Volunteer Handbook

Waves

Grade 8

Class Question:

How can we affect sound as it travels from one end of a space to another?

Scientist (Your Name):____

Teacher's Name:____

SciTrek Volunteer's Name:_____________________________________

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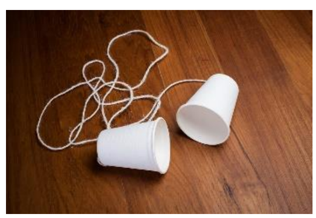
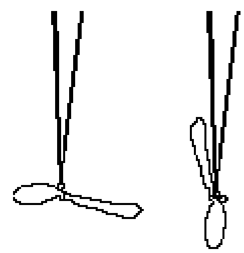


Cups on String



Spoon and String

Day 1 Intro to Mechanical Waves

- To begin, the SciTrek lead will ask the class for examples of different types of waves. The students will be most familiar with ocean wave, 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.
- The lead 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. The lead 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

- Before we begin battle ropes the lead 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 SciTrek 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.

You 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.

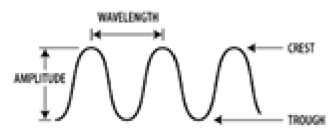
2. Students should notice that they had to work harder (put in more energy) to create more frequent waves. Correlate more energy with greater wave frequency and shorter wavelength. Then correlate less energy with a lower frequency and longer wavelength.
3. Greatest amplitude can be seen when making transverse 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.

Day 2 Investigating Sound Waves

- Today the lead 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 wave so that it travels to the pup.



- 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

- The lead will be performing this demo in front of the entire classroom, so it is important as the volunteer that you make sure the students are paying attention to the lead.
- 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

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

- 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.

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 the 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 eardrum.

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)*** *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.*

In the Student Packet

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.

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	*~75.0*
White Foam	400 Hz	*~71.0*
Wood	400 Hz	*~66.0*
Black Foam	400 Hz	*~71.0*
Green Foam	400 Hz	*~72.0*
Foam with lots of holes	400 Hz	*~67.0*

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: Mediums

In front of you, there are 3 baggies filled with different materials. Your lead is going to hold the frequency device and or play a song on one side, and one of you is going to stand on the other side of the balloon with your ear up against it. Answer the following questions based on your observations. *Read the lecture for the students as well as have directions ready for what the students are supposed to do!*

1. What frequency was easier to hear through all the materials?

It was easiest to hear higher frequencies through all the mediums. Over small distances, higher frequency waves will travel faster than lower frequency waves!

2. Was there a difference between hearing the frequency and the song picked? Describe the differences.

When you changed the medium to the sound or frequency, it made a significant change to how the sound was observed on the other side! The sand bag sounded very muffled while the air bag sounded like the sound was amplified.

3. Which material was the easiest to hear through? Which one was the most difficult? Why?

It was easiest to hear through the bag that contained the air. Most of the sound was able to travel through the medium without much resistance! The sand bag was the most difficult to hear through!

4. Fill out the table using the decibel meter with the frequency emitter **at 440 Hz**

	Frequency	Decibel Meter Reading
Air (Control)	440 Hz	*Highest Reading*
Water	440 Hz	*Middle Reading*
Sand	440 Hz	*Lowest Reading*

Station 3: 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.*

In the Student Packet

1. What causes the water to move?

The frequency of the sound waves causes the water to vibrate!

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

Lower frequencies will cause more disturbance, while higher frequencies will cause little disturbance to the surface of the water!

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

Low frequency! Lower frequencies have large enough wavelengths to disturb the surface of the water.

4. What is the range of frequencies that you see affecting the surface of the water on the speaker?

Around 70~120, depends on the volume of the speakers and the volunteers phone!

Fully submerge the water speaker in the plastic tub.

5. When you play the speaker underwater, then take it out what do you observe in the change in its sound?

Lower end of the spectrum ~50. Higher end of the spectrum ~1600. At these levels the students should be able to hear noise when it is above the water, but when it is submerged, they should not be able to hear anything!

6. How much of a difference in volume is there when removing the speaker from the tub at a high frequency vs removing it from the tub at a low frequency?

At both ends of the spectrum, the waves frequency will eventually cut out. However, at the lower end of the spectrum, the students will observe that the lower frequencies will cause the water and tub to vibrate while the high frequencies will not.

