Drexel-SDP GK-12 ACTIVITY

Activity Template

Subject Area(s): Sound

Associated Unit: None

Associated Lesson: None

Activity Title: Auditory Sound Wave Exploration

Grade Level: 8 (7-9)

Activity Dependency: None

Time Required: 60 minutes

Group Size: 2-3 students

Expendable Cost per Group: US $0.00

Summary:
In this activity, students will visually and auditorily explore several properties of sound waves, focusing on amplitude, frequency, and phase. An interface provides a straightforward method for creating a connection between a visual representation of the sound wave and what the student hears. As a result, students will learn about the relationships between amplitude and volume, frequency and pitch, and phase and auditory differences of sound waves. In general, the specific properties of sound waves discussed in this activity provide knowledge that can be directly applied to many other types of waves, including ocean surface waves, radio waves, seismic waves, and light waves.

Engineering Connection:
The basic properties of waves are essential knowledge for any engineer working with any type of wave. Such engineers may work in telecommunications, digital signal processing, audio equipment manufacturing, or seismology (study of earthquakes). In telecommunications, the

three system elements consist of a transmitter, transmission medium, and receiver. The transmitter takes information and converts it into a signal, which requires knowledge of wave properties to properly encode the information in the signal. The transmission medium is just the object that carries the signal from the transmitter to the receiver. The receiver takes the received information and decodes the signal back into usable information. Again, this would require knowledge about the signal's wave properties to properly transform the signal into the information that was originally sent. As a digital signal processing engineer, the main objective is to generate and analyze signals for various applications. A few examples of applications include identification of a person by his voice signal, classification of a type of sound, and separating a signal from static-like noise in the signal. All of these examples show that the wave properties are the basis of many types of engineering careers and are used quite extensively and in much greater detail than is covered in this activity.

Keywords: sound waves, amplitude, frequency, phase

Educational Standards

Science: 3.4 – Physical Science, Chemistry, and Physics
Math: 2.2 – Computation and Estimation
2.8 – Algebra and Functions

Learning Objectives

After this lesson, students should be able to:

- Explain the basic properties of waves in general
- Describe the relationship between amplitude and volume for sound waves
- Describe the relationship between frequency and pitch for sound waves
- Understand how changes in phase cause shifts in wave graphs

Materials List

Each group needs:

- copy of the worksheet
- computer with internet connection to access the interface

Introduction / Motivation

The fundamental properties discussed in this activity are the basis for describing and characterizing all types of waves. The use of sound waves provides an ideal medium for teaching wave properties because students continuously experience sound waves as they sit listening to the activity. Sound waves play a crucial role in the students' daily lives as they walk to school, sit in class, listen to their iPods, or communicate with friends by using their cellphones. Each of the events has specific relations to waves, including the receiving of sound waves by the students' ears, the transmission of sound wave information over air waves to their cellphones, and the decoding of information into an audio signal in the memory of an iPod to be transmitted through the iPod headphones. Many students use waves in many forms daily, but do not recognize how the basic properties of waves are related to the effect they observe when the

properties are changed. In this activity, students will explore the wave properties applied specifically to sound waves both visually and auditorily through the supplied interface.

