



Drexel-SDP GK-12 ACTIVITY

Lit Up

Subject Area(s) Algebra, Measurement, Physical Science, Science and Technology

Associated Lesson Undulating Frequencies

Activity Title Lit Up

Grade Level 7 (6-8)

Time Required 25 mins

Group Size 3-4

Expendable Cost per Group US \$5

LED replacement diodes (seasonal item), resistors, 9V batteries and snap connectors, small circuit “breadboards”

Summary

In this activity, students will explore the relationship between visible light wavelengths and energy by experimenting with light emitting diodes (LEDs) in simple circuits.

Engineering Connection

Light emitting diodes (LEDs) are finding increased use in many applications that have turned to low-power alternative light sources. Though commonly found as indicator lights on many electronics, LEDs are now replacing incandescent lamps in computer monitors, spotlights, and Christmas light decorations.

The structures present in LEDs span multiple length scales (milli- to nano-) but in this activity the focus rests on how a specific component of that structure – the band gap of the chemicals used to dope the LED – plays a role in defining the energy state and resulting visible wavelength of the LED.

Keywords

Energy, voltage, amperage, circuit, LED, band gap, wavelength

Educational Standards

- PA Science:
 - 3.1.7 – Unifying themes
 - 3.2.7.B – Apply process knowledge to make and interpret observations
- PA Math:
 - 2.4.5.B – Use models, number facts, properties, and relationships to check and verify predictions and explain reasoning
 - 2.5.8.B – Verify and interpret results using precise mathematical language, notation and representations, including numerical tables and equations, simple algebraic equations and formulas, charts, graphs, and diagrams
 - 2.6.5.A – Organize and display data
 - 2.7.8.D – Compare and contrast results from observations and mathematical models
 - 2.8.8.B – Discover, describe, and generalize patterns, including linear, exponential, and simple quadratic relationships

Learning Objectives

After this activity, students should be able to:

- Identify colors of the visible light spectrum (ROYGBIV) with decreasing wavelengths
- Relate the concept of energy flow to excitation of particles and the resulting emitted light.
- Discuss how amperage and voltages observed across the LED leads may affect the resulting light output

Materials List

Each group needs:

- One calculator
- One breadboard
- One 390- Ω resistor
- One 9V battery
- One digital multimeter
- Red, Blue, and Yellow LEDs
- Worksheet

Introduction / Motivation

Plug the LEDs in the breadboard away from the resistor. Place the breadboard on each group's desk and complete a K/W/L chart (what you know, what you want to learn, what you learned). Guide students' questions toward topics about circuits and light, but allow for flexibility if a related question arises.

Demonstrate the setup in front of the class. We're going to measure the voltage across the different-colored LEDs to explore a possible relation between the wavelength of that color and the energy needed to produce it. First, we take the 9V battery attached to the snap connector and plug the positive and negative terminals to columns on the breadboard. Next, we connect

one end of the resistor with the column of the positive terminal, and insert the other end into a row in the middle. The last thing we need to do is plug the positive (longer) terminal of the LED into the same row as the resistor, and the negative terminal into the same column as the battery's negative terminal. That should complete the circuit and our LED will light up.

Once the LED is illuminated, take your multimeter (set to read between 1-4 V DC) and touch each probe to different leads of the LED. Record the voltage that you measure across the LED on your worksheet.

Vocabulary / Definitions

Word	Definition
Light Emitting Diode (LED)	A light emitting diode consists of a chemically-doped "p-n" junction that permits the flow of electrons at specified energy states. The diode illuminates at or above the energy state.
Band Gap	The energy gap required for electrons to flow from one side of the junction to the other. This energy is determined by the chemical composition of the junction.
Wavelength	A wavelength is the distance between peaks (or troughs) on a waveform.
Voltage	The energy per unit charge, typically measured between two points. Also known as the electrical potential between two points.
Amperage	Units for electric current, which is a measure of the rate of flow of electric charge

Procedure

Background

The breadboards have been wired with a 9V battery as the input power source. A 390- Ω resistor and LED are wired in series. An LED is made up of a p-n junction – chemically doped silicon that allows electron flow. When connected to a power source that has energy at or above the **band gap** energy of the junction, the input voltage (a flow of electrons) will cause the electrons to flow across the junction and the LED will illuminate at a wavelength corresponding to that band gap energy. For this activity, we use LEDs that emit light in the visible light spectrum.