Station 4: Cup and String Demo

Set-Up: So, 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.*

In the Student Packet

1. What causes the water to move?
   The sound wave is traveling through the water.

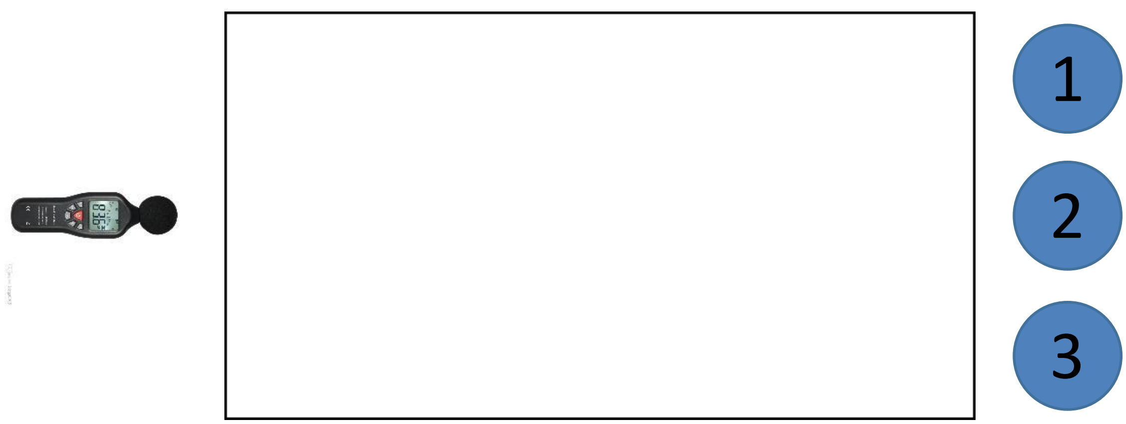
2. How do lower/higher frequencies affect the surface of the water?
   Lower frequencies will have much more influence on the surface of the water

Day 4 The Final Experiment + Control

Directions for the Student Volunteer: In front of each of the groups will be a box containing a bunch of materials. The students will take these materials outside of the box and place them to the side of it. Each box contains 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:

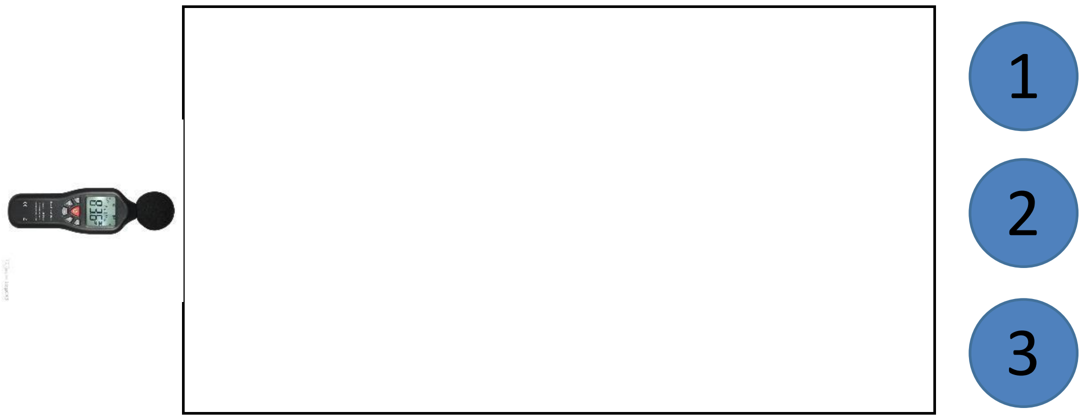
Material Used	Frequency Used	Orientation of Pieces	Location of Speaker	Volume Recorded
	300 Hz	*(No Walls)*	2	



Choosing your first variable: ____.