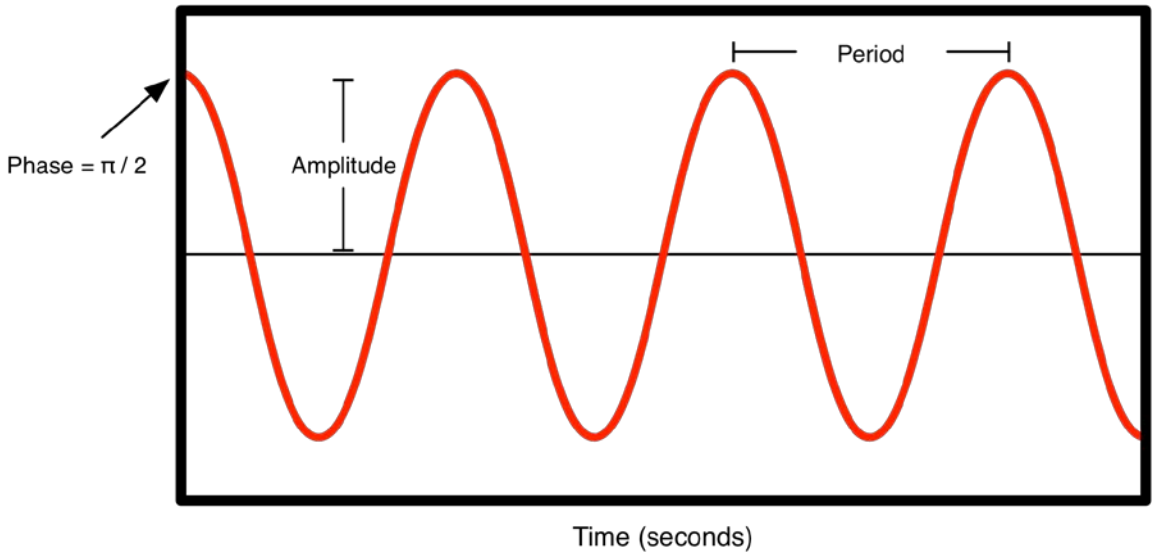
Vocabulary / Definitions

Word	Definition
period	the duration of one cycle of a repetitive event
cycle	one iteration of a repeating event
frequency	the number of cycles or repetitions per second
amplitude	the maximum height of a wave
phase	the fraction of a complete cycle relative to a reference point

