SCIENCE

DAY 21

MIRANDA

PHASE 3
WEEKS 5-6
What will it take to live in Space? 
Building a Space Habitat

Background Information: Planet Earth is able to meet the basic living requirements for trillions of organisms, including humans. The oxygen we need is in the air around us, the atmosphere protects us from radiation, drinking water can be found in rivers and lakes, and food can be readily found in most places.

On Earth, cycles exist where one species’ waste products are used by another species, so that the waste products do not build up to high levels: an example of this is the complex carbon cycle in which oxygen and carbon dioxide are alternately produced and used by plant species and animal species.

However, in space, none of these requirements for human survival are met. Therefore, to live and work in space, we have to take with us everything we need, and we need to devise ways to recycle or dispose of the waste we produce. We must do this while limiting the weight of material taken to space and building in backup safety equipment (redundancy).

Let’s Think!
(answer questions directly on this sheet)

1. What do humans need in order to survive and work efficiently on Earth?

2. What items would be considered most essential for survival in space?

3. How can we build space facilities with the highest efficiency, lightest weight and longest durability?

The Design Process (rubric attached)

1. Pick six to eight of the requirements of a space habitat (see picture below) and include them in a design for four people.

2. Include a description of the different technologies needed for the habitat, e.g. an electrolyser to produce oxygen from water, or a Sabatier reactor to split carbon dioxide into methane and water, technology that is being tested on the ISS.

3. In the design, incorporate features to support a sense of well-being such as windows, paint color or leisure areas.

4. Draw a blueprint of your habitat that you can upload (picture/scan or completed on the computer).
Considerations for designing a space habitat

Earth requirements
What do we expect for our everyday life on Earth?
- Shelter from weather - a home and clothing
- Clean drinking water and a sanitary living environment
- Breathable air
- Nutritious food
- Medical care
- Adequate sleep and leisure time
- Physical well-being.

Requirements for a planetary space habitat
Many of our requirements in a space habitat would be similar to those on Earth, but some would be specific to the new environment.
- Shelter from radiation, micrometeorites, dust, the surrounding vacuum and the extreme temperature environments
- Significant reduction in standard water use, increased water recovery and recycling\textsuperscript{\textdagger}. This includes hygiene facilities that use very little water - for the astronauts to wash their clothes and bodies, and a toilet
- Breathable air - a way to either recycle old air (oxygen provision, carbon dioxide and contaminant removal) or supply new air\textsuperscript{\textdagger}
- Nutritious food - to be either brought and stored or produced in the habitat

- Medical facilities for minor problems such as cuts, rashes, infections, toothache and motion sickness, and for more serious problems such as broken bones, kidney stones and heart attacks
- Sleeping quarters
- Exercises addressing cardiovascular muscle and skeleton maintenance
- Temperature regulation systems to compensate for the temperature extremes. Surface temperatures on the Moon can be as low as \(-270\) °C in permanently shadowed craters at the poles, and higher than 121 °C in the full sun at the lunar equator\textsuperscript{\textdagger}\textdaggerash.
- Communication systems (contact with mission control as well as family and friends on Earth)
- Recycling or disposal of liquid waste (urine) and solid waste (general garbage, faeces\textsuperscript{\textdagger}\textdaggerash. This needs to be done under the guidelines of planetary protection\textsuperscript{\textdagger}\textdaggerash.
- Monitoring systems for the life-support systems (air- and water-quality monitoring, radiation dose measurements)
- A food preparation and eating area
- Work areas for exploration experiments (geology, biology, chemistry, etc.). This is a requirement to justify long-duration space exploration.

Many of these considerations were also important in the design of the ISS. For more details, see Harteveld-Velani & Walker (2008).
Scientific Drawings: Space Habitat

Teacher Name: Dr. Miranda

Student Name: ____________________________

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
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<td>Title is clear yet borrowed.</td>
<td>Title is not very clear and borrowed. No Title.</td>
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<tr>
<td>Labels</td>
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<td>Labels are neat, clearly written and identifies all structures.</td>
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<td>Labels are not neat or clearly written, and not all components of the space habitat are identified. There are 3 or less labels, or labels are illegible.</td>
</tr>
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<td>Requirements</td>
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<td>Student chooses 6-8 requirements of a space habitat.</td>
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<tr>
<td>Drawing - general</td>
<td></td>
<td>Drawing is neat, free from mistakes, and appears to be completed with effort.</td>
<td>Drawing is neat, few mistakes, and appears to be completed with some effort.</td>
<td>Drawing is not very neat, or free from mistakes, and appears to be completed little effort. Drawing was completed haphazardly, and took little to no time to complete.</td>
</tr>
</tbody>
</table>

