Sound All Around - Teacher Notes

INTRODUCTION

Sound is a difficult concept for students to grasp if not presented properly. This series of activities enhances student comprehension of sound by involving additional senses beyond hearing and helps them make this abstract concept more concrete. Although most students sense sounds through hearing, the concept of waves traveling though the air is a difficult one for children to grasp. After all, children can't usually see or feel the waves that we claim are moving from the source of the sound to the receiver. In this exercise, students conduct various hands-on activities that enable them to investigate the properties of sound. The exercise culminates with the "amazing trash can" demonstration, where the instructor creates sound waves that students can "see" and "feel".

OBJECTIVES

The students will investigate and explain how sounds are produced by vibrating objects.

The students will explain the relationship between the speed (rate) of the vibrations and the pitch of the sound.

SCIENCE STANDARDS

National Science Standard:
Sound is produced by vibrating objects. The pitch of a sound can be varied by changing the rate of vibration.

Georgia Performance Standards:

S4P2 Students will demonstrate how sound is produced by vibrating objects and how sound can be varied by changing the rate of vibration.

SCIENCE REFRESHER

What is Sound?

Sound is produced when objects vibrate and these vibrations are transmitted by atoms in air, water, or substances some distance. For example, when our vocal chords vibrate, they produce waves that travel through the air. These sound waves contain energy that travel in the form of compressional waves. When these waves enter the ear of a listener, they can be interpreted as sounds.

A vibrating object initiates waves when it “nudges” the molecules next to it, causing them to nudge adjacent molecules, and so on – causing the vibration to move through the substance. Consider sound traveling from one person to another through the air. The vibrating vocal cords on the speaker nudge nearby molecules in the air, causing a chain reaction that transmits the sound wave to the ear of the listener (see box below to view an animation of sound travel). The vibrations are channeled into the inner ear, where specialized structures convert them to electrical signals and convey them to the brain for interpretation. This is covered in slightly more detail in the

Interactive Animations – Sound Moving Through Air
http://www.fearofphysics.com/Sound/dist.html
A series of animations from the “fear of physics” web site show how sounds are transmitted through the air from the source to the recipient. Animations are suitable for showing in class to aid student comprehension.

Additional Resources – Overview: The Human Ear
http://www.entnet.org/HealthInformation/earWorks.cfm
A one-page explanation of the operation of the human ear from The American Academy of Otolaryngology—Head and Neck Surgery Foundation.

Properties of Sound

Different objects produce different types of sound waves, and so sound different to our ears. Objects that vibrate rapidly produce many waves per second and have a “higher” *pitch* or *frequency* than objects that vibrate fewer times per second. Someone singing soprano therefore creates more sound waves per second than someone singing bass. The frequency of sound is described by the wavelength, the physical distance from the crest of one peak in the sound wave to the next (Figure 1). Frequency is measured in hertz, abbreviated Hz. Humans can hear sounds ranging from about 20 Hz to 20,000 Hz. Many animals can hear sounds at higher frequency than humans. The classic example is a dog whistle, which produces a high-frequency sound that human ears cannot sense, but canine ears can.

The strength, or loudness, of the sound is measured by the *amplitude* of the sound wave and is measured in decibels, abbreviated dB. Prolonged exposure to loud sounds damages the human ear and leads to hearing loss. An estimated one-third of senior citizens currently suffer from significant hearing loss as a result of their prolonged exposure to high-decibel sounds.

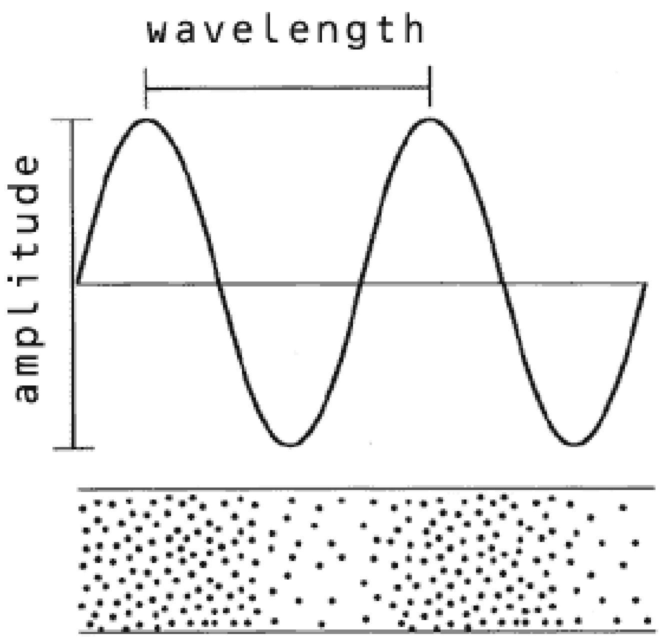

Figure 1. Diagram of a sound wave showing wavelength and amplitude.
[http://www.execulink.com/~robin1/res/da/wave.gif]

	**Interactive Simulation – Planet Science's PS100X Sound Sampler** http://www.planet-science.com/outthere/index.html?page=/outthere/sound_check/whatis_sound.html This shockwave element shows the characteristics of sound clips and enables users to modify them. Several libraries of sounds are provided and users can change the frequency of the sound by choosing from different "keys" – and conduct many more activities as well.