Though the units of energy potential calculated in Chemistry (electron-volts, eV) differs from that of Physics and Electrical Engineering disciplines (Joules, J), the theoretical principle of measuring the electron flow across the circuit should hold for this experiment.

Before the Activity

- Demonstrate how to complete the circuit using a breadboard (see Introduction)
- Discuss use of digital multimeter to measure the quantities of voltage and amperage V , I across LED leads

With the Students

1. Verify that groups are wiring resistors and LEDs in correct order
2. Check student's measured quantities to make sure they are recording the proper values displayed on the multimeter.
3. Observe students and answer questions

Attachments

1. Worksheets appended to this document

Safety Issues

- There are no safety issues with the low voltages and currents encountered in this activity.

Troubleshooting Tips

- If LED is not lighting up, ensure:
 1. Battery terminals are connected to breadboard
 2. LED polarity (positive/negative leads) is correct
 3. Components are plugged into breadboard's rows/columns properly to complete circuit.
- If incorrect voltages are measured (should be in range of 2.5-3.5 V), check multimeter setting to ensure detection of DC voltage within correct range.

Investigating Questions

The LEDs should have increasing voltage values in the order of Red, Yellow, and Blue. LEDs available for replacement in strands of holiday lights may have a tinted cap to accentuate the color. To emphasize the point that the color originates from the energy jump equal to the band gap LEDs with clear caps can be shown for a comparison (these are available at Radio Shack, but cost several dollars per LED).

1. For the LEDs that appear **colored when off**,
 - a. are there differences in the voltage values measured? *Yes*
 - b. if the colors are ordered from lowest to highest voltage, is there a possible connection to the sequence of the visible light spectrum? *Red(lowest) → Yellow → Blue (highest)*
2. In the electromagnetic spectrum, are the wavelengths increasing or decreasing when going from Red to Blue? *Wavelengths are decreasing.*
3. If the measured voltage scales with the energy across the LED band gap necessary to produce each color, what is the relation between *energy* and *wavelength*?

Assessment

Activity Embedded Assessment

Title: Lit Up (worksheet appended to Activity)

Additional Multimedia Support

Activity_LitUp_Media.zip contains these files:

Aqua Teen Hunger Force Boston Bomb Scare.mp4, originally downloaded from

<http://www.youtube.com/watch?v=7kdP8WBB4II>

Boston Panic – Aqua Teen Hunger Force Marketing Campaign.mp4, originally downloaded

from <http://www.youtube.com/watch?v=9yigQGKaf2A>

LED_Throwie.mp4, originally downloaded from http://www.youtube.com/watch?v=YjTP_T-wR9w

MIT_DiscoDanceFloor.mov, originally downloaded from

http://www.youtube.com/watch?v=q35_7ANzhfE

Owner

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Name: _____
Lit Up

1. For each Red, Blue, Yellow, and Clear LED:
Find voltage across LED when lit, for 19.1 mA and 40.9 mA

	Color	<i>V, Volts</i>
<i>I=40.9 mA</i>	Red	
	Blue	
	Yellow	
	Clear	

2. Are there any differences in the voltage values measured for the colored LEDs? List the colors of LEDs in order of measured voltages.
3. Do blue or red LEDs operate at a higher voltage? How does this compare with the order of the colors' wavelengths in the visible light spectrum?
4. The equation $E = \frac{1240}{\lambda}$ relates the band gap energy (in electron-volts) to the wavelength of light produced. Estimate the band gap energy for each color (*except clear*).

Do these values follow the pattern you noticed in Question (2) ?

5. What relation do you think exists between *energy* and *wavelength* associated with colored light?