Online Resource:
https://www.nasa.gov/feature/students-design-space-habitat-concepts-for-mars
SCIENCE

DAY 22

MIRANDA

PHASE 3
WEEKS 5-6
ENTRY-LEVEL SURVEY

WAVES

1. Create a model of a simple wave and label the features: crest, trough, nodes, wavelength, amplitude, and frequency.

2. a. How does changing the amplitude affect the energy of a wave?

b. How does changing the frequency affect the energy of a wave?
3 a. In what ways are water and sound waves similar?

---------------------------------------------------------------

---------------------------------------------------------------

b. In what way do light waves differ from sound and water waves?

---------------------------------------------------------------

---------------------------------------------------------------

4. Imagine that you are standing over a table and looking down on a flashlight and a book resting on the table. Complete the diagram below to show how mirrors can be used to make the light from the flashlight shine on the flag on the other side of the book (without moving the flashlight or the book).

Draw mirrors using simple lines like this:

Draw the path of the light with arrows like this:

![Flashlight](image1)

![Book](image2)

![Flag](image3)
5. Two students are debating about the electromagnetic spectrum.

Student A says, "Sunlight is made of red, yellow, orange, green, blue, indigo, and violet, all the colors of the electromagnetic spectrum."

Student B says, "The waves that make up the electromagnetic spectrum may come from the Sun, but they are invisible—we can't see them."

Is either student correct? Explain why you think so.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

6. How are waves used to transmit information from one place to another?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
SCIENCE

DAY 23

MIRANDA

PHASE 3
WEEKS 5-6
Using the video linked below: Watch the presentation and complete the questions below.
Video Link:
https://www.kqed.org/quest/17358/science-of-big-waves

"Big Waves" Questions

1. Where is Mavericks?

2. Where do the waves at Mavericks begin?

3. How do storms help create ocean waves?

4. What factors affect the size of the waves?

5. How big are the biggest ocean waves at Mavericks?

6. Is the water moving along with the wave? Explain.

7. What happens when an ocean wave gets close to the shore?

8. Why does Mavericks have such big waves, when nearby coves do not?

9. Why is it dangerous to surf on big waves?
SCIENCE

DAY 24

MIRANDA

PHASE 3
WEEKS 5-6
Waves and Wave Properties

Why are we able to see?
Answer: Because there is light.

And...what is light?
Answer: Light is a wave.

So...what is a wave?
Answer: A wave is a disturbance that carries energy from place to place.

A wave does NOT carry matter with it! It just moves the matter as it goes through it.

Some waves do not need matter (called a "medium") to be able to move (for example, through space).

These are called electromagnetic waves (or EM waves).

Some waves MUST have a medium in order to move. These are called mechanical waves.
Wave Types

1. Transverse waves: Waves in which the medium moves at right angles to the direction of the wave.

Parts of transverse waves:

Crest: the highest point of the wave
Trough: the lowest point of the wave
2. Compressional (or longitudinal) waves:
Waves in which the medium moves back and forth in the same direction as the wave.

- **Vibrations of particles**

- **Direction of wave**

Parts of longitudinal waves:
Compression: where the particles are close together
Rarefaction: where the particles are spread apart
Wave Properties

Wave properties depend on what (type of energy) is making the waves.

1. Wavelength: The distance between one point on a wave and the exact same place on the next wave.

2. Frequency: How many waves go past a point in one second; unit of measurement is hertz (Hz).

The higher the frequency, the more energy in the wave.

10 waves going past in 1 second = 10 Hz
1,000 waves go past in 1 second = 1,000 Hz
1 million waves going past = 1 million Hz
3. Amplitude: How far the medium moves from rest position (where it is when not moving).

Remember that for transverse waves, the highest point is the crest, and the lowest point is the trough.

