

Name _____ Date _____ Partners _____

Variation of Light Intensity

Sources:

Activity P32: Variation of Light Intensity (Light Sensor). *Pasco Scientific. 1999.*

Materials

<i>Pasco</i> Light Sensor (model CI-6504A)	Ring stand, 90° holder clip, finger clamp
Incandescent (desk) lamp	Analog connector cable
Fluorescent lamp	Flashlight
Lab jack	Tape

Purpose:

The purpose of this activity is to compare the variation in intensity of light from light source. You will compare how the light from a DC light source compares to light from an AC light source. You will also examine how the light from a fluorescent tube compares to the light from an incandescent bulb.

Background:

Electric light bulbs are powered by a 60 Hz (or 50 Hz in some countries) sinusoidal AC wave. The maximum amplitude of the voltage, and thus a maximum brightness, occurs twice per cycle because an electric bulb is excited when voltage increases, regardless of the polarity of the voltage. An electric bulb will have maximum intensity 120 times per second (or 100 times/second). It will also have a minimum (zero) intensity 120 times per second (or 100 times/second).

Fluorescent lights blink on and off at a particular frequency. The light intensity from incandescent bulbs powered by AC fluctuates as well. The light intensity from an incandescent bulb powered by DC should not vary.

In this experiment you will use a Light Sensor to measure the intensity of light from light bulbs powered by AC and DC. Use *DataStudio* to monitor and display the variations, if any, in the light intensity. Compare the light intensity of fluorescent and incandescent lights powered by AC, and an incandescent light powered by DC.

Part I: Experimental Setup

1. Open *Data Studio* and from the menu prompt select OPEN ACTIVITY. Choose Teaching Labs Mr. Wizard and then choose the PHYS 636 folder. Find the file “Variation of Light Intensity” and open it.

2. Place the incandescent lamp about 50 cm from the Light Sensor. You do not need to calibrate the Light Sensor for use in this experiment. However, you may need to adjust the sensitivity of the Light Sensor, depending on the brightness of the light source and how close the sensor is to the source. Turn out room lights.

The Light Sensor has a GAIN switch on top of the sensor box. The GAIN switch selects the amount of amplification for the signal that is sent to the interface. The settings are 1, 10, and 100. The setting of 10 amplifies the signal 10 times and the setting of 100 amplifies the signal 100 times. Let's begin with this switch on 1.

Turn on the desk lamp and under the EXPERIMENT menu choice in *Data Studio* select MONITOR DATA. You will notice that the time clock turns green to indicate that the program is monitoring data. You will also notice that the clock is counting upwards from zero to indicate the time since monitoring was initiated.

Two displays appear. One is **Digits 1** showing voltage values from the Light Sensor. The voltage values indicate light intensity detected. The other display is a **Scope** window that indicates the Voltage as a function of time. Notice that if you slide the desk lamp or the Light Sensor closer together or farther apart the voltage reading in the digits display will change depending on whether the light intensity is increasing or decreasing. Note that the Light Sensor can only measure voltages up to about 4.8 V for any GAIN setting. If the voltage reading in the Digits display is recording the maximum 4.8 V for the Light Sensor then the GAIN on the Light Sensor is either set too high or the Light Sensor is too close to the desk lamp. Change the distance between the Light Sensor and the desk lamp and the GAIN setting on the light sensor to become comfortable with their effect on the voltage reading. Remember that since the different light sources have different intensities, you will have to find optimal distances and GAIN settings for recording the voltage each time you change the light source.

An oscilloscope is a versatile measurement tool that can display "real-time" plots of voltage versus time or voltage versus voltage (in "X-Y" mode). The vertical and horizontal axes of an oscilloscope can be scaled independently while data is being displayed. Unlike a graph that has a beginning and an end, an oscilloscope's plot of voltage (known as a trace) is refreshed or "redrawn" continuously, as long as data are being measured. One other difference is that an oscilloscope displays voltages, not calculated values (for example, velocity). An oscilloscope can be set up so that a plot of voltage will begin when a specific starting condition (or 'triggering' condition) is met.

The Scope display in *Data Studio* can emulate an oscilloscope with up to three real time 'traces' in a single Scope display window at one time (more than one Scope display can be open at the same time). It displays data without storing it in memory. In addition, the Scope display cannot display stored data sets (data displayed in the Data List). As a result, any data that is seen on the Scope cannot

be displayed in any other *Data Studio* display after stopping data collection, unless you transfer the data of the last trace taken.

The Scope is well suited for displaying voltages that are changing rapidly, such as the signal from a Light Sensor or a high frequency analog output from the Signal Generator. For example, a single "screen" of the Scope can display the voltage from events that last for as short a time as 20 microseconds or as long as 10 seconds.

