How Science Works

Grade 8

Module 1

Class Question:

How do different materials affect the way sound waves travel?

Scientist (Your Name):_____

Teacher's Name:_____

SciTrek Volunteer's Name:

Day 1: Intro to Mechanical Waves

- To begin, as the SciTrek lead, you will ask the class for examples of different types of waves. They will be most familiar with ocean waves, but some may also say sound waves or microwaves (electromagnetic waves). During this discussion, they will fill out examples of the type of waves they can think of, and different characteristics of waves in their notebooks.
- You will explain to the kids that these are all types of waves, but we will be focusing on mechanical waves today.
- Go over the definition of a mechanical wave—the students will be filling this out in their notebook, and the definition will be presented on a PowerPoint in the classroom:

"A mechanical wave is an oscillation of matter that transfers energy through a medium. The wave can move over long distances, but the oscillating medium never moves far from its initial equilibrium position."

- You can give the example of 'doing the wave' at a sporting event—it's not a true wave but you can relate each person as an atom in the medium, as the wave propagates the people transmit the 'energy' as the stand up and sit back down, but the person never actually moves positions or changes seats.
- Next, you will introduce three types of waves: longitudinal, transverse, and surface waves. There will be a metal slinky in order for you to demonstrate longitudinal and transverse waves. The surface waves will be demonstrated by dropping a coin into a bowl of water.
- After seeing the three types of waves, you will introduce the following vocab words. We already went over transverse and longitudinal, but it is very important to get the kids thinking about waves using terms such as 'amplitude,' and 'frequency.' This vocab will be on a power point for the kids to copy into their notebooks.

<u>Important Vocab to remember:</u>

- Amplitude: The maximum distance from the equilibrium point of a wave (ie how tall it gets).
- Wavelength: The distance between two peaks (crests) of a wave (ie how wide it is)
- Frequency: The number of waves that pass a fixed place in a given amount of time-measured in cycles per second.
- Transverse Waves: particles of the medium travel **perpendicular** to the motion
- Longitudinal Waves: particles of the medium travel **parallel** to the motion of wave propagation

Class Demo: Gummy Bear Bridge

- In front of the classroom is a handmade gummy bear bridge. As the lead, you will hit one side of the wave to demonstrate what mechanical waves are.
- There will be different types of wave propagation displayed. Transverse and longitudinal waves can be created, but not surface waves (you cannot make surface waves because there are no particles undergoing circular motion).
- To create transverse waves, you can move the end stick in a vertical up & down motion. This will create a wave travelling perpendicular to the propagation.
- To create longitudinal waves, give the stick a flick in the horizontal direction—this will lead to waves traveling parallel to the propagation Discuss with the students the type of wave propagates more easily. The transverse wave will be more evident than the longitudinal.

In their notebooks, the students will draw the types of waves they see on the gummy bear bridge.

1) transverse ↑↓	*2) longitudinal* ↔	*3) surface* **N/A**

During this demo, it is important to continue to use the new words such as amplitude, frequency, and wavelength. Get the kids thinking about how the frequency changes with energy input. Also have them notice that there is a higher amplitude seen when creating transverse waves than with longitudinal waves.

<u>More energy input</u>: Waves with **large** amplitudes, **high** frequencies, and **short** wavelengths.
<u>Less energy input</u>: Waves with **small** amplitudes, **low** frequencies, and **long** wavelengths.

Experiment: Battle Ropes (MS-PS4-1)

- Before we begin battle ropes, you will introduce the two types of ropes in the classroom: a thick rope and a thin rope. We will have shorter pieces of the ropes to pass around to the kids so they can make predictions about each rope in their notebook:
    - The thin rope will allow waves to more easily propagate through, and will take less energy to generate waves than the thick rope would.

- Take the kids outside, and before we break into groups, two volunteers will show the difference between “high energy mode” and “low energy mode,” giving the students an example of how it should look when creating the waves.