Interesting Facts about Sound Waves

Echoes and Sonar

Now that you know a bit about how sound waves travel, it should be clear how echoes work. If you stand in a cavernous room and make a loud noise, the noise comes back at you as an echo. This occurs because the sound waves are carried through molecules in the air to a distant wall and they cause the wall itself to vibrate slightly. Some of the sound is absorbed and transmitted by the atoms in the structure of the wall, but some of the vibrations "bounce back" and create a new sound wave that travels back toward its source – the echo.

Sonar used by submarines to navigate underwater is practical application of echoes. Sound waves are generated by the sub, and they bounce off of objects and are captured by sensors on the submarine. If you know the speed at which the sound wave travels through water, you can quickly calculate how far away the object is and navigate around it. Bats use sonar in a similar way to locate prey and avoid objects while flying (Figure 2), and dolphins use sonar to navigate underwater.

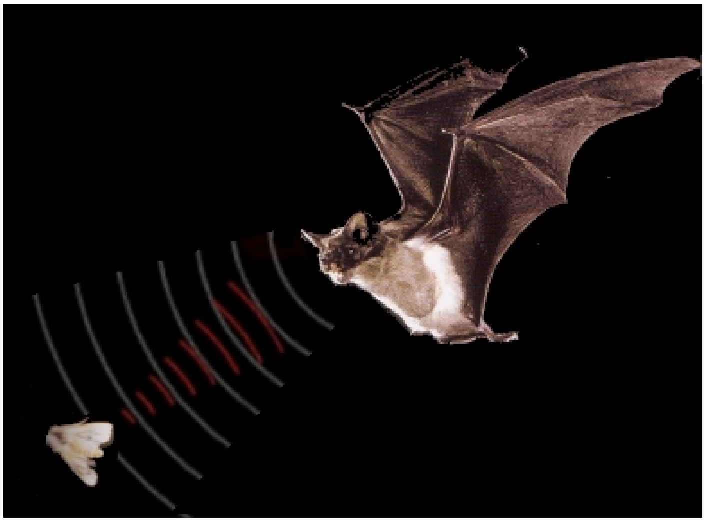

Figure 2. Bats use sonar to detect and capture prey, such as moths.
[http://www.batcon.org/news2/images/sonar.jpg]

Ultrasound
The movement of sound waves has many applications in the modern world. One such use is ultrasound, where sound waves are bounced off objects inside the human body or other objects to visualize internal structures. Ultrasounds are commonly used to track fetal development in the womb, but are also used to “see” other internal organs.

Who Needs Ears?
Not all creatures that sense vibrations do so with ears. Snakes, for example, place their jawbone on the ground to sense vibrations caused by prey items (such as mice) or by larger creatures that they wish to avoid.

If you scream in outer space, will anyone hear you?
The famous statement “In space, no one can hear you scream” is actually true. Sound travels through a medium, such as air or water, by causing a chain reaction that bumps molecules into one another to transmit sound. There is no air in space, and the few particles that are there are too spread out to effectively transmit a sound wave. Inside a spacecraft filled with air, however, sound would travel as on Earth.

The Speed of Sound
Sound travels through air at a speed of about 1,080 feet per second (330 m/sec), which is considerably slower than the speed of light 186,000 *miles* per second (299,000 km/sec). This is why you see a firework go off the night sky before you hear the “boom” and why you see lightning flashes well before hearing the associated sound.

Sound does not travel at the same speed through all substances though. The speed at which sound travels through a medium is dependent on its density and its elasticity (ability to “move”). In general, sound travels faster in material that is not dense and stiff. Typically, sound travels fastest in solids, slower in liquids, and slower yet in gases. Sound travels through liquid water at about 4,900 feet per second (1,500 m/sec) and through steel (a solid) at approximately 17,000 feet per second (5,200 m/sec).

