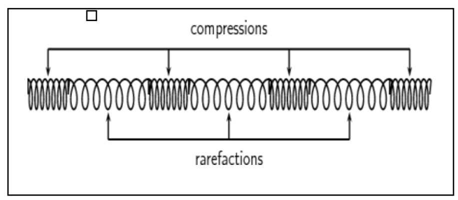
3 - Exploring Sound with Technology (Teacher Pages)

Activity Overview	The goal of this activity is to provide students with a culminating experience with sound. The virtual simulation PhET Sound is found at the following URL [https://phet.colorado.edu/en/simulation/sound] and the Twisted Wave Recorder app will be used for these investigations.
PhET	Using PhET simulation, students will have opportunities to understand characteristics of a sound wave by manipulating frequency, amplitude, and air pressure. The images of sound waves the students will observe are representations of sound waves. PhET is an animated simulation modeling sound waves, although it does not show 3-dimensional model of a sound wave.
Materials	Laptops Tablets Slinky URL: https://phet.colorado.edu/en/simulation/sound
Guiding Questions for PhET Simulation	We will use the PhET simulation to explore sound as a mechanical wave. There are three questions we want to answer: • How does sound travel through a medium such as air? • Can sound travel in a vacuum like outer space where there is no air?
Exploring Sound with Technology **Since a sound wave is a disturbance that is transported through a medium [air] via a particle to particle interaction, sound is a mechanical wave requiring a medium.**	**Exploring Sound with PhET**  • Sound is a mechanical wave which transfers energy to the surrounding medium. We typically think of the medium as air; however, sound can also propagate in other media such as liquids or solids. • A slinky wave can be used as a model for a sound wave. A wave is created within the slinky when one end of the slinky is pushed causing a back and forth motion of the first coil which begins to alternately ‘push’ and ‘pull’ on the second coil. The push and pull disturbance moves through the slinky as each coil is displaced from its original [equilibrium] position. As you can see in the image above, there are regions of compression [the particles are close together] and other regions where there is little compression called rarefaction [particles are farthest apart]. Notice the diagram of a longitudinal wave shown above. • Sound propagates through the air as a longitudinal wave when air particles transfer the energy as the particles collide with one another. The following brief YouTube video [see the following URL] provides an explanation for sound as a mechanical wave using a slinky as the model: https://www.youtube.com/watch?v=Bcqp6t4ybxU • The PhET link: **https://phet.colorado.edu/en/simulation/legacy/sound** is a way to engage students with a virtual simulation of sound as a mechanical wave. • At this station, students will have the opportunity to manipulate multiple

	aspects of sound including frequency and amplitude. Students will also be able to determine how variations in air pressure impacts sound. The PhET simulation model notes that changes in air pressure result in changes within the gaseous medium through which sound travels. This model demonstrates that sound requires a medium to propagate. Students will be able to remove all of the air from the virtual sound box and observe changes in air pressure indicated by the dial above the speaker. • When manipulating frequency and amplitude, students will be able to observe changes in the representations of sound waves and also hear the resulting changes in the sounds generated. • PhET simulations allow students to gain experience with technology, reinforce understanding of sound as a mechanical wave, and address misconceptions about sound.
Something to think about **What changes occur in sound waves and in the sounds we hear when there is a change in frequency?**	○ Statement: Sound is a mechanical wave. ○ Both frequency and amplitude alter the sounds we hear. The PhET Sound Simulation allows students to explore sound and make and test predictions of how the sound and the resulting virtual model sound waves will change when the frequency, amplitude, or air pressure are manipulated. ○ Frequency: Sound waves are actually a transfer of energy as the sound travels away from a vibrating source. The source could be the sound a whistle makes or the sound of the human voice. The Frequency refers to the speed of the sound or the number of vibrations that an individual particle makes in a specific period of time [typically one second]. ▪ When students manipulate the PhET simulation, they will note that there are more sound waves within the same space at higher frequencies and a lower number of sound waves within the same space at lower frequencies. ▪ Note that as the frequency increases, the sound waves become increasingly close to one another. ▪ The students will hear a sound with an increasingly higher pitch as the frequency increases. ○ Amplitude: Amplitude refers to the size of the vibration and, therefore, determines the loudness of the sound. Note the diagram below. The sound waves on the left are identified and low amplitude and those on the right are examples of high amplitude. ▪ Another way to think about amplitude is that the size of the vibration changes with changes in amplitude. So a sound with lower amplitude would be a soft sound whereas a sound with higher amplitude would be a louder sound. ▪ Ask students to note the changes in sound they hear when manipulating the amplitude in the PhET simulation. ○ Air Pressure: It is important to note that sound requires a medium such as air, liquid, or solid to travel over distance and to be heard. If the air pressure is decreased, the sound diminishes until the number of air

