SciTREK

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.

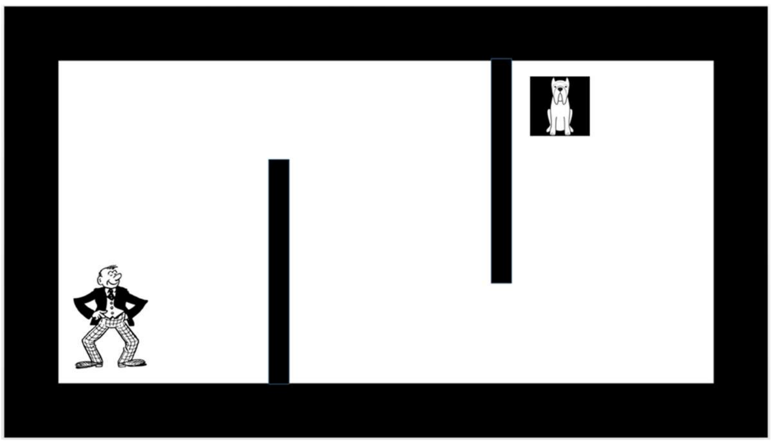
Conclusion Discussion:

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.

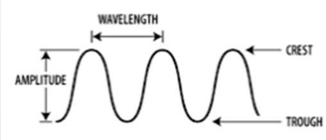
Day 2: Investigating Sound Waves (MS-PS4-2)

- 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.

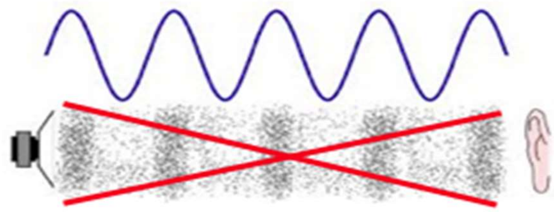
Performing the Demo:

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 Station Demos/Experiments

Directions for the teacher:
The volunteers will each spread out to each of their stations. The groups will usually be sitting at their stations but if not, move each group to a numbered station. The volunteer will give a short lecture on the topic being presented and will continue with the demo. Students will have questions to answer about the lecture given and the demo performed. Each of the student volunteers will have a set of directions laid out for them. Each of the demos should last around 7-10 minutes

Station 1: Soundproofing

Lead:__________________________________

In front of you is a box that contains two different sections. One section acts as a soundproof room with a **decibel meter** on the inside. You will be given a small lecture by your station lead and at the same time, you will be answering questions based on the lecture.

1. What is a **decibel meter**?

   A decibel meter is a device used to measure the intensity of sound

2. What makes a certain surface better at soundproofing an area?

   Thickness, a rough surface, soft but dense materials.

3. What do you think the box in front of you is for?

   Testing the soundproof capabilities of different materials.

The purpose of this demo is to test to see what surfaces act best for blocking out sound or soundproofing an area. In front of you are different materials that you and your SciTrek lead will test to see what material acts best for soundproofing an area.

	Frequency	Decibel meter reading
No Foam (Control)	400 Hz	
White Foam	400 Hz	
Wood	400 Hz	
Black Foam	400 Hz	
Green Foam	400 Hz	
Foam with lots of holes	400 Hz	

After you record your data, write a two to three sentence paragraph that summarizes your findings. Make sure to include what acted as the best and what acted as the worst material for soundproofing an area.

Station 2: Amplified Confined Sound

Lead:____.

1. Draw what you see below. What do you think is going to happen when the phone is inside the cup?

   The sound is going to be amplified. This results of different waves bouncing off the cup and directed back towards the outside of the cup, producing a much louder noise than without the cup.

2. What do you think is going to happen when the decibel meter is in front of the cup? When it is away from the opening of the cup?

   The decibel meter will measure a higher decibel in front of the cup while measuring a smaller decibel while behind the cup.

3. Go back to your drawing of the cup. Try to draw a cross-section of the cup and show how the waves amplify sound in front of the cup

   The students should draw something of a cylinder cut in half and all of the waves should cumulate towards the outside of the cup.

Station 3: Frequency and Water Vibrations

Lead:____.

1. What causes the water to move?

   The sound wave is traveling through the water.

2. How do lower/higher frequencies affect the surface of the water?

   Lower frequencies will have much more influence on the surface of the water

3. When you feel a vibration in your chest while close to a loud speaker, do you think the sound is at a high frequency or low frequency?

   Low frequencies are more noticeable.

Station 4: Cups on a String

Lead:____.

