Be a Sound Engineer

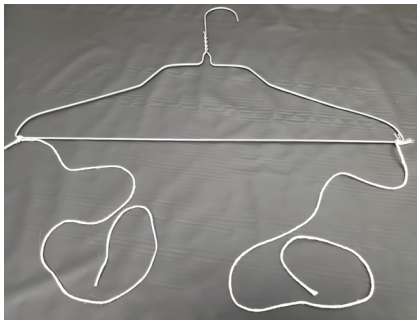
Physics Question: *How can we increase the energy of sound waves to make a sound louder?*

MATERIALS:

- Wire hangers (1 per pair of students, plus 1 for demonstration)
- Building materials:
  - Small paper cups
  - Large paper cups
  - Aluminum tart tins
  - Paper bowls
  - Masking tape
  - Cotton string
  - Scissors
- Pencils
- Lab notebooks
- Sound Engineer Career Card
- Optional materials:
  - Plastic cups of various sizes
  - Other string types, such as yarn or thick twine
  - Construction paper, cardstock, or cardboard
  - Other bowl- or cup-shaped containers, such as recycled food containers

Prepare

1. Cut pieces of cotton string about 12–18 inches long, to make two pieces for each wire hanger. Tie each of the two pieces of string to opposite ends of the hanger's bottom bar. Once assembled, the hangers can be reused for multiple groups of students.
2. Use one of the hangers to create a demonstration amplifier by taping the free end of one of the pieces of string to the base of a small paper cup.
3. Decide how you will make the building materials available to students (for example, by creating a central materials station in the classroom, or providing smaller materials kits to tables or groups) and organize the materials accordingly.
4. Before beginning the activity, hang the "Research Lab" sign in a visible location.



Engage

1. Introduce the sound engineer career by showing the group the career card and asking questions to encourage students to think about what a sound engineer might do:
   - *What do you notice about this picture? What do you think this person is doing?*
   - *Have you heard the word "engineer" before?*
   - *What do you think a sound engineer might do or study?*
2. Explain that sound engineers solve problems about sound. They might control the microphones and speakers at a music concert, record the sound effects for a movie or video game, or design sound systems for auditoriums or theaters.
3. Introduce the storyline of the activity like this:
   - Imagine we are a team of sound engineers and this is our research lab. What does our lab look like?
   - We work for a video game company, helping to make the sound effects that go into the video games.
   - The company is working on the sounds for a new game, and they have a problem they'd like us to solve.
4. Ask for a volunteer to help you demonstrate the problem. Using one of the hangers with two strings attached, demonstrate how to hold the loose end of each string between thumb and index finger, loop the strings once or twice around your index fingers, and place your index fingers in your ears. Invite the volunteer to do the same and then to lean forward so the hanger is dangling freely from their fingers.
5. Strike the hanger with a pencil or other hard object. Ask the volunteer to make observations about what they notice. Then ask the rest of the group to compare it to their own experience.
   - *What happened when I hit the hanger with the pencil?*
   - *What did it sound like?*
   - *What did the rest of you hear? Why do you think that could be?*
6. Explain that this is your engineering problem: the video game designers want you to record this really cool sound to use in their video game, but your recording equipment doesn't have fingers or ears! If you want to record this sound for the game, you need to make it loud enough for everyone in the room (and your recording equipment) to hear.
7. **Make connections** to students' experiences with making sounds louder.
   - *What things can you think of that make a sound louder?*
   - *Do they have anything in common? What features might be important for making a sound louder?*
8. Explain that to understand why those things work (and how to solve your problem) you need to think about **sound energy**.
   - *What things can you think of that make sounds?*
   - *What are some different ways you can make a sound?*
   - *What kinds of sounds do you think have a lot of sound energy? What sounds might have less energy?*
9. Invite students to try placing a hand on their throat and humming.
   - *What do you feel when you hum?*
10. Point out that **sound energy happens when something is vibrating**—wiggling back and forth very fast. That vibrating object makes the air around it vibrate, which then makes the air next to *that* vibrate, sending a wave of vibration traveling through the air until it reaches our ears. Use examples to illustrate the idea, such as:
    - Vocal cords in your throat vibrate when you talk, which vibrates the air in your lungs and mouth
    - Two objects vibrate when they hit each other, like clapping hands or a drumstick hitting a drum

11. **Ask questions** to help the group consider how sound energy is traveling in your hanger system.
    - *What is vibrating? Where do you think the sound energy is traveling?*
    - *Why do you think the sound energy reached our volunteer's ears, but not anyone else's?*

Explore

1. Explain that you've started working on making an **amplifier**—something that makes a sound louder—and you have developed a **prototype**—a beginning design that needs improving. Show the hanger with small cup attached and ask for a volunteer to test it by listening near the cup.
    - *What do you hear? How is it different from without the string/cup?*
    - *Where is the sound energy traveling in this design? How might that be connected to the sound being louder?*
    - *What's still not so great about this design?*
2. Explain that the team's job is to improve on this amplifier design to make the sound as loud as possible.
    - *What could we change to make the sound louder?*
    - *Remember the things we mentioned before that make a sound louder. How could they give us ideas for this design?*
    - *What might affect the sound? The size of the cup? Its shape? The type of string? More cups or strings?*
3. Divide the class into pairs of research partners. Explain that engineers plan before they build. Invite pairs to look at the available materials, draw some ideas for their design on p. 21 of their lab notebooks, and choose one idea to try first.
4. Give a hanger to each pair. Invite them to test the sound first with the string/finger/ear technique to hear what it sounds like. Then invite them to begin building and testing their design.
5. As groups design and build, **encourage scientific thinking** by asking them to make predictions, test frequently, and try again:
    - *Which shape do you think will make the sound loudest?*
    - *Which parts of your design worked that time, and which parts didn't?*
    - *What could you change about the parts that didn't work?*
6. After 10–15 minutes, pause for a whole group research check-in. Remind the group that scientists and engineers work together and learn from each other. **Cultivate rich dialogue** by encouraging pairs to share challenges they're having and ask the group for solutions, or share parts of their design that have been successful:
    - *What's a problem you're still trying to solve about your amplifier?*
    - *Has anyone else found a solution to that problem? What could they try?*
    - *What's one part of your design that is working well?*
7. Allow the group to return to designing and building their amplifiers. Encourage them to use ideas from the group discussion to improve their designs.