- Next, breaking into small groups, there will be a SciTrek volunteer holding one side of the rope steady, while students can take turns creating waves and feeling how the two

ropes differ. The SciTrek volunteer will prompt them to try and create transverse, longitudinal and surface waves. The student should come to the conclusion that transverse and longitudinal waves can be created, while surface waves cannot.

- There will then be one student that creates transverse waves for 15 seconds while the SciTrek volunteer counts how many waves are made. This will be done with both the thick and thin rope. The other students in the group will record the number of waves created.

- There will only be one student conducting the waves during the counting portion in order to keep the results consistent. This is why we will have all students play with creating waves using the different ropes before we record how many waves can be created.

- The same process will then be repeated creating longitudinal waves. The student will create waves while the Sci Trek volunteer counts how many are created over 15 seconds.

- Return to the classroom and have the Sci Trek volunteer go over the questions in the student notebook with their group.

The SciTrek volunteer will be going over the following questions with the students. You can walk around and help groups as needed. Below are suggested answers to the questions in the student notebook. Make sure that the answers are not just given to the students, but rather you and the volunteer help the students reach the correct conclusion.

1. It will be harder to create waves using the thick rope. With the thick rope, the students should notice that it takes a higher amount of energy to create the same frequency of waves as with the thin rope. A **higher** frequency will result from a **higher** energy input.

<u>More energy input</u>: Waves with **large** amplitudes, **high** frequencies, and **short** wavelengths.
<u>Less energy input</u>: Waves with **small** amplitudes, **low** frequencies, and **long** wavelengths.

2. Students should notice that they had to work harder (put in more energy) to create more frequent waves. Correlate more energy with greater wave frequency and shorter wavelength. Then correlate less energy with a lower frequency and longer wavelength.

3. Greatest amplitude can be seen when making transverse waves. Connect that back to the gummy bear bridge. The greater amplitude was seen with transverse waves on the gummy bear bridge—the longitudinal waves were much harder to see.

4. The rope that took the MOST energy to make a wave is the thicker rope. Using the thick rope, in order to create the same frequency as when using the thin rope, more energy input is required.

5. The types of waves that students are able to make: longitudinal and transverse; no surface waves. Students cannot make surface waves because there are no particles undergoing circular motion, only made in the ocean! Trick questions for the students.

6. Other waves like this may be seen on guitar strings which create sound waves based on the energy input the guitarist puts in.

Conclusion Discussion:

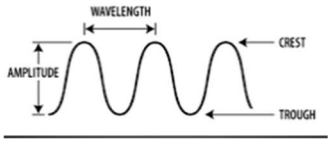
If there is time, after the students answer the questions in their notebooks, you can lead a discussion reaching a conclusion as a class. We want to conclude that it takes more energy to produce shorter wavelengths, which then creates a higher frequency of waves. The opposite can also be true: less energy produces longer wavelengths, but at a lower frequency.

Day 2: Investigating Sound Waves (MS-PS4-2)

- Today as the lead, you will be doing a brief introduction, discussing the fact that sound waves are a type of mechanical wave, and therefore need a medium to travel through. A sound wave is a mechanical vibration that passes through a medium, such as a solid, liquid, or gas, to become a sound. The kids will then complete the first two questions in their notebook.

- The first question asks them to draw the best path from the man to the dog in the picture. The kids should understand that sound waves will not travel through the wall, however they may travel around it as a single large wavelength or reflect off of walls to arrive at the listener.

Assist our friend in calling his dog, draw in a continuous sound



- The next question asks how changing the amplitude and/or wavelength, could make it easier or more difficult to get the sound wave to the pup?
    - If they are having trouble with this, you can help to remind them what amplitude and wavelength are. Help them reach the conclusion that a *large* amplitude and *long* wavelength would allow for one wave to be drawn reaching the listener, and a *shorter* wavelength and *smaller* amplitude would take more waves to reach the listener.

