Name: _____ Date: _____

Waves and Energy SNAPs Lab Overview

Objectives

1. Students will be able to describe the relationship between the amplitude of a mechanical wave and its energy.
2. Students will be able to compare and contrast how transverse and longitudinal waves transfer energy.
3. Students will be able to use computer models to explain how sound wave characteristics correspond with physical observations of sound.
4. Students will be able to evaluate prototypes that harness energy from water waves.

Science Skills Station

Students will study the relationship between amplitude and the energy carried by a wave. Students will graph, interpret and analyze data to study the relationship between seismic wave amplitude, magnitude and energy. Students will make observations of sound waves to determine the physical characteristic of sound that relates to the energy carried by sound waves.

Narrative Station

Students will read about energy transfer by mechanical waves so to better understand that waves transfer energy, not matter. Students will also watch a video about how the amplitude of a mechanical wave is related to the wave's energy.

Assessment Station

At this station, students will answer questions about key terms and ideas relating to waves and energy. Students will have to employ lower, mid and higher order thinking skills to answer these questions.

Problem-Solving Station

Students will evaluate the use of wave power to generate electricity. Specifically, students will evaluate three different prototypes that harness energy from water waves. Students will consider the use of wave power against other sources of renewable and nonrenewable energy. If time allows, students will evaluate how scientists and engineers apply the engineering design process to developing the wave energy industry.

Name: _____ Date: _____

Waves and Energy SNAPs Pre-Lab Assignment

Directions

1. Read through the Lab Overview.
2. Create a new entry for Waves and Energy in the table of contents in your lab journal and determine the pages of your lab entry. *Complete the following steps on the first page of this entry.*
3. Define the following terms in your lab journal:
    - Wave
    - Medium
    - Equilibrium
    - Mechanical wave
    - Transverse wave
    - Longitudinal wave
    - Seismic wave
    - Earthquake
    - Magnitude
    - Amplitude
    - Wavelength
    - Frequency
    - Sound
    - Pitch
    - Volume
4. Write a 4-5 sentence summary about what you will do in this laboratory.

Name: _____ Date: _____

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    - Transverse wave
    - Longitudinal wave
    - Seismic wave
    - Earthquake
    - Magnitude
    - Amplitude
    - Wavelength
    - Frequency
    - Sound
    - Pitch
    - Volume
4. Write a 4-5 sentence summary about what you will do in this laboratory.

Science Skills Station

Objective

1. Graph, interpret and analyze data to determine the relationship between a seismic wave's amplitude and the energy carried by the wave.
2. Make observations to determine the characteristic of sound that corresponds to the amplitude and thus, the energy carried by sound waves.

Skills Utilized

- Make observations
- Infer and/or Predict
- Organize data in a table
- Analyze and interpret data
- Determine relationships
- Graph data

Overview

At this station, you will study the energy carried by mechanical waves. Specifically, you will study energy carried by seismic waves and sound waves. Follow the directions for each activity. Record all observations, data and answers on your recording sheet.

Activity #1

An earthquake is a shaking of Earth's surface. An earthquake releases energy in the form of waves called **seismic waves.** The strength or magnitude of an earthquake depends on the amount of energy carried by the seismic waves. We often measure the magnitude of an earthquake using a scale known as the **Richter Scale**. The Richter scale assigns a number to quantify the strength of an earthquake. The value is based on the amplitude of the seismic waves generated by the earthquake. To the right is a table of Richter Scale value for different amplitudes of seismic waves.

