Waves of Light

Overview:

Most poisonous gases emitted from a volcano are colorless, so scientists rely on electromagnetic waves outside the visible spectrum to detect them. In this lesson, students learn about properties of the electromagnetic spectrum, including the wavelengths of visible light, ultraviolet energy, and infrared energy.

Objectives:

The student will:

- build "rainbow" glasses from a diffraction grating;
- illustrate the visible color spectrum as viewed through these glasses;
- describe where visible, infrared and ultraviolet light fall on the electromagnetic spectrum; and
- describe the wavelengths associated with different parts of the electromagnetic spectrum.

Materials:

- Poster board
- Diffraction grating sheets (13,500 lines)
- Scissors
- Colored pencils
- Tape
- Liquid crystal sheets or squares (23 to 27º C range)
- Transparency: "Waves of Light"
- Student Information Sheet: "Rainbow Glasses"
- Student Worksheet: "Waves of Light"

Answers to Student Worksheet:

1. Students should say that they see "rainbows" or colors when they look at light sources.
2. The order of the colors should be red, orange, yellow, green, blue and violet (or vice versa).
3. The wavelengths are: red = 650 nanometers, orange = 590 nanometers, yellow = 570 nanometers, green = 510 nanometers, blue = 475 nanometers, violet = 400 nanometers.
4. Ultraviolet lies beyond the violet end of the spectrum; infrared lies beyond the red end of the spectrum.

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Activity Procedure:

1. Ask students to list types of waves. Ask what is being transported by an ocean wave (energy, not water. Water is the medium through which the energy travels).
2. Explain that light is actually a type of wave: an electromagnetic wave. Unlike a mechanical wave, such as an ocean wave, it does not need to travel through a medium: it can travel though space.
3. Explain that visible light is only part of the electromagnetic spectrum. Sunlight, or light from a lamp, is white light, which contains all the colors in the visible spectrum. Display the TRANSPARENCY: "Light Waves" to help illustrate these concepts.
4. Explain that electromagnetic waves are described in wavelengths (light) or frequencies (e.g., radio waves). The wavelength of a wave is measured from one peak to the next peak of the wave, or one trough to the next. Wavelengths of light are very small—the wavelengths of visible light are between about 400 and 700 nanometers (a nanometer is one billionth of a meter).
5. Explain that color is usually the result of light reflected from objects. For instance, a leaf absorbs all wavelengths except those around 500 nanometers (green). Light at 500 nanometers is reflected back to our eyes and appears green to us (Note: color can also result from light that is emitted or transmitted. This concept is beyond the scope of this lesson but could be discussed if desired).
6. Explain that we cannot see most wavelengths in the electromagnetic spectrum. However, scientists use properties of ultraviolet light and infrared light to detect substances that are normally not visible to humans, such as colorless gas emitted from volcanoes.
7. Distribute the Student Worksheet: "Waves of Light" and the Student Information Sheet: "Rainbow Glasses." Tell students that they will build "rainbow" glasses that will help them visualize the visible portion of the electromagnetic spectrum. If necessary, display the transparency during this step to help students complete the worksheet.
8. Once students have completed the worksheet, pass out liquid crystal sheets. Explain that infrared energy is absorbed and radiated by human skin as heat. Although we cannot see it, we can use detectors, such as liquid crystal sheets, to visualize the infrared radiation. Scientists can detect heat from volcanoes using similar sensing equipment.
9. Let students experiment with the sheets. If a hand is pressed to a desk, the sheets can detect the residual handprint. The sheets will also respond to direct application of a hand, or nose, etc.
10. Discuss as a class why infrared detection might be useful (scientists can tell if a volcano is heating up from a distance, without having to climb directly onto the volcano). Visit the California Institute of Technology's Cool Cosmos website for other useful applications of infrared light, including environmental monitoring, law enforcement, archeology, and navigation: (http://coolcosmos.ipac.caltech.edu/cosmic_classroom/light_lessons/our_world_different_light/index.html).

Extension Idea: California Institute of Technology's Infrared Zoo website (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/index.html) has a look at infrared pictures of both warm and cold blooded animals.

Name:_____ **Student Worksheet**

Waves of Light

Background Information:

White light contains all the colors of the rainbow. When white light travels through a prism or diffraction grating, each color within the light is bent at a different angle. This bending breaks the colors into a band (a rainbow). We cannot see many types of light, such as ultraviolet and infrared energy, but we can detect them with special equipment.

Materials:

- Poster board
- Diffraction grating
- Scissors
- Colored pencils
- Tape

Procedure:

1. Cut out all parts of the glasses on the student information sheet.
2. Tape the stems of the glasses to the main part of the glasses, making one continuous piece. This piece will be used as a pattern for making glasses.
3. Place the pattern on the poster board. Trace around the pattern with a pencil. Cut out the glasses.
4. Cut out two pieces of diffraction grating about 1/2 centimeter larger than the eyeholes. These will be used as the lenses for the glasses.
5. Place the lenses over the eyeholes on the backside of the glasses. Use tape to secure the edges of the diffraction grating to the glasses. Make sure that the tape does not cover the eyeholes.
6. Answer the questions below.

Questions:

1. Look at various light sources in the classroom with the diffraction glasses. Describe what you see.

   _____

   _____

2. Look towards a window, still wearing the glasses. Color the boxes below in the order that you see the colors through the glasses:

3. Using information from your teacher or another source, label each color above with its corresponding wavelength in nanometers.

4. We cannot see ultraviolet or infrared light, but they are part of the electromagnetic spectrum. Label where ultraviolet and infrared light fall on the spectrum.

Rainbow Glasses