Demo: Bell in a Jar

- To prepare for the next demo, a volunteer will have decibel meter on his or her phone that should be put under the doc camera if possible.
- As the lead, you will be performing the bell in a jar demo. But before you begin, explain that you are going to remove the air from the jar while the 'bell' is inside. The kids need to make a prediction in their notebook as to what will happen.

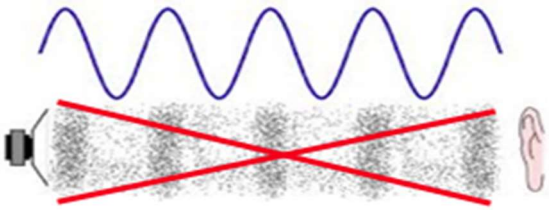
Performing the Demo:

1. Tell the kids they might want to cover their ears because you will be playing the loud sound outside the jar.
2. You will play the sound outside, and look at the number that comes up on the decibel meter.
3. You will then put the 'bell' in the jar and use the pump to remove the air.
4. Observe the number on the decibel meter.
5. Finally, slowly release the chamber and observe the decibel meter increasing as the air is let back in.

- The main point to get across with this demo is that **sound needs a medium to travel through**. If all of the air could be sucked out, the bell would be quieted entirely because there would be absolutely no medium for the sound to propagate through.

- As a class, prompt the students to record in their notebook whether their prediction was correct or not. There is another question asking them to use the picture below to demonstrate what happened to the sound. You can help them reach the conclusion that without air, there is no medium for the sound to travel through. The students can draw an X through the sound waves to demonstrate that they were unable to propagate through a medium and create sound.

- You can then discuss an astronaut in space, and ask the students if they think that he would be able to communicate with his teammate inside the spaceship using regular sound waves. The answer that they should reach is no, regular sound waves would not reach our astronaut; however radio waves (electromagnetic) used for communication will!



String and Spoon Experiment:

- The students will then break into their small groups, and the volunteers will help them with the string and spoon experiment.

- As the lead, you can walk around the room and help groups as needed.

- Each group should have a spoon with two strings tied to it (one on each end). The students will then take turns experimenting with the apparatus. They will do this by wrapping the strings three or so times around each index finger, and striking it GENTLY on a metal surface (such as the frame on a chair). They will make observations about the sound of the spoon. They will then execute the experiment again, but this time they will plug their ears to listen to the sound.

- As a group, the students can work together to answer the questions in their notebook. Again, you can float around and help the groups as needed.

IN STUDENT NOTEBOOK:

1. How does this sound? High or low pitch? Loud or quiet? Can you relate this sound to something familiar to you?

Sound is like a loud drum, gong, muffled explosion, etc.

2. How did the sound change (pitch, sound level, etc.)?

Sound was louder, more intense when plugging ears.

3. *What are some predictions as to why the sound is different (Hint: think about the bell in a jar demo, and what is different about the path the sound is travelling)?*

Holding the string directly to your ear eliminates the medium (air) that the spoon's sound had to travel through before, you can still hear the sound thanks to the string now acting as the medium to the listener.

4. When the spoon comes in contact with the metal surface, what happens at the collision? Do you notice any physical change to the hanger or surface? (HINT: Use your 5 senses)

Vibration is created when the coat hanger collides with the surface. This vibration is energy in a form of tiny waves that is transferred through the coat hanger to the string to the hand and into the ear, creating a sound. There is no physical change to the hanger or surface.

5. What do you think will happen if the spoon hits a non-metal surface will it make the same sounds? Let's try it. How does it sound?

The sounds are different when hitting a non-metal surface. The non-metal surface (i.e. the wooden desk) makes a muffled "tinging" sound or bell. The energy transfer as described above is the same except the amount of energy transferred through the medium. The non-metal surface disrupts the transfer of energy thereby alternating the sound.

6. Let's say we create a semi-sealed environment by only blocking one ear and leaving the other open. When you hit the spoon against the metal, does it make the same sounds? Why do you think it is different than a sealed environment?