Remember that for compressional waves, the points where the medium is close together are called compressions and the areas where the medium is spread apart are called rarefactions.

The closer together and further apart the particles are, the larger the amplitude.
The energy of a wave is proportional to the square of its amplitude. Mathematically speaking...

4. Wave speed: Depends on the medium in which the wave is traveling. It varies in solids, liquids and gases.

A mathematical way to calculate speed:

\[
\text{wave speed} = \text{wavelength} \times \text{frequency} \\
(\text{in meters}) \times (\text{in Hz})
\]

OR

\[v = f \times \lambda (\text{lambda})\]

Problem: If a wave has a wavelength of 2 m and a frequency of 500 Hz, what is its speed? Answer: speed = \(2 \text{ m} \times 500 \text{ Hz}\) = 1000 m/s
All About Waves—Notes Outline

A _______________ is a disturbance that carries _______________ from one place to another.

___________ is NOT carried with the wave! A wave can move through matter (a ____________). If it must have a medium, it is called ______________ wave. If it can travel without a medium (such as in space), it is called ______________ wave.

Wave Types
1. ______ waves: Waves in which the medium moves at _______ angles to the wave direction.
   Parts of a transverse wave:
   _______: the highest point of the wave
   trough: the _______ point of the wave
2. __________ (longitudinal) wave: Waves in which the medium moves _______________ in the same direction as the wave.
   Parts of a compressional wave:
   _______: where the particles are close together
   _______: where the particles are spread apart

Wave properties depend on what ______________ makes the wave.
1. _______: The distance between one point on a wave and the _____________ on the next wave.
2. _______: How many waves go past a point in _______; measured in _______ (Hz).
   The higher the frequency, the more _______ in the wave.
3. _______: How far the medium (crests and troughs, or compressions and rarefactions) moves from _______________ (the place the medium is when not moving). The _______ energy a wave carries, the _______ its amplitude. Amplitude is related to energy by ________________.
4. _______: Depends on the medium the wave is traveling in. This varies in ____________, _______ and _______.
   Equation for calculating wave speed:
   wave speed = _______ (in m) x _______ (in Hz)

Problem: So- if a wave has a wave speed of 1000 m/s and a frequency of 500 Hz, what is its wave length? Answer: wavelength= ________________
Anatomy of a Wave Worksheet

Objective: Identify the parts of a wave and draw your own diagrams of waves.

Background: Many types of waves exist, including electromagnetic waves and mechanical waves. Waves move in different ways and have different properties.

Part 1

In the diagram below, identify the parts of a wave by using the provided definitions.

- #crest = crest
- #trough = trough
- #line of origin = line of origin
- #wavelength = wavelength
- #amplitude = amplitude

The highest point of the wave above the line of origin.
The lowest point of the wave below the line of origin.
Signifies the original position of the medium.
The distance between two consecutive crests.
The distance from the line of origin to a crest or trough of a wave.

Part 2

On separate sheets of paper, draw four different waves with the following measurements. Label the parts and include the measurements.

<table>
<thead>
<tr>
<th>wave #</th>
<th>crest</th>
<th>trough</th>
<th>wavelength</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 cm</td>
<td>1 cm</td>
<td>2 cm</td>
</tr>
<tr>
<td>2</td>
<td>3.5 cm</td>
<td>3.5 cm</td>
<td>2.5 cm</td>
</tr>
<tr>
<td>3</td>
<td>.5 cm</td>
<td>.5 cm</td>
<td>3 cm</td>
</tr>
<tr>
<td>4</td>
<td>2 cm</td>
<td>2 cm</td>
<td>.5 cm</td>
</tr>
</tbody>
</table>

Concluding question: State which wave you think has the highest frequency and which might have the lowest frequency. Explain the reasons for your selections.
SCIENCE

DAY 25

MIRANDA

PHASE 3
WEEKS 5-6
Exploring Waves

**Purpose:** To explore a few simple characteristics of waves traveling along a rope and sound waves traveling through air.

