



Drexel-SDP GK-12 ACTIVITY

Activity Template

Subject Area(s): Sound

Associated Unit: None

Associated Lesson: None

Activity Title: Patterns in Sound Waves

Grade Level: 8 (7-9)

Activity Dependency: None

Time Required: 120 minutes

Group Size: 2-3

Expendable Cost per Group: None

Summary: In this activity, students will learn the fundamental characteristics of sound waves while visualizing the wave mathematically on the computer screen. Students will get a chance to work extensively with mathematics concepts by performing calculations using the collected data. These concepts can be applied to any type of wave, such as light, radio or seismic waves.

Engineering Connection:

Engineers who specialize in digital signal processing are interested in the characteristics of the signals they receive such signals are in the shape of the traditional sine wave, more or less. Using measurements of frequency, period, and wavelength of a digital wave, doctors are able to use medical devices to monitor heart rate and blood pressure, similarly, an audio forensic scientist uses sound waves to distinguish between persons' identities.

Keywords: sequences, patterns, pitch, frequency, linear equations, wavelength, period, line of best fit, scatter plot, computer application, graph, acoustics

Educational Standards

Science: None

Math: 2.6 Statistics and Data Analysis
2.8 Algebra and Functions
2.11 Concepts of Calculus

Learning Objectives

After this lesson, students should be able to:

- Calculate frequency, period and wavelength
- Write linear equations for a sequence
- Plot data on an XY graph
- Create a line of best fit

Materials List

Each group needs:

- Computer
- Copy of the worksheet
- Pure Data program

Introduction / Motivation

There are many types of waves, ranging from light waves to ocean surface waves, and analysis of these waves requires the knowledge of the waves' characteristics, such as wavelength, frequency, amplitude and period. An engineer specializing in acoustics could use knowledge of waves daily to develop better stereo speakers, microphones, surveillance equipment, or even soundproof structures that could be used by recording studios. Without knowledge of wave fundamentals an acoustic engineer would be incapable of producing valuable products.

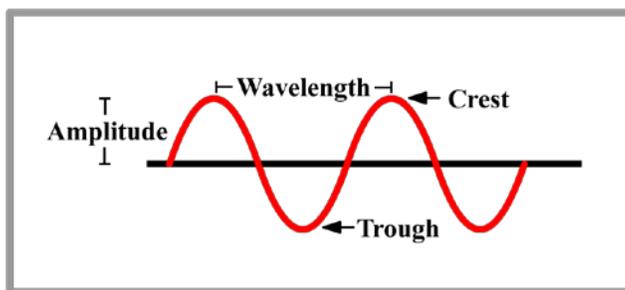
Vocabulary / Definitions

Word	Definition
cycle	one completion of a repeating pattern
period	the time it takes for one cycle of the wave to pass a given point
frequency	the number of cycles or occurrences of an event per unit of time
wavelength	the distance between repeating units of a wave

Procedure

Background

A wave can be represented by the measurements of its components, which include the amplitude, period, wavelength and frequency. From these values a wave can be simplified to a set of numerical values and later reconstructed to replicate the wave that was measured. The frequency of the wave is measured by finding the number of times the wave repeats (cycles) in a second and has the unit label Hertz (Hz). The unit Hertz is thus measured in cycles per second. The period of a wave is the amount of time in seconds that it takes for one pattern of a wave to pass a given point. The wavelength is a measure of the length of one complete cycle of the wave. All of these terms are shown below in the example diagram.



Before the Activity

- Download and install Pure Data on all computers
- Upload the interface file to all computers, attached
- Print out a worksheet for each group, attached

With the Students

1. First, teach students the terminology listed in the vocabulary and background sections with an example wave on the screen using the supplied interface
2. Explain to the students that their job is to determine and calculate different characteristics of sound waves seen on a graph
3. Give the students the worksheet and have them open the interface (This is located at <http://schubert.ece.drexel.edu/gk12> under the Activities category)
4. Make sure each student has the interface open and working
5. The students should then follow the procedure specified on the worksheet
6. Have the students stop after they have collected the data for the *Data Sequences* section
7. Check students' work for correctness because this data is crucial for calculations in later sections
8. After most students have completed the worksheets, wrap up by having the class redefine the characteristics of sound waves as a class

Attachments

- [Patterns In Sound Handout](#)

Safety Issues

- No safety issues

Troubleshooting Tips

There are no common problems for this activity.