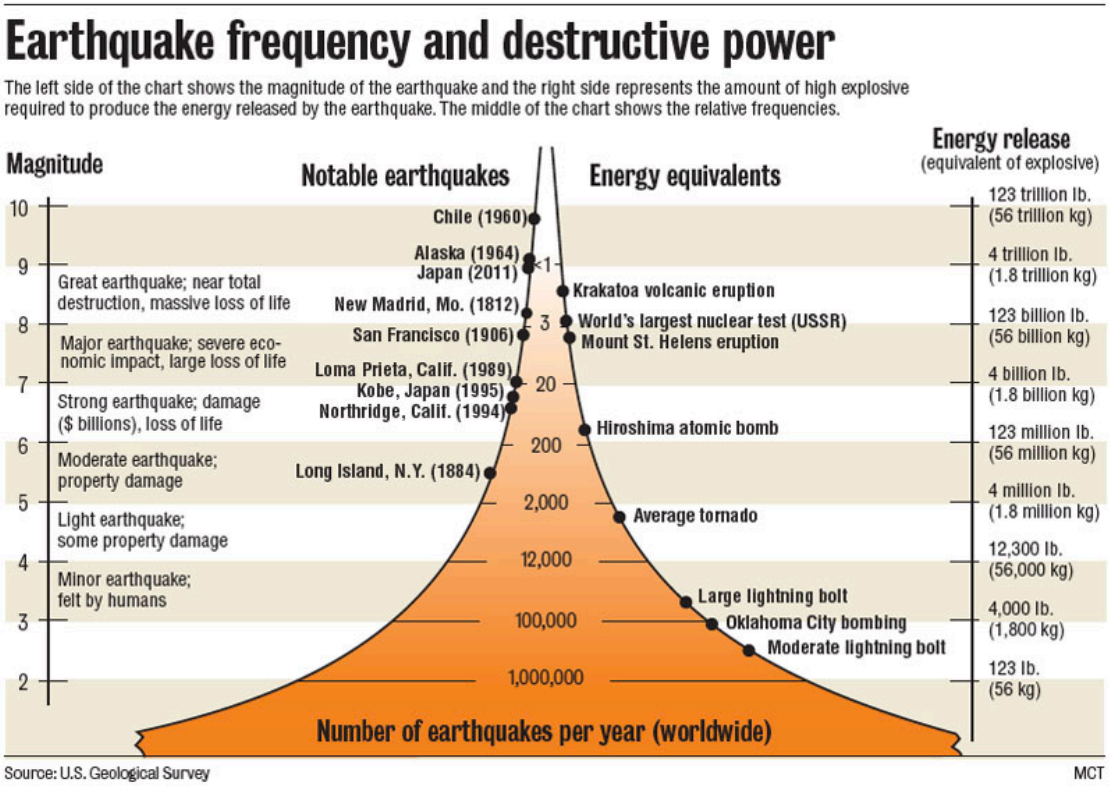
Amplitude	Richter Scale Value
0.1 mm	1.0
0.3 mm	2.0
1.0 mm	3.0
3.0 mm	4.0
10 mm	5.0
30 mm	6.0
100 mm	7.0
300 mm	8.0

Directions:

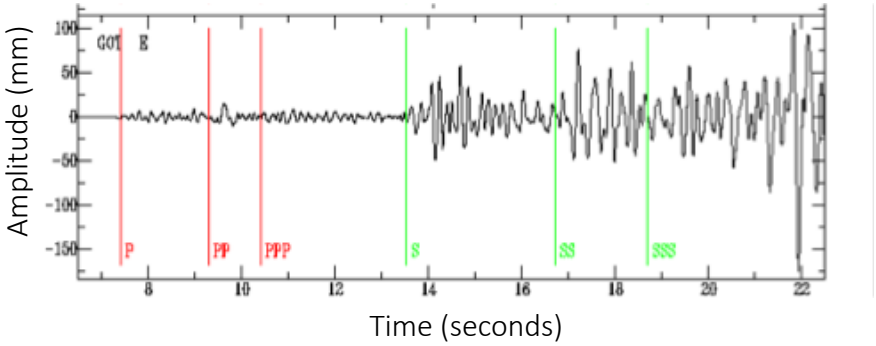
1. Graph the data in the table. Use the grid on your recording sheet or separate graph paper.
2. Use your graph to help you answer the questions.

Questions:

1. What is the relationship between the amplitude of a seismic wave and the Richter scale value assigned to the wave?
2. Below is a graph that summarizes the relationship between an earthquake's magnitude and the energy released. According to the graph, what is the relationship between the energy released by an earthquake and its magnitude?