**Getting Ready:** Navigate to the Simple Wave Simulator Interactive at The Physics Classroom website: https://www.physicsclassroom.com/Physics-Interactives/Waves-and-Sound/Simple-Wave-Simulator/Simple-Wave-Simulator-Interactive

**Getting Acquainted:** Once you’ve launched the interactive and resized it, experiment with the interface. Tap on the Slow Motion, Real Time, and Fast Motion tabs at the top of the interface to observe how to control the tempo of the animation. Toggle back and forth between a sound wave and a rope wave by tapping on the Show Wave as ... button. Finally, observe the sliders at the bottom of the interface for controlling the Frequency, Wave Speed, and Wave Amplitude.

**Exploring Waves on a Rope**

Set the animation to Show Waves on a Rope using a Real Time tempo and **Frequency**, **Wave Speed**, and **Wave Amplitude** values of 0.10 Hz (approximately), 100 cm/s, and 2 cm respectively. Then use the controls on the animation to answer the following questions.

1. In Physics, we distinguish between **wave motion** and **particle motion**. Wave motion refers to the movement of a wave-like pattern from one location on the medium to another. When you view a water wave moving along the surface of water, you are observing wave motion. There is a very obvious movement of a collection of crests and troughs along the water surface. In the Simple Wave Simulator, there is a collection of crests and troughs moving through a rope; this is wave motion. But there are also three points on the rope that are colored red. When you observe the motion of these points, you are observing particle motion - the motion of particles of the rope. Describe the motion of these particles.
2. There are a variety of ways to categorize waves. One way is to categorize waves as being transverse waves, longitudinal waves, or surface waves. Waves in each of these categories differ from one another in terms of how the direction of the particle motion compares to the direction of the wave motion. The waves traveling through the rope are transverse waves. For transverse waves, compare the direction that the particles move to the direction that the wave moves.

3. Now use the Frequency slider to increase the frequency to a high value. Compare the motion of the particles when the frequency is high to the low-frequency motion. How would you describe the difference?

4. Does moving the Frequency slider from a low to a high value change the listed Wave Speed in this animation? Circle: Yes No

5. Change the Wave Amplitude from a high value to a low value. In terms of particle motion, how would you describe the difference between a high amplitude wave and a low amplitude wave?

6. Does a change in amplitude effect the wave speed? Run two tests with high and low amplitude using a similar procedure used in Question #5. Make a claim and support your answer with evidence.
Assessment

Use your explorations of waves on a rope and waves through the air to answer these questions.

1. As a transverse wave travels through a rope from left to right, the parts of the rope ____.
   a. move along a line from left to right
   b. oscillate back and forth about a fixed location
   c. move along a sine-wave like path from left to right

2. For a transverse wave, the particles of the medium move ____ to the direction that the wave moves.
   a. perpendicular
   b. parallel
   c. diagonal

3. For a longitudinal wave, the particles of the medium move ____ to the direction that the wave moves.
   a. perpendicular
   b. parallel
   c. diagonal

4. The frequency of a wave describes ____.
   a. how fast a point on the wave moves along the medium
   b. how often particles of the medium oscillate back and forth
   c. how far particles move away from their normal resting position

5. Increasing the frequency with which particles within a rope vibrate will cause the
speed of waves to ______.

a. increase
b. decrease
c. ... nonsense! Frequency changes do not affect speed.

6. The amplitude of a wave describes ______

a. how fast a point on the wave moves along the medium
b. how often particles of the medium oscillate back and forth
b. how far particles move away from their normal resting position

7. Increasing the amplitude of a wave within a rope vibrate will cause the speed of waves to ______.

a. increase
b. decrease
c. ... nonsense! Amplitude changes do not affect speed.

8. The wavelength of a wave increases if the _____ Select two answers.

a. frequency increases
b. amplitude speed increases
c. speed increases
d. frequency decreases
e. amplitude decreases
f. speed decreases
SCIENCE

DAY 26

MIRANDA

PHASE 3
WEEKS 5-6
Wave Interactions

Objectives
Describe wave reflection, refraction, and diffraction.
Explain how wave interference affects amplitude of waves.

Important Terms

• Reflection
• Refraction
• Diffraction
• Standing Wave
• Wave Interference
Introduction

Did you ever hear an echo of your own voice? An echo occurs when sound waves bounce back from a hard object.

Wave Interactions

- These three ways that waves may interact with matter are called reflection, refraction, and diffraction.
Reflection

- An echo is an example of wave reflection. Reflection occurs when waves bounce back from a barrier they cannot pass through.
- **Reflection** can happen with any type of waves, not just sound waves.

