Name _____ Section _____

# Activity 2: Electromagnetic Waves – Radiant Energy I

## 2.1 How Do Electromagnetic Waves and Other Waves Transmit Energy?

Your instructor will discuss the properties of waves.

### 1) Transferring energy with waves

a) Stretch a slinky along the length of your table with a student holding each end. Vibrate one end of the slinky to send sine waves along it. What can you do to increase the frequency of the waves?

b) What does increasing the frequency of the waves do to the wavelength?

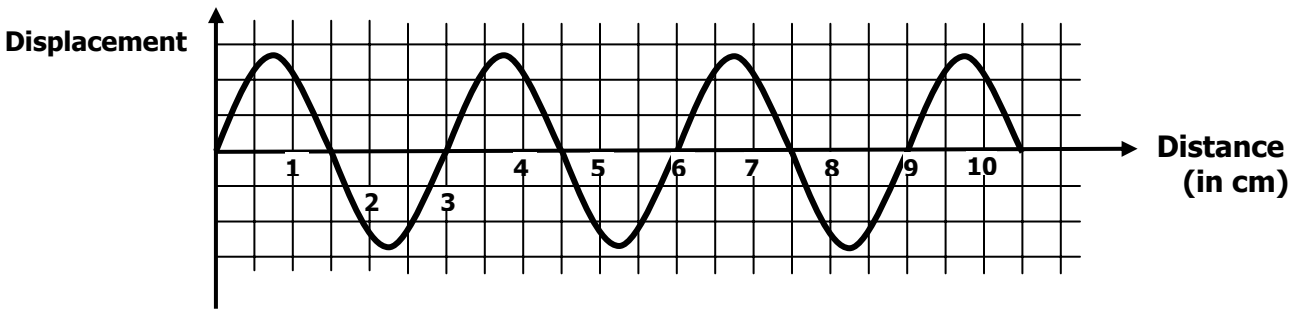
c) Place a Styrofoam ball near the slinky. Send one pulse wave along the slinky to knock the ball off of the table. Is it possible to transfer energy without a transfer of matter?

d) Group Discussion Question: List examples of transfer of energy without a transfer of matter.

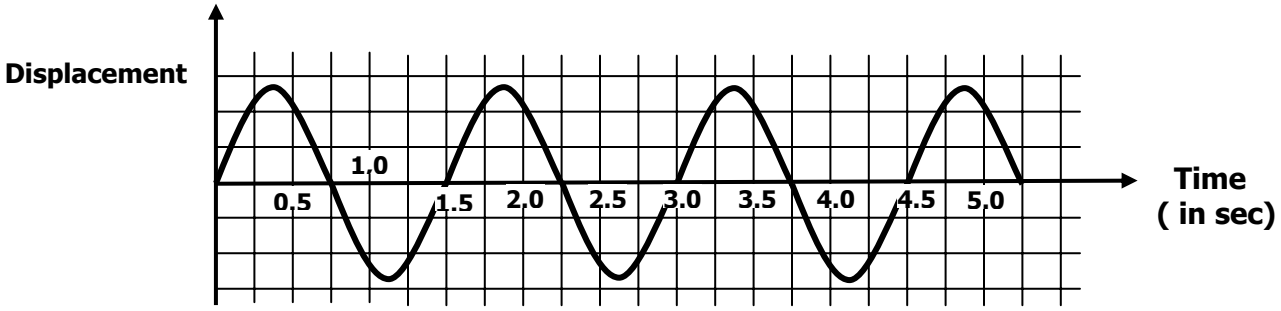
### 2) Wave Speed and Frequency

Your instructor will discuss wave periods and frequencies. Use this information to find the speed of the wave illustrated in the diagrams below.

a) Find the wavelength (in meters) of the wave in the diagram. **3 cm = 0.03 m**



b) The diagram below shows the displacement of a wave over time, at a fixed point along the path of the wave. Find the period of the wave in the diagram. _____




c) Calculate the frequency of the wave (in cycles/second, or Hertz).

d) Calculate the speed of this wave.

e) Based on the speed you calculated, could these diagrams represent a wave of electromagnetic radiation? Why or why not?

f) Find the wavelength of a wave of electromagnetic radiation that has a frequency of $6 \times 10^{14}$ Hz.