FOR YOUNGER GROUPS:

- Shorten or skip the planning and drawing step. Young learners may find it easier to work out their ideas with the materials in hand.
- Be ready to assist with some fine motor tasks like cutting tape.
- As students work on their designs, use your prototype model as an example to help them visualize possibilities, for example, by demonstrating different places on the cup where the string could be attached.

Reflect

1. Gather the whole group together. Invite each pair to demonstrate their design for the group.
   - *How did you end up with this design?*
   - *What did you try that didn't work?*
   - *How would you improve it even more if you had more time or different materials?*
2. Discuss the results of the team's research:
   - *What do our designs have in common?*
   - *What conclusions can we draw about how to make a sound louder?*
   - *What should we tell our company about the best way to record this sound for the video game?*
3. Encourage the group to reflect on how they were like sound engineers during the activity. You may want to show the sound engineer career card again, or refer to the science skills stickers in their notebooks:
   - *What are some of the things we did today as sound engineers?*
   - *How did we think like scientists? What science skills did we use?*
   - *What did you do today that made you feel like a scientist?*
4. Allow time for students to draw or write their reflections in their lab notebooks. Invite them to choose a science skills sticker that reflects a skill they used and add it to their notebooks.

Extend

- How do you make a sound softer? Invite students to investigate materials that dampen sound waves instead of amplifying them and design a system to make a loud sound (such as a buzzer) as soft as possible.
- Invent a new instrument: Use found objects and recycled materials to explore how vibration creates sounds. What kinds of objects and actions create sound? How can you make the sounds louder or softer? Can you make the sound higher or lower? Challenge students to create a musical instrument from one of the sounds they discovered.
- Create amplifiers for other sounds. Ask students to adapt or redesign their amplifiers to work for other sound sources. Invite them to find their own soft sound and try to amplify it, or challenge them to design a speaker for a mobile phone so it can play music for the whole room.
- Investigate sounds in your environment. Use a decibel meter app on a mobile device—there are several free apps available for both Android and iOS—to explore and measure the loudness of sounds in your classroom, building, or outdoor area. Make charts or graphs to show the relative loudness of the sounds you discovered.

Background

- **Sound engineers**, also called *audio* or *acoustical* engineers, design systems to solve problems relating to sound waves. Some sound engineers use technology to help produce live concerts, theater shows, or music recording sessions; they might set up microphone systems, balance and mix sounds from different sources, or add sound effects. Other sound engineers research and develop new kinds of sound technology, like microphones and speakers for electronic devices, or they might help design auditoriums and concert halls to control how sound travels to the audience. Sound engineers need to understand the **physics of sound** to know how sound waves travel in different situations and what happens when they interact with each other. Engineers who work with sound technology also need to know how sound energy can change into electrical energy (and back into sound again).

- **Sound is vibration**. A sound happens when something vibrates. Vocal cords in your throat vibrate when you talk or sing; two objects that strike each other, like clapping hands or a drum and drumstick, create a vibration; and instruments like violins and guitars use vibrating strings. The vibrating object causes the air around it to vibrate, creating waves of energy that travel through the air. Our ears detect these waves, and our brains interpret them as sound.
- **Sound energy travels differently through different types of material**. Some materials reflect sound waves, causing them to bounce around, while others absorb, or dampen, sound waves. (Have you ever noticed that a bare, empty room has more echo than one full of carpet and furniture?) Some materials transmit or enhance certain types of sounds better than others, depending on how much energy the sound has.
- The energy of a sound is measured in two different ways: how fast it is vibrating (called the *frequency*), and how big the vibrations are (called the *amplitude*). **The speed of vibration determines how high or low the sound is**. Faster vibrations (high frequency) have more energy and sound higher; slower vibrations (low frequency) have less energy and sound lower. **The size of vibration determines how loud the sound is**. Larger vibrations are louder, and smaller vibrations are softer. In this activity, students explore amplifying a sound—making a sound louder (increasing the amplitude) by designing a system that will create larger vibrations.

Sound Engineer Quick Guide

ACTIVITY SECTION	DO	ASK
Engage	Use career card to discuss career **Introduce story:** • Work for a video game company • Record sound effects for games Demonstrate hanger sound with volunteer Discuss how sound energy travels	*What do you think this person is doing?* *What do you think a sound engineer does or studies?* *What happened when I hit the hanger? What did the rest of you hear?* *What are some different ways to make a sound?* *What is vibrating in our sound? Where is the sound energy traveling?*
Explore	Demonstrate prototype amplifier Design, build, and test amplifier designs Research check-in to share ideas Improve amplifier designs	*What could we change to make the sound louder?* *Which parts of your design worked that time, and which parts didn't?* *What's a problem you're still trying to solve about your amplifier?* *Has anyone else found a solution to that problem? What could they try?*
Reflect	Demonstrate group's amplifiers Report conclusions to video game company Reflect on career connections Use stickers & notebook to draw/write reflections	*How did you end up with this design?* *What do our designs have in common?* *What should we tell our company about the best way to record this sound?* *How were we like sound engineers today?* *What science skills did you use?*