Many students assume incorrectly that sound speed is related only to density, and ignore the influence of elasticity – this is incorrect. For example, Steel is approximately 6,000 times denser than air, but its elasticity is 2 million times higher than air, resulting in material traveling much faster through steel than air. You can therefore sense an oncoming train sooner by feeling for vibrations in the train track than by listening for its sound through the air.

Why Does Your Voice Sound "Funny" Sometimes?
Sound speed differences also explain why inhaling helium from a party balloon makes your voice sound funny. Helium gas differs in density and elasticity from normal air, so your voice sounds higher when carried by helium than when carried by air. Other gases, such as xenon, cause the voice to sound lower than normal. It is advisable not to demonstrate any type of gas inhalation with young students, as there are serious potential health issues associated with such activities.

If you ever listen to a tape recording of your own voice it sounds very different than the sound you hear when you speak. This is because you predominantly sense your voice through vibrations carried by your bones to the ear, not by "hearing" your voice carried by air. Since sound travels differently through bone than air, the voice you hear everyday is at a different frequency than the voice that others hear from you. Hence, when you hear your voice as others do, it sounds unusual.

Additional Resources – Online Videos on Sound from Exploratorium
http://www.exploratorium.edu/listen/online_watch.php
A series of short video clips from Exploratorium science museum in San Francisco that show students practical applications involving sound. Videos can be viewed online or downloaded and archived for future use.

MATERIALS – HANDS-ON ACTIVITIES

Tuning Fork Vibrations:	Tuning fork(s), plastic cup, paper towels. Tuning forks are available at many school supply stores.
Rubber Band Guitars:	Shoeboxes, various rubber bands, scissors
Drum It Up:	Toy drum, drum sticks, uncooked rice
The First Phones:	Plastic cups w/small slit cut in bottom, 40 inch pieces of cotton string, paper clips, scotch tape
Too Loud:	Internet-connected computer

CONSTRUCTION AND MATERIALS – AMAZING "WHOOSH" TRASH CAN

20-30 gal plastic trash can

Shower liner	Large enough to completely cover top opening of trash can. Available at home improvement stores.
Bungee Cord with clip	Secures shower liner over trash can top
Block of wood	Approximately 1 inch wide by 1 inch deep and 5 inches long
Screw and washer	Used to secure wood block in middle of shower liner on can
Fog machine and "fog juice"	Available at party stores year-round, sold in many additional stores near Halloween.

"Whoosh" Trash Can Construction

(1.) Cut a 5-6 inch diameter round hole in the middle of the bottom of the trash can.
(2.) Place shower liner or other thick plastic over top opening of garbage can. Push the liner so that it bows slightly into the can and allow about 10 inches of liner to overlap the edges of the trash can.
(3.) Use one or more bungee cords to secure the liner over the top of the trash can. The bungee cord will nestle nicely under the top rim of the can.
(4.) Place the wood block in the center of the liner on the outside of the can. Screw a screw into the wood block (with the washer between the screw head and the liner from the inside of the can, to secure the wood handle in place. Make sure the screws do not protrude from the wood block.

EXPLORATION (Teacher-led):

Preparation

Before you begin, ask your students the things they want to know about sound. Common responses include questions like "What is sound made of?" and "How do we hear sound?". Explain that sounds are vibrations that are carried by the air, water, and other substances to our ears, where they are sensed and recognized by our brains. Break students into five groups, one for each station. Place laminated direction sheets at each station along with materials. Assign each group a starting station and have students rotate between stations every 5-7 minutes on your announcement.

Procedure – Hands-on Activities

(1.) Tuning Fork Vibrations

Students strike tuning forks on the heel of their shoe and closely observe its vibrations. Students observe differences in vibration between longer and shorter tuning forks. Students place vibrating forks in a cup of water to see the transfer of energy from the tuning fork to water. Each group cleans up sprayed water with the paper towels before the next group arrives.

Guiding Questions:

1. Explain how you think the tuning fork caused the water to splash.
2. Why does one tuning fork sound differently than another?

(2.) *Rubber Band Guitars*

Create guitars by cutting a 3-inch diameter hole in the top of a shoebox toward one end. Stretch 3-4 rubber bands of differing thickness around the shoebox and across the hole. Students at this station pluck each of the strings and listen carefully for differences in the sounds.

Guiding Questions:

(1.) Explain how the rubber band produced sound when you plucked it.
(2.) Why do you think the rubber band vibrates louder on the guitar then it does all by itself?

(3.) *Drum it Up*

This station shows students the energy in sounds. They place a small handful of rice grains on the drum's surface and gently tap the drum with a drum stick. The rice grains move about as vibrations are generated in the drum's surface.