3. Based on the data presented in the graph you made and the graph above, how is the energy carried by seismic wave related to its amplitude?
4. Below is a seismogram - a graph of actual seismic waves. The seismograph is of a 7.8 magnitude earthquake that struck San Francisco in 1906. How might the seismic waves look different if the earthquake had a magnitude of 5.0?



Activity #2

Sound is produced by a vibrating object. A vibrating object causes particles around it, including particles in the air, to vibrate. Vibrating air particles create sound waves that can be heard by humans. In this activity, you will observe sound with different pitch and volume. You will use your observations to determine the characteristic of sound that corresponds to the amplitude and thus, the energy carried by a sound wave. Follow the directions. Record all observations, data and answers on your recording sheet.

Directions:

1. Use a computer to access the following website: http://bit.ly/2GVfbFn. *If the site asks you for permission to use Adobe Flash, allow it to be used by this website.*
2. Adjust "V/div" and "ms/div" to 1. Make sure the "sine" light is glowing yellow.
3. Adjust the **computer volume** to medium-high.
4. Set the **keyboard volume** to the middle. To do this, click and slide the volume bar.
5. To make a sound, move the pointer finger over a keyboard key. Click and hold down the mouse button over the key. The frequency of the sound is shown in the "frequency box." A graph that illustrates the wavelength, frequency and amplitude of the wave is shown in the box above the keyboard.
6. Part 1: Examine the pitch produced by **five** different keys. Choose keys from the left, middle and right of the keyboard. Maintain the volume at a constant level. Record your observations. Specifically:
   - Record the frequency of the sound
   - Describe what the sound is like (if you can hear it)
   - Draw a picture of what the wave looks like
7. Part 2: Examine the volume of sound. Choose one key in the middle of the keyboard. Observe what the sound is like at **three** different volume levels: low (all the way left), medium (in the middle) and high (all the way right). Record your observations. Specifically:
   - Record the volume of the sound
   - Describe what the sound is like (if you can hear it)
   - Draw a picture of what the wave looks like

Questions:

1. How does changing the pitch and volume of sound affect the frequency, wavelength and/or amplitude of sound waves?
2. What physical characteristic of sound can be used to determine the energy carried by sound waves? Explain.
3. What is the relationship between volume, amplitude and the energy carried by sound waves?

Narrative Station

Objective

1. Explain how energy carried by a wave caused particles of matter to oscillate.
2. Describe the relationship between amplitude and the energy transferred by a wave.

Skills Utilized

- Answer questions relating to a text
- Cite textual information
- Determine meaning of key terms
- Summarize information
- Analyze data in an illustration
- Make connections

Activity #1

Directions: Read the following informational text. Then answer the questions.

ENERGY TRANSFER BY WAVES

A wave transfers energy as it moves. When you see a wave move through a substance, you are observing energy transfer through the medium. In a transverse wave, particles of the medium oscillate perpendicular to the direction of the wave's movement and thus, energy transfer. In other words, particles move up and down as energy moves left or right. In a longitudinal wave, particles of the medium move in the same direction as the wave's movement and thus, energy transfer. In other words, particles oscillate parallel to the direction of the wave. After a wave passes, particles return to equilibrium.

A wave does NOT transfer matter. A wave causes particles in matter to move up and down or left and right. However, the particles always return to equilibrium once a wave passes. Seismic waves caused by an earthquake provide a good example of this. The waves pass through the ground, causing the ground to shake. The waves travel miles away from their source. However, the ground does not travel with the waves. Ocean waves also provide a good example. Ocean waves do not "pile up" on the shore. In other words, water does not accumulate on beaches. However, the energy transferred by ocean waves is transferred to the beach. A person standing on the shore can be knocked down by the energy carried by ocean waves.

Questions

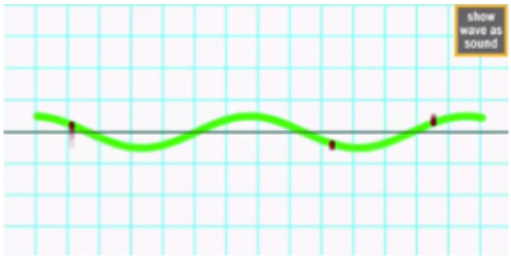
1. What does a wave transfer as it moves through a medium?
2. Does energy transfer occur in the same direction as the motion of particles in a medium? Explain.
3. Many students do not understand that waves do not transfer matter. Use at least one example to help explain this concept.

