Lesson 13 Electromagnetic Radiation and Sound

Focus on the NYS Learning Standards

PS 4.4a	Different forms of electromagnetic energy have different wavelengths. Some examples of electromagnetic energy are microwaves, infrared light, visible light, ultraviolet light, X-rays, and gamma rays.
PS 4.4b	Light passes through some materials, sometimes refracting in the process. Materials absorb and reflect light, and may transmit light. To see an object, light from that object, emitted by or reflected from it, must enter the eye.
PS 4.4c	Vibrations in materials set up wave-like disturbances that spread away from the source. Sound waves are an example. Vibrational waves move at different speeds in different materials. Sound cannot travel in a vacuum.

Demonstrate an understanding of the electromagnetic spectrum, interactions of light waves, and the nature of sound waves.

The **electromagnetic spectrum** is the complete range of electromagnetic waves that are ordered from the shortest to the longest wavelength.

Reflection is the bouncing back of a light wave when it hits an object.

Absorption is the transfer of light waves to matter.

Transmission is the passing of light energy through matter.

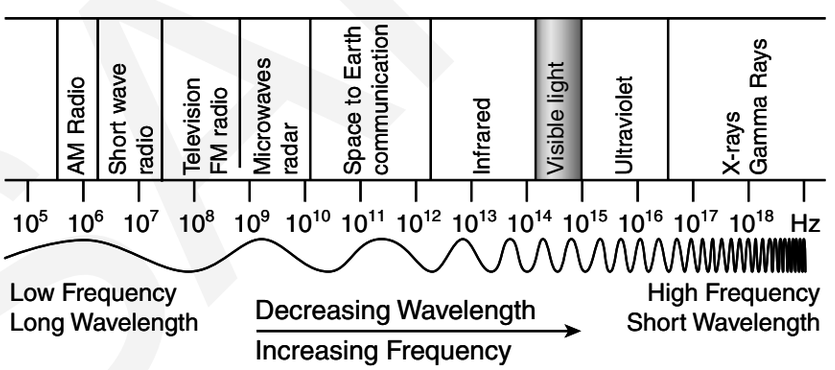
Refraction is the bending of light when it enters a new material at an angle.

Sound waves are vibrations that spread through matter away from a vibrating source.

Guided Instruction

DIRECTIONS Read the following information.

A doctor looks at an X-ray of an arm. What is an X-ray? Can an X-ray "see" more than your normal eye can see? X-rays, visible light, your radio, and even the microwave you use every day all have things in common. They are all part of the electromagnetic spectrum. The **electromagnetic spectrum** is the complete range of electromagnetic waves. In the electromagnetic spectrum, waves are ordered from the longest wavelength (lowest frequency) to the shortest wavelength (highest frequency).



Radio waves have the longest wavelengths and the lowest frequencies of all electromagnetic waves. Most radio waves we receive travel through the air. You hear radio waves when your radio converts the electromagnetic waves into sound that comes out of your radio speakers. *Microwaves* have shorter wavelengths and higher frequencies. Microwave ovens use microwaves to heat food, but because the waves pass through glass and plastic, they keep cool while the food gets hotter.

Guided Questions

What is the **electromagnetic spectrum**?

What are two uses of electromagnetic waves?

Infrared light has shorter wavelengths and higher frequencies than radio waves. Infrared light causes the warmth you feel when you place your hand near an electric stove that has been turned on. Some bathroom lights, toasters, and heat lamps use infrared light.

If you have ever seen a rainbow, you know about *visible light*, or light that you can see. Visible light has shorter wavelengths and higher frequencies than infrared rays. Red has the longest wavelength and violet has the shortest wavelength.

Ultraviolet light has higher frequencies than visible light and so has more energy. Ultraviolet lamps are sometimes used to kill bacteria in food. The Sun also emits ultraviolet light. Ultraviolet light has health benefits in small doses, but overexposure to ultraviolet light can lead to skin cancer.

X-rays have very short wavelengths. X-rays carry more energy than ultraviolet rays and can penetrate most materials. Your bones absorb X-rays, allowing doctors to use X-ray technology to observe the bones in your body.

Gamma rays are the electromagnetic waves with the shortest wavelengths and the highest frequencies. They have the most energy and are the most penetrating of all electromagnetic waves. Gamma rays are sometimes used to kill cancer cells as part of radiation therapy.

All electromagnetic waves can interact with matter in different ways. However, because you can see visible light waves, it is easier to learn about wave interactions by using visible light waves only. When light strikes matter, it may be reflected, absorbed, or transmitted.

Reflection is the bouncing back of a light wave when it hits an object. You can see objects around you because of reflection. For example, when you look at a wall, light reflecting off the wall enters your eye and you can see the wall. Reflection also allows you to see yourself in a mirror. Light reflects off your body, hits the mirror where it reflects again, and then enters your eye.

Absorption is the transfer of light waves to matter. When light energy is absorbed by an object, the energy is transformed into another form of energy. Often, the light energy is transformed into thermal energy. Therefore, objects that have absorbed light energy feel warm. Dark-colored objects tend to absorb more light energy than light-colored objects.

