EMR and Matter Interactions

A Carolina Essentials™ Activity

Student Worksheet

Overview

You may have read articles or seen news stories about health problems caused by talking on the cell phone for too many hours or living near high tension electrical power lines. Maybe you've noticed these signs: Caution: Microwave in Use, Hot Surface: IR Lamp in Use, or X-Ray in Use.

All of these objects use some form of electromagnetic radiation (EMR). Are some forms of EMR more harmful than others? Is there a way to use characteristic wave properties to help predict human health risk?

Phenomenon

What interactions between microwaves and matter can you identify in the photograph on the left?

What interactions between X-rays and human tissue can you identify in the photograph on the right?

Record your answers in the space below.

SAFETY REQUIREMENTS

MATERIALS

Soft gummy candies (bears, marshmallows, or candy melts)

Cardboard or foam core board

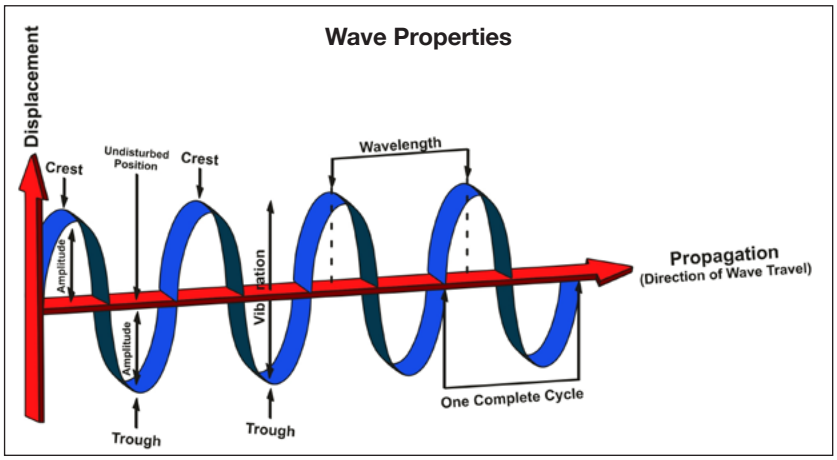
Scissors or craft knife

Wooden craft stick or coffee stirrer

Metric rulers

Calculators

As a reminder, wave properties include:



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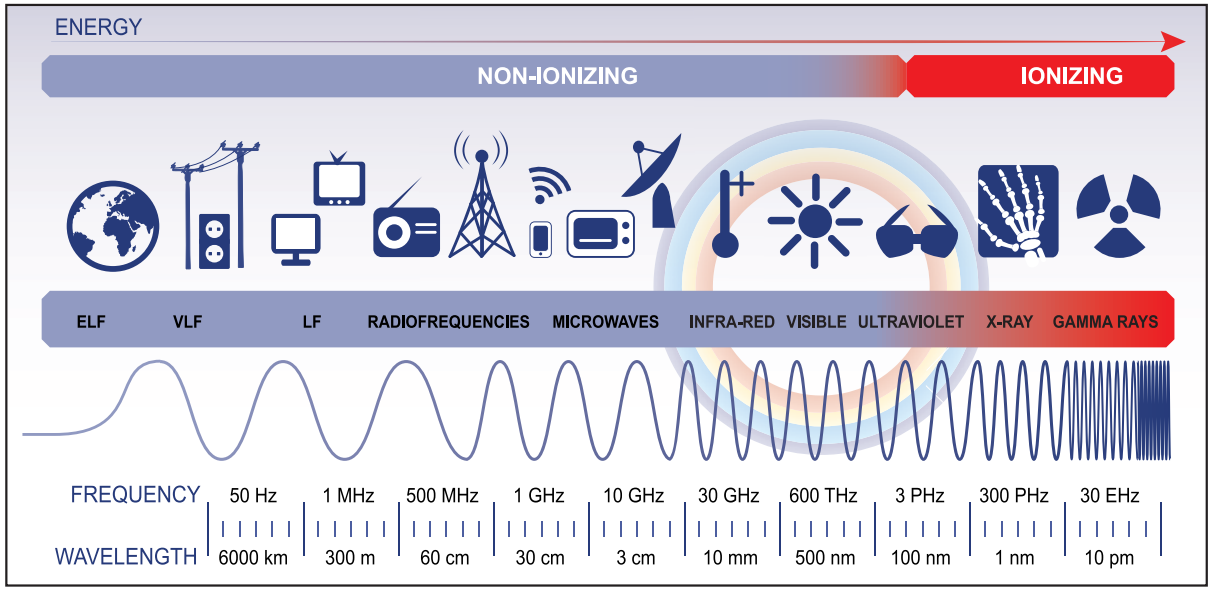
The bands on the electromagnetic spectrum include:



Essential Question

What are the effects of interactions between matter and different frequencies of radiation?

Activity Objectives

1. Identify the wavelength of a microwave using changes in candies produced by interactions between the microwave radiation and candy.
2. Use the wave equation to calculate the speed of the microwave.
3. Use the activity data, observations, and proportional reasoning to make an argument regarding different frequencies of EMR, interactions with matter, and possible human health concerns.

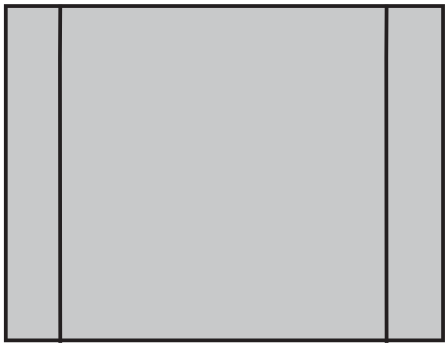
Safety and Disposal

Candy will be hot and sticky out of the microwave and could cause burns. Handle carefully. If completing this activity at home, parent supervision is necessary.

Activity Procedure

Your teacher may perform these steps for you as a demonstration.

1. If the microwave has a carousel, remove it.
2. Construct a carboard mounting tray for the candy by measuring the dimensions of the floor of the microwave.
3. Add 5 inches to the width measurement. Draw a line on each side of the cardboard, 2.5 inches from the edge (see image on far right).
4. Score lines on the edges of the cardboard, but do not cut the sections off.
5. Fold the end sections down to make a stand for the cardboard tray (see image below).



6. Draw a straight line across the middle of the cardboard, from left to right. This line will be used to position the candy.
7. Make sure the tray fits easily in the microwave.
8. Remove the tray from the oven and make any necessary changes.
9. Place the candy along the positioning line, making sure that the candy pieces touch and cover the full width of the tray.
10. Place the tray in the microwave and microwave on full power for 5 to 7 seconds.

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11. Check the softness of each candy piece with the craft stick. If the candy has softened, place a mark on the mounting tray where the candy has softened.
12. If there is no indication of softening, repeat the procedure until it is evident that some pieces of candy have become soft and are beginning to melt.

Data and Observations

Beginning on the left edge, measure the distance from the edge to each mark, in centimeters. Use the following image as a reference.

Analysis and Discussion

1. Average the distances between marks. Record the distance in centimeters.

2. Use the average to determine the wavelength of the microwave.

3. Convert the microwave wavelength into meters.

4. Locate and record the frequency of the oven's microwave. This is found on a sticker or plate inside the oven or on the oven door.

5. Convert gigahertz (GHz) to hertz (Hz).

6. Calculate the speed of the microwave using the wave equation, velocity equals wavelength times frequency. $v = \lambda \times f$

7. All electromagnetic waves travel at the speed of light, rounded to 3×10^8 m/s. Calculate and evaluate the percent error for the value calculated above.

8. You have established the speed of the electromagnetic radiation above, which applies to all types of EMR. Use the candy as a rough model for living tissue, since it is made from sugars, proteins, and fats, and make a claim relating possible tissue damage to wave frequency and wavelength. Begin with a mathematical statement of proportionality.