Activity #2

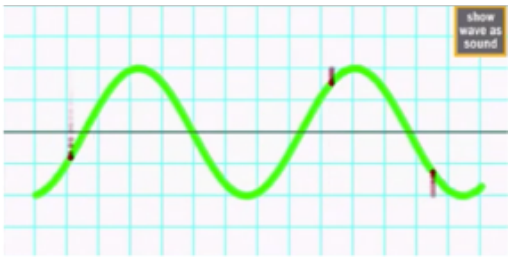
Directions: Use a computer or tablet to watch a 3 ½ minute video: http://bit.ly/2EMIVn5. Answer the questions after watching the video.

Questions:

1. What wave property is directly related to a wave's energy?
2. What is a wave energy generator?
3. How does a wave's amplitude vary with the energy transferred by a wave?
4. Compare and contrast the energy carried by the two waves below.



Wave A



Wave A

5. How does changing the pitch of sound affect the energy carried by sound?
6. How does changing the volume of sound affect the energy carried by sound?

Assessment Station

Objective

Recall concepts, terms and ideas relating to waves and energy.

Skills Utilized

- Define key terms
- Label a diagram
- Explain a concept
- Make calculations
- Determine relationship
- Compare and contrast
- Interpret or analyze data
- Make inferences
- Illustrate a concept

Assessment Direction

1. Answer the following questions. Write down your answers on the recording sheet.
2. There are two bonus questions. If time allows, try to answer these questions.

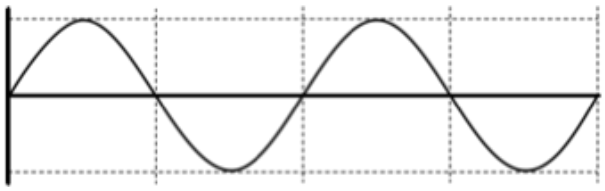
Question #1

A mechanical wave transfers:

A. Energy
B. Matter
C. Both energy and matter

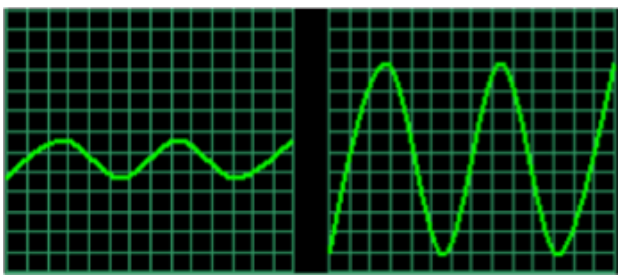
Question #2

What wave property is related to the energy carried by a wave? Label that property on the graph below.



Question #3

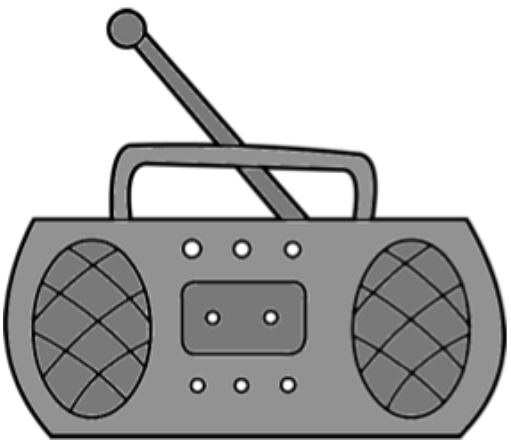
Compare and contrast the energy carried by the two waves below. Which wave carries more energy? Explain.



