WARD'S™
DataHub
The Power of Twelve
The Convenience of One

Variation of Light Intensity:
Measuring the Light Intensity of Different Light Sources
(Teacher's Guide)

OVERVIEW

Students will measure the light intensity of different light sources using the Ward's DataHub light sensor. Based on the results, the students will proceed to relate each light source to its corresponding light efficiency.

MATERIALS NEEDED

Ward's DataHub
USB connector cable*
LED flashlight with batteries
Candle
Fluorescent light bulb
Matches
Lamp with an 11 watt bulb

** – The USB connector cable is not needed if you are using a Bluetooth enabled device.*

NUMBER OF USES

This demonstration can be performed repeatedly.

FRAMEWORK FOR K-12 SCIENCE EDUCATION © 2012

* The Dimension I practices listed below are called out as **bold** words throughout the activity.

Dimension 1 Science and Engineering Practices				
	✓	Asking questions (for science) and defining problems (for engineering)		Use mathematics and computational thinking
	✓	Developing and using models	✓	Constructing explanations (for science) and designing solutions (for engineering)
	✓	Planning and carrying out investigations	✓	Engaging in argument from evidence
	✓	Analyzing and interpreting data	✓	Obtaining, evaluating, and communicating information

Dimension 2 Cross Cutting Concepts				
		Patterns		Energy and matter: Flows, cycles, and conservation
		Cause and effect: Mechanism and explanation	✓	Structure and function
		Scale, proportion, and quantity		Stability and change
	✓	Systems and system models		

Dimension 3 Core Concepts	Discipline	Core Idea Focus
	Physical Science	PS1: Matter and Its Interaction
		PS1.A: Structure and Properties of Matter
		PS3: Energy
		PS3.A: Definitions of Energy
		PS4: Waves and Their Applications in Technologies for Information Transfer
		PS4.B: Electromagnetic radiation

NGSS Standards	Middle School Standards Covered	High School Standards Covered
	MS.PS-SPM: Structure and Properties of Matter	HS.PS-SPM: Structure and Properties of Matter
	MS.PS-E: Energy	HS.PS-E: Energy
	MS.PS-WER: Waves and Electromagnetic radiation	HS.PS-ER: Electromagnetic Radiation

NATIONAL SCIENCE EDUCATION STANDARDS © 2002

Content Standards (K-12)			
✓	Systems, order, and organization		Evolution and equilibrium
✓	Evidence, models, and explanation		Form and Function
✓	Constancy, change, and measurement		

Physical Science Standards Middle School		Physical Science Standards High School	
✓	Properties and Changes of Properties in Matter		Structure of Atoms
	Motions and Forces	✓	Structure and Properties of Matter
	Transfer of Energy		Chemical Reactions
			Motions and Forces
			Conservation of Energy and Increase in Disorder
		✓	Interactions of Energy and Matter

✓ Indicates Standards Covered in Activity

LEARNING OBJECTIVES

Core Objectives (National Standards):

- Develop the ability to refine ill-defined questions and direct to phenomena that can be described, explained, or predicted through scientific means.
- Develop the ability to observe, measure accurately, identify and control variables.
- Decide what evidence can be used to support or refute a hypothesis.
- Gather, store, retrieve, and analyze data.
- Become confident at communicating methods, instructions, observations, and results with others.

Activity Objectives:

The purpose of this activity is to relate light intensity and light source efficiency to create a hypothesis about the amount of light sent out by different light sources and proceed to test it using the Ward's DataHub light sensor.

Time Requirement:

45 - 60 minutes

VOCABULARY

Ambient Light: The soft indirect light that fills the volume of a room with illumination.

Candle: A cylinder or block of wax or tallow with a central wick that is lit to produce light as it burns.

Fluorescent Lamp: A lamp consisting of a tube coated on the inside with a fluorescent material. Mercury vapor in the tube, emits ultraviolet radiation that is converted to visible radiation by the fluorescent material.

