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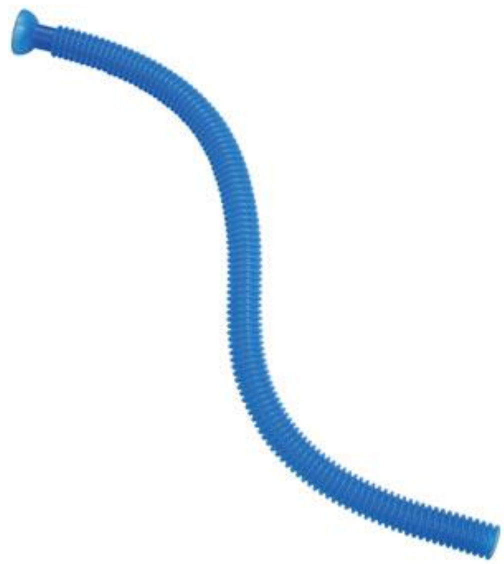
Sound Tube

SS-600

Background Information



Sound is a mechanical wave unlike light (which is electromagnetic in nature). Sound waves are pressure waves, which travel longitudinally through gases or liquids as molecules or atoms are repeatedly compressed (compression) or spread apart (rarefaction). The frequency at which these alternating, or oscillating, compressions and rarefactions occur determines the **pitch** of the sound. Low frequency oscillations produce lower pitches, higher frequencies produce higher pitches. Frequency is measured in cycles per second or Hertz (Hz). Humans can typically detect sounds in the range of 20 Hz to 20,000 Hz.

Sound waves can also travel through solids, but since the atoms or molecules in a solid cannot be compressed as easily as they are in liquids or gases, a different mechanism is involved.

A pebble falling into water pushes against the liquid, generating ripples or waves that travel outwards from the push. Sound waves begin when something pushes against a gas or liquid. Clapped hands or the vibrating tines of a tuning fork push against the air, producing pressure waves. We hear these pressure waves when they reach our eardrums, which vibrate in response. This vibration sends signals via our nerves to our brains, which interpret those signals as sound.

Musical instruments produce sounds in a number of different ways, but many involve a means to make a column of air contained within the instrument vibrate. Drums and kazoos use tightly stretched membranes; saxophones, clarinets, oboes, and harmonicas use reeds; guitars and violins use strings; trumpets and tubas use a person's lips; the column of air in a flute or a pan pipe vibrates when air is blown across it. The size and shape of the column of air, the materials in the instrument, and the technique of the musician all contribute to the **timbre**, or tone quality, of the sound produced. It is the timbre that allows us to distinguish between sounds of the same loudness and pitch produced by different instruments.

When a Singing Tube—also called a corrugated resonator—is whirled in a circle, it becomes a simple centrifugal pump. The difference in velocity between the moving free end of the tube and the stationary end held in the hand produces a pressure gradient, with lower pressure at the free end. This pressure gradient causes air to flow through the tube. If the tube is smooth sided, little sound is produced by this flow of air. However, the ridges in the Singing Tube disrupt the airflow to produce loud, musical tones. The faster the tube is whirled, the higher the pitch of those tones.

The lowest pitch is the first **harmonic** for that particular tube; the subsequent higher pitches are overtones of the first harmonic. The pitch, loudness, and timbre of the sound the listener hears are determined by the tube length, distance between corrugations, the velocity at which the tube is whirled, and the Doppler Effect since the tube's free end alternately approaches and retreats from the listener.

For an academic study of the physics and history of the Singing Tube you can refer to "A Physically Informed Study of a Musical Toy: the Singing Tube" by Stefania Serafin and Juraj Kojs of Aalborg University, Copenhagen Denmark at **http://hdl.handle.net/2027/spo.bbp2372.2004.169**.

Also available online is a musical composition for singing tube and other instruments, *Garden of the Dragon*, (2003) by Juraj Kojs at **http://www.kojs.net/Dragon.html**. The second excerpt features the singing tube: **http://www.kojs.net/Dragon%20files/DragonExc2.mp3**.