Wave A Wave B

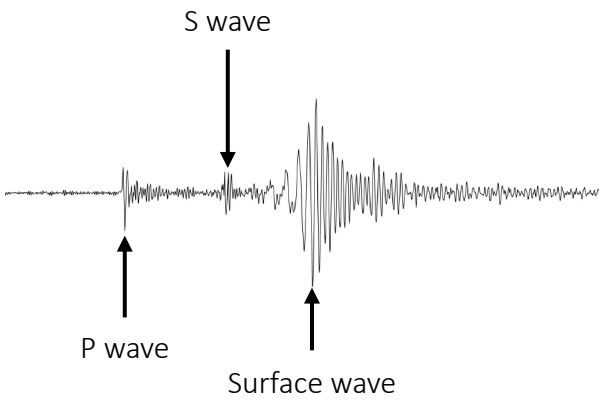
Question #4

What type of sound would carry more energy: a high-pitched noise or a very loud noise? Justify your answer.



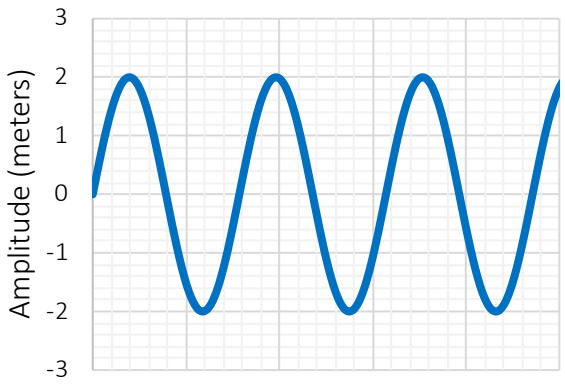
Question #5

Below is a graph of three types of seismic waves: P waves, S waves and surface waves. Which waves would cause the most damage to structures on the ground? Explain.



Question #6

Below is an image of a wave. How would the wave change if it had more energy? Would it change if it had less energy? Draw pictures of waves with more and less energy than the wave graphed below.



BONUS Question #7

A **tsunami** is a large sea wave or series of waves that resemble a rapidly rising tide. Tsunamis can cause massive destruction in coastal regions.

Tsunamis are most often caused by earthquakes that occur in the ocean. How much destruction would be caused by a tsunami associated with a weak earthquake that occurs in the ocean? What if the earthquake was very strong?

BONUS Question #8

Why is listening to loud music with headphones harmful to your hearing? Explain your answer in terms of energy transfer.

Problem Solving Station

Objective

1. Evaluate prototypes that generate electrical power from water waves.
2. Evaluate the use of water waves to generate electricity to other sources of energy.

Skills Utilized

- Evaluate possible solutions
- Compare multiple solutions

Background Information

Wave power is the capture of energy from water waves. Wave power is often harnessed from ocean waves because ocean waves contain tremendous energy. According to the United States EIA, the energy potential of ocean waves off the coasts of the United States could be as much as 65% of the electricity generated in a single year!

Activity#1

Directions: Use a computer to access and watch a 5-minute video about prototypes that harness energy from water wave: http://bit.ly/2BgkKOb. Use information in the video to:

- Describe the structure and function of the duck gen, sea-snake gen and limpet gen
- Compare the amount of electricity generated by each wave power generators
- Evaluate each prototype. Consider the pros and cons of each prototype.

To recap the information in the video and to analyze diagram and read about the implementation of the prototypes: http://www.creative-science.org.uk/wavetanks.html.

Questions:

1. Which wave power generator is best? Justify your answer.
2. What locations around the world would benefit from wave power generators?

Activity #2 (optional)

Directions: Use the computer to watch a 12-minute video about the wave energy industry: http://bit.ly/2nTtEsV. Then answer the questions.

Questions:

1. Compare the use of water waves to renewable energy sources, such as the sun and wind as well to nonrenewable energy sources, such as fossil fuels.
2. Why isn't the wave energy industry more developed?
3. What problems have arisen in the process of developing wave energy?
4. Evaluate the use of computer models and simulations in improving Annette von Jouanne's prototype.
5. Explain how the graduate students exploited the engineering design process to develop a prototype that harnesses energy from water waves.
6. What are possible cons to the use of wave energy?

Synthesis/Summary Project

Objective

Students will employ higher order thinking in order to summarize and synthesize important information learned in the laboratory activity.