**3) *Light and sound in a vacuum*** Your instructor will demonstrate a vacuum jar that contains a buzzer and a light bulb.

a) Describe the differences you observe between sound waves and waves of electromagnetic radiation.

b) A sound wave has a wavelength of 0.5 meters and a frequency of 680 Hz. What is the speed of this wave?

c) How many times greater is the speed of light than the speed of sound?

d) Group Discussion Question: Scaling Quantities. Try to answer the following questions without using your calculator.

1) If the distances in graph 2.a were in meters, what would be the speed of the wave? _____

2) If the times in graph 2.b were in minutes, rather than seconds, what would be the speed of the wave? _____

## 2.2 Refraction of Radiant Energy

### 4) Refraction of light

a) Look sideways at a pencil in a cup of water. Does the pencil appear to bend? _____ What is it that actually bends?

b) Why is the light beam bent?

c) Shine a light through a slit and then through a prism and onto a sheet of paper. What happens to the beam of light?

d) Why is the light split into colors?

e) List the colors of visible light from longest to shortest wavelength.

f) Which color of light is bent the most?

g) Observe the color wheel. What color do you see when the wheel spins? Why?

h) Group Discussion Question: Why is the light beam bent as it travels through the prism?

## 2.3 Focusing Radiant Energy

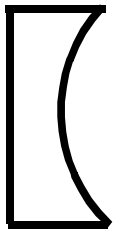
### 5) Light reflected from mirrors

Your instructor will show you how to use the light box and a plane mirror to determine the angle of reflection of light from a mirror.

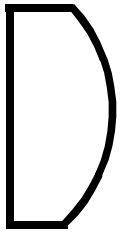
a) Draw a diagram showing light beams striking and reflecting off of a plane mirror.

b) How does the angle that light strikes a mirror (the angle of incidence) compare to the angle that light is reflected from the mirror (the angle of reflection)?

c) Shine light from the light box onto the surface of a curved mirror. Draw light beams on the diagrams below showing the path of the light reflected from the mirror. Which type of mirror focuses light? _____



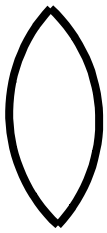
**Concave Mirror**



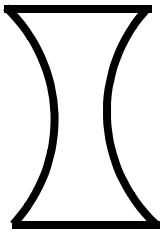
**Convex Mirror**

**6) Light passing through lenses**

a) Shine light from the light box onto the surface of a concave and a convex lens. Draw light beams on the diagrams below showing the path of the light traveling through the lens. Which type of lens focuses light? _____



**Convex Lens**



**Concave Lens**

b) Group Discussion Question: Light that passes through a prism is split into colors. Why is light that passes through a lens not split into colors?

## 2.4 What is the Quantum Model of Electromagnetic Radiation?

**7) Energy of a photon:** Your instructor will discuss the quantum (photon model) of radiant energy

a) Find the energy of a photon with a frequency of $5 \times 10^{12}$ Hz.

b) What is energy of a photon with a wavelength of $2 \times 10^{-6}$ meters?

**8)** **Solar Powered Toys** Observe the demonstration of a toy that operates with power from a solar cell.

Does the solar toy work when an incandescent bulb shines on its solar cell? ____

Does it work when a glow coil shines on its solar cell? _____

Explain your observations.

**9)** **Solar Cells** Try to operate the solar-powered toy by shining different radiant light sources onto the solar cells.

a) First, predict which light sources will operate the solar cells. Then check your predictions by shining each light source onto the solar cells.

| | **Prediction** | **Answer** |
|---|---|---|
| 1) microwaves | _____ | _____ |
| 2) visible light | _____ | _____ |
| 3) ultraviolet light | _____ | _____ |

b) Why do some light sources operate the solar cells, while other sources do not?

c) Explain why solar cells are also called photoelectric cells.

d) Suppose that a solar cell produces an electric current only when it absorbs photons with at least $3.0 \times 10^{-19}$ joules of energy per photon.

What is the maximum wavelength of electromagnetic radiation that will make the solar cell work? What type of electromagnetic radiation is this?

e) Group Discussion Question: If visible light has enough energy per photon to make the solar cell operate, which other forms of electromagnetic radiation do you think would operate the solar cell? Which forms of electromagnetic radiation would not work?