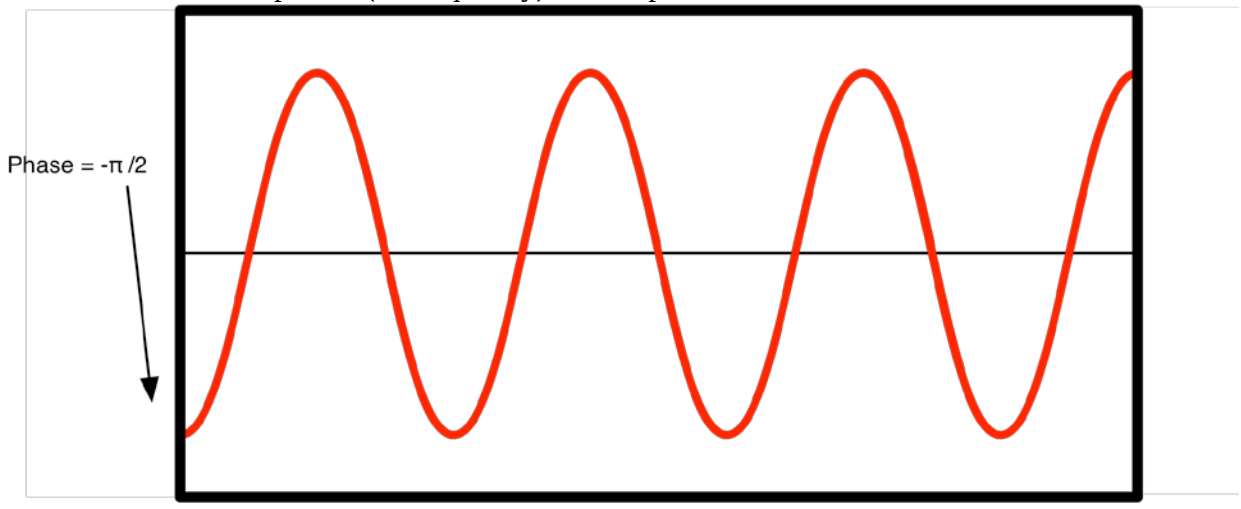
Procedure

Background

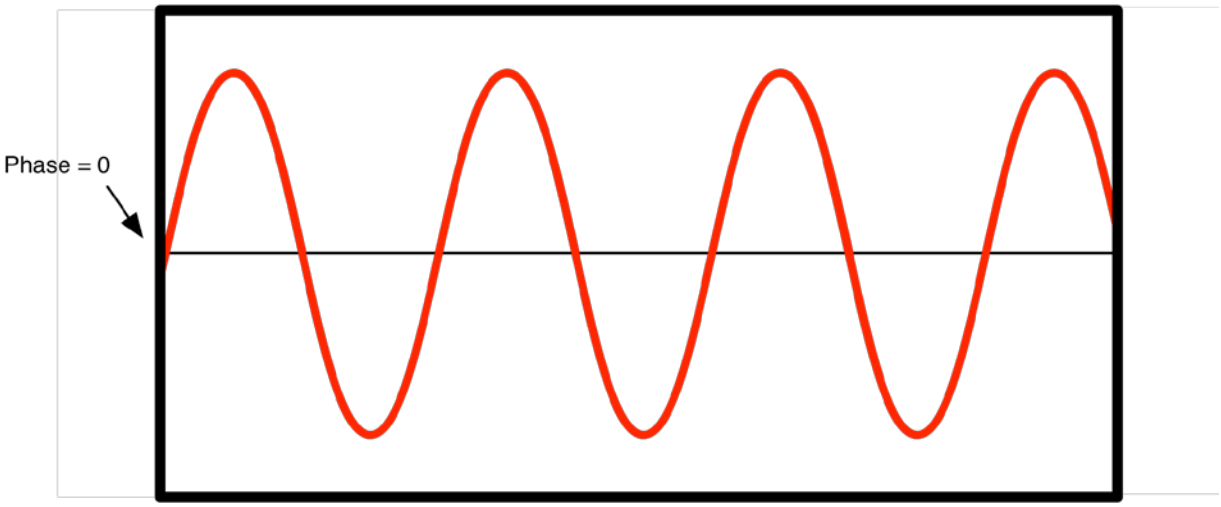
Waves can be characterized by a few basic components that include the period, amplitude, and phase for signals containing only one frequency. Therefore, given these components, a signal can be perfectly reconstructed, and other properties of the signal can be calculated from the three known components. The density of the wave is defined by the period of the wave, which determines how much the wave is compressed or stretched. The amount of energy in a wave is characterized by the amplitude, which determines the maximum height of the wave relative to its resting position. The phase component is related to the starting position of the wave relative to the generalized starting position. All of these components are shown in the figures below.



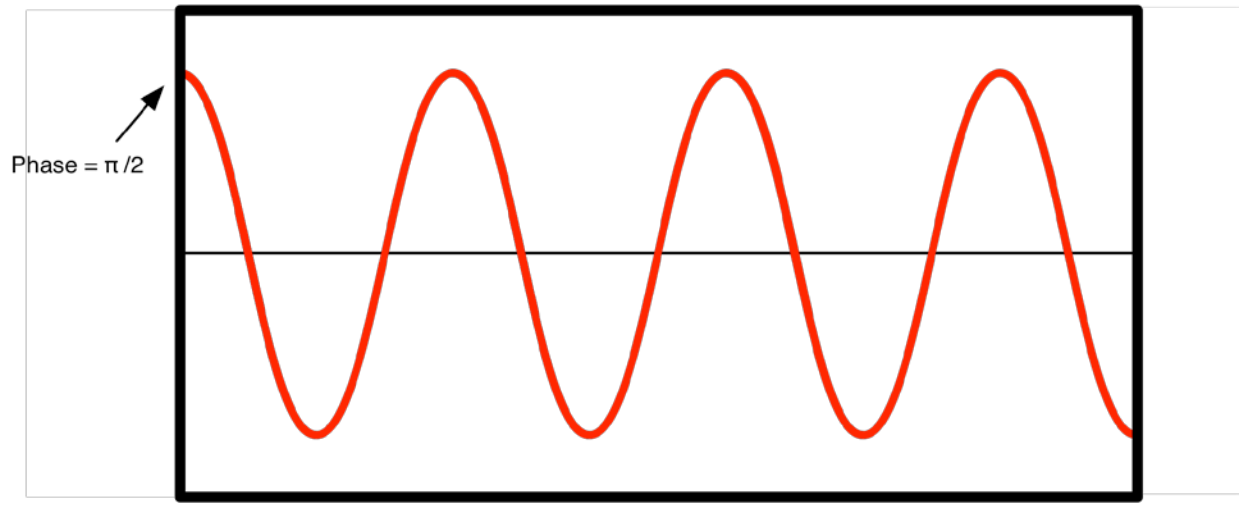
To make the phase property more clear, there are three graphs below showing several different phase values with the period (or frequency) and amplitude constant.



