SENDING SECRET MESSAGES (1 Hour)

In this activity, students explore how sound waves travel through various materials. They will build a sound transmission device and work to transmit a secret message to their teammates.

Topic: Sound waves and sound transmission

Real-World Science Topics

- An exploration of how sound waves travel
- An exploration of how sound waves travel through different media

Objective

Students will gain an understanding of how sound waves travel through different media by building a sound transmission device.

Materials Needed for Student Teams

- string
- wire clothes hangers
- spool of thin gauge copper wire (or other thin wire)
- paper cups
- scissors
- wire clippers

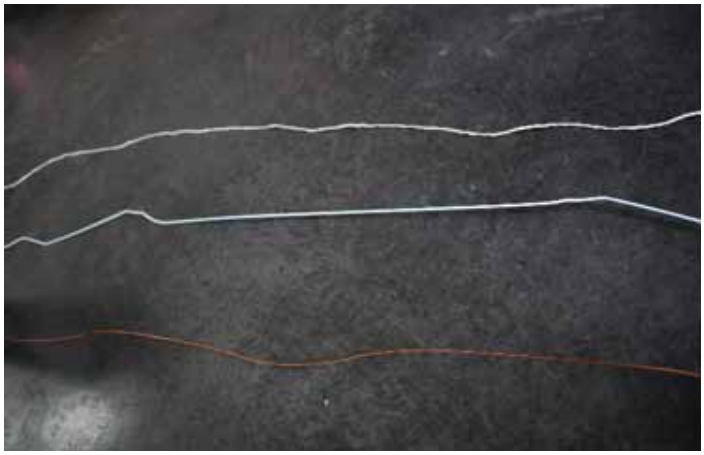
Teacher Preparation

Depending on the level of your class, you may wish to have one or two sample transmission lines built before the activity so that students have a model for their transmission lines.

STEPS FOR *SENDING SECRET MESSAGES*

1. **Warm-up Activity:** Have students tap lightly on their desks with their fingernails or a pencil. Have students listen to the sounds they hear. Then, have students lower their ears to the desk and ask students how the sound changes. Students should note that the sound seems louder when they lower their ears to their desks. Have students think about why this might happen. Challenge students to tap so lightly on their desks that the sound is only audible when their ears are lowered to the desk. Tell students that in this activity, they will use this idea to build a device that will successfully transmit secret messages from one person to another.

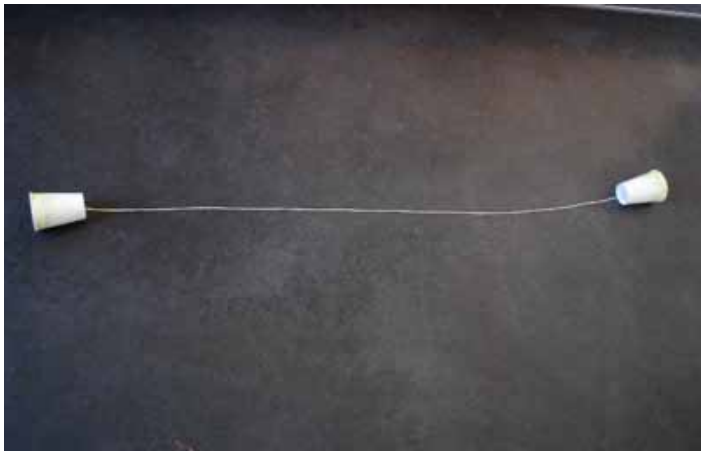
2. Ask students to think about times when they have heard sound through materials other than air. If needed, prompt them to think about hearing things while underwater. Ask if they have ever heard someone talking through a wall. Allow students to share their descriptions of sound traveling through various materials. Then, tell students that they will work in small groups to experiment with sound traveling through different materials. If you wish, frame this activity in the context of a top-secret mission. Students will be challenged to whisper a top-secret message to another teammate while other students try to intercept the message. Show students the materials they will use in this activity, as shown in the photo to the right.



3. Divide students into teams of three to five students and distribute the materials and **Student Handouts**. Explain to students that they will use the materials to create a transmission line for sound. The transmission line provides a path for the sound to travel. Instruct students to use caution when working with the wire (hangers or copper wire), as the wire can be sharp. Teams should make three different lines: one of string, one of copper, and one of wire hangers. All three lines should be the same length (it is easiest to have all lines be the same length as the straightened hanger, as this is the most difficult material to manipulate). **Caution students to be very careful when using scissors to cut the string and wire. Depending on student ability, you may need to assist students when cutting the wire.** The above image shows three lines, one of string, one of a wire clothes hanger, and one of thin copper, stretched out and ready for testing.

STEPS FOR *SENDING SECRET MESSAGES*

4. Allow students to observe the properties of each material by touching, bending, tapping, and listening to each material. Then, have students guess which material will make the best transmission line. Then, allow them to construct their sound transmission lines by attaching a paper cup to each end of the string or wire. To do this with the wire, students can poke each end of the wire through the bottom of the paper cup and then bend the end of the wire so that the wire is secured to the inside of the cup. To do this with the string, students can poke a hole through the bottom of the paper cups (using a pen or pencil). Then, they can insert each end of the string through the holes and tie the string into a thick knot to secure it in place, as shown in the photo to the right.



5. Allow students time to experiment with their transmission devices. Have them talk into the cups to see how the sound transmits through the device, and allow them to make any modifications to their design based on their observations.