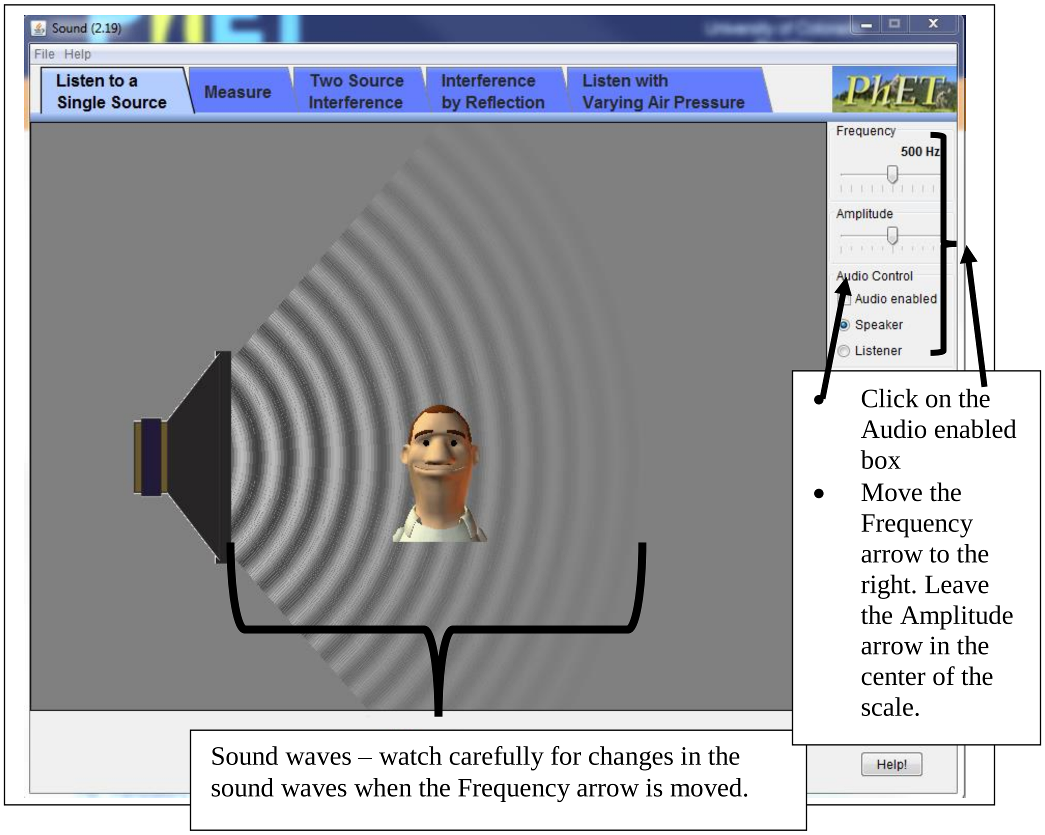
	particles become so small that sound waves can no longer travel. Outer space is a vacuum and, therefore, there is no sound. Explosions in space are seen but not heard.
Exploring Sound with Technology and Linking to the Standards	Next Generation Science Standards: **4-PS4-1.** Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. Disciplinary Core Ideas: ○ Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). (4-PS4-1) Science and Engineering Practices: ○ Develop a model using an analogy, example, or abstract representation to describe a scientific principle. Crosscutting Concepts: ○ Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena.
Assessment	Formative assessment is suggested: ○ Use the questions suggested at each step as a means to assess students' understanding. ○ Challenge students to collaborate in teams to analyze and interpret their data to develop supporting evidence which describes sound as a mechanical wave.

Sound Science: Exploring Sound with PhET, a virtual simulation [Teacher page]

Frequency:

Click on the ‘Listen to a Single Sound Source’ Tab at the top of the PhET window. **[Note: be sure to click the Audio Enabled box to hear the sound.]**

- The image in the figure to the left is what students will see when they click on the ‘Listen to a Single Sound Source’ tab.
- Students will be able to manipulate both frequency and amplitude by moving the arrows on the Frequency and Amplitude controls on the right side of the screen.
- Change the frequency first by moving the arrow. Listen to the change in the sound and watch for changes in the sound waves.