A colored line (perhaps red in this case) will appear in the scope display recording the continuous voltage data that is being recorded from the Light Sensor. If a colored line does not appear in the Scope window then the controls need to be adjusted so that the colored line appears. To adjust the controls you can first adjust the number of volts per vertical division on the Scope display by clicking on the left or right arrows. For example, if the control reads "5 ms/div", then the distance between two vertical lines on the Scope display represents a time difference of 5 ms. Similarly, the horizontal lines represent the number of volts per horizontal division as indicated by the control in the box in the top right corner of the window. There is also a vertical offset control in the top right corner of the display so that the voltage can be vertically offset from the x-axis, so that it appears in the Scope display. Experiment with the different controls to become comfortable with their use. Once you have become comfortable with their use, adjust the controls so that the sinusoidal wave representing light intensity (voltage) from the Light Sensor appears in the window. You can also click on the triangle on the left of the Scope display. When it turns to red, it has become active. This is a trigger level, and you can move it to a particular level to trigger the beginning of the voltage sweep on the Scope. This helps to stabilize the view. Set the time scale to 20 ms/div. Although this will look a little crowded on the Scope display, this allows us to later transfer a sufficient amount of data.

Now select STOP to stop monitoring the intensity of the desk lamp.

Part II: AC Incandescent (desk) Lamp

1. Now click on START to continue taking data. Adjust the position of the Light Sensor and the gain so that a voltage between 0.6 V and 2 V is being recorded in the Digits window.
2. Feel free to move the Scope window around so that both the Digits window and the Scope window are visible. If you have not already done so from the previous Experimental Setup, adjust the vertical offset adjustment and the voltage scale in the upper right hand window of the Scope display.
3. Save the Scope display data by clicking on the Transfer Data icon at the top of the Scope display window. To identify the Transfer Data icon, hover the

mouse over the icons momentarily to reveal a Tool Tip identifying the icon. Select STOP to stop monitoring data.

- Once you have identified the oscillating pattern of the Light Intensity, sketch its form below.



- Click on the Run icon under Voltage, ChA (this represents the recording voltage data from the Light Sensor) and drag the icon and drop it on the FFT icon in the Display window. A new window appears titled FFT 1 displaying a graph of the Relative Amplitude of the Light Intensity vs. Frequency (Hz). Move the mouse over the graph and notice that the arrow turns into a magnifying glass. The magnifying glass can be used to zoom in on a particular part of the graph. The maximum intensity peak appearing between 100 and 150 Hz is interesting, so zoom in on this portion of the graph by clicking on the graph and creating a box around the relevant portion of the graph. Do this several times until the area around the peak is displayed clearly. Measure the frequency of the peak by clicking on the Smart Tool icon at the top of the FFT window.
- Drag the Smart Tool over the peak maximum and record the frequency at this point in the Data Table below.

Data Table

Light Source	Frequency (Hz)
Incandescent, AC	
Fluorescent, AC	
Incandescent, DC	

Part III: AC Fluorescent Lamp

1. Close the Digits, Scope, and FFT display windows, unplug the desk lamp and plug in the fluorescent lamp.
2. Click *START* to begin recording the intensity from the fluorescent lamp. Drag the Run #2 icon under Voltage, ChA over the Digits display and drop it to observe the voltage. Adjust the position and GAIN of the light sensor until a suitable voltage between 0.5 V and 2 V is being recorded.
3. Drag the Run #2 icon under Voltage, ChA over the Scope display and adjust the controls to observe the voltage wave produced. Save the Scope display data by clicking on the Transfer Data icon at the top of the Scope display window. Sketch below a picture of the voltage wave displayed. You may want to use the trigger to get a clear illustration of the intensity variation.



4. Click *STOP* to stop recording data from the Light Sensor. Drag the Run #2 icon under Voltage, ChA over the FFT display and zoom in on the peak frequency. Using the Smart Tool, record the frequency corresponding to the maximum peak in the Data Table above.

Part IV: DC Incandescent Lamp (flashlight)

1. Close the Digits, Scope, and FFT display windows, unplug the fluorescent lamp and turn on the flashlight and tape it on the lab jack so that the beam is pointing into the Light Sensor.
2. Click *START* to begin recording the intensity from the flashlight. Drag the Run #3 icon under Voltage, ChA over the Digits display and drop it to observe the voltage. Adjust the position and GAIN of the light sensor until a suitable voltage between 0.5 V and 2 V is being recorded. The flashlight beam may need to be directed off-center in order to achieve this range.
3. Drag the Run #3 icon under Voltage, ChA over the Scope display and adjust the controls to observe the voltage wave produced. Save the Scope display

data by clicking on the Transfer Data icon at the top of the Scope display window. Sketch a picture of the voltage wave displayed below.



4. Click STOP to stop recording data from the Light Sensor. Drag the Run #3 icon under Voltage, ChA over the FFT display and zoom in on the peak frequency. Using the Smart Tool, try to find a maximum value for the peak.

Question 1: Do you observe a clear maximum peak for the flashlight? If not, why?

5. Record the frequency for Run #3 in the Table above.
6. In order to more clearly view the results of your experiment, drag the saved data icons over the Graph display. This will allow you to view the results simultaneously.

Question 2: How does the frequency of light intensity variation for the fluorescent AC bulb and the incandescent AC bulb compare to the accepted value for AC frequency? Explain any difference.

Question 3: How does the light from a DC light source compare to light from an AC light source?

Question 4: How does the light from a fluorescent tube compare to the light from an incandescent bulb?