



Science Objectives

- Students will explore an animation of a sound wave in air.
- Students will vary the frequency and intensity, or amplitude, of the wave and determine the relationship between the two.
- Students will determine the amplitude and frequency of a sound wave from a graph.
- Students will explore the relationship between the wavelength and frequency of a sound wave as it relates to the wave's period.
- Students will describe the relationship between the sound pressure (Intensity) and the simulation of a compression wave.
- Students will discover the relationship between intensity, pressure and amplitude.

Vocabulary

- Frequency
- Period
- Hertz
- Compression Waves
- Wavelength
- Amplitude
- Decibels
- Pressure
- Longitudinal Waves

About the Lesson

This lesson addresses the relationship between the points of high or low pressure in a sound wave as shown by the graphs as well as the pattern of the repetition of the points as related to frequency.

As a result, students will:

- Explore the simulation of a sound wave.
- Discover the connection between frequency and pressure.
- Calculate the period of a wave and determine the corresponding frequency and wavelength.
- Explore the peaks and troughs of a wave and relate them to the amplitude of a wave.

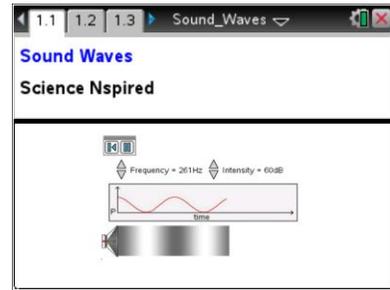


TI-Nspire™ Navigator™

- Send out the *Sound_Waves.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers.
- Quick Poll students for Formative Assessment.

Activity Materials

- Compatible TI Technologies:  TI-Nspire™ CX Handhelds,  TI-Nspire™ Apps for iPad®,  TI-Nspire™ Software



Tech Tips:

- This activity includes screen captures taken from the TI-Nspire CX handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire App. Slight variations to these directions may be required if using other technologies besides the handheld.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at <http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials>

Lesson Files:

Student Activity

- Sound_Waves_Student.doc
- Sound_Waves_Student.pdf

TI-Nspire document

- Sound_Waves.tns



Discussion Points and Possible Answers

Have students read the background information stated on their activity sheet.

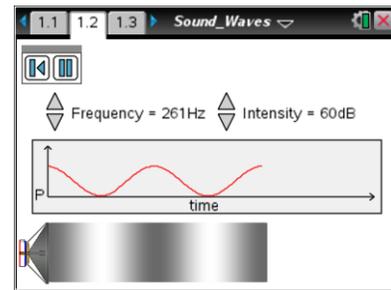
In this investigation students will explore a simulation of a sound wave.

Students will take note of changes in the sound wave as the frequency or intensity of the sound is modified. Then, they will determine the period and wavelength of the sound from its graph.

As students explore the sound waves, they will discover the relationship between the frequency, wavelength, and period of a wave as well as the relationship between the pressure, intensity, and amplitude.

Part 1: Exploring Sound Waves

1. After reading the instructions on page 1.2, close the directions box by selecting .
2. The graph shows the pressure (vertical axis) of the sound wave over time (horizontal axis). Students select the Play button  and observe. To pause the simulation select . To reset select .



- Q1. What do you observe as you run the simulation? Write down your answer and then share this with a neighbor and the class as requested.

Answer: As time goes by, the top part shows a wavy line that goes up and down, for P. The sound coming out of the speaker at the bottom shows dark and then light areas that correspond to the high and low points of the graph.

3. Now students should explore the simulation of the sound wave when holding the frequency constant but adjusting the intensity.

Assign frequency values to individuals or groups of students, and have them run the simulation with different values for the intensity. Note the frequency steps in the slider.

- Q2. How do the two plots change as you change the intensity of the sound?

Answer: As the intensity gets larger, the peaks get higher in the top plot and the bottom plot has darker parts corresponding to the peaks above and lighter parts at the low points in the top graph. The peaks and troughs appear to occur at the same times for all intensities.



- Q3. Now check with students who had a different frequency as you and explain how their results differ from yours.

Answer: The other groups found the same results. Some students might note that the peaks and troughs occurred at different times for different frequencies.

4. Now students should explore the changes in the sound when holding the intensity constant but adjusting the frequency. Assign frequency values to individuals or groups of students, and have them explore the simulation.

- Q4. How did the two plots change as you held the intensity constant and adjusted the frequency?

Answer: The peaks and troughs stayed at the same levels, but as the frequency got larger the peaks occurred more often, were closer together over the time period. In the bottom plot, the dark regions occurred more often and were closer together.

- Q5. Now check with other students that had a different assigned intensity as you and explain how their results differ from yours.

Answer: They all had similar results with the peaks and troughs being darker/lighter and higher/lower based on their assigned intensity.

- Q6. Summarize the way sound travels in relation to the intensity and frequency settings.

Answer: As the intensity is increased, the peaks get higher and the areas of the compressed wave get darker. As the frequency increases, the rate at which the peaks occur increases.

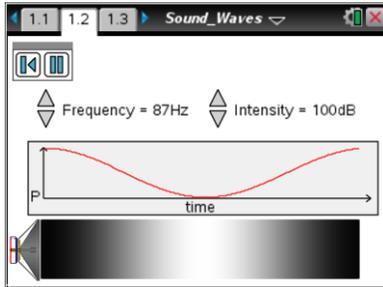
- Q7. What are the units used to report the frequency of a wave, and what exactly do they measure?

Answer: Frequency of a wave is measured in Hz, which are Hertz. Hertz measures cycles per second and is the time it takes to complete one cycle (peak to peak trough to trough).