Questions:

1. Listen to the sound and carefully observe the sound waves before moving the arrow. Now, move the Frequency arrow to the right. How does the sound change?
    a. The sound becomes lower [has a lower pitch].
    b. The sound becomes higher [has a higher pitch].
    c. There is no change in sound.

2. Next, think about the sound waves. How do the sound waves coming from the speaker change when the arrow is moved to the right?
    a. The sound waves are closer together, there appear to be more sound waves.
    b. The sound waves move farther apart, there appear to be fewer sound waves.
    c. There is no change in frequency when the arrow is moved to the right.

3. Why do you think this happens?

    When the frequency of the sound produced is increased by moving the arrow to the left, there are more sound waves produced by the PhET simulation in the same period of time. This change causes the sound created by the simulation to have a higher pitch. Higher pitch sounds have an increased frequency of sound waves. In other words, you will notice that there are more sound waves within the same space.

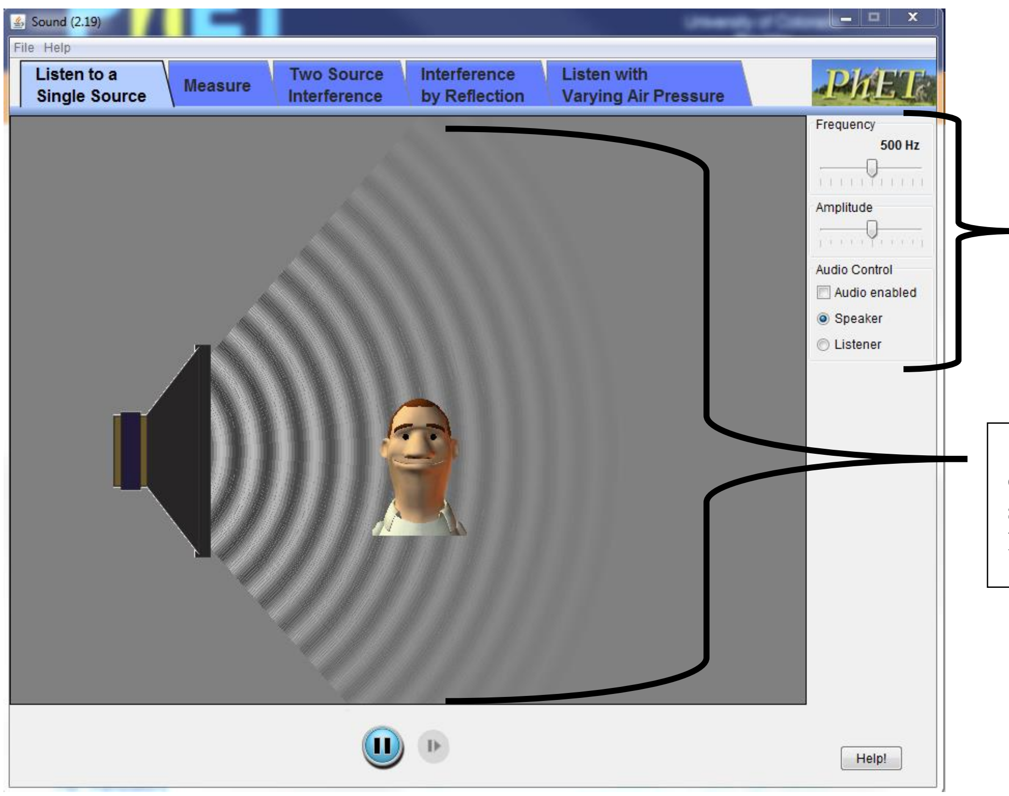
4. How do the sound waves coming from the speaker change when the arrow is moved to the left? Why do you think this happens?

When the frequency of the sound produced is decreased or lowered by moving the arrow to the right, there are fewer sound waves produced by the PhET simulation in the same period of time. This change causes the sound created by the simulation to have a lower pitch. Lower pitch sounds have a lower frequency of sound waves. You will notice that the distance between the waves pictured in the simulation increases as the frequency of the sound is lowered.

Amplitude:

Once again, click on the ‘Listen to a Single Sound Source’ Tab at the top of the PhET window.

[Note: be sure to click the Audio Enabled box to hear the sound]



- Click on the Audio enabled box
- Move the Amplitude arrow to the right. . Leave the Frequency arrow in the center of the scale.