Next Generation Science Standards

1-PS4-1: *Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.* [Clarification Statement: Examples of vibrating materials that make sound could include tuning forks and plucking a stretched string. Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork.]

1-PS4-4: *Students can use this tool to conduct an investigation of how sound waves can communicate over a distance.*

MS-PS4-2: *Students can use this tool to develop and use a model to describe how sound waves are reflected, absorbed, or transmitted through various materials.*

Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions.

Materials:

- one or more Singing Tubes
- one Super Size Wave Spring
- a shallow baking pan half filled with water
- a small, soft ball (super ball)
- one or more lengths of smooth flexible tubing, such as segments of old garden hose, similar in size to the singing tube
- two tuning forks of different pitch
- assorted musical instruments, actual, toy, or homemade. These can include but certainly aren't limited to:
  - percussion instruments: drum, bell, xylophone, water glass etc.
  - stringed instruments: guitar, violin, ukulele etc.
  - open-tube instruments: flute, recorder, trumpet, penny whistle etc.
  - open-tube instruments with reeds: clarinet, saxophone, oboe, squeaky toys, harmonica, party horns etc.
  - open-tube instruments with air flow disruptors: pea whistle *
  - closed-tube instruments: trumpet with a mute, pan-pipes, narrow-necked bottle etc.
  - membranophones: kazoo, comb with waxed paper * *

* *A pea whistle resembles the Singing Tube in that the pea disrupting the air flowing through the whistle produces the loud sound. You may have experienced this effect if you had the misfortune of washing your whistle just before going out to supervise recess on a very cold day! You can demonstrate the importance of the pea to the class by carefully splitting open an inexpensive, plastic pea whistle along its seam line, removing the pea, then gluing the whistle body back together again.*

* * *Comb/waxed paper "kazoo": Cut a piece of waxed paper as long as the comb, and twice as wide. Fold the paper in half. Holding the comb with the teeth downwards, place the comb inside the folded paper so the fold is against the back. Using thumbs and forefingers, hold the paper lightly against the comb at both ends. Press the comb and paper lightly against your lips and say "ooo."*

Introduction:

(If the students have not yet learned about solids, liquids, and gases you will have to explain that gases, the air around us, and liquids, water, are made of tiny particles, molecules, which are too tiny for us to see. The molecules in liquids are close together so it is easy to see and feel water. The molecules in gases are much farther apart, so we cannot see gases unless the molecules are strongly colored. However, we can feel gases. Ask the students to blow gently onto the backs of their hands. They cannot see the air, gas, which came out of their mouths, but they can feel it.)

Clap your hands once. Ask the students who heard the sound your hands made? How did the sound get from your hands to their ears? Sound travels to our ears as waves. We cannot see those waves in air, but they resemble the ripples that occur when an object is dropped into a liquid. Invite a student to drop the ball into the pan of water. The ripples or waves formed because the ball pushed some of the water molecules closer together while other molecules were spread farther apart. When we clap our hands, some molecules in the air are pushed closer together, while others are spread farther apart.

Stretch the Super Sized Wave Spring the length of a long table or along the floor. Invite two students to hold the ends in place. One student represents the clapped hand, the other an eardrum. Instruct the clapped hand student to gently push his end of the spring once towards the eardrum student. Point out that the compressed section of spring travels away from the push. This resembles the invisible sound wave produced by the clapped hand. The compressed section of spring represents the air molecules pushed together by the clapped hand. When the push, or sound wave, reaches our eardrum, the eardrum vibrates, sending signals to our brains, which we recognize as sound.

Invite one or more students to strike the lower toned tuning fork. What do they feel? They should feel the vibrations of the fork in their hands. How does the tuning fork produce sounds? The vibrating tines push against the air molecules, producing sound waves. Invite two different students to hold the ends of the extended spring—one representing the tuning fork and the other the eardrum.