Time (seconds)

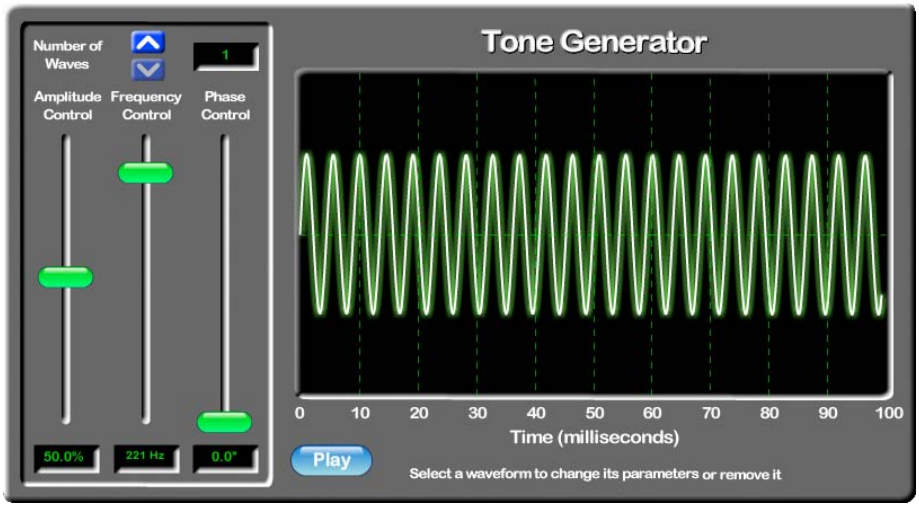


Time (seconds)



Time (seconds)

The frequency of the wave can be determined from the period of the signal since the period is the reciprocal of the frequency (period = 1/frequency). Understanding the relationship between frequency and period is important for this activity because the interface only has a frequency control and not a period control. The interface is shown below with controls for the amplitude, frequency, and phase of the wave. Also, there is an option to add more than one wave to the audio signal at a time by changing the number of waves using the up and down arrows.



Before the Activity

- Print out a copy of the lab for each student
- Prepare at least one computer with the interface ready for demonstration
- Print out an answer sheet in order to check the students' work on the handout

With the Students

1. Ask the students what they know about waves and how they might describe a wave to someone (such as the height, strength, etc.)
2. Explain to the students that their job is to explore properties of sound waves using the interface provided
3. Provide the students with a general background of sound wave properties that can be taken directly from the Background section
4. Go through an example of how to use the interface so that students can spend their time working on the worksheet and not sitting there figuring out the interface
5. Provide the students with the handout and have the students work together in small groups of preferably two students, but no more than three students
6. Have the students check with you periodically to see if their answers are correct since the answers are provided below
7. Wrap up by explaining any misunderstandings with the frequency calculations

Attachments

- Wave Properties Handout
- Wave Properties Handout Answers

Safety Issues

- None

Troubleshooting Tips

Make sure the students have the volume up on the computer or the students will think that the interface is not working.

Investigating Questions

- What types of waves besides sound waves do you know of?
- How does the change in wave properties affect these types of waves (i.e., change in frequency of light waves changes the color)?

Assessment

Pre-Activity Assessment

Class Discussion:

- Talk with the students about examples of waves that the students experience on a daily basis (sound waves, radio waves, ocean waves, light waves, etc.)

Activity Embedded Assessment

Lab handout/worksheet: Have the students fill out the Wave Properties handout and review their answers as a measure of the concept comprehension

Post-Activity Assessment

None

Activity Extensions

- The students could research different types of waves and determine the effects changes in the properties have on the observed waves
- Have the students pick a type of engineer that deals with a type of wave they are interested in and write a short paper on how the engineer uses the type of wave they chose

Activity Scaling

- For lower grades, the students could simply use the frequency and amplitude sliders and describe what effects are experienced as the sliders are changed.

