distance⁻². A straight line that passes through the origin would verify the inverse square relationship.

2. If you have a window facing the sun, it may be interesting to try an experiment to measure the intensity of the sun. If your sensor has a range switch set it to the 150,000 lux range and load the calibration for that setting. Place the Light Sensor 10 cm from a 150 W clear light bulb and measure the intensity. Point the Light Sensor at the sun and measure the intensity of the sun relative to the light bulb. How many light bulbs would you have to place 10 cm from the Light Sensor to be equal to the intensity of the sun? Use the mathematical relationship found in this lab to calculate the intensity of the sun if it was placed 10 cm from the Light Sensor. Determine how many of these light bulbs would be equivalent to this value.
3. Use the Light Sensor to measure the intensity of the sun over the period of an entire school day.
4. Use the Light Sensor to examine sunglasses. By what percentage is the sun’s intensity reduced when sunlight passes through the lens of sunglasses?
5. Use the sensor to compare other light sources to the light source that you used in the lab. For instance, how does intensity vary as you move away from a long fluorescent bulb or a circular fluorescent bulb?

Vernier Lab Safety Instructions Disclaimer

THIS IS AN EVALUATION COPY OF THE VERNIER STUDENT LAB.

This copy does not include:

- **Safety information**
- **Essential instructor background information**
- **Directions for preparing solutions**
- **Important tips for successfully doing these labs**

The complete *Physics with Vernier* lab manual includes 35 labs and essential teacher information. The full lab book is available for purchase at:

<http://www.vernier.com/cmat/pwv.html>



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