Incandescent: Emitting light as a result of being heated.

LED: Light-emitting diode, a semiconductor diode that glows when a voltage is applied.

Light Intensity: Candle power: luminous intensity measured in candelas.

Luminous Flux: The rate of flow of light energy.

Sunlight: Light from the Sun.

Watt: The SI unit of power, equivalent to one joule per second, corresponding to the rate of energy in an electric circuit where the potential difference is one volt and the current, one ampere.

INTRODUCTION

Have you ever experienced an electricity blackout when it is dark outside? Usually people run to find candles and flashlights so they can see something in the pitch-black. Even if we try to light the room by placing several candles around, or use the most powerful flashlight we have, it may still not be enough to brighten the room as well as a light bulb could.

- **How should we place several candles in a room in order to achieve the most light?**

- **What do you think the efficiency of a light source depends on?**

Carry out the experiment with your class so that at the end, students will be able to answer the following question:

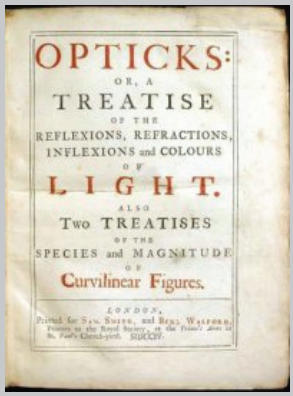
- **How are the intensity and efficiency of a light source related?**

DID YOU KNOW?

Why is the sky blue? The atmosphere scatters electromagnetic radiation differently. Those rays at the shorter end of the spectrum, or the blue rays, scatter more than the longer wavelength rays (red and orange colors). However, we do see these longer wavelengths at sunset when the angle of the sun's light enters the atmosphere just right. This is known as Rayleigh scattering.

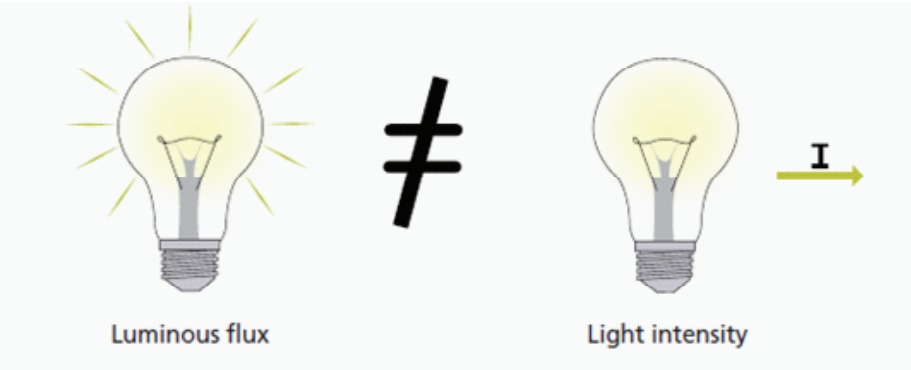
DID YOU KNOW?

Opticks was written by physicist Sir Isaac Newton in 1704. It contained experiments and the deductions that Newton made from them, and covered all of the major topics in what would be considered today physical optics. Newton first began doing experiments regarding light in the 17th century.

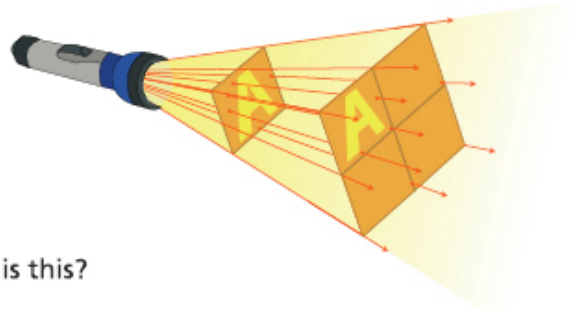

OPTICKS:
OR, A
TREATISE
OF THE
REFLEXIONS, REFRACTIONS,
INFLEXIONS and COLOURS
OF
LIGHT.
ALSO
Two TREATISES
OF THE
SPECIES and MAGNITUDE
OF
Curvilinear Figures.