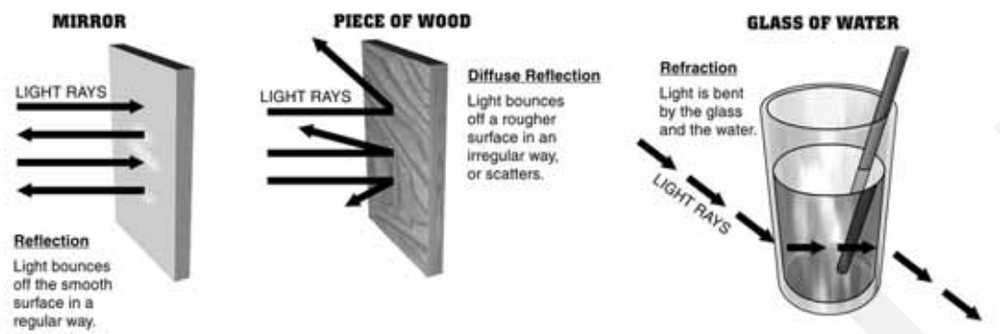
Transmission is the passing of light energy through matter. Visible light can be transmitted through glass and water. As a result, we can see things that are on the other side of a glass window or things that are underwater.

Guided Questions

Which has more energy: *infrared light* or *ultraviolet light*?

What wave interaction allows you to see objects?

Sometimes when light is transmitted through a material, it is also refracted. **Refraction** is the bending of light when it enters a new material at an angle. The image below shows light refracting twice: once when it enters the water and once when it exits back into air. The image also shows that refraction causes the straw in the water to appear to be broken.



Guided Questions

You encounter electromagnetic waves every day. Another kind of wave that you observe every day is sound waves. **Sound waves** are vibrations that spread through matter away from a vibrating source. For example, when a person plucks a guitar string, the string vibrates. The vibrating string causes the particles in the air around the string to vibrate. The vibrations in the air particles spread away from the string, and when the vibrations reach you ear, you can hear the sound of the string. Because sound travels by the vibration of particles, sound waves cannot travel in a vacuum or in space.

What is a **sound wave**?

The speed of sound waves depends on the material through which the waves are traveling. Sound travels the fastest through solid materials and slowest through gases. The table to the right shows the speed of sound in different materials.

Speed of Sound at 20°C	
Air	343 m/s
Water	1,482 m/s
Steel	5,200 m/s

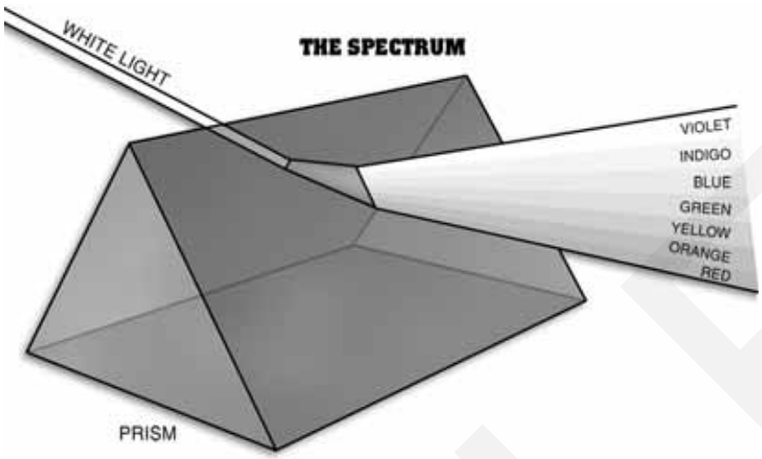
DIRECTIONS For each question, write your answer in the spaces provided.

1. What happens when light is refracted?

2. Why can't sound travel in a vacuum?

Apply the NYS Learning Standards

DIRECTIONS Study the diagram, read the following information, and answer the questions.



White light is a mixture of different wavelengths of color. The colors of light can be separated when white light is refracted through a prism as shown above. Red, yellow and green have longer wavelengths than blue and violet. When white light shines on a red object, all the wavelengths are absorbed except for those of red. The red wavelengths are then reflected to your eyes where your brain interprets the color. The retina of your eyes contains cells called *rods* and *cones*. Rods respond to night or low-light vision and cones respond to daylight or bright vision and color. There are three different kinds of cones.

Kind of Cone	Wavelength in Nanometers (nm)	Colors the Cones Respond to
L (long) cone	564	Red, yellow, orange, green
M (medium) cone	534	Green, blue
S (short) cone	420	Indigo, violet

1. Explain why visible light can have different colors.

_____

_____

2. Why does the human eye see colors?

_____

_____

3. Using the information in the table above, infer to which color the human eye is most sensitive.

_____

_____

NYS Test Practice

DIRECTIONS Choose the best answer for each question. Then circle the number of the answer you have chosen.

1 In old western movies, a character sometimes puts his or her ear to the ground to listen for approaching horses. Why does doing this help the character hear?

(1) Sound waves travel faster through the ground than through the air.

(2) Sound waves from footsteps travel only through the ground, not through the air.

(3) Sound waves are amplified, or made louder, when they travel through the ground.

(4) Sound waves travel only in one direction through the ground.

2 Which of the following waves has the shortest wavelength?

(1) gamma ray

(2) infrared ray

(3) visible light

(4) X-ray

3 If a human was born with very few L cones, what probably would be the result in this person's ability to see colors?

(1) The person may not see the color indigo.

(2) The person may not see the color blue.

(3) The person may not see the color violet.

(4) The person may not see the color red.

4 What interaction of light causes the effect shown in the image below?

(1) absorption

(2) reflection

(3) refraction

(4) transmission

5 As the wavelength along the electromagnetic spectrum increases, how does the frequency change?

(1) It increases.

(2) It decreases.

(3) It stays the same.

(4) It is impossible to tell.

6 Suppose a ringing alarm clock was placed inside a vacuum chamber. Then, a vacuum pump is used to remove all the air from inside the chamber. Which of the following best predicts what you will hear?

(1) The sound of the alarm clock will remain the same.

(2) The sound of the alarm clock will become higher pitched.

(3) The sound of the alarm clock will get louder over time.

(4) The sound of the alarm clock will fade away completely.