Name ________________________ Date ____________ Partners________________________________

Light Intensity versus Position

Background:

The light from a point light source spreads out uniformly in all directions. The intensity at a given distance r from the light will be equal to the power output of the light divided by the surface area of the sphere through which the light has spread. Since the area of a sphere varies as the square of its radius r, the intensity will vary as $1/r^2$.

A Light Sensor is used to measure the intensity of light directed into it. The Light Sensor used in this lab is a Si PIN photodiode that responds to light in the 320 nm through 1100 nm wavelength range, so it is capable of measuring the intensity of all visible light. The light incident on the photodiode in the Light Sensor creates electron-hole pairs within the Si photodiode causing a current to flow. The voltage produced by this flowing current is what the PASCO probe is measuring. Consequently, all the measurements will plot the voltage measured from the Light Sensor as a function of the distance from the Sensor. As more light reaches the photodiode, the voltage across the photodiode will increase.

Purpose:

The purpose of this activity is to investigate the relationship between light intensity and the distance from a light source. The lab will answer whether the total light energy that passes through an imaginary spherical boundary changes as the distance from the point light source increases. Additionally, the lab will determine whether the light intensity on the surface of an imaginary spherical boundary changes as the distance from the point light source increases. Finally, the lab will examine how the change in light intensity with distance for a 'real' light source compares to the change in light intensity for an ideal 'point' light source.

Materials

Incandescent (desk) lamp	Meter Stick
Pasco Light Sensor (model CI-6504A)	Ring stand, 90° holder clip, finger clamp
Analog connector cable	Masking tape

Procedure:

1. Open *Data Studio* and from the menu prompt select OPEN ACTIVITY. Look under TeachingLabs on Mr. Wizard and click on the PHYS 636 folder. Find the file "Light Intensity vs. Distance from Light Source" and open it.

Modified from Activity P33:
Light Intensity versus Position,
PASCO Scientific 1999, pp.239-247

2. There are three windows that appear on the screen. The first one is a table called "Intensity of Light vs. Distance from Light Source". This table will be where you record all of the measurements obtained in the lab. You will record the distance from the lamp to the light sensor in the left column and voltage (corresponding to the light intensity reaching the Light Sensor) in the right column. The second window displays a graph, which will record your intensity/position measurements as they are recorded in the data table. The third window reads the voltage recorded by the Light Sensor. This voltage, proportional to the light intensity, is what you will record in the left column of the data table.

3. Turn on the desk lamp and under the top menu select EXPERIMENT and MONITOR DATA. You will notice that the Digits display window is now recording the voltage. Turn out the room lights and arrange your Light Sensor to minimize stray light sources from windows, doors, and other groups. Have your Light Sensor face a dark area if possible. Become familiar with the GAIN multiplier on top of the Light Sensor by moving the desk lamp closer to the Light Sensor and farther away from the Sensor. Remember that the Light Sensor can only read **a maximum of 4.8 V** before it reaches saturation, regardless of the GAIN that is being used. Set the distance from the bulb to the Light Sensor to be 1 m, and you will observe the minimum voltage in the Digits display window measured in this experiment. Adjust the GAIN setting on the Light Sensor and intensity of the desk lamp so the Light Sensor is able to observe a lamp intensity of about 0.1 V to 0.4 V at 1 m. Highlight the Table on the left and type in the distance, which should still be 1.0 m. Measure it precisely. Type Tab and you are prompted to type in the Voltage reading from the Digit display. Type enter and you are ready to enter the next distance. Notice that the graph will automatically update to include this new point when you push enter.

4. Repeat this process of recording the voltage and distance from the Light Sensor every 5 cm closer to the source. Record as many points as possible before the Light Sensor reaches its maximum reading of 4.8 V. Then click STOP.

5. Click on the Graph window to have it supersede the Digits window. There should be a smooth set of data points corresponding to the data that was entered into the table.

6. Use the fit routine to plot an inverse square curve fit to your set of data points in order to determine whether intensity has varied as the inverse square of position in this experiment. Click on Fit and choose the INVERSE SQUARE FIT and a corresponding curve fit will be applied to the data set. Click on the Curve Fit icon (on the top row) or double-click on the box that appears on the graph that provides information about the curve fit. Record the fitting values below relating the inverse square of position and intensity.

Inverse Square Fit: A (Scale Factor) ______________

B (Y Offset) _________________

Mean squared error ____________

Root MSE ___________________

7. Write out below the fit to your data using your fitting equation.

Question 1: Discuss the fit to your data. Is it satisfactory?

Question 2: How does the total light energy that passes through an imaginary spherical boundary change as the distance from the point light source increases?

Question 3: Does the light intensity on a 1 cm^2 area of an imaginary spherical boundary change as the distance from the point light source increases? If so, how?

Question 4: How does the change in light intensity with distance for a 'real' light source compare to the change in light intensity for an ideal 'point' light source?

Question 5: What is the mathematical relationship between light intensity and distance?

Question 6: The light bulb is not really a point source. How does this affect the experiment (and what can be done to minimize the error)?

Sources:

Activity P33: Light Intensity versus Position. *Pasco Scientific*. 1999.

Horowitz, P. and Hill, W. *The Art of Electronics*. 2nd ed. New York: Cambridge University Press. 1989.