The sounds are different when hitting a non-metal surface. The non-metal surface (i.e. the wooden desk) makes a muffled "tinging" sound or bell. The energy transfer as described above is the same except the amount of energy transferred through the medium. The non-metal surface disrupts the transfer of energy thereby alternating the sound.

7. Draw a diagram describing how the waves move from the collision of the spoon and the surface to your ear drum.

Picture should have energy wave from spoon + surface → string → finger → ear

8. What type of wave is transferring the energy through the string to the ear?

Longitudinal waves. They are always characterized by particle motion being parallel to wave motion.

Day 3: Stations

Student Volunteer Directions: At Orientation, you will be tasked with having to be in charge of one or two different stations during this day. Make sure that you know the small lecture information that you will be giving to your group of students. These are the following directions for each of the different stations and how to set them up! ***It is important that you download the following frequency generating apps to perform some of these demonstrations! For apple it is called Sonic v and for android it is called frequency generator.***

Station 1: Soundproofing Materials

Set-Up: In front of you all is a small box with two ends. One end has an echo resistance soundproof foam on the inside and the other contains a location to place a phone emitting a certain frequency. Within the soundproof panel side there will be a ***decibel meter****.*

Student Volunteer Directions: ***(Lecture)*** *Read the information from the sheet provided and then have them answer the questions that they have that pertain to the demo. (If you don't know what questions pertain to the lecture than have the kids answer as many questions possible before starting the demo). Do not start the demo until all students have completed these questions.* ***(Demo)*** *Close the flap end at the top of the box and then have one of the students place a material in front of the decibel meter so it creates an almost air tight seal around the decibel meter. Select the frequency 400 Hz on your phone app. Record the number seen on the decibel meter by hitting the pause button.*

Station 2: Cup Demo

Set-Up: This demo will demonstrate what happens when a sound wave is directed in a certain location. In front of you there will be a small cup and a decibel meter. Make sure the kids do not touch the decibel meter until instructed to do so.

Student Volunteer Directions: ***(Lecture)*** *Read the information from the sheet provided and then have them answer the questions that they have that pertain to the demo. (If you don't know questions pertain to the lecture than have the kids answer as many questions possible before starting the demo). Do not start the demo until all the students have completed these questions.* ***(Demo)*** *Place the phone inside of the cup and set the frequency on the phone to around 400 Hz. Hold the decibel meter in front of the cup and measure the noise. Ask the students to make observations of what they hear before and after the phone is placed into the cup. Have the students then stand in front of the open side of the cup and stand behind the open end of the cup. Ask them questions about their observations and try to get them to explain why they think this is happening.*

Station 3: Cup and String Demo

Set-Up: This demo will demonstrate what a physical wave looks like when a frequency is placed inside one of two cups connected by a string. Make sure the kids do not touch the demo until instructed to do so.

Student Volunteer Directions: ***(Lecture)*** *Read the information from the sheet provided and then have them answer the questions that they have that pertain to the demo. (If you don't know questions pertain to the lecture than have the kids answer as many questions possible before starting the demo). Do not start the demo until all the students have completed these questions.* ***(Demo)*** *In this experiment there will be two solo cups connected by fishing line. The object of the experiment is for the students to figure out which frequency is transmitted best by the cups. The optimal frequency will be between 500 and 650Hz. This will not be the loudest frequency heard in open air, however. A good idea would be to demonstrate the loudest frequency in open air (outside the cups) and show the students. This frequency will be around 3000Hz. To produce these frequencies, you will need to download the "Sonic" app from the app store and use your phone speaker. When the students are attempting to find the loudest frequency, make sure the phone speaker is inside the cup, and that the fishing line is taught. (not too tight though, it is breakable) The line must be taught so that the sound waves vibrate well along the fishing line.*

Station 4: Underwater Speaker

Set-Up: This experiment will be a bit complicated. The students will have in front of them a glass container filled with water. Students will be making observations as you place an underwater speaker inside of the water and adjust the frequency within the water.