1. Which frequency travels best from cup to cup?

Around 500 to 600 Hz.

2. Does the sound travel better when the fishing line is loose or taught?

When the fishing line is taught.

Station 5: Lasers in a Tank

Lead:____.

1. Unlike sound, does light need a medium to travel through?

No, unlike sound, light does not need a medium to travel through. That is because it is a electromagnetic wave.

2. Play around with the lasers and the water inside the glass container (DO NOT POINT IN ANYONE'S EYE) and see how many possible reflections you yourself were able to get. Write this number down below.

The kids will surprise us with how much they will be able to deflect the light

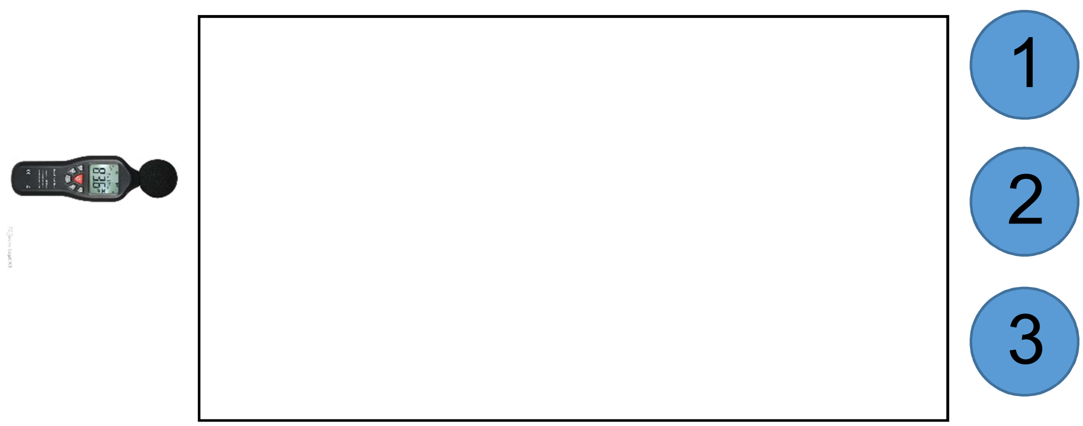
3. Below you is a box for you to draw how many reflections you can get as the laser travels from one end of the box to the other.

Day 4: The Final Experiment + Control

Directions for the teacher: In front of each group will be a box containing all of necessary materials. Students will take these materials outside of the box and place them to the side of it. Each box is encased/surrounded/covered by 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 the one below.*

Control Experiment:

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

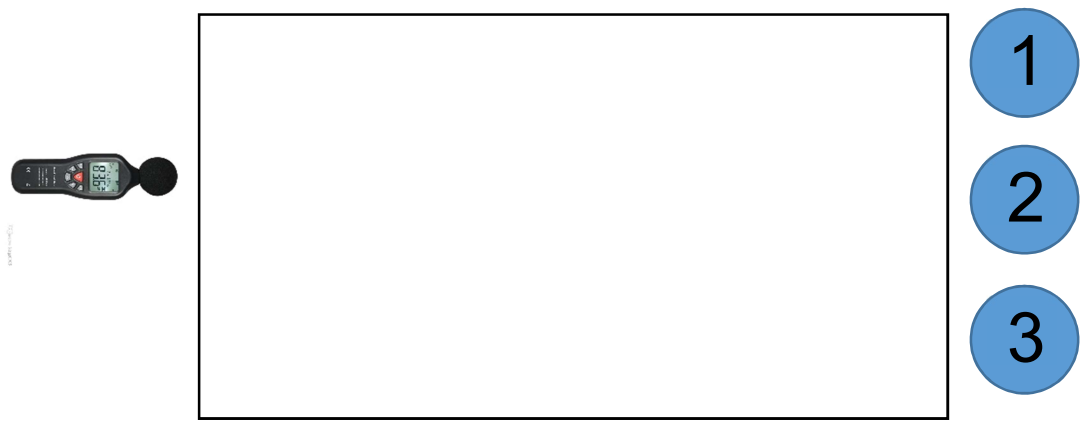


The students will perform the control experiment and test one variable (preferably the material variable or the orientation variable because they are set to do four trials of this one variable). They will write a short summary of their results (conclusion). They should have a good idea of what needs to be done and how to prepare for the next day.

Day 5: The Final Experiment + Optimization

Directions for the teacher: Today the 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 utilize 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 to look like this…

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 then proceed to write a short summary accounting for all of the things they learned, their "findings," and what conclusions they can come to after performing all of the experiments.*