ARIZONA SCIENCE CENTER
Never stop wondering.
Never stop imagining.™

Light and Sound

Week 8: Grades 6-8

Day	Topics	Related Standards
1	Reflection	**Develop and use mathematical models** to explain wave characteristics and interactions.
2	Refraction	
3	Electromagnetic Spectrum	
4	Wavelength Frequency and Period	
5	Wavelength and Temperature	

Light and Sound

Day 1: Reflection

Teacher/Parent Background:

The image we see in a reflection is a flipped image from the original. Because light travels in straight lines, the angle of incoming light equals the angle of the reflected outgoing light on shiny surfaces. On dull surfaces, light rays reflect in many directions, called "scattered light. The color the eye detects depends on which wavelengths of light are absorbed and reflected. If dull objects scatter all wavelengths, they appear white. If they absorb all wavelengths, they appear black. If dull objects absorb all wavelengths but reflect red, the eye detects red objects. When a surface is very smooth, like polished metal, glass, or the surface of still water, light is reflected like a mirror.

Overview: In this activity, students test reflection of light. Students will use a PhET simulation to better understand reflection of light.

Related Standards:

Develop and use mathematical models to explain wave characteristics and interactions.

Key Terms:

- Reflection: Energy waves bouncing on the surface of an object (mirrors or echoes return energy back to the source.)

Materials List:

- Computer with internet access
- Laser pointer or flashlight and multiple mirrors (for extension)

Activity Description:

1. Give students access to the Bending Light PhET simulation
2. Ask students to follow instructions on the Student Resource page.
3. Student answers will vary. Students should come away with the understanding that the angle of the incoming light beam will be reflected the same amount.

Closure:

Discuss the following with students:

1. What is reflection? Reflection occurs when light hits a shiny surface and bounces off.
2. Give examples of materials that reflect light. Answers will vary. Possible answers include: a mirror, shiny metal, and a white board.
3. Can you design a product to look around corners? What materials would you use? Yes, materials should include a mirror as well as other various, appropriate items.

Extensions:

Bending Light!: Ask students to create a system to bounce light from one mirror to another to hit a bull's-eye. Students should use as many mirrors as they can to hit the bull's-eye with the laser pointer or flashlight. Focus on how they set up and adjust their mirrors in the system. Note: Mirrors have to be placed at different angles for light to bounce off and hit the bull's-eye. *Precautions:Tell students the dangers of shining the laser pointers in each other's eyes.*

Student Resources

Did you know? When light hits the surface of a body of water, some of it is reflected and some of it is transmitted into the water. The reflected light makes a reflection of the surroundings on the surface of the water. The transmitted light helps us to see the fish, rocks, and other objects in the water.

Procedure

1. Click on Intro.

2. Place the protractor so that 90 is on the surface of the water and 0 is on the dotted line.

3. Place the intensity meter above the protractor.

4. Turn the laser on.

5. Place the laser at 20 degrees.

6. Drag the sensor to the reflected light beam and measure the light intensity.

7. Record it in the data table.

8. Drag the sensor to the transmitted light beam and measure the light intensity.

9. Record it in the data table.

10. Move the laser to each degree listed on the data table, and then measure and record the reflected light intensity.

Angle of Incoming Light	Intensity of Reflected Light	Intensity of Transmitted Light
20		
30		
40		
50		
60		

Conclusions

1. How does the angle of the incoming light beam affect how much it is reflected?

2. If you are trying to see the reflection of the trees on the surface of the water, at what angle should you look at the water? Hint: The light must be reflected for you to see a reflection on the water. Explain or draw a labeled diagram.

3. If you are trying to see down into the water, at what angle should you look into the water? Hint: The light must be transmitted for you to see into the water. Explain or draw a labeled diagram.

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Day 2: Refraction

Teacher/Parent Background:

A refracted image is distorted or changed from the original. When light rays are transmitted or pass from one medium to another (from air to water) other than straight on, the speed of light changes slightly, which causes the light rays to change direction slightly at the boundary of those two mediums. This bending of light rays is called refractionThis happens when you look at a pencil in water, and the part below the surface of the water looks bent. This refraction of light can cause partially submerged objects in water to appear distorted. Refracting light is important to the eye. The amazing flexible convex lens inside the eye focuses incoming light that our brain interprets as the world humans see. For those with poor vision, eyeglass lenses can refract or bend light rays to focus better or to magnify the image. Convex lenses (curved away from incoming light) are also used to make objects appear closer. Hand lenses, microscopes, telescopes, or binoculars are examples of convex lenses. Concave lenses (curved toward incoming light) are used to spread out images. Concave lenses are used in glasses to correct nearsightedness (myopia), and in door viewers, or peepholes.

