SAE STEM@Home™: A World of Sounds

EDUCATOR GUIDE

Resources from A World In Motion®
What Is Making Music?

In the Making Music challenge, students explore the how, what, and why of sound and vibrations through several activities. Students begin by exploring sound and sound waves and learned about concepts such as pitch and longitudinal and transverse waves. They also learn how the human eardrum works by building a model of the eardrum and observing how it reacts to sound.

In preparation for their final task of constructing an instrument, students examine a variety of musical instruments. This exploration provides insight into why instruments make different sounds and what components of the instruments are responsible for the particular sounds they make. For example, in one activity, students investigate how string length, width, and tightness affect a note’s pitch.

Using this information, as well as knowledge gained in previous lessons, students then work in teams to design an instrument with specific characteristics. Students collaborate in teams to engineer an instrument, then test their prototype, and finally demonstrate their instrument during an in-class presentation.

Making a Musical Instrument

Musical Instrument Supplies

If your child hasn’t had a chance to engineer and play with a musical instrument, you can make one at home! You can use a variety of craft materials, such as:

• yarn
• string
• Popsicle sticks
• bells
• balloons
• aluminum tins
• rubber bands (all sizes)
• paper clips

The idea is to produce an instrument that uses strings (like rubber bands or string/yarn), or uses bells, tin cans, or balloons to generate sound. Have your child experiment with different sizes of rubber bands (thick vs. thin; short vs. long) and different tins (wide vs. narrow; tall vs. short). You can even use glasses filled with different amounts of water and a spoon to hear differences in pitch.
STEM CONNECTION
How Is Music Made?

Vibrations

A musical instrument involves different kinds of vibrations. Sound is a vibration that begins as a wave of pressure that moves through different mediums, like air or water. A musical instrument like the one made in the Making Music challenge is made up of various materials that allow it to have a certain pitch. For example, the different materials used for strings produce different tones and sounds.

You may be familiar with different instruments (ones that use strings versus ones that use air) but in general all instruments generate sound from vibrations. The guitar, for example, produces sounds based on the strings being plucked at different positions and tensions. The flute, in comparison, makes it sounds based on the amount of air pressure used and finger valve placements. When the air flows through the flute, a vibration is created that generates a sound.

Music is made up of a variety of components, all which interact with one another to generate unique sounds. Sounds waves can have different pitches, frequencies, and intensities (or volume). Read below to learn a bit more about each of these components that make up the backbone of this module, A World of Sounds.

Sound Waves

Sound is produced by vibrations that bump into each other. This bumping motion creates wave like motions between molecules. In turn, fast vibrations create waves that are close together while slower vibrations create waves that are more stretched out. Each of these waves create a different tone, or pitch. If the molecules are bumping into each other quickly and close together, this will produce a high pitch sound, like a whistle. If the molecules are not vibrating as quickly, and therefore producing slower waves, the sound will be low pitched, like a tuba.
Types of Waves
Waves can be categorized in two ways: by the direction of their movement or by the types of matter that they are able to travel through.

Direction of Movement
One way to categorize waves is by their direction of movement. This is based on the movement of the particles within the medium (water, air, etc.) relative to the direction the wave travels as a whole.

Longitudinal Waves
Longitudinal waves are waves in which the disturbance moves in the same direction as the wave. This means the particles of the medium (coils of slinky in this case below) move in a direction that is parallel to the direction that the waves move. Using a Slinky as the example, suppose it is stretched out, as in the picture below. If it is stretched out in a horizontal direction across a room, and a person on the left holding it plucks it creating a vibration or pulse, the coil on the left will transmit the energy left to right. As the energy travels left to right, the coils of the slinky will also move left to right. In this particular example, the particles of the slinky are moving parallel to the direction that the vibrations are moving, creating a pulse. This type of wave is longitudinal. Longitudinal waves are always comprised of a particle movement that is parallel to the wave motion.

Longitudinal waves cause vibrations that can travel through solids, liquids or gases. A sound wave that travels through the air is a classic example of a longitudinal wave. In this case, the sound wave travels from the lips of the person talking to the ear of the person listening. The air acts as the medium here since particles in the air vibrate back and forth in the same direction from the speaker to the listener. Each particle “bumps” into one another so as to move it forward. This energy transport continues along the path of particles until the sound waves reaches the listener’s ear.
**Transverse Waves**

Transverse waves are waves where the disturbance moves perpendicular to the direction of the wave. You can think of the wave moving left to right, while the disturbance moves up and down. A visual of a transverse wave can be seen in the picture below. While the boy moves the rope up and down, the waves are also moving perpendicular, left to right and therefore, the energy is transferred left to right. However, none of the particles are transferred along a transverse wave. The particles instead move up and down as the wave is transmitted through the medium.