BACKGROUND

The luminous flux gives us an idea about the light intensity sent out by light sources in all space dimensions, for example by a light bulb. But when you consider a projector, it is clear that it lights only in one direction: forward. That is why we need to know how the luminous flux is distributed into every space dimension, using the definition of light intensity.



Light intensity (I) is defined as the "luminous flux that is emitted per unit of solid angle (steradian) into a specific direction". The unit of measure is the lumen **per steradian, or candla (cd). The mathematical equation that defines light intensity is:**



$$I_v = \frac{dF}{d\Omega}$$

What is this?

I_v = light intensity (cd)
F = luminous flux (it is measured in lumens, meaning luminous power perceived per unit area)
$d\Omega$ = differential of solid angle (steradians)

At this point, encourage students to formulate a hypothesis to test as part of this activity. Students may find it helpful to formulate their hypothesis as an answer to the following question:

- **If light intensity and light efficiency are related, how would the efficiency vary depending on the light source?**

CONNECTING THE WARD'S DATAHUB TO A COMPUTER

If you are using a Bluetooth communication device:

Right-click on the Bluetooth icon in the lower right corner of the screen and select the Ward's DataHub you are using. The icon will change from gray to blue, as shown at right, indicating that the Ward's DataHub and the computer are now connected via Bluetooth.

If you are using a USB communication device:

In order to use USB communication, connect the Ward's DataHub and the computer with the USB cable supplied. Click on the USB icon at the lower right corner of the screen. This icon will change from gray to blue, as shown at right, indicating that the Ward's DataHub is connected to the computer via USB.

USING THE WARD'S DATAHUB

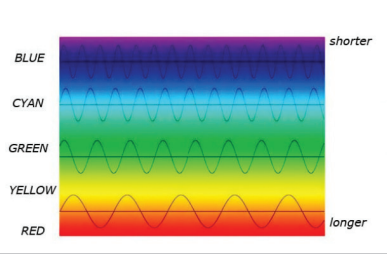
= Select key = On/Off and Escape key = Scroll key

To collect measurements with the Ward's DataHub, it must first be configured as follows:

1. Turn on the Ward's DataHub by pressing the On/Off/Esc key.	
2. Go to setup by using the Scroll key; then select Setup by pressing the Select key.	then
3. Select the Set Sensors option by pressing the Select key.	
4. If any sensor(s) appear on the screen, press the key representing that sensor to deactivate it. Once you have a blank window, press the **Light Sensor** key once.	
5. Press the On/Off/Esc key once to return to the setup menu.	
6. Press the Scroll key to highlight the Sampling Rate and then press the Select Key	then
7. Press the Scroll key until "**Manual**" is highlighted, then press the Select key.	then
8. Press the On/Off/Esc key to return to the setup menu.	
9. Press the Scroll key to highlight the Number of Samples and then press the Select Key.	then
10. Press the Scroll key until "**Manual**" is highlighted, then press the Select key.	then
11. Press the On/Off/Esc key three times to return to the main operating screen.	x 3
12. **Press the Select key to start measuring.** (You are collecting data when there is an icon of a Runner in the upper left hand corner of the screen.)	
13. Once you have finished measuring, stop the Ward's DataHub by pressing the Select key, followed by the Scroll key.	then

DID YOU KNOW?

There are different colors of light. This is because the light waves have different wavelengths. Red light has the longest wavelength while violet light has the shortest wavelength.