We continue to hear the sound of the tuning fork long after it was struck because the tines continue to vibrate. Instruct the tuning fork student to gently push on the spring on your marks so that the compressions are spaced three to four seconds apart. Strike the higher pitched tuning fork. How do the two forks' sounds differ? The tines of the higher pitched fork vibrate more rapidly than those of the lower pitched fork. Instruct the tuning fork student to again gently push on the spring on your marks so that the compressions are spaced one second apart. Higher sounds have a higher frequency, more pushes per second, than lower sounds.

Invite the students to hum while pressing their fingers gently against their throats. What do they feel? They feel their vocal cords vibrating as the air from their lungs passes through them. We recognize the sound waves produced by our vocal cords as voices.

Exploration:

If you have toy and homemade instruments available, allow the students time to explore them. Explain that they are to discover what vibrates to produce the sound for each item. You will probably have to demonstrate how to play a comb with waxed paper*, how to produce a tone by blowing across the mouth of a bottle, and how to make a water glass sing by rubbing the rim. (You will want to closely supervise the latter!) Reassemble the class so they can share what they discovered.

If you have actual musical instruments demonstrate each to the class. Invite students to touch the instruments as they are played to feel the vibrations.

Next, introduce the Singing Tube and the length of smooth tubing. Ask the students to compare the two. How are they alike? How are they different? Invite several students in turn to spin the smooth tube as fast as they can. (Be sure they have plenty of room so nothing or no one is accidentally struck). Do they hear anything other than a soft whoosh?

Now invite several students to spin the Singing Tube. What do they hear now? How many different sounds do they hear? (The Singing Tube is capable of producing five different pitches. If the students were unable to produce more than two, you may want to demonstrate those higher pitches for them.) Why did the smooth tube only make a soft whoosh sound, while the corrugated tube made loud musical tones?

Ask the students to think about what they observed with the other instruments as they formulate explanations. After the students have shared their ideas, you can let them in on the secret. When a smooth tube is whirled, air is sucked in through the end held in the hand, and goes out through the moving end. In the Singing Tube, the air molecules are pushed together and spread apart as they bounce over the ridges, causing the musical sounds. The air molecules flow smoothly through the smooth tube, so no musical sound waves are produced.

Take Your Lesson Further

As science teachers ourselves, we know how much effort goes into preparing lessons.
For us, "*Teachers Serving Teachers*" isn't just a slogan—it's our promise to you!

Please visit our website for more lesson ideas:

TeacherSource.com/lessons

Check our blog for classroom-tested teaching plans on dozens of topics:

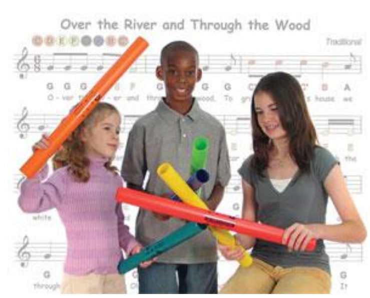
http://blog.TeacherSource.com

To extend your lesson, consider these Educational Innovations products:

Super Size Wave Spring (SPR-210)
This super size version of the ever-popular spring toy is a perfect way to demonstrate wave theory in a way your students will never forget. Easily model transverse and longitudinal or compression waves and teach the relationship between wavelength and frequency. Measures 75 mm in diameter, 150 mm in length, and stretches up to 10 meters.

Wave Modeling Spring (SPR-1)

This 6-foot-long spring stretches to over 30 feet! Perfect for modeling standing and moving transverse waves as well as moving sound waves. Demonstrate the relationship between wave-length and frequency in a way your students will never forget. These gigantic springs are difficult to find and have myriad uses in the classroom and laboratory.



Basic Boomwhacker Set (BOM-150)
These eight labeled tubes produce the C-Major Diatonic Scale. Included in package: eight tubes, 12 in. to 24 in. long. See optional Octavator End Caps to lower the pitch by an octave.

3D Standing Wave Machine (OPT-400)
Create mesmerizing standing waves with a simple string by adjusting the speed of the machine's two motors and the distance between them. In the dark, the light from red, green, and blue LEDs allows a full spectrum of brilliant color. The variations in standing waves are limitless! Great for teaching about nodes, antinodes, and wavelength.