Reflection

- Reflected waves have the same speed and frequency as the original waves before they were reflected.
- However, the direction of the reflected waves is different.
Refraction

- Refraction is another way that waves interact with matter.
- **Refraction** occurs when waves bend as they enter a new medium at an angle.

Refraction

- Light bends when it passes from air to water.
- The bending of the light causes the pencil to appear broken.
Diffraction

- Did you ever notice that when you’re walking down a street, you can hear sounds around the corners of buildings?
- Sound waves spread out and travel around obstacles.

Wave Interference

- 2 Types: Constructive and Destructive Interference
Wave Interference

- Wave interference may occur when two waves that are traveling in opposite directions meet.
- The two waves pass through each other, and this affects their amplitude. How amplitude is affected depends on the type of interference. Interference can be constructive or destructive.

<table>
<thead>
<tr>
<th></th>
<th>Destructive</th>
<th>Constructive</th>
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</thead>
<tbody>
<tr>
<td>Wave 1</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Wave 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interference</td>
<td>=</td>
<td>=</td>
</tr>
</tbody>
</table>

Standing Wave

- When a wave is reflected straight back from an obstacle, the reflected wave interferes with the original wave and creates a standing wave.

What is the wavelength of the standing wave?
Review Quest

• What is reflection? Give an example.
• Define constructive interference.
• State how destructive interference affects wave amplitude.
• What is a standing wave?
  - Create a sketch of sound waves to show why you can hear a sound on the other side of brick wall.
SCIENCE

DAY 27

MIRANDA

PHASE 3
WEEKS 5-6
Transverse and Longitudinal Waves

Answer the questions about waves.

1. What kind of wave is pictured above?

2. Label the following on the wave above:
crest, trough, wavelength, amplitude, direction of travel.

3. In what direction would the particles in this wave move, relative to the direction of wave travel?

4. What kind of wave is pictured above?

5. Label the following on the wave above:
compression, rarefaction, wavelength, direction of travel.

6. In what direction would the particles in this wave move, relative to the direction of wave travel?

For each wave described below, identify the wave as more like a transverse wave or a longitudinal wave.

7. The wave created by moving the end of a spring toy up and down

8. The wave created by moving the end of a spring toy back and forth parallel to the length of the spring

9. A sound wave

10. An ocean wave

11. An electromagnetic wave
Waves Worksheet #2

A: __________________________
B: __________________________
C: __________________________
D: __________________________
E: __________________________
F: __________________________

Frequency

1. How many wavelengths long is Wave 1?
2. How many wavelengths long is Wave 2?
3. How many wavelengths long is Wave 3?
4. Which wave has the highest frequency?
5. Which wave has the lowest frequency?
6. What is the definition of frequency?
7. How can you tell by looking at it if a wave has high or low frequency?

Frequency Connection

There are three members of a family. The dad has a deep, low voice. The mom has a medium-high voice, and the baby has the highest voice.

8. Which wave belongs to the dad’s voice? _______________________
9. Which wave belongs to the mom’s voice? _______________________
10. Which wave belongs to the baby’s voice? _______________________


Wave 4:

Wave 5:

Wave 6:

Amplitude

1. Which wave has the highest amplitude?
2. Which wave has the lowest amplitude?
3. Use a ruler and measure the amplitude of Wave 5:
4. What is the definition of amplitude?
5. How can you tell by looking at it if a wave has high or low amplitude?

Amplitude Connection

Juan is playing the piano. The music starts out at *meso-forte* (medium high volume). It then *crescendos* into *forte* (loud) and Juan plays dramatically. The music ends at *piano* (quietly) with a sweet melody.

6. Which wave represents the music at the beginning?
7. Which wave represents the music in the middle?
8. Which wave represents the music at the end?

