24.1 Radiant Energy and the Electromagnetic Spectrum

1) **Vibrating electric charges**: Your instructor will demonstrate the effect on a radio of electromagnetic radiation produced by vibrating charge.

   a) What happens to the radio broadcast when the radio antenna receives electromagnetic radiation from the spark of the Wimshurst machine?

   b) How did energy from the separated charges on the Wimshurst machine reach the radio?

   c) We have seen that moving electric charge produces an electric current. What type of energy does vibrating electric charge produce?

24.2 How Do Electromagnetic Waves and Other Waves Transmit Energy?

Your instructor will discuss the properties of waves.

2) **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.
3) **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) Diagram #1 below shows the information we could extract from a photo of a wave, such as a water wave or a slinky wave. Find the wavelength (in meters) of the wave in the diagram. ______________

   ![Displacement vs Distance](image1)

   b) Diagram #2 below shows the same wave as it would appear on an oscilloscope screen. It shows the displacement of the wave over time at a fixed point along the path of the wave. The \( P \) period of a wave is the time it takes for one complete wave cycle to pass a fixed point. From diagram #2, find the period of this wave in seconds. ______________

   ![Displacement vs Time](image2)

   c) The frequency \( f \) is a measure of how many complete waves pass a fixed point per second. From diagram #2, find the frequency of the wave.

   d) From diagrams #1 and #2, find the speed of this wave. How far does this wave travel in one second?

   e) Previously, we have used the equation: speed = distance/time.

   For a wave, distance is the wavelength \( L \) and time is the wave period \( P \).

   The wave period is the inverse of the frequency \( f \): \( P = 1/f \).

   Using the variables \( L \) and \( f \), write an equation for the speed of a wave.
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f) Based on the speed of this wave, could these diagrams represent a wave of electromagnetic radiation? Why or why not?

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

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

1) If the distances in wave diagram #1 on the previous page were in centimeters, instead of in meters, what would be the speed of the wave? __________

2) If the times in wave diagram #2 were in minutes, rather than seconds, what would be the speed of the wave? __________

24.3 Types of Radiant Energy

5) Examples of electromagnetic radiation: Your instructor will demonstrate the different types of radiant energy (electromagnetic radiation)

a) Radio waves Which devices operate using radio waves?

b) Microwaves Which devices use microwaves?

c) Infrared radiation

1) Which devices illustrate infrared radiation?

2) How do we experience this type of electromagnetic radiation? If you closed your eyes, how could you tell if an incandescent light bulb was lit?
d) **Visible light**

1) Your instructor will demonstrate a large bulb. Can a bulb that does not appear to be lit radiate energy? If so, what type of radiant energy? ______________________________________________________

2) Observe the bulb through a diffraction grating as your instructor slowly increases the energy to the bulb.
   a) What are the major colors of the light do you observe?
   
   b) Why is the portion of the spectrum just below the visible spectrum named “infrared”?
   
   c) What are the major colors you observe when the energy to the bulb is increased further?
   
   d) Why is the portion of the spectrum beyond the visible spectrum named “ultraviolet”?

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e) **Ultraviolet light**  Which devices illustrate ultraviolet radiation?

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f) **X-rays**  What are some uses of X – ray radiation?

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g) **Gamma rays**  Your instructor will place a sample of radioactive Cobalt-60 near a Geiger counter. What do the sounds from the Geiger counter indicate about Cobalt-60?

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h) Group Discussion Question: How are radio waves, microwaves, infrared radiation, visible light, ultraviolet light, X-rays, and gamma rays similar? How are they different?
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Period 24 Exercises: Radiant Energy

Write answers to the questions below. Show your mathematical steps and the units of the quantities. This sheet with your answers should be turned in at the beginning of Period 25.

1. Comparing waves of radiant energy:
   a) Which wave has a greater wavelength – a radio wave or a visible light wave?
      ____________________________
   b) Which wave has a higher frequency – a microwave or an infrared wave?
      ____________________________
   c) Which wave travels at a faster speed – a microwave or an ultraviolet wave?

2. Using ratios for comparisons:
   A typical value for the speed of sound in dry air is 300 meters/second. How many times greater is the speed of light than the speed of sound? (Hint: comparisons involve ratios.)

3. Comparing sound and electromagnetic waves:
   a) Find the wavelength of a 1500 Hz sound wave.
      ____________________________
   b) Find the wavelength of a wave of electromagnetic radiation of the same frequency (1500 Hz).
      ____________________________
   c) If a wave of electromagnetic radiation had a frequency of 1500 Hz, could that wave be visible light? Why or why not? (Hint: See textbook Figure 24.5.)