Sound waves – watch carefully for changes in the sound waves when the Frequency arrow is moved.

Questions:

5. Listen to the sound and carefully observe the sound waves before moving the arrow. Now, move the Amplitude arrow to the right. How does the sound change?
    a. The sound becomes lower [has a lower pitch].
    b. The sound becomes higher [has a higher pitch].
    c. There is no change in sound.

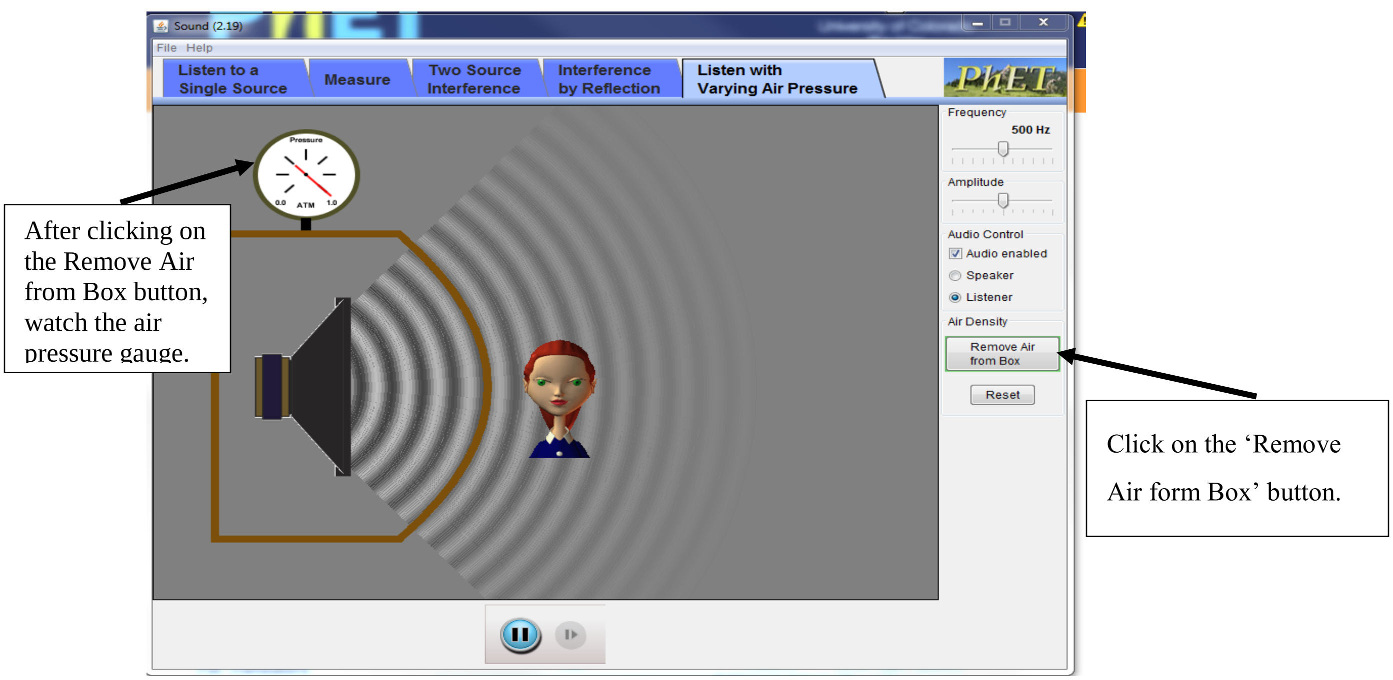
6. Next, think about the sound waves. How do the sound waves coming from the speaker change when the Amplitude arrow is moved to the right?
    a. The sound waves are closer together, there appear to be more sound waves.
    b. The sound waves move farther apart, there appear to be fewer sound waves.
    c. There is no change in frequency when the arrow is moved to the right.

7. Why do you think this happens?
   Amplitude refers to the volume of the sound produced. Notice that when amplitude arrow is moved to the right the sound is loud and easy to hear. Also note that the sound waves are more clearly defined.

8. How do the sound waves coming from the speaker change when the Amplitude arrow is moved to the left?
   Amplitude refers to the volume of the sound produced. Notice that when amplitude arrow is moved to the left the sound is softer. If the arrow is moved to the left side of the scale, the sound will no longer be audible. Also note that the sound waves are less clearly defined and will no longer be visible if the arrow is moved to the left end of the scale.