Overview: In this activity, students test refraction of light. Students will refract light using various tools and newspaper.

Related Standards:

Develop and use mathematical models to explain wave characteristics and interactions.

Key Terms:

- Refraction: The bending or redirection of energy waves as they pass from one substance to another.
- Lens: A clear piece of curved glass or plastic that bends passing light to focus or spread light rays.

Materials List:

- Newspaper or other source of small print
- Magnifying glass
- Marble, clear

- Glass with water
- Eyeglasses

Activity Description:

1. Give students the Student Resource page and ask them to follow the instructions.
2. Student answers should be as follows:

Refraction Test Item	Picture of Results	Description of Results
Eyeglasses	Answers will vary.	Words get bigger.
Marble	Answers will vary.	Words appear distorted.
Water in a jar	Answers will vary.	The words look broken and larger.
Magnifying Glass	Answers will vary.	The words appear larger.

Closure:

Discuss the following with students:

1. What is refraction? Refraction occurs when light bends as it moves from one medium to another.
2. Give examples of materials that refract light. Answers will vary. Possible answers include: eyeglasses, lenses, and water.
3. Explain how water can reflect and refract light. Water can refract (bend) light as light rays move pass from the air into the water, making objects appear distorted. On a sunny day, light shining on a body of water reflects light, acting like a mirror. The Sun on the water creates the shiny surface.

Extensions:

Watch and Learn!: Watch How Telescopes Work to better understand how reflecting and refracting light helps us to see far away objects. Later, stargaze with a telescope.

Student Resources

1. Place each refraction test item over the newsprint (or other source of small print) and record your observations.

Refraction Test Item	Picture of Results	Description of Results
Eyeglasses		
Marble		
Water in a jar		
Magnifying Glass		

2. Write your own definition of the word *Refraction*.

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Day 3: The Electromagnetic Spectrum

Teacher/Parent Background:

There are many different forms light energy can take, and we describe these different forms according to their positions on the electromagnetic spectrum. The electromagnetic spectrum is the range of all types of electromagnetic radiation, or energy that travels through space. The spectrum is described in terms of wavelengths. As energy travels, it moves like a wave with crests and troughs (similar to how a slinky moves on the floor if one shakes it from left to right with one end fixed).

Overview:

In this activity, students are going to use an online interactive to learn about the electromagnetic spectrum.

Related Standards:

Develop and use mathematical models to explain wave characteristics and interactions.

Key Terms:

- Wavelength: The distance between any two corresponding points on successive oscillations of a wave, such as from peak to peak.
- Electromagnetic Spectrum: A grouping of all possible energy levels of electromagnetic radiation from radio wave to gamma rays, including visible light.
- Radiation: The transfer of energy by the movement of electromagnetic waves or subatomic particles.

Materials List:

- Pen/pencil
- Computer with internet access

Activity Description:

1. Give students the Student Resource page and ask them to follow the instructions.

Closure:

Discuss the following with students:

1. What is the electromagnetic spectrum? It is a range of all types of electromagnetic radiation. The wavelengths range from very short wavelengths, including gamma and X-rays, to very long wavelengths, including microwaves and radio waves.
2. What are some examples of things that use radio waves? Radios, televisions, cellular phones, and wireless networking use radio waves. Radio waves are used to explore space, such as with radio telescopes.
3. Microwaves have recently taught scientists something interesting. Where are they believed to have originated from? Scientists have discovered background microwave radiation left over from the early formation of the universe. This gives us some idea about how far away other galaxies are from our galaxy.

Extensions:

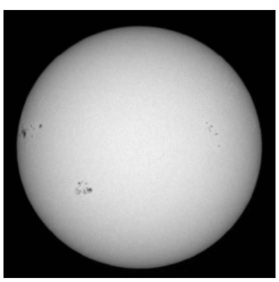
Watch and Learn!- TEDEd: Light Waves Visible and Invisible

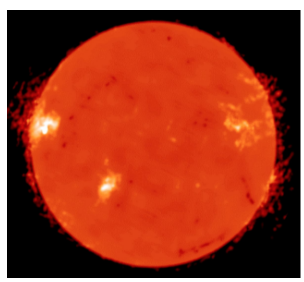
Student Resources

1. Go to: http://earthguide.ucsd.edu/eoc/special_topics/teach/sp_climate_change/p_emspectrum_interactive.html
2. Slide the green arrow to the different types of waves and record what the wave is used for and draw the wave in the table below.