ACTIVITY

1. Place the four different light sources approximately 30 cm away, in the following order: candle, flashlight, lamp, and fluorescent bulb. Darken the room, covering the windows and turning off any artificial light sources.
2. To collect the data, place the DataHub light sensor approximately 10 cm away from the light source.
3. Push the  button on the DataHub.
4. Light the candle and observe how the measurements vary on the DataHub screen.
5. Wait until the intensity value you are measuring stabilizes.
6. Take just one manual sample of the light intensity.
7. Once you have finished with the candle, extinguish it without turning off the DataHub, and then turn on the LED flashlight. Repeat steps 5 and 6.
8. Measure the light intensity of the lamp and the fluorescent bulb as you did with the other light sources.
9. Uncover the windows, but do not turn on any lights in order to measure the light intensity of the ambient light in the room. Then measure the intensity of Sunlight by pointing the light sensor directly at the Sun.
10. Once you've finished measuring, turn the DataHub off.

DID YOU KNOW?

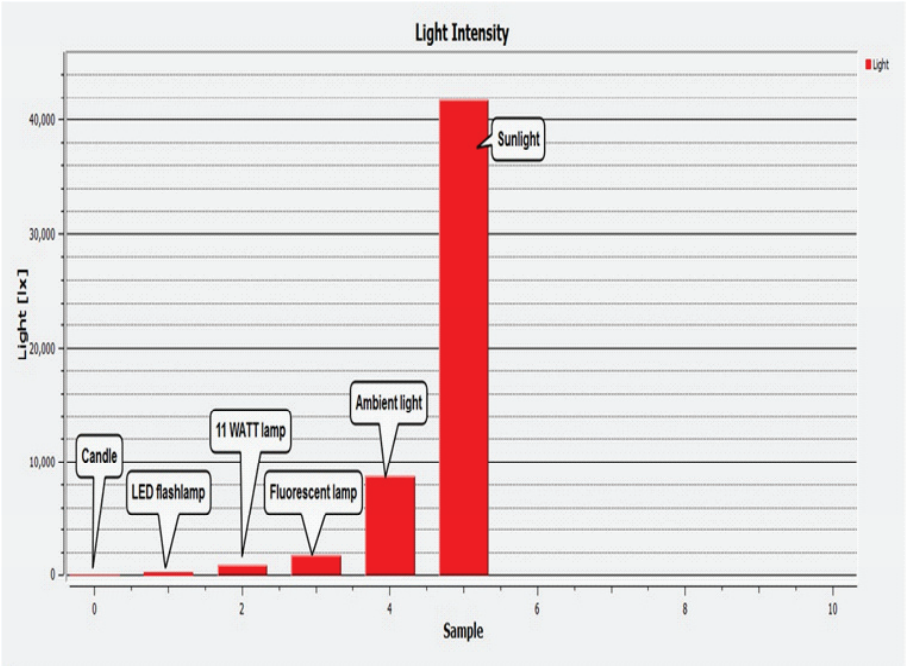
Have you ever walked outside and thought "Gee! It is so bright out here!"? You probably reach for your sunglasses without giving it a second thought, but do you know how sunglasses work? They provide protection from intense light. The eyes natural response to too much light is to close the iris, and then squint. Damage can occur to the retina if this light is too intense. Sunglasses also provide protection from ultraviolet rays that can damage the cornea and retina of your eyes.

RESULTS AND ANALYSIS

The following steps explain how to analyze the experiment results.

1. Connect the DataHub to the computer using the USB communication cable or via the Bluetooth wireless communication channel.
2. On the upper menu, press the  button. Select 
3. Select the last experiment on the list.
4. Observe the graph displayed on the screen.
5. Press the bar graph icon and set the display to a Bar Graph display.
6. Press the  button and write notes on the graph specifying your observations according to the moment you registered the data.
   - **How do the results relate to your initial hypothesis? Explain.**
   - **How do the data curves vary for each light source?**
   - **What similarities do the data curves present?**
   - **Which was the brightest light source? Which was the least bright?**

The graph below should be similar to what the students obtained.



CONCLUSIONS AND ASSESSMENTS

1. What was the variation between the different light sources you analyzed? **Communicate** which light source was the highest intensity and which was the lowest.

   Students should analyze the different values of light intensity, defining which were the highest and lowest and the range of variation between them.