Guiding Questions:

(1.) What do you think is happening to the rice grains? Draw a picture to explain what you observe.
(2.) Would an object larger than a grain of rice, such as a potato, vibrate the same as the rice grain?
(3.) How could we tell that the drum is vibrating even if we didn't have any rice?

(4.) *The First Phones*

Create the classic string and cup "telephone" by cutting a small slit in the bottom of each plastic cup. Thread the string through the slit and secure it on the inside with a paper clip and tape the paper clip to the bottom of the cup. Repeat the process with another cup on the other end of the string. Students hold the cup to their ear and gently pull the string tight. They then take turns plucking the string and listening closely to what they hear. One student can speak into the cup while the other holds it to their ear to see if they can discern what is being said. This activity shows that sound can be carried by materials other than air – such as string.

Guiding Questions:

(1.) Explain how do you think the sound is getting from one cup to the other?
(2.) Do you think that real phones work in the same way? Explain.

(5.) *Too Loud*
Students go to National Institute on Deafness Website at http://www.nidcd.nih.gov/health/education/decibel/decibel.asp and complete an interactive activity called “How Loud is Too Loud.” Ensure the computer's sound is functioning and at proper volume and the speakers or headphones are functional to avoid problems during class time.

Guiding Questions:

(1.) Do you think that the communities where we live are getting quieter or louder overall? Explain why you think this.
(2.) What are some things that you can do to prevent your hearing from being damaged?

Explanation (Concept Building)
Reconvene the class after all stations have been visited and review the concepts covered at each station. Introduce the trash can demonstration by once again discussing sound waves, frequency of waves (pitch), and volume (amplitude of waves). Some teachers proceed directly to the trash can demonstration while others allow students to create miniature versions of the trash can using plastic cups (see box below).

Procedure – Trash Can Whoosh Waves

(1.) Fill the fog machine with fog juice and turn it on to warm up. Shoot 2-3 squirts of fog into the can through the hole in the bottom. Show your students the trash can apparatus and ask them to predict what shape of wave it will produce. Have them explain the basis for their hypothesis.
(2.) To produce a “whoosh wave”, hold the trash can parallel to the floor with the hole facing away from you.
(3.) Pull the wooden handle back slightly and then push it quickly forward. A small but distinct compression wave will be produced that will easily be felt by your students.
(4.) Move around and hit each of your students with a wave. Try to see if you can produce a wave that will travel across the entire room. Explain that human vocal cords make similar waves when they vibrate and produce sound.
(5.) Release a series of waves so students can visualize the patterns of waves that are produced. Vary the types of waves produced by pressing the liner with differing force and frequency.
(6.) Refill the can as needed with fog.
(7.) The fog is manufactured so as to not set off fire alarms but try to limit the amount that is produced to 4-5 trashcans so as to avoid a build up of fumes.

Additional Activity – Miniature Whoosh Trash Cans
You can have your students work hands-on by creating miniature versions using a plastic cup with a small hole cut in the bottom, and the top opening covered with plastic secured with a rubber band. Fill each student’s cup with fog from the fog machine and allow them to experiment with creating waves of differing frequency and amplitude.

Essential Questions

1. How is sound produced by an object?

2. What causes sounds to differ in their pitch?

3. How do sounds travel through different materials?

Safety and Disposal
There are no hazardous materials in this exercise. The greatest safety issue is ensuring students do not expose themselves to excessively loud noises. For example, make sure students don't hold tuning forks too close to their ears. Also be sure to properly control your use of the whoosh can to avoid excessive build up of fog in the classroom.

Explanation (Concept Building)
Here are the key concepts that should be emphasized in this lesson:

1) Sound is produced by vibrating objects. When we speak our vocal chords produce vibrations that travel as sound waves through the air. When these vibrations enter the ear of a listener, they can be interpreted as sounds.

2) Objects that vibrate rapidly produce many waves per second and have a "higher" *pitch* or than objects that vibrate fewer times per second. Someone playing the flute soprano would normally create more sound waves per second than someone playing the tuba.

Additional Resources – Online Sound Games from Exploratorium
http://www.exploratorium.edu/listen/online_try.php
Interactive games from Exploratorium science museum in San Francisco that has students listen carefully and gain insight on sounds and sound perception – without even realizing they're learning.

Extension Activities:
An excellent extension activity for this lesson is to construct a set of palm pipes for your students to play as musical instruments. Palm pipes are easy to make from PVC pipe and each pipe of different length vibrates with a different pitch. The pipes can be used as a class to play a wide variety of songs and the music for several songs is included. Directions for construction of these pipes can be found at:
http://webtech.kennesaw.edu/tbrown/curiosity/palmpipes.htm