Student Volunteer Directions: ***(Lecture)*** *Read the information from the sheet provided and then have them answer the questions that they have that pertain to the demo. (If you don't know questions pertain to the lecture than have the kids answer as many questions possible before starting the demo). Do not start the demo until all the students have completed these questions.* ***(Demo)*** *Connect your device to the blue tooth speaker and do a test before placing it in the water. Be sure to test to see if the device is connected to the speaker by playing a low frequency on the phone (around 200 Hz) Place the speaker in the water and ask for some suggestions of what the frequency should be adjusted to. Whenever you make a change to the frequency, ask the students to look and make some observations of what they see above the water.*

Station 5: Lasers in a Box

Set up: This demo is also a little difficult. The students need to be on their best behavior for this demonstration. ***Make sure that the students never flash the lasers in anyone's eyes! They do run a huge risk of causing permanent damage!*** *In front of the students is a glass container containing water and c a couple of lasers.*

Student Volunteer Directions: ***(Lecture)*** *Read the information from the sheet provided and then have them answer the questions that they have that pertain to the demo. (If you don't know questions pertain to the lecture than have the kids answer as many questions possible before starting the demo). Do not start the demo until all the students have completed these questions.* ***(Demo)*** *Place a laser on the outside of the box and try to angle it to produce some reflections on the side of the glass. Explain to the students that sound travels in an infinite number of waves and what the laser is showing is one of those ways that sound travels. Have the kids play around with the lasers and have them draw whatever reflections they made.*

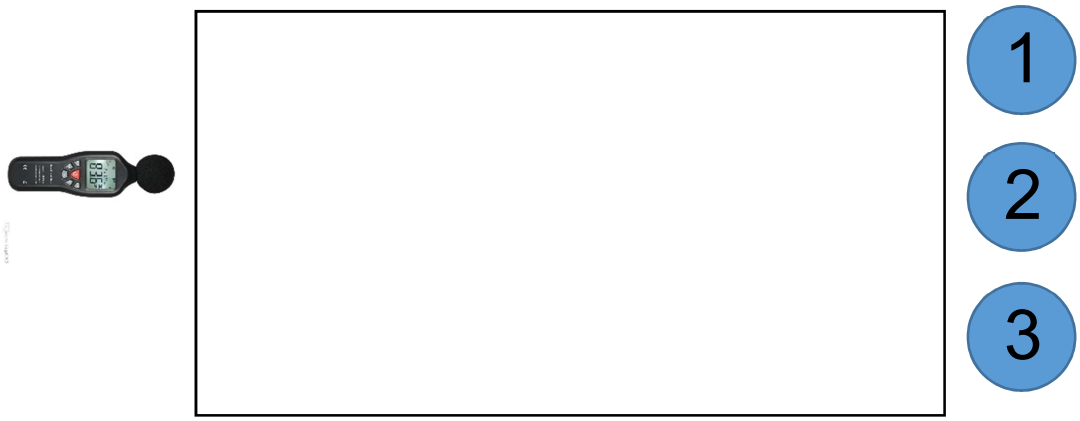
Day 4: The Final Experiment + Control

Directions for the Student Volunteer: In front of each group will be a box containing all the necessary materials. Students will take these materials outside of the box and place them to the side of it. Each box is surrounded with echo absorbent foam to nullify sound from entering the inside of the box. The students will refer back to their big question and ***conduct a control*** *experiment without using any barriers. Each student will have multiple graphs looking like this.*

The speaker used in this experiment will be none other than your phones. Make sure to use the frequency generator app and not any other source of sound.