Q8. Can you determine the time that is shown before the simulation clears and repeats? Explain.

Answer: For any frequency, the student should determine how many times the pattern repeats. For example at 87 Hz you get this plot:

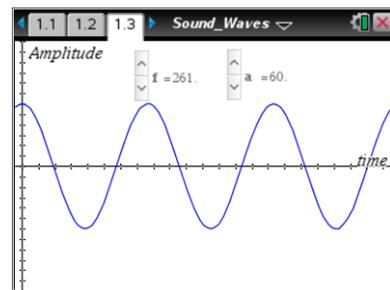


It appears that you get 1 cycle so at 87 cycles/sec we have 0.0115 seconds per cycle.

Part 2: The Wavelength and Period

Move to page 1.3.

5. Have students examine the graph. They may change the values for f and a to get different graphs. Explore this and share with the class as requested.



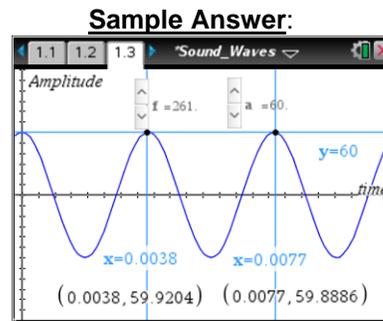
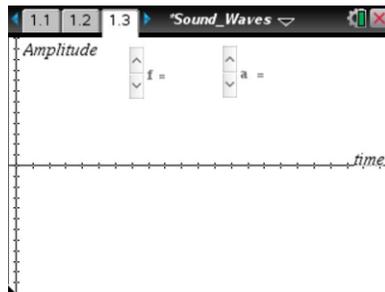
Q9. What do you think the a and f stand for? Why?

Answer: The variable a appears to be like the intensity from the first page. It makes the graph have higher or lower peaks. The variable f acts like the frequency in that it makes the number of peaks increase or decrease.



6. Assign students values for a and f . Have them adjust their settings to create the assigned wave.

Q10. Sketch your graph and draw lines on it showing a horizontal line at the peak and vertical lines at two successive peaks or troughs. Label these lines. To get the values for the times off of the graph select **Menu > Trace > Graph Trace** and use the right and left arrows (◀ and ▶) to move along the wave. Select **enter** to leave a set of coordinates on the screen.

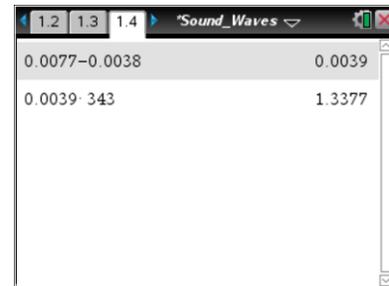


Teacher Note: You can have the students place the horizontal and vertical lines on the graph in the Nspire by creating Text boxes such as: $x = 0.0038$ and $y = 60$. In each case you then drag the Text box to the x - or y -axis to get the graph.

7. To determine the wavelength (λ) of this sound wave, students can subtract the two successive times from their graph to calculate how long it takes to complete one cycle. If the speed of sound is known, they can just multiply this time by the speed of sound to get the wavelength (distance = rate X time). Since the speed of sound changes depending on the material it vibrates in and the temperature, we will assume that we are in air at 20 degrees Celsius and that the times reported are in seconds. This makes $s = 343$ meters/second.

Q11. What is the wavelength of your sound wave in meters?
(Calculate using the Scratchpad or insert a *Calculator* page.)

Answer: For the example in Q10 we have a change in time of 0.0039 seconds which yields 1.34 meters at 261 Hz.

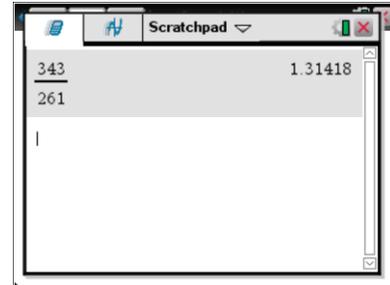


Tech Tip: To insert a *Calculator* page, have students select **+ >** **Calculator**.



8. Students also use the formula $\lambda = \frac{s}{f}$ where s is the speed of sound and f is the frequency to determine the wavelength (λ).

Q12. What is the wavelength of your sound wave using this formula?
(Use the Scratchpad  to calculate or insert a *Calculator* Page.)



Answer: Again from Q10 we have 1.31 meters

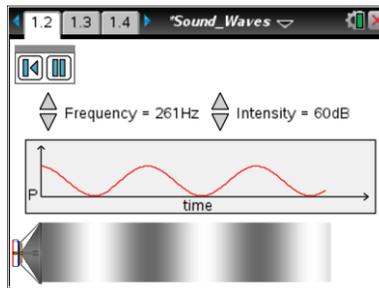
Q13. How do the two wavelength values, from questions 11 and 12, compare? How can one account for any differences?

Answer: The two values are a very close match. When you trace the graph, you get a time close to the peak, but not the exact times, so there should be some variation from the second exact calculation.



TI-Nspire Navigator Opportunities

Allow a student to volunteer to be the Live Presenter and demonstrate how they created the horizontal and vertical lines and how they determined the times at which the wave started to repeat (Graph Trace). Pick questions from the Student sheet and Quick Poll them. Have the students show their calculations and graphs with Class Capture or make Presenter. Include an Image - Point on Question to determine if students know where the high and low pressure points are in the Compression wave.



Wrap Up

When students are finished with the activity, collect the .tns files using TI-Nspire Navigator or Connect-to-Class. If you Quick Poll the class or if you added Questions into the tns file, save to the Portfolio. Discuss the class answers using the Review and explore individual files as a class.