Point Value	Project Options	Brief Description
5	Critique the laboratory	Write a one-page essay critiquing the laboratory. What were good and poor features of the laboratory? How well did the activities meet the objective of the lab? How could you improve the laboratory?
5	Design an experiment	Design a controlled experiment that could help you further study the ideas in this lab. Identify the materials you would need, the control and experimental groups and variables. Write a detailed method.
5	Form an argument	Write a one-page scientific argument for or against ideas in this laboratory. Use and cite empirical evidence to support your argument and to refute opposing arguments. Include all references/sources.
5	Determine limitations	Write a one-page essay discussing limitations to studying the ideas in this lab. How are humans limited in understanding these ideas? What scientific or technological advances need to be made in order to better study these ideas?
5	Make an INB manipulative	Create an interactive notebook activity to help you study, review or better understand the ideas studied in the laboratory. Include graphics or drawings. Include an answer key.
10	Communicate scientific ideas	Write a traditional lab report, blog or "newspaper style" article summarizing the laboratory. Discuss what was studied in the lab, what findings were made and the successes and failures of the lab.
10	Create an artistic summary	Design an artistic summary of the concepts studied in this lab. Create a comic, write a song or poem, paint, doodle or draw. This project is graded on content as well as artistic creativity.
15	Make a 3D Model	Create a three dimensional model of the concepts studied in this lab. The model should be scaled and proportionate to idea or concept the model represents.
15	Utilize Technology	Make a 2 to 5-minute video or podcast, PowerPoint or computer animation of the concepts studied in lab. You can summarize the concepts or create a teaching tool that students could use to learn about these concepts. Submit the project via email or thumb drive.
15	Write a children's book	Write a 5-10 page children's book to help kids (age 5 to 7) learn about the concepts studied in this laboratory. Use large font and graphics or drawings. Each page should have no more than 3 sentences. This project is graded on content and appropriateness for children.
15	Create a game or review material	Create a game or other activity that could help review the concepts studied in this lab (such as a board game, task cards or a jeopardy-style PowerPoint). Include an answer key.

Name: _____ Date: _____
Group Members: _____

Waves and Energy Lab Recording Sheet

Directions: Record all observations and answers to questions on this sheet.