Final Waves Goodbye

Compare waves A-D by both amplitude and frequency to the Standard Wave. (Higher/Lower/Same)

<table>
<thead>
<tr>
<th></th>
<th>Standard Wave</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
</tr>
</tbody>
</table>
SCIENCE

DAY 28

MIRANDA

PHASE 3
WEEKS 5-6
INVESTIGATIONS 1-2 I-CHECK
WAVES

1. Label each term in the word bank on the wave diagram below:

<table>
<thead>
<tr>
<th>Word Bank</th>
<th>wave</th>
<th>wavelength</th>
<th>amplitude</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Wave Diagram]

2. What are two defining characteristics of all waves (not included in the word bank above)?

3. For each mechanical wave, describe a medium through which it transmits:

<table>
<thead>
<tr>
<th>Wave</th>
<th>Medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td></td>
</tr>
<tr>
<td>Ocean</td>
<td></td>
</tr>
<tr>
<td>Sound</td>
<td></td>
</tr>
</tbody>
</table>

4. A student measures the frequency of a wave as 2 waves/second, and the wavelength as 40 cm/wave. Use the velocity equation \(v = f \times \lambda\) to calculate the speed of the wave. Show your work and include units.
5. A student taps a drum and you hear the noise.
   a. Describe how a sound wave is made when the student taps the drum.

   ______________________________
   ______________________________
   ______________________________
   ______________________________
   ______________________________

   b. Describe how the sound wave travels from the drum to your ear.

   ______________________________
   ______________________________
   ______________________________
   ______________________________
   ______________________________

   c. The student increases the amplitude of the drum noise. Which of the following is true? (Mark all that apply.)
      The sound wave will transfer more energy.
      The sound will be louder.
      The frequency will increase.
      The pitch will increase.
      The wavelength will increase.

6. A city wants to build a new sports arena. What are some possible constraints that a building engineer will need to consider?
7. Look at the two wave diagrams shown below, then answer the questions.

![Wave Diagrams](image)

a. Which wave has the longest wavelength?
   - A  Wave A
   - B  Wave B
   - C  They are the same.

b. Which wave has the highest amplitude?
   - F  Wave A
   - G  Wave B
   - H  They are the same.

c. Which wave has the highest frequency?
   - A  Wave A
   - B  Wave B
   - C  They are the same.

d. Which wave is transferring more energy?
   - F  Wave A
   - G  Wave B
   - H  They are the same.
8. How would you describe the relationship between wavelength and frequency?

9. Compare how a compression wave and a transverse wave move through a spring using an example.
Sound Waves

It's a quiet day at home, until your cell phone ringtone plays loudly from the other room. You dash over to pick it up. How did the sound of the phone make it from the device to your ear halfway across the house?

When you tap a tuning fork against a surface, you can feel the vibration of the metal in your hand. You can also hear the vibration as sound waves travel from the vibrating tuning fork to your ear through the air. The sound of a motorcycle, the cheerful laugh of your baby cousin, and the music of your favorite band performing live are all sounds due to vibrations.

Love loud music? The rocking sounds from on stage are a form of energy we can hear. The energy is produced by vibrating objects—such as strings, drum heads, and your favorite singer's vocal cords.
Vibration is a repeating pattern that you can sometimes hear. Sound comes from a vibrating source. It travels in energy pulses through a medium like air. The graph above shows the pattern of energy pulses as a bell vibrates. The graph represents these energy pulses as air pressure changing over time. It shows an compression as crests and expansion as troughs.

Sound waves are like the motion of the spring that you pushed and pulled. It created a series of compression waves, also known as longitudinal waves. The energy pulse traveling along the spring is like the energy pulse sent through the air by a vibrating object. The pulse creates a sequence of compressions. The sound travels as a compression wave through the air to your ear. It makes tiny bones and hairs in your ear vibrate. Your nervous system then interprets the vibrations as sounds.

Your ears collect and detect sound waves. The vibrations move through the ear canal to the inner ear, where they are converted to nerve impulses.
Sound has two important properties. It has intensity (amplitude) and frequency, which we interpret as volume and pitch. How can you use a graph of a sound wave to tell how loud it is and how high or low it is? The amplitude of the wave shows how loud the sound is. In sound, amplitude equals volume. Above are graphs of two sounds that are the same pitch. Which sound is louder? The sound graphed in red is louder. Its amplitude is greater than the amplitude of the sound represented by the blue graph.

What does the graph tell us about pitch? A sound's wavelength determines its pitch. The shorter the wavelength, the higher the frequency and the higher the pitch. In the above graph, the two sounds are the same pitch because their wavelengths are the same. But the red sound is louder. Look at the sound waves graphed below. What can you tell about the pitch and volume of these two sounds?

