



*Drexel-SDP GK-12 LESSON*

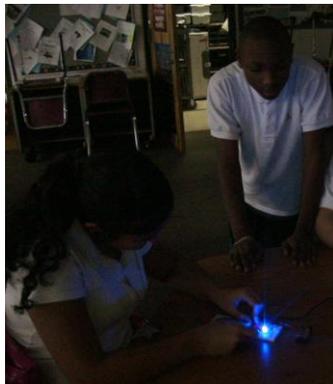
## Undulating Frequencies

**Subject Area(s)** Measurement, Number & Operations, Physical Science, Problem Solving, Science and Technology

**Associated Unit** Complete the Circuit

**Lesson Title** Undulating Frequencies

### Header



**Grade Level** 7 (6-12)

**Lesson #** 1 of 2

**Time Required** 10 minutes

### Summary

This lesson prefaces and interfaces with the **Lit Up** activity. Before experimenting with LEDs, students should benefit from this background lesson on light, energy, and wavelength. Students also need the visual aid of the visible light spectrum when completing the **Lit Up** worksheet. The lesson can conclude with video clips of LED applications, such as LED “throwie” construction, the 2008 Boston bomb scare resulting from LED signs used in a Cartoon Network advertising campaign, and the Disco Dance Floor project undertaken by MIT students.

## Engineering Connection

Light emitting diodes (LEDs) represent a fusion of chemistry, physics, and engineering. Not only are LEDs gaining widespread usage in electronics for their low power consumption and long service life, but they are tangible examples of the electromagnetic spectrum. The principle of light (or charged particle) emission corresponding to particular wavelengths and energy states has been used to advance technology and enhance many industries.

## Keywords

Light emitting diode, LED, wavelength, energy, electron-volt, spectrum

## 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 lesson, students should be able to:

- Identify ways in which different regions of the electromagnetic spectrum are used
- Relate wave theory to useful or dangerous types of electromagnetic waves

## 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).*

*Introduce the idea of electromagnetic waves using several slides of a presentation. What you have in front of you is a **light emitting diode**. When you give it power, it lights up. Ask: *Is there just one type of LED color?* LEDs do come in different colors, but let's start to explain how the colors of LEDs are modulated by looking into the more basic concept of light. Light is thought to travel through space as a wave. One main feature of a wave formation is its **wavelength**, which determines how many times that wave will oscillate in a given time or space. Wavelengths can range from very small ( $1 \times 10^{-14}$  m) to very large ( $1 \times 10^4$  m) sizes.*

The wavelength of a wave determines its energy (and vice-versa). Taking a look at the spectrum chart, can anyone tell me how:

1. Gamma rays are used? You might've seen a hospital or treatment center commercial about this (*cancer treatment and radiation therapy, i.e. GammaKnife*)...
2. X-rays are used? How many of you had an x-ray taken? *Show of hands*... What did you do before the x-ray? *Don a heavy vest*... That vest had lead in it, which is a heavy metal that absorbs x-rays. Otherwise, the radiation may kill cells in your tissue and lead to cancer. *Sidenote: the earliest inventors and users of the x-ray machine died of cancer due to overexposure.*
3. Ultraviolet rays are harmful? Where have you heard of ultraviolet rays? *Sunglasses, UV sticker; sunscreen and sunblock, skin products.* UV rays, which are normally absorbed in ozone (a global warming topic), have increased in the past decade due to a hole in the ozone layer (and consequently not being absorbed prior to hitting Earth's surface). These rays, like gamma and x-rays, are smaller than your body's cells and pose a cancer risk should they penetrate the cell. *Melanoma is a type of skin cancer, and its diagnosis rate has increased in recent years.*
4. Infrared rays are used? This may not be as obvious. Infrared light has been incorporated into recent models of grills and microwaves to speed cooking time. Remote controls (and older computer models with infrared ports) beam information in the infrared, and since it is a measure of heat, it is used in *thermal imaging* cameras for military (night vision) or other industry-specific use (air leaks in HVAC systems and insulation). *Infrared literally refers to wavelengths "less than" red.*
5. Radar and other waves characterized by higher wavelengths are self-explanatory.

The wavelength that this LED is characterized by, as well as others that we can see, occur within the visible light spectrum. Since the wavelength is related to a quantity of energy that is released (or absorbed), we can modulate the color of the LED by changing the energy needed to activate it.

This **activation energy** is based on physics and chemistry: provided a sufficient energy input, electrons will flow through a p-n junction (made up of two materials that have a specific energy gap). When the electrons flow through the junction, the energy released by electrons traversing the gap correspond to a color in the visible light spectrum.

Now, with this background information on wavelength and energy, and how these principles are used in LEDs, you are encouraged to measure the voltage (*a buildup of potential energy from electron flow*) across an LED in a completed circuit.

Conclude the lesson and activity with video clips and links provided, or other interesting applications.

### **Lesson Background & Concepts for Teachers**

Wavelength is inversely proportional to energy: smaller wavelengths, higher energies.

HyperPhysics is a great site to learn more about theory relating to electromagnetic spectrum.

## 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.

## Associated Activities

Lit Up

## Lesson Closure

Video clips and applications: usage of LEDs and GE’s research and development of organic LEDs (OLEDs), which are made in sheets.

## Assessment

### Pre-Lesson Assessment

*KWL chart*

### Homework

*Students may be challenged to find different devices that LEDs are used in, and the purpose of the LED in that device.*

## References

“Light Emitting Diode Structure.” Available <<http://hyperphysics.phy-astr.gsu.edu/hbase/Electronic/led.html>>.

## Owner

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