Type of Wave	What It Used For	Drawing of Wave
Radio		
Microwave		
Infrared		
Visible Light		
Ultraviolet		
X-Ray		
Gamma Ray		

The photos below are both images of the sun.





- How are the pictures of the Sun different from each other?

____

____

- How are they alike?

____

- The first picture of the Sun was taken with a camera that collects visible light, and the second was taken with a radio telescope. What do radio waves tell astronomers about the object they are viewing?

____

Light and Sound

Day 4: Wavelength, Frequency, Speed, and Period

Teacher/Parent Background:

Electromagnetic waves are produced by vibrating, charged particles that result in changes in electric and magnetic fields. Microwave, radio, radar, visible light, ultraviolet, X-rays, and gamma rays are well-known frequencies of electromagnetic waves. Electromagnetic waves are described using their wavelength, frequency, speed, and period.

Overview:

In this activity, students will calculate wavelength, frequency and period to describe different waves on the Electromagnetic Spectrum.

Related Standards:

Develop and use mathematical models to explain wave characteristics and interactions.

Key Terms:

- Frequency- the number of waves that pass a fixed place in a given amount of time.
- Period- the time it takes to complete one cycle. The standard unit of a wave period is in seconds, and it is inversely proportional to the frequency of a wave.

Materials List:

- Pencil/Pen
- Calculator (optional)

Activity Description:

1. Give students the Student Resource page and ask them to follow the instructions.
2. Answers to the Student Resource page are as follows:

1. A wave cycles up and down three times per second, and the distance between each wave is 1.7 m. Calculate the following:

a. Frequency of the wave **3Hz**

b. Wavelength of the wave **1.7m**

c. Speed of the wave **5.1 m/s**

2. A sound wave with a frequency of 320 Hz travels through air with a velocity of 300 m/s. Calculate the wavelength of the sound wave.

.9375 m

3. A gamma ray is a high-energy, high-frequency, electromagnetic wave that travels at the speed of light, 3.0 x 108 m/s. Calculate the wavelength of the wave if its frequency is 1020 Hz.

$3x10^{-12}$ m

4. The frequency of a longitudinal sound wave is 900 Hz, and the speed is 320 m/s. What is the wavelength of the sound wave?

.356 m

5. Which wave has a greater wavelength: red light or blue light?

Red Light

Closure:

Discuss the following with students:

1. The energy that is radiated to Earth by the Sun includes visible light, infrared radiation, ultraviolet radiation, and other types. These different forms of radiation are distinguished based on what property? Wavelength
2. Explain why Gamma rays are potentially so dangerous and damaging. Gamma waves have lots of energy because they have a short wavelength. They are the most powerful wavelengths known. They are dangerous because they can kill living cells.

Extensions:

Exploring the Doppler Effect!- Sound waves are not a part of the electromagnetic spectrum; however, they are shifted by the Doppler effect the same way that electromagnetic waves are. The unaided human eye is not capable of directly observing the Doppler shift of light on Earth, but the unaided ear can easily detect the Doppler shift of sound waves.

A sounds pitch is related to the frequency of the waves that produce that sound. Sound waves with higher frequencies produce sounds with higher pitches, while sound waves with lower frequencies produce sounds with lower, deeper pitches. The Doppler effect creates an apparent shift in the frequencies of sound waves as the source of the sound moves toward or away from an observer.

Experiment with the Doppler effect by choosing an object that creates a repetitive sound that has only one pitch. This can be an alarm clock, a beeping timer or a cell phone with a repetitive ringtone. Students can stand in one spot in a wide-open area, preferably outside. Have someone else hold the object producing the sound and stand several feet away from the student. Students should listen carefully to the sound, paying careful attention to the pitch. Then, the person with the sound producing object should run past the student a few times.

Students should pay attention to the way the pitch changes. Discuss the phenomenon of the changing pitch as the sound moves closer and farther away.

Student Resources

Use the equations provided to help you solve the problems below.

The speed of the wave (v) can be calculated using the equation:

$$v = \lambda f$$

where v is the speed in meters per second, λ is the wavelength in meters, and f is the frequency in Hertz.

The period of the wave (T) can be calculated using the equation:

$$T = 1 / f$$

where T is the period in seconds and f is the frequency in Hertz.

1. A wave cycles up and down three times per second, and the distance between each wave is 1.7 m. Calculate the following:

    a. Frequency of the wave

    b. Wavelength of the wave

    c. Speed of the wave

2. A sound wave with a frequency of 320 Hz travels through air with a velocity of 300 m/s. Calculate the wavelength of the sound wave.