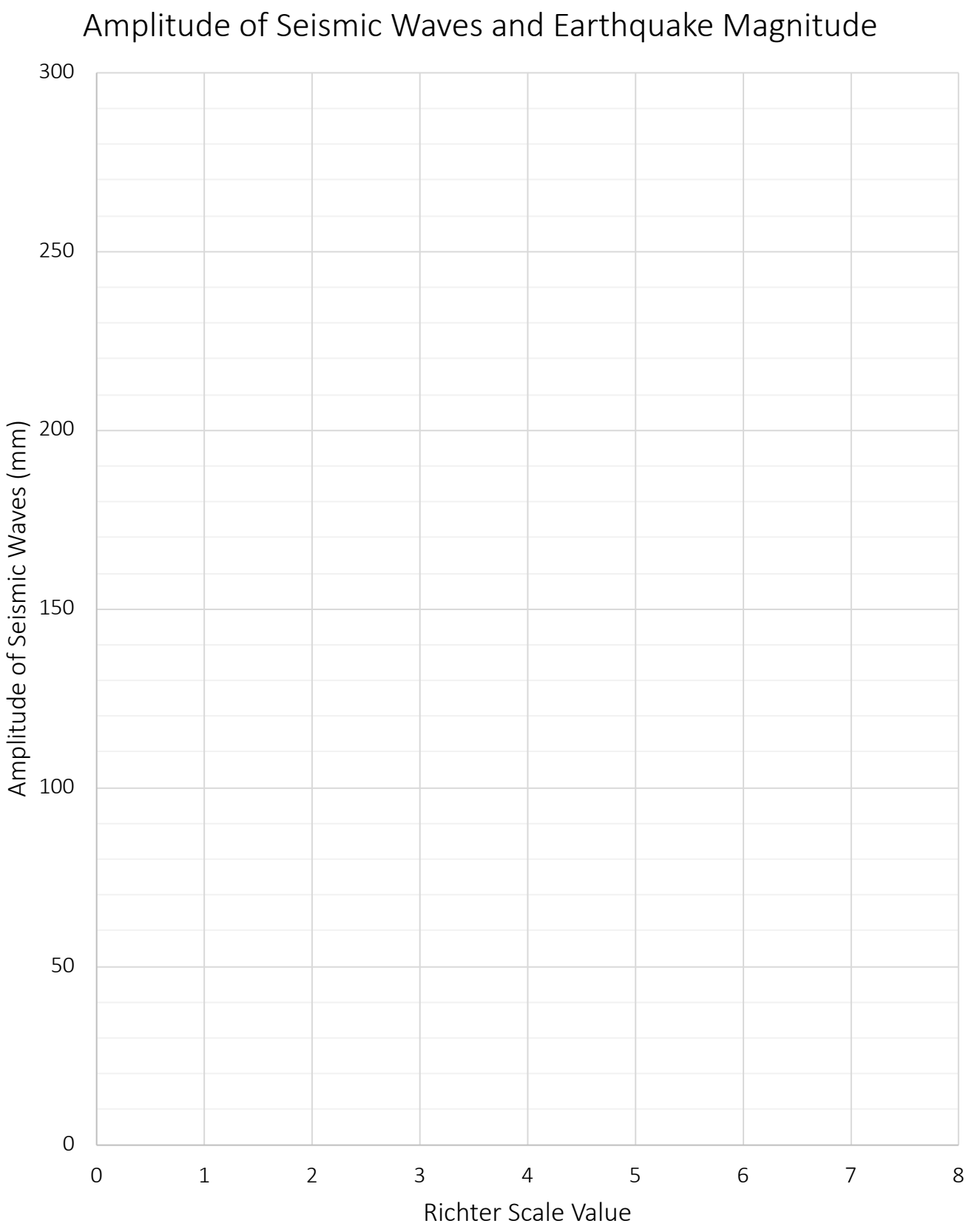
Science Skills Station

Activity #1
Complete the graph on next page or separate paper.

Questions

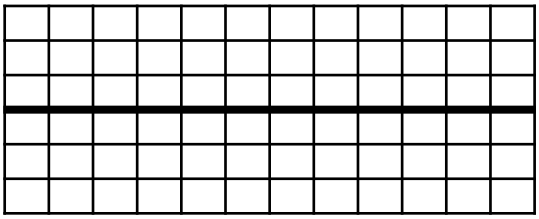
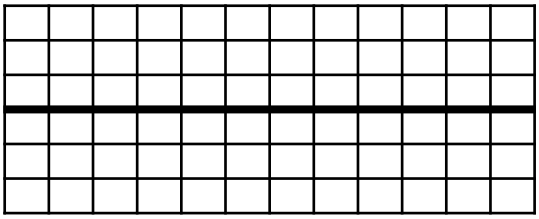
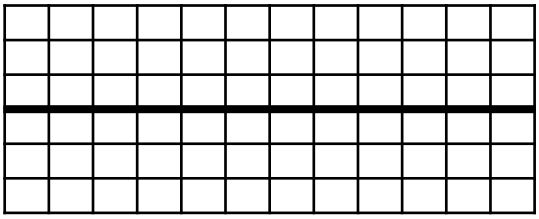
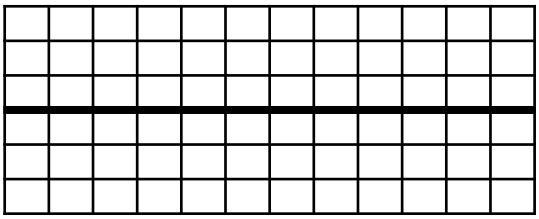
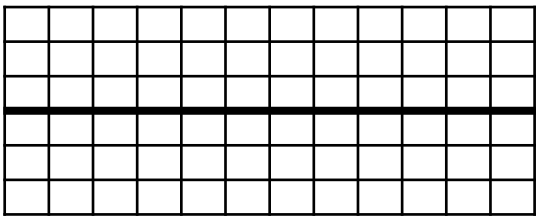
1. _____
   _____
   _____
2. _____
   _____
   _____
3. _____
   _____
   _____
4. _____
   _____
   _____