Use the purple and orange wave graphs to compare the pitch and volume of these two sounds.
The amplitudes of the two waves are about the same. So these two sounds are about the same volume. What about the wavelengths? The wavelength of the orange wave is longer than the wavelength of the purple wave. The orange wave graph represents a lower-pitched sound.

Sound is a mechanical wave, and the medium is usually air. But sound waves travel through other media, including liquids such as water, and solids such as walls and railroad tracks. Sound waves change as they pass through a new medium. You may have noticed the differences if you have listened to sounds underwater.

**Think Questions**

1. When a bell rings, how does the sound travel to your ear?
2. How can you use a graph to model a compression wave, like sound?
3. Can you hear a vibration that was made in a vacuum (empty space)? Explain.

A microphone changes sound energy to electrical energy. Mechanical waves are transformed into electric current that flows to an amplifier or recording device. This makes it possible to send your voice to the back of the room or around the world, or to record and save it for another day.

Complete all think questions (1-3) on page 20, on a separate sheet of paper or on the reverse of this sheet.
SCIENCE

DAY 30

MIRANDA

PHASE 3
WEEKS 5-6
Electromagnetic Waves

Light from the Sun may look white or yellowish, but it can be separated into a rainbow of colors. In the sky, you can see this when light passes through a piece of glass called a prism. When light enters glass, it is bent or refracted, and bent or refracted again as it leaves the glass. The result is a spectrum of rainbow colors because each color bends a different amount. In this diagram, each color is represented by a line. Each line represents the same length of line, but each color is different. The amount of space between the colors is not important because each color is different. The amount of space between the colors is not important because each color is different.
Spectroscopes can separate different wavelengths of light. This separation is due to the interaction of light with atoms and molecules. These light sources can identify the chemical composition of substances. You used a spectroscope to examine an unknown lightbulb, and you observed a thin yellow band of light at 589 nm. What conclusion can you make about the light source?
Forensic scientists apply a substance to surfaces where they suspect fingerprints may be present. When a UV light is shined on the surface, the prints are revealed.

Invisible Wavelengths Beyond Violet

What kinds of rays are in the electromagnetic spectrum? The shortest visible wavelengths are violet. Even shorter than violet light are ultraviolet light, X-rays, and gamma rays. As you know, wavelength and frequency have an inverse relationship. Short wavelengths are associated with high frequency and high energy.

Ultraviolet (UV) light has wavelengths shorter than visible violet light, from about 10 to 400 nm. Ultraviolet waves have higher frequency and higher energy than visible light waves. These properties are one reason that ultraviolet light can cause sunburn and skin damage. The energy is high enough to excite the electrons within a molecule.
Invisible Wavelengths Beyond Red

Some waves are longer than the longest visible wavelengths (red). They include infrared waves, microwaves, and radio waves. As you know, long wavelengths are associated with low frequency and low energy.

The National Radio Astronomy Observatory in Greenbank, West Virginia, operates the world's largest radio telescope, sensitive enough to pick up signals coming from 13 billion light years away.

Infrared (IR) waves range from 700 nm to about 1 millimeter (mm). As with all spectra, infrared spectra can be used to identify and study chemicals.
Microwave spectra can be used to analyze the energy of molecules in gases.

Radio waves range from 1 m to 100 km long. Large radio telescopes observe radio waves. The radio telescope in Greenbank, West Virginia, is used to study radio waves coming from galaxies and gas clouds in space. More than 140 different molecules have been observed in space based on their radio wave spectra.

This graph shows a microwave spectrum for water vapor in the atmosphere at Mauna Kea, Hawaii.

Take Note

Think about the three kinds of electromagnetic radiation with lower frequency and energy than visible light: infrared waves, microwaves, and radio waves. What other sources of this radiation have you heard about? What questions do you have about these sources of radiation?
Animals and Vision

Your eyes can respond only to light with wavelengths in the visible range. Thus, you can see blue, red, green, and all the other colors of the rainbow. But try as you might, your eyes cannot see colors beyond the visible spectrum. But what about other animals?

Almost all animals have between one and five color receptors. The receptors let animals see fine differences in colors. Most humans have three, but a rare genetic mutation gives some people four. Does this extra color receptor let people see ultraviolet or infrared or even X-rays? No, but it does let those people see fine differences between colors more easily.