Investigating Questions

- What happens to the wavelength as the frequency increases?
- What happens to the period, as the frequency gets decreases?
- How does the clarinet change the pitch produced?
- What about the trombone allows the frequency to change?

Assessment

Pre-Activity Assessment

Class Discussion:

- Have students attempt to formulate a definition of sound as a class
- Discuss how sound is produced and what is needed to produce sound

Activity Embedded Assessment

Worksheet: Have the students complete the attached worksheet and gauge their comprehension based on the correctness of the worksheet

Post-Activity Assessment

Challenge Problem: As a final assessment, give the students the Challenge Problem, which is the last page of the worksheet. This problem ties in all terms learned and is a good indicator of understanding of the material.

Activity Extensions

- Have students find engineering fields that use waves in their applications
- Have students create a poster of a specific type of wave (i.e., sound, light, radio) and present it to the class

Activity Scaling

- For lower grades, this activity may not be possible because the mathematics concepts needed to complete the worksheet will not be known
- For upper grades, this activity would work fine because the students will have the needed knowledge of the mathematics concepts. It would be possible to increase the group size with the upper grades because they would be more familiar with the material

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Patterns in Sound Waves

Names: _____

Materials

- Pattern Matching Int.pd
- Computer
- Pure Data software

Procedure

1. Open the file Pattern Matching Interface (This is located at <http://schubert.ece.drexel.edu/gk12> under the Activities category)
2. The Frequency Selection Bar will be used to select different frequencies that appear in white box
3. Start by clicking in the first block of the selection bar
4. Determine the time each cycle of the wave begins starting with time 0 seconds and record that data in the *Data Sequences* section below. For example, the sequence for block 1 is 0, 12. Note: the length of the sequences can be different for each block
5. Repeat step 4 for the other five blocks in the Frequency Selection Bar
6. Complete the rest of the worksheet

Data Sequences (numbers in sequences must be between 0 and 18)

Block 1: 0, _____

Block 2: 0, _____

Block 3: 0, _____

Block 4: 0, _____

Block 5: 0, _____

Block 6: 0, _____

Calculations

1. Write a linear equation for the pattern created from the data collected in the Data Sequences section (example: $y=15x-15$).

Block 1: _____

Block 4: _____

Block 2: _____

Block 5: _____

Block 3: _____

Block 6: _____

2. Calculate the frequency and period for each block. Make sure you include the units!
(Reminder: frequency = $1/\text{period}$)

Block 1: Frequency: $f =$ _____
Period: $T =$ _____

Block 4: Frequency: $f =$ _____
Period: $T =$ _____

Block 2: Frequency: $f =$ _____
Period: $T =$ _____

Block 5: Frequency: $f =$ _____
Period: $T =$ _____

Block 3: Frequency: $f =$ _____
Period: $T =$ _____

Block 6: Frequency: $f =$ _____
Period: $T =$ _____

Wavelength for Block 2: $\lambda =$ _____

Wavelength for Block 3: $\lambda =$ _____

Wavelength for Block 4: $\lambda =$ _____

Wavelength for Block 5: $\lambda =$ _____

Wavelength for Block 6: $\lambda =$ _____

Plotting

Now that we have calculated the period and wavelength for each block we need to collect the data into a table. Fill in the following table.

Block Number	Period (s)	Wavelength (m)
1		
2		
3		
4		
5		
6		

Create a XY graph using the information from the above table with Time on the x-axis and Wavelength on the y-axis.

Insert a line of best fit on the graph above and determine the slope of that line. Show your work below.

Challenge Problem

5. Suppose the following pattern of cycle starting times is obtained from a wave:

$$\text{Time} = 1\text{s}, 3\text{s}, 7\text{s}, 13\text{s}, 21\text{s}, 31\text{s}, 43\text{s}$$

Find both the first and second differences of this pattern.

Complete this pattern for the next four terms of the sequence.

Since we know the mathematical relationship between frequency and period, determine if the frequency is getting higher or lower as time progresses. Show your work!

(Hint: Each interval has a specific frequency!)

Would the wavelength be increasing or decreasing as time progresses?