Science Skills Station



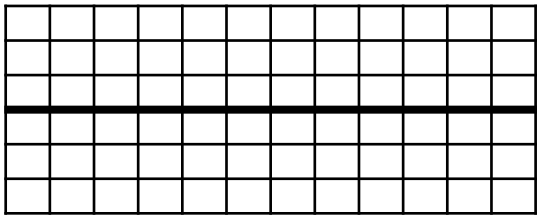
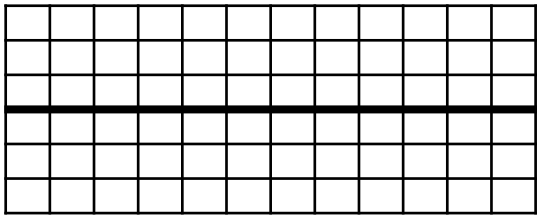
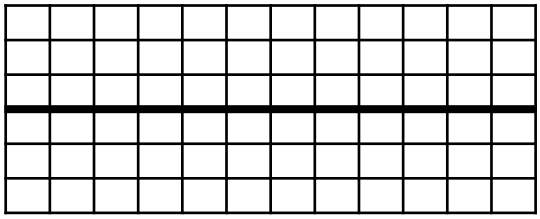
Science Skills Station

Activity #2: Part 1

Frequency	Describe the sound	Illustrate the sound wave
		
		
		
		
		

Science Skills Station

Activity #2: Part 2

Volume	Describe the sound	Illustrate the sound wave
		
		
		

Questions

1. _____
   _____
   _____
2. _____
   _____
   _____
3. _____
   _____
   _____

Narrative Station

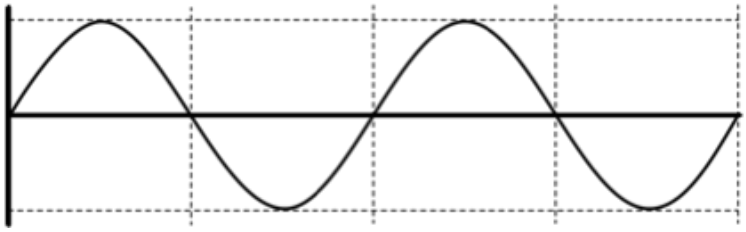
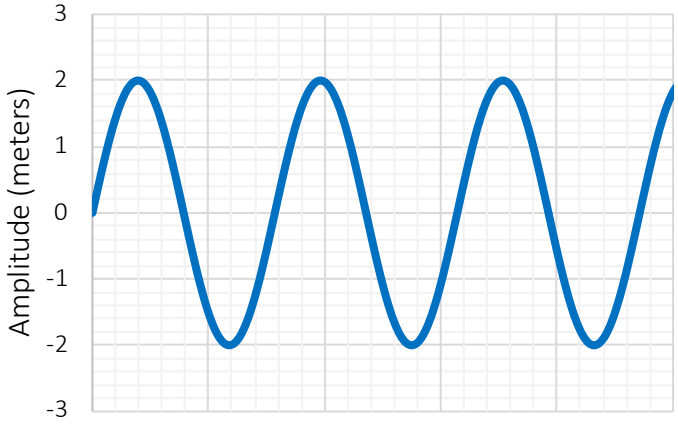
Activity #1

1. _____
2. _____
3. _____

Activity #2

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

Assessment Station

1. _____
2. 
3. _____
4. _____
5. _____
6. 

BONUS QUESTIONS

7. _____
8. _____

Problem-Solving Station

Activity #1

	Describe the prototype	Electricity generated	Evaluate the prototype
"Duck Gen"			
"Sea-Snake Gen"			
"Limpet Gen"			

Questions

1. _____
   _____
   _____
   _____
2. _____
   _____
   _____

Problem-Solving Station

Activity #2

Questions

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____