This graph shows how well humans can detect each wavelength of the visible spectrum. What range of colors are we most sensitive to—that is, which do we perceive best?

Some snakes are capable of sensing prey with infrared waves. This smooth tree python has infrared receptors on its lips that let it find prey by detecting the animal's body temperature.
Bees and other pollinating insects can detect light in the ultraviolet range of the spectrum. They can detect special markings on flowers that have nectar. Some birds can also see ultraviolet. Their feathers can have patterns that reflect ultraviolet rays. These patterns help birds locate mates. Many animals that see ultraviolet light do not see the red end of the spectrum.

Some animals can detect infrared waves. For example, rattlesnakes, pit vipers, boas, and pythons have infrared-sensing pits on their heads. Some vampire bats have three infrared-sensing pits on their nose. This sense helps them find the best place to attack.

Some insects also can detect infrared. Blood-sucking bedbugs have infrared-sensing organs on their antennae that help locate their prey. Some species of beetles have evolved infrared sensing for detecting forest fires, so that they can lay their eggs in newly burned wood.

Both photos show the same cluster of flowers, but the bottom view, showing ultraviolet light, is more similar to how a bee sees them. The bee finds nectar-rich blossoms, and the flowers attract an effective pollinator.

Think Questions

1. What waves are in the electromagnetic spectrum, besides visible light?
2. How do light spectra help identify light sources?
Complete the Following Electromagnetic Spectrum (Above)
Include all levels of radiation throughout the entire spectrum, as well as the individual wavelengths found in Visible Light.
Waves of the Electromagnetic Spectrum

Understanding Main Ideas
Complete the table.

<table>
<thead>
<tr>
<th>Type of Electromagnetic Radiation</th>
<th>Example of Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Microwaves</td>
<td>Radio Broadcasting</td>
</tr>
<tr>
<td>2. Infrared rays</td>
<td></td>
</tr>
<tr>
<td>3. Visible light</td>
<td>Seeing</td>
</tr>
<tr>
<td>4. Ultraviolet rays</td>
<td>Check for broken bones inside</td>
</tr>
<tr>
<td></td>
<td>the body</td>
</tr>
<tr>
<td>5.</td>
<td>Diagnose and treat cancer</td>
</tr>
<tr>
<td>6.</td>
<td></td>
</tr>
</tbody>
</table>

Building Vocabulary
Answer the following questions in the spaces provided. Use a separate sheet of paper if you need more room.

7. What is the electromagnetic spectrum?

8. Why is too much exposure to ultraviolet radiation dangerous?

9. What is a thermogram?

10. How can a person detect infrared rays without an instrument?
Waves of the Electromagnetic Spectrum

A motion detector is a device that can sense when a person or object moves through a room. Read the passage and study the figures. Then use a separate sheet of paper to answer the questions that follow.

Motion Detectors

Many businesses have burglar alarms that are connected to motion detectors. One type of motion detector can sense the infrared rays given off by a person’s body. An alarm is set off when infrared rays hit a sensor on the detector. This type of device is called a passive infrared (PIR) motion detector.

Another type of PIR motion detector involves two sensors in different parts of an office. This type of detector sounds an alarm only after both sensors have been hit by infrared rays from a person’s body.

PIR motion detectors only sense infrared rays; they do not transmit them. By contrast, part of an active infrared (AIR) motion detector gives off infrared rays. A second part of the detector in another part of the room reflects these rays back to the first part where they hit a sensor. If someone walks through the path of the invisible infrared rays given off by the detectors, his or her body will prevent the rays from hitting the sensor. When this happens, the alarm is set off.

1. Label each of the motion detectors shown above as one-sensor PIR, two-sensor PIR, or AIR.

2. Suppose a business has a nighttime alarm system with a one-sensor PIR motion detector. What do you think would happen if a lamp close to the sensor was left turned on overnight?

3. Suppose a business has a nighttime alarm system with a two-sensor PIR motion detector. What do you think would happen if a lamp close to one of the sensors was left turned on overnight?

4. Do you think that a motion detector that used visible light instead of infrared rays would work very well? Explain your answer in terms of both passive and active detectors.