Listening with Varying Air Pressure

During this activity, you will vary the air pressure within the PhET Sound Box. To do this click on the Listen with Varying Air Pressure tab. You will go to a new window with a speaker and an air pressure gauge. During this investigation you will have the opportunity to change the air pressure within the sound box and then remove all air from the sound box.



The image above is what you will see after clicking on the 'Listen with Varying Air Pressure' tab. Both the Frequency and Amplitude arrows should be in the center of the scale. After clicking on the Remove Air from Box button, watch the air pressure gauge, the red needle will go to zero as all of the air leaves the box.

Sound Science: Exploring Sound with PhET [Student pages]

Name: ____

Frequency:

Click on the 'Listen to a Single Sound Source' Tab at the top of the PhET window. **[Note: be sure to click the Audio Enabled box to hear the sound.]**

Questions:

1. Listen to the sound and carefully observe the sound waves before moving the arrow. Now, move the Frequency arrow to the right. How does the sound change?
   a. The sound becomes lower [has a lower pitch].
   b. The sound becomes higher [has a higher pitch].
   c. There is no change in sound.

2. Next, think about the sound waves. How do the sound waves coming from the speaker change when the arrow is moved to the right?
   d. The sound waves are closer together, there appear to be more sound waves.
   e. The sound waves move farther apart, there appear to be fewer sound waves.
   f. There is no change in frequency when the arrow is moved to the right.

3. Why do you think this happens?

4. How do the sound waves coming from the speaker change when the arrow is moved to the left?
   a. The sound waves are closer together, there appear to be more sound waves.
   b. The sound waves move farther apart, there appear to be fewer sound waves.
   c. There is no change in frequency when the arrow is moved to the right.

5. Why do you think this happens?

Amplitude:

Once again, click on the ‘Listen to a Single Sound Source’ Tab at the top of the PhET window.

[Note: be sure to click the Audio Enabled box to hear the sound]

Questions:

6. Listen to the sound and carefully observe the sound waves before moving the arrow. Now, move the Amplitude arrow to the right. How does the sound change?
    a. The sound becomes lower [has a lower pitch].
    b. The sound becomes higher [has a higher pitch].
    c. There is no change in sound.

7. Next, think about the sound waves. How do the sound waves coming from the speaker change when the Amplitude arrow is moved to the right?
    a. The sound waves are closer together, there appear to be more sound waves.
    b. The sound waves move farther apart, there appear to be fewer sound waves.
    c. There is no change in frequency when the arrow is moved to the right.

8. Why do you think this happens?

9. How do the sound waves coming from the speaker change when the Amplitude arrow is moved to the left?
    a. The sound waves are closer together, there appear to be more sound waves.
    b. The sound waves move farther apart, there appear to be fewer sound waves.
    c. There is no change in frequency when the arrow is moved to the right.

10. Why do you think this happens?

Listening with Varying Air Pressure

During this activity, you will vary the air pressure within the PhET Sound Box. To do this click on the Listen with Varying Air Pressure tab. You will go to a new window with a speaker and an air pressure gauge. One of the themes throughout the sound activities has been the importance of a medium for conducting sound waves. We explored multiple materials as conductors of sound waves including: tuning forks, water, plastic wrap, sugar crystals, string, and plastic cups. During this investigation you will have the opportunity to change the air pressure within the sound box and even remove all air from the sound box.

Questions:

11. Make a prediction. What do you think will happen when the air leaves the box?

If all of the air leaves the box, then____

____

12. Now test your prediction by clicking on the 'Remove the Air from the Box' button shown in the image above.
    a. What happened to the sound as the air left the box?

    b. When the red needle in the Air Pressure Gauge pointed to zero and all of the air had left the box, could you still hear a sound? ______
        i. Did this observation support your prediction? ______
        ii. Why do you think this happened? Use evidence from your experiences with sound to support your answer.