6. Next, instruct students to develop a secret message. The message should be short, no more than a sentence. Remind students to keep their message appropriate for the classroom. Instruct students to work quietly so that other groups cannot overhear them as they develop their secret message. Tell students that one member of the group will send the message over the transmission line to another member of their group. To make the task trickier, the rest of the class will attempt to intercept the message by listening closely as each group transmits their message. Allow students a few minutes to practice sending their messages over the transmission line.

7. Have one group at a time come to the front of the class and send their secret message over their transmission line. As they send their secret message over their transmission line, the rest of the class should listen carefully to try to "intercept" the secret message. After a group has sent their message, allow the class to share what they thought they heard. If a group had its secret message intercepted, they fail their mission. Continue in this manner until all groups have attempted to send their secret message across their transmission line.

8. **Wrap-up Activity:** After all groups have sent their secret messages, bring the class back together as a large group to discuss the activity. Have students think about why they were able to hear sound that traveled through a solid piece of material but they couldn't hear that same sound through the air. Explain that sound causes small particles in matter to be disturbed from their positions, causing them to vibrate and bump into other particles. To help students visualize this, have them think about a crowded room of people. Each person represents a particle in matter. If a person on one side of the room pushes the person next to him or her, that person will create an initial disturbance. This person will then bump into the person standing next to him or her, and that person will bump into the next person, and so on, until the person on the opposite side of the room eventually feels the push. Explain that sound travels in a similar way. When a

person talks into the paper cup on one side of the sound transmission device, he or she creates an initial disturbance, causing the particles in the wire or string to vibrate and bump into each other. This disturbance travels along the wire or string until it reaches the other end, where the other person hears it.

Remind students that the particles in solid materials are packed together very tightly, like the people in a crowded room. However, the particles in a gas, such as air, are much farther apart from each other. The particles in a gas would be similar to just a few people standing in a room very far apart from each other. If a person on one end of the room is pushed, that person might bump into the next person in the room, and that person might also bump into another, but the strength of the initial push will be much weaker each time the push is transferred, because the people have so far to travel before they bump into each other.

With this in mind, have students volunteer reasons why sound travels easier through solid materials, which have tightly packed particles, than through gases, which have loose particles.

Sending Secret Messages Extension Activities

1. Challenge students to create obstacles for each other's transmission lines. Allow groups to brainstorm ways to sabotage one team's "secret mission" by altering the transmission line. Then, allow students to carry out the alterations to another team. Teams can then try again to send their message across the transmission line. For example, one team might decide to tie a knot in another team's string transmission line. A different team might decide to place a metal clip in the middle of another team's metal transmission line. After students attempt the experiment again, this time with alterations, discuss which alterations stopped the sound from transmitting and why.
2. Challenge students to develop simple experiments to test how sound travels though different materials. For example, students can see how the sound from simple musical instruments, such as a triangle or a tambourine, moves when placed underwater. Is the sound still audible? Challenge students to test several sounds and to describe what happens to the sound waves.

What is sound?

We hear sounds all around us, all the time. Sound is one form of energy. Sound is produced when something causes the particles around us to vibrate. For example, when we speak, our vocal cords cause the air in front of our mouths to vibrate. When we clap our hands together, the striking of skin on skin causes air around our hands to vibrate. Our ears are finely tuned to recognize differences in these vibrations, and they allow us to hear a myriad of sounds.

How does sound travel?

Much like light, another form of energy, sound travels in waves. When a sound is created, the vibrating object (such as a plucked guitar string) causes the particles around it to vibrate. These vibrating molecules bump into the surrounding molecules, which in turn bump into other surrounding molecules, and so on, allowing the sound to be transmitted. A standard way of thinking about sound transmission is to imagine a line of small springs suspended next to one another in the air. If a spring on one end is tapped, it will begin to vibrate, causing the next spring in the line to vibrate, and so on.

Why do sound waves travel better through particular types of media?

As mentioned above, sound travels by displacing the particles around the initial source of the vibration. This can happen in solids, liquids, and gases. If you were to place your ear on a table and tap the opposite side of the table, you would be able to hear the tap more clearly than you would through the air. This happens because the particles in solids are packed closely together, allowing them to transmit the disturbance from your finger tapping very quickly and without much energy loss. (Imagine the springs described above placed very closely together.) The particles in a gas, such as air, are much farther apart. When a particle is displaced, it must travel a greater distance before it strikes another particle. (Imagine the springs described above spaced very far apart.) Because of this, the disturbance loses more energy as it is transmitted through air, causing sound to transmit less efficiently, and thus travel a shorter distance, through air.

Key Vocabulary

sound: vibrations that travel through a medium

transmission: the action of something moving from one place to another

particle: a small piece of matter

1. What material did you choose for your transmission line and why?

[Sample answer: My group chose the string. We chose the string because, when we tapped the string, we could hear the sound travel the whole length of the string.]

2. Draw a picture of your completed transmission line. Label the materials you used.

[Images will vary, but should contain labels denoting the material and the paper cups.]

3. With your group, decide on a short secret message. Write it below.

[Answers will vary.]

4. Was your team successful in transmitting your secret message? Explain why you were or were not successful.

[Sample answer: My team was not successful because another team overheard our message.]

5. Based on this experiment, do you think sound travels better through solid objects or through gases, such as air? Why do you think this happens?

[Sample answer: I think sound travels best through solid objects because the particles in solids are closer together than the particles in a gas. This allows sound to travel more easily through a solid than through a gas.]

Name:

Date:

1. What material did you choose for your transmission line and why?

2. Draw a picture of your completed transmission line. Label the materials you used.

3. With your group, decide on a short secret message. Write it below.

4. Was your team successful in transmitting your secret message? Explain why you were or were not successful.

5. Based on this experiment, do you think sound travels better through solid objects or through gases, such as air? Why do you think this happens?