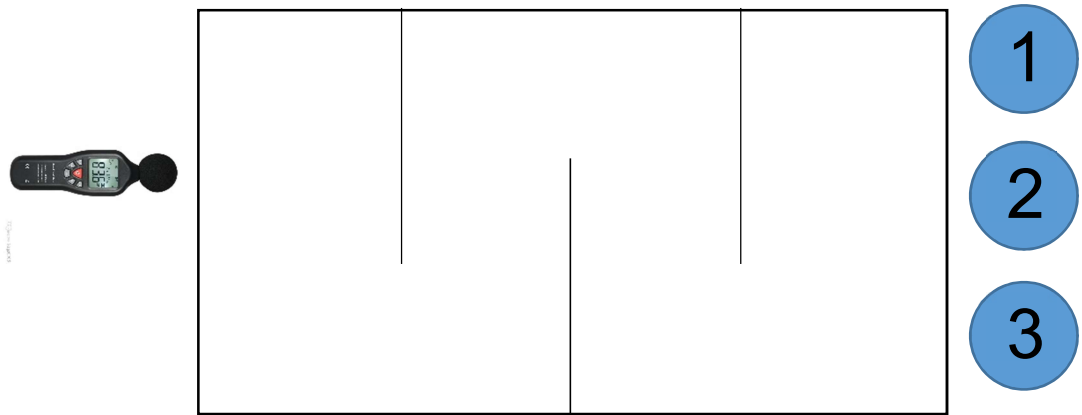
Control Experiment:

Material Used	Frequency Used	Orientation of Pieces	Location of Speaker	Volume Recorded
Black Foam	300 Hz	*(No Walls)*	2	



The students will perform the control experiment and test one variable (preferably the <u>*material*</u> *variable or the* <u>*orientation*</u> *variable because they are set to do four trials of this one variable). They will write a short summary of their results. They should have a good idea of what needs to be done and how to prepare for the next day. They will have multiple variables to test during this day. A good place for them to start is to test the orientation of the walls or the material used for the walls*

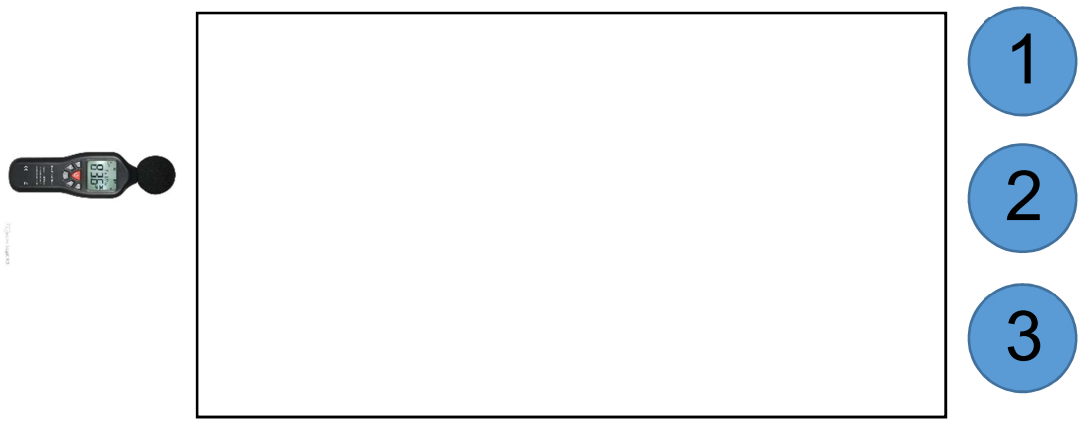
Big Note: Make sure that when the students are testing for materials or anything that requires them to use walls, make sure that they use this outline inside of the box with the thin white or black foam!!!



Day 5: The Final Experiment + Optimization

Directions for the Student Volunteer: Today students should finish up testing all of their variables. After finishing all of their tests, each group will perform an optimization test where they will be utilizing the best features of each variable they tested to see how much sound reduction can take place. Again, they will have multiple tables to run multiple trials.

Material Used	Frequency Used	Orientation of Pieces	Location of Speaker	Volume Recorded
	300 Hz		2	



*After testing their optimization experiment **twice**, they will record their results. At the end they will clean up all of their materials and then write a short summary accounting all of the things they learned, their "findings," and what conclusions they can come to after performing all of the experiments.*