2. How does the amount of light relate to the light intensity in your **model system**?

   Students should relate more powerful light sources to greater light intensity and less bright light sources, like a candle, to less light intensity.

3. How do you think the light flux varies in each of the light sources you **analyzed**?

   Students should conclude that the more light intensity, the more luminous flux there is. Both parameters depend on the relative distance between the location of the Ward's DataHub light sensor and the light source.

4. According to your experience, **argue** which light source you think is the most efficient light source from the three artificial sources studied?

   Students should indicate that the most efficient light source is the LED flashlight, because it uses less energy to function, for this reason it is considered to be energy saving.

5. Write a **concluding** paragraph describing what you observed during the experiment.

   Students should reach the following conclusions:

   Different light sources have different light intensities and this relates to their associated functions. However, light intensity cannot be related to the efficiency of the source. The LED flashlight is not the most luminous sources, but presents greater efficiency than the candle and the lamp. On the other hand, sunlight is the most powerful light source and yet, is the most efficient.

ACTIVITIES FOR FURTHER APPLICATION

The aim of this section is for students to extrapolate the knowledge acquired during this class and apply it to different contexts and situations. Furthermore, it is intended that students question and present possible explanations for the experimentally observed phenomena.

1. How could you increase the light intensity of a candle?

   Students should explain that they could achieve this by increasing the amount of light the candle produces, in other words, making the flame larger. We can establish the following connection: The larger the candle flame is, the more light intensity it produces, and vice versa (the smaller the candle flame, the less light intensity).

2. How are light intensity and electrical power related?

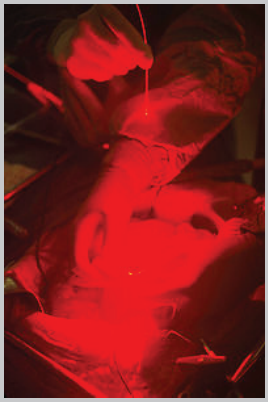
   Students are expected to establish that light sources which emit more light intensity use more energy in the process. On the other hand, we should point out the example of the candle, which uses less energy in the lighting process. In both cases, energy is "lost" through heat. This shows that light efficiency depends on how much energy we use to illuminate, rather than produce heat.

3. How is a natural light source like the Sun different from an artificial light source such as a light bulb?

   Students should quantify that the Sun's light intensity is much higher than the intensity of any artificial light source, and that this depends directly on the amount of energy used by the Sun to produce this intensity of light.

DID YOU KNOW?

Light is more than color. It is very fast traveling energy, traveling throughout the universe. Light travels at 300000000 meters/second. In prehistoric times, the energy from light was harnessed through fire and the invention of illumination devices such as candles and gas lamps took this to another level. The first electric powered light was invented in the late nineteenth century. Today, light is used in highly focused and powerful laser beams in such diverse applications as surgery and splitting molecules.



Laser radiation being delivered via a fiber.

WARD'S™ DataHub
The Power of Twelve
The Convenience of One

Variation of Light Intensity: Measuring the Light Intensity of Different Light Sources *(Student Guide)*

INTRODUCTION

Have you ever experienced an electricity blackout when it is dark outside? Usually people run to find candles and flashlights so they can see something in the pitch-black. Even if we try to light the room by placing several candles around, or use the most powerful flashlight we have, it may still not be enough to brighten the room as well as a light bulb could.

- **How should we place several candles in a room in order to achieve the most light?**
- **What do you think the efficiency of a light source depends on?**

After carrying out this experiment, you should be able to answer the following question:

- **How are the intensity and efficiency of a light source related?**

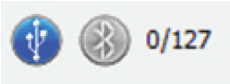
CONNECTING THE WARD'S DATAHUB TO A COMPUTER

If you are using a Bluetooth communication device:

Right-click on the Bluetooth icon in the lower right corner of the screen and select the Ward's DataHub you are using. The icon will change from gray to blue, as shown at right, indicating that the Ward's DataHub and the computer are now connected via Bluetooth.