3. A gamma ray is a high-energy, high-frequency, electromagnetic wave that travels at the speed of light, 3.0 x 108 m/s. Calculate the wavelength of the wave if its frequency is 1020 Hz.

4. The frequency of a longitudinal sound wave is 900 Hz, and the speed is 320 m/s. What is the wavelength of the sound wave?

5. Which wave has a greater wavelength: red light or blue light?

Light and Sound

Day 5: Wavelength and Temperature

Teacher/Parent Background:

Electromagnetic waves are produced by vibrating, charged particles that result in changes in electric and magnetic fields. Microwave, radio, radar, visible light, ultraviolet, X-rays, and gamma rays are well-known frequencies of electromagnetic waves. Electromagnetic waves are described using their wavelength, frequency, speed, and period.

Overview:

In this activity, students will use multiple representations to describe the relationship between the temperature of an object and the wavelength of electromagnetic radiation it emits.

Related Standards:

Develop and use mathematical models to explain wave characteristics and interactions.

Key Terms:

- Frequency- the number of waves that pass a fixed place in a given amount of time.
- Period- the time it takes to complete one cycle. The standard unit of a wave period is in seconds, and it is inversely proportional to the frequency of a wave.

Materials List:

- Pencil/Pen
- Calculator (optional)

Activity Description:

1. Give students the Student Resource page and ask them to follow the instructions.
2. Answers to the Student Resource page are as follows:

   1.Plot a line of best fit. Is the function linear? Proportional?

Linear, non-proportional

2. What is the rate of change (slope) for the function on the graph?

   The rate of change is -0.03 microns for each degree Celsius increase.

3. Use the following formula to solve for the equation of the line on your graph: $y - y1 = m(x - x1)$ To use this formula, you will need to know one point on the line and the slope of the line.

   y= -0.3x+10.46

4. Use your equation to predict the wavelength of an object with a temperature of 42°C.

   9.2 microns

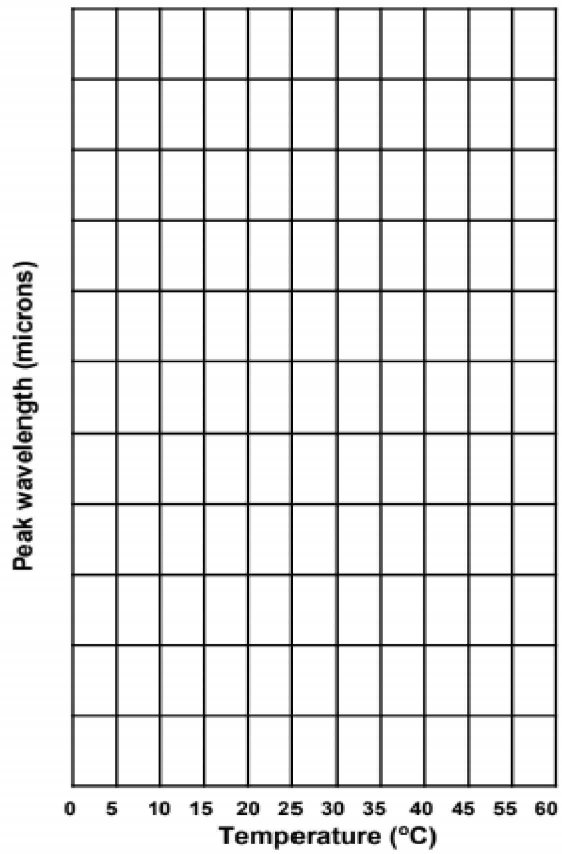
Extensions:

Watch and Learn!- Wave Properties

Student Resources

The amount of electromagnetic radiation emitted by an object at a particular wavelength depends on its temperature. Use the data in the table to draw conclusions about the relationship between temperature and the wavelength of light emitted.

Temperature (°C)	Peak Wavelength (microns)
30	9.56
31	9.53
32	9.50
33	9.47
34	9.44
35	9.41
36	9.38
37	9.35
38	9.32
39	9.29
40	9.26



1. Plot a line of best fit. Is the function linear? Proportional?

2. What is the rate of change (slope) for the function on the graph?

3. Use the following formula to solve for the equation of the line on your graph: $y - y1 = m(x - x1)$ To use this formula, you will need to know one point on the line and the slope of the line.

4. Use your equation to predict the wavelength of an object with a temperature of 42°C.