In a transverse wave, the vibrations are essentially at a right angle compared to the direction the wave is traveling. Some examples of transverse waves include vibrations in a guitar string and electromagnetic waves, such as light waves and radio waves.

**Types of Matter**

An additional way to organize waves is based on their ability to transfer energy through different types of matter.

**Electromagnetic Waves**

An electromagnetic wave is capable of transferring energy through a vacuum, like space. These types of waves are made because the particles that are vibrating have a charge. An example of this are the electromagnetic waves that are made on the sun that travel to Earth. These waves are capable of traveling to Earth because of their ability to travel through a vacuum. All light waves are examples of electromagnetic waves.

**Mechanical Waves**

In contrast, mechanical waves are not able to transfer energy through a vacuum, or space, and instead require a medium. A sound wave would be one example of this and an explanation as to why light can travel through space, but not sound. The slinky wave in the above example is another type of mechanical wave. It requires the coils of the slinky in order to transfer energy. A jump rope would be another example. The wave a jump rope creates requires the jump rope to make it.
Pitch
Sound has both volume and pitch. The pitch of a sound is how high or low a sound is. Pitch is basically your ears’ response to the frequency of a sound. Higher pitched sounds have a high frequency (loud and sharp, like nails on a chalkboard) where low pitched sounds have a lower frequency (deep and dull, like thunder). The volume of a sound is different than its pitch. Instead, volume depends on its intensity, or amplitude. Bigger, stronger, more amplified vibrations result in a bigger, or louder, sound.

More About Sound
Voices
The human voice is a unique type of instrument which vibrates to produce sound and is unique to each individual. The larynx, otherwise known as the voice box, is a hollow muscular organ found in the throat between the mouth and the trachea. The vocal cords are found within the larynx. It is here where vibration occurs, and therefore sound is created. These cords are comprised of two, very thin pieces of muscle. When we speak, the vocal cords allow for air to pass through and, in turn, causes them to vibrate.

Animal Sounds
While animals do not speak, they still communicate with one another, and just like us- the sounds they produce depend on vibrations as well. The vibrations they create differ in pitch and frequency. Different animals use different forms of sounds to communicate. Some animals make noises to call to one another while other make noises to warn of approaching danger.

Animals are also unique in the sounds they can hear and create. Dogs, for example, hear much higher pitched sounds than human ears can hear. Bats, as another example, use a form of sonar to communicate with one another and determine location.

Hearing Sounds
Living things hear with their ears, where sound is taken in and converted into signals that can be interpreted by the brain. The shape and size of an organism’s ears change how it hears sound. Most mammals have inner and outer ears, similar to humans, however the outer ear varies tremendously. Many animals have large outer ears that can move significantly to better hear sounds. Scientists say that human ancestors may have had the ability to move their ears to a much greater extent and the muscles that did so are still present in modern day humans. You may know people who can wiggle their ears with these muscles.

Many animals have ears that do a lot more than help them to hear. In fact, the size and shape of animals’ ears vary tremendously depending on a variety of factors, including the size and the shape of the shelter an animal uses, how the animal hunts, and the climate the animal lives in. If an animal
spends much of its time in tight quarters, like a groundhog, it is likely to have very small, compact ears so that it can fit through tight spaces. Some animals—like hound dogs—have long, floppy ears that help them find prey, not by hearing it but by dragging on the ground and stirring up scents from the ground. Other animals, such as elephants, have ears that help them stay cool and decrease their own body heat. They are full of blood vessels, which aid cooling by radiating heat away from their body. Their ears also flap to generate cooling air currents.

Life Without Sound

For some, it is necessary to communicate without sound. Hearing loss is a problem that can occur in young and old. When the outer ear, inner ear, or auditory nerve are damaged, hearing loss can occur. American Sign Language is one approach for those who are deaf or hard of hearing to communicate.

Animals can experience hearing loss as well. Just like humans, their ears depend on a diverse and complicated system to carry vibrations to the brain, which then generates messages. Any disruption in the system can cause hearing loss.

Some animals can also learn sign language to communicate with humans. Koko the Gorilla, born in 1971 at the San Francisco Zoo, was part of a scientific experiment in which her trainers taught her Sign Language. By the end of her life, Koko had learned over 1000 words and was able to communicate clearly with her trainer.
1. Investigating Voices
In this simple activity, children explore their own voice through vocal graphs.

**Draw Your Voice**

**Materials**
- A voice recording app, such as the Voice Memo app for Apple products or the Samsung Voice Recorder app for Android devices.
- Colored markers, crayons, or colored pencils
- Notebook paper

2. What About Waves
In this activity, children experiment with stamping tubes, a type of musical instrument. The stamping tubes demonstrate how design can impact an instrument’s sound.