If you are using a USB communication device:

In order to use USB communication, connect the Ward's DataHub and the computer with the USB cable supplied. Click on the USB icon at the lower right corner of the screen. This icon will change from gray to blue, as shown at right, indicating that the Ward's DataHub is connected to the computer via USB.



USING THE WARD'S DATAHUB

= Select key = On/Off and Escape key = Scroll key

To collect measurements with the Ward's DataHub, it must first be configured as follows:

1. Turn on the Ward's DataHub by pressing the On/Off/Esc key.	
2. Go to setup by using the Scroll key; then select Setup by pressing the Select key.	then
3. Select the Set Sensors option by pressing the Select key.	
4. If any sensor(s) appear on the screen, press the key representing that sensor to deactivate it. Once you have a blank window, press the **Light Sensor** key once.	
5. Press the On/Off/Esc key once to return to the setup menu.	
6. Press the Scroll key to highlight the Sampling Rate and then press the Select Key	then
7. Press the Scroll key until "**Manual**" is highlighted, then press the Select key.	then
8. Press the On/Off/Esc key to return to the setup menu.	
9. Press the Scroll key to highlight the Number of Samples and then press the Select Key.	then
10. Press the Scroll key until "**Manual**" is highlighted, then press the Select key.	then
11. Press the On/Off/Esc key three times to return to the main operating screen.	x 3
12. **Press the Select key to start measuring.** (You are collecting data when there is an icon of a Runner in the upper left hand corner of the screen.)	
13. Once you have finished measuring, stop the Ward's DataHub by pressing the Select key, followed by the Scroll key.	then

ACTIVITY

1. Place the four different light sources approximately 30 cm away, in the following order: candle, flashlight, lamp, and fluorescent bulb. Darken the room, covering the windows and turning off any artificial light sources.
2. To collect the data, place the DataHub light sensor approximately 10 cm away from the light source.
3. Push the button on the DataHub.
4. Light the candle and observe how the measurements vary on the DataHub screen.
5. Wait until the intensity value you are measuring stabilizes.
6. Take just one manual sample of the light intensity.
7. Once you have finished with the candle, extinguish it without turning off the DataHub, and then turn on the LED flashlight. Repeat steps 5 and 6.
8. Measure the light intensity of the lamp and the fluorescent bulb as you did with the other light sources.
9. Uncover the windows, but do not turn on any lights, in order to measure the light intensity of the ambient light in the room. Then measure the intensity of Sunlight by pointing the light sensor directly at the Sun.
10. Once you've finished measuring, turn the DataHub off.

RESULTS AND ANALYSIS

1. Connect the DataHub to the computer using the USB communication cable or via the Bluetooth wireless communication channel.
2. On the upper menu, press the  button. Select 
3. Select the last experiment on the list.
4. Observe the graph displayed on the screen.
5. Press the bar graph icon and set the display to a Bar Graph display.
6. Press the  button and write notes on the graph specifying your observations according to the moment you registered the data.

- **How do the results relate to your initial hypothesis? Explain.**

  _____

  _____

  _____

- **How do the data curves vary for each light source?**

  _____

  _____

  _____

- **What similarities do the data curves present?**

  _____

  _____

  _____

- **Which was the brightest light source? Which was the least bright?**

  _____

  _____

  _____

  _____

CONCLUSIONS AND ASSESSMENTS

1. What was the variation between the different light sources you analyzed? **Communicate** which light source was the highest intensity and which was the lowest.

_____

_____

_____

_____

2. How does the amount of light relate to the light intensity in your **model system**?

_____

_____

_____

_____

3. How do you think the light flux varies in each of the light sources you **analyzed**?

_____

_____

_____

_____

4. According to your experience, **argue** which light source you think is the most efficient light source from the three artificial sources studied?

_____

_____

_____

_____

5. Write a **concluding** paragraph describing what you observed during the experiment.

_____

_____

_____

_____