- For upper grades, the worksheet could include more of the mathematical components of sound waves that require the students to model a specific frequency sound wave with the proper wave equation.

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Wave Properties Handout

Names: _____

Determining the affect changes in amplitude has on the wave

1. Using only one wave, move the amplitude slider up and down to determine how the amplitude slider affects the wave. Listen to the changes in sound and the changes of the wave on the screen and write your observations below.

Determining the affect changes in frequency has on the wave

2. Using only one wave, move the frequency slider up and down to determine how the frequency slider affects the wave. Listen to the changes in sound and the changes of the wave on the screen and write your observations below.

Determining the affect changes in phase has on the wave

2. Using only one wave, move the phase slider up and down to determine how the phase slider affects the wave. Listen to the changes in sound and the changes of the wave on the screen and write your observations below.

Determining the period for a given frequency

Given the information presented about the period of a wave, determine the period of the wave for the frequencies listed below using the interface provided. Simply adjust the frequency slider to the specified frequency, set the amplitude slider to 50%, and put the phase slider to 0. Then determine the length of one period in milliseconds. Check your answer using the following formula: frequency = 1/period.

3. Frequency: 25 Hertz Measured period: _____ Calculated period: _____

4. Frequency: 20 Hertz Measured period: _____ Calculated period: _____

5. Frequency: 33 Hertz Measured period: _____ Calculated period: _____

6. Frequency: 10 Hertz Measured period: _____ Calculated period: _____

Determining the relationship between frequency and period

After measuring and calculating several frequency and period pairs, what is the relationship between the frequency and period of waves? Fill in the blanks below with either increases, decreases, or does not change.

7. As the period of a wave increases the frequency of the wave _____.

8. As the period of a wave decreases the frequency of the wave _____.

Wave Properties Handout Answers

Names: _____

Determining the affect changes in amplitude has on the wave

1. Using only one wave, move the amplitude slider up and down to determine how the amplitude slider affects the wave. Listen to the changes in sound and the changes of the wave on the screen and write your observations below.

An increase in the amplitude slider results in an increased loudness or volume of the sound and an increase height of the wave.

A decrease in the amplitude slider results in a decrease loudness or volume of the sound and a decrease in the height of the wave.

Determining the affect changes in frequency has on the wave

2. Using only one wave, move the frequency slider up and down to determine how the frequency slider affects the wave. Listen to the changes in sound and the changes of the wave on the screen and write your observations below.

An increase in the frequency slider results in an increased pitch of the sound and a compression of the wave.

A decrease in the frequency slider results in a decrease in the pitch of the sound and a stretching of the wave.

Determining the affect changes in phase has on the wave

2. Using only one wave, move the phase slider up and down to determine how the phase slider affects the wave. Listen to the changes in sound and the changes of the wave on the screen and write your observations below.

An increase in the phase shifts the wave to the right with no changes in the sound of the wave.

A decrease in the phase shifts the wave to the left with no changes in the sound of the wave.

Determining the period for a given frequency

Given the information presented about the period of a wave, determine the period of the wave for the frequencies listed below using the interface provided. Simply adjust the frequency slider to the specified frequency, set the amplitude slider to 50%, and put the phase slider to 0. Then determine the length of one period in milliseconds. Check your answer using the following formula: frequency = 1/period.

3. Frequency: 25 Hertz	Measured period: 40ms	Calculated period: 40ms
4. Frequency: 20 Hertz	Measured period: 50ms	Calculated period: 50ms
5. Frequency: 33 Hertz	Measured period: 30ms	Calculated period: 30.3ms
6. Frequency: 10 Hertz	Measured period: 100ms	Calculated period: 100ms

Determining the relationship between frequency and period

After measuring and calculating several frequency and period pairs, what is the relationship between the frequency and period of waves? Fill in the blanks below with either increases, decreases, or does not change.

7. As the period of a wave increases the frequency of the wave decreases.

8. As the period of a wave decreases the frequency of the wave increases.