**Stamping Tube Concert**

**Materials**
- 3 or more cans (such as a soup can) of the same size
- Duct tape
- Towel
- Can opener

3. Exploring Animal Talk
In this activity, children explore different sounds animals make and try to recreate the sounds themselves.

**Wild Instruments**

**Materials**
- An envelope (business or standard size)
- Rubber band
- Paper clip (heavy duty is best)
- Straw
- Scissors
4. All About Ears
In this activity, children put their own ears to the test to see how well they can detect locations of various sounds.

Where's That Noise Coming From?

Materials
- 6 pennies
- Empty paper towel roll
- Paper cups
- Stapler
- Scissors
- Tape

5. Introducing the Sound of Silence
In this activity, children explore body language and other methods of non-verbal communication to understand what is happening in a video.

What’s Happening Here?

Materials
- Notebook and pencil
- Friend, or family member (optional)

6. Wrap-Up
In this activity, children make their own musical instrument using common household materials.

Make a Wind Instrument

Materials
- 6-8 straws
- 2 pieces of cardboard (5 cm x 15 cm)
- Glue
- Scissors
1. Investigating Voices

Think About It!

1. Why do you think our vocal cords are made up of muscle?
   Vocal cords need to be able to move, shorten, lengthen, open and close. Because of their flexibility, muscles a variety of movements come easily.

2. How do you think a singer takes care of his or her voice?
   Singers may try to not overuse their voices and may rest their voices, the same way a basketball player would rest their legs after a long game. It is also important to not scream and yell, to drink lots of water, and keep healthy.

2. What About Waves?

Sound and Solids: Visualizing Vibrations Video

1. What did you notice when the boy hit the tuning fork softly and placed it in the water? Were the waves slow or fast?
   Children might suggest any of the following: the tuning fork sound was quieter, less vibrations were made in the water, or little disturbance was made. Their answers should also include that the waves were slower.

2. What did you notice about the sound the tuning fork made when it created fast waves in the water? Was it high or low sounding?
   Children might suggest that the water’s waves were much bigger and traveled faster, the tuning fork sound was much higher sounding and it caused more of a disturbance in the water.

Think About It!

1. Why do you think changing the length of the stamping tube changes the sound that is produced?
   The longer the tube, the more air is present which creates a lower pitch (the air molecules have more space to move around and don’t bump into each other as often as they would in a more confined space).

2. What about sound travel surprised you the most?
   This could be anything of interest to the child. Things such as how sound travels faster through water or that a faster vibration cause a higher pitched sound.

3. Exploring Animal Talk

Think About It!

1. Why do you think it is important for bats to have extra good hearing?
   Bats have poor eyesight, and they travel a lot at night, so having a good sense of hearing helps them to compensate for their inability to see well.

2. What surprised you most about animal communication?
   Children will have lots of imaginative thoughts. They might mention dolphins and bats using sonar or spiders using vibrations to locate prey.
3. Why do you think dolphins can make sounds that travel fast through the water?  
   Because dolphins live in the ocean, it is important that they can communicate with their families, or pods. Since the ocean is a big body of water, it is important for them to be able to communicate well so that they can stay together, avoid danger, etc.

4. All About Ears

Think About It!

1. Look at the picture of the mouse below. Why do you think the mouse has ears like these?  
   Children may have a variety of thoughts. They may say that they have these ears because they need to be able to fit in small spaces and also be able to hear well. So, they have small, compact ears but the large outer ear helps them to detect sound easily.

2. If you were designing an animal that lives in the jungle high up in the trees, what kind of ears would you give it and why?  
   Answers will vary. For example, a child might say, “I would give it moderate size ears that have a large outer ear so that they can hear sounds from far away. They may have ears that are moveable so that they can hear which direction a sound is coming from, or what level (high or low). They would also need to have ears that are flexible and not too big to allow them to climb.”

5. Introducing the Sound of Silence

Think About It!

1. How do you think your life would change if you couldn’t hear?  
   Answers will vary.

2. Try to think of as many inventions or devices we have that help people understand what is being said or happening if they cannot hear. What are they? Can you come up with an invention that might help?  
   Answers will vary, though children should understand that people who are deaf or hard of hearing may use hearing aids, Sign Language, or lip reading. Children may also recognize that there are many ways in which sound is used to alert people, such as police car and tire truck sirens and telephone ringers. Suggestions for inventions might explore how the deaf could be alerted in these types of situations.

3. Why do you think it is important to have different kinds of communication?  
   Answers will vary, though children should understand that people who are unable to hear, or are deaf, need to be able to communicate with others in non-verbal ways and this is related to safety.