Exploring Sound with Technology (Teacher Pages)

Activity Overview	The goal of this activity is to provide students with the capacity to explore sound using the *Twisted Wave* app. With this technology, students will be able to observe a digital representation of their own voices. This unique app allows any sound to be recorded and edited. We will use this app to engage students with a two-dimensional model of the sound wave. It is important to point out to students that the app does not provide a three-dimensional view of the sound wave. This app can be downloaded at no charge from iTunes for Mac + PC. The URL is: **https://itunes.apple.com/us/app/twistedwave-audio-editor/id401438496?mt=8**
Materials	Laptops, tablets, smart phones URL:**https://itunes.apple.com/us/app/twistedwave-audio-editor/id401438496?mt=8** **[preload the app on to iPads for use in the classroom]**
Guiding Question	How do sound waves change with changes in our speech? For instance, do sound waves of a high pitched voice [young child] look different from sound waves of a deep voice [adult male]?
Exploring Sound with Technology	**Exploring Sound with Technology** • Using the *TwisedWave Recorder* app ask students to record their own voices. They will be able to see two-dimensional digital representations of the sound of their voices. Students can compare a high pitched voice with a deeper, lower pitch voice. The students will note variation in the appearance of the digital models generated as different sounds are recorded and displayed by the app. • Loud sounds are deeper sounds, like a man's voice. Soft sounds are high pitch sounds like a young girl's voice. Ask students to study the images of sound generated by the app and see how the digital representations of sound provided by the *Twisted Wave Recorder* app differ.
Something to think about	Sound is something that most of us take for granted. We hear an array of sounds every day and we do not really think about what we are hearing sound is just another part of our world. • When a sound is created, the sound itself is a vibration also known as a mechanical wave. Why call sound a mechanical wave? Because sound waves transfer energy and can make other materials [like gases, liquids, and solids] vibrate as well. • When sound travels, it causes the molecules or particles of air to vibrate. Eventually, the vibration reaches our ears. Sound waves cause the eardrum to vibrate and that vibration is conducted to three tiny bones behind the eardrum which conducts the vibration into the inner ear. Nerves in the inner ear are stimulated by the vibration and a nervous impulse travels to our brain where meaning is formulated.

Exploring Sound with Technology: Twisted Wave Recorder App (Teacher Page)

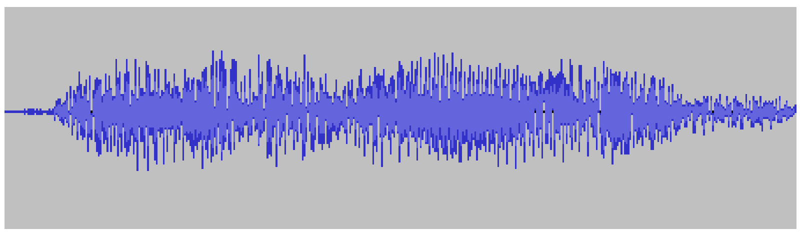
You will use the *TwistedWave Recorder* App to conduct an exploration of sound. Use the iPad and this App to make and test predictions about sound.

Everyone in your team should take a turn and speak into the iPad. The *TwistedWave Recorder* App will convert the sound of your voice into a two-dimensional digital representation of sound waves.

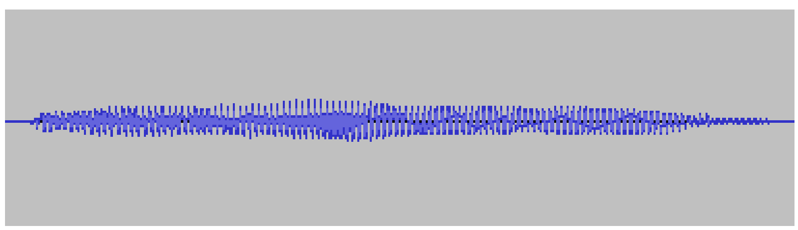
Questions:

1. How does a loud sound look different from a soft sound?
    a. After watching each person in your team speak into the iPad, do you have any evidence to support your claim?

Loud sounds will translate into more prominent waves, the waves have larger amplitude. Whereas a softer sound would have low peaks or low amplitude.



Loud sound



Soft sound

2. How does a high-pitched sound look different from a low-pitched sound? Provide evidence to support your claim.

High-pitched sound will have more waves squeezed together (high frequency) whereas a low-pitched sound will have waves further apart (low frequency)

Name: ____ Student Page

Visualizing Sound Using Technology: TwistedWave App

You will use the TwistedWave App to visualize the sound of your voice and the voices of your friends. This is an interesting exploration of sound. Use the iPad and this App to make and test predictions about sound.

Everyone in your team should take a turn and speak into the iPad. The *TwistedWave Recorder* App will convert the sound of your voice into a digital representation of sound waves. This app is very similar to the technology used by recording studios when artists record music.

Questions:

1. How does a loud sound look different from a soft sound?
    a. After watching each person in your team speak into the iPad, do you have any evidence to support your claim?

2. How does a high-pitched sound look different from a low-pitched sound? Provide evidence to support your claim.