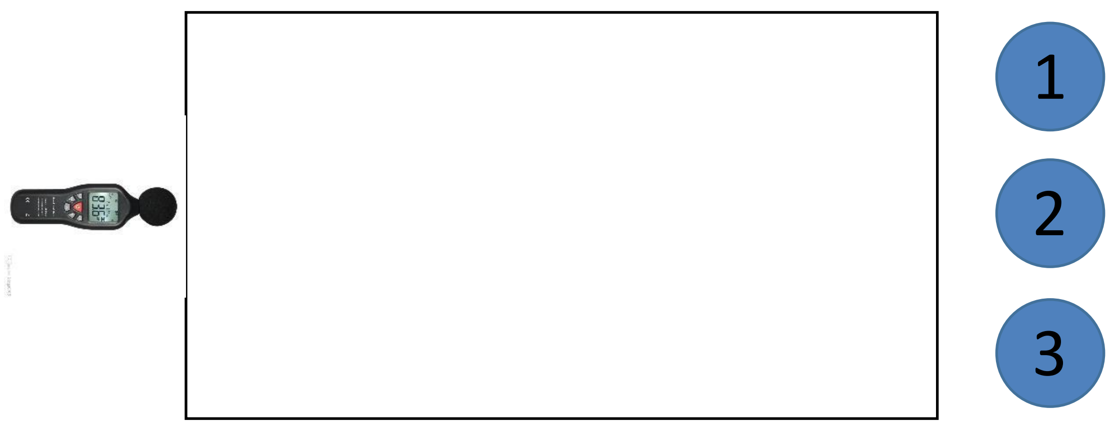
Test #1

Material Used	Frequency Used	Orientation of Pieces	Location of Speaker	Volume Recorded
	300 Hz	*(Draw Below)*		



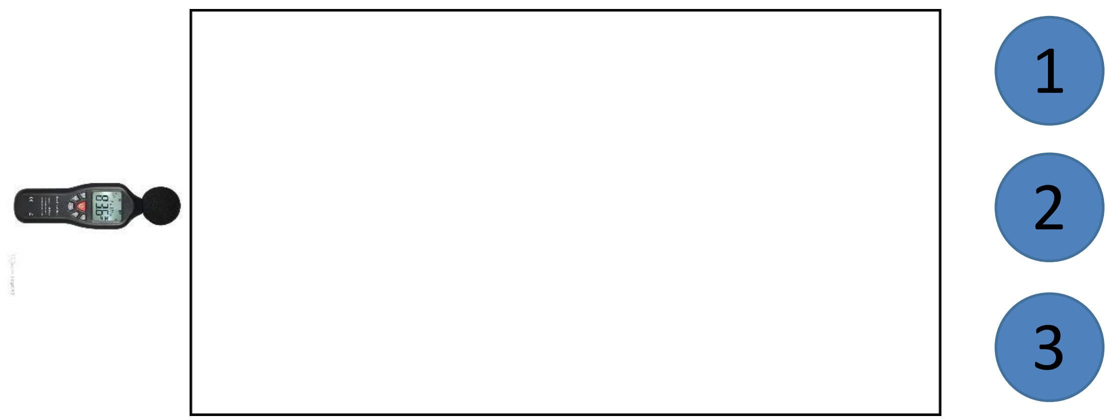
Test #2

Material Used	Frequency Used	Orientation of Pieces	Location of Speaker	Volume Recorded
	300 Hz	*(Draw Below)*		



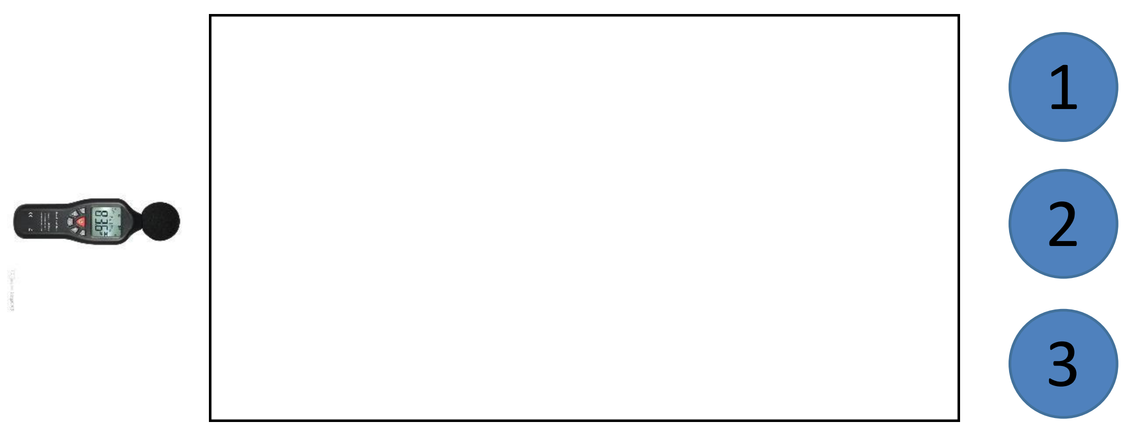
Test #3

Material Used	Frequency Used	Orientation of Pieces	Location of Speaker	Volume Recorded
	300 Hz	*(Draw Below)*		



Test #4

Material Used	Frequency Used	Orientation of Pieces	Location of Speaker	Volume Recorded
	300 Hz	*(Draw Below)*		



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 paragraph conclusion of their results. They should have a good idea of what needs to be done and how to get going 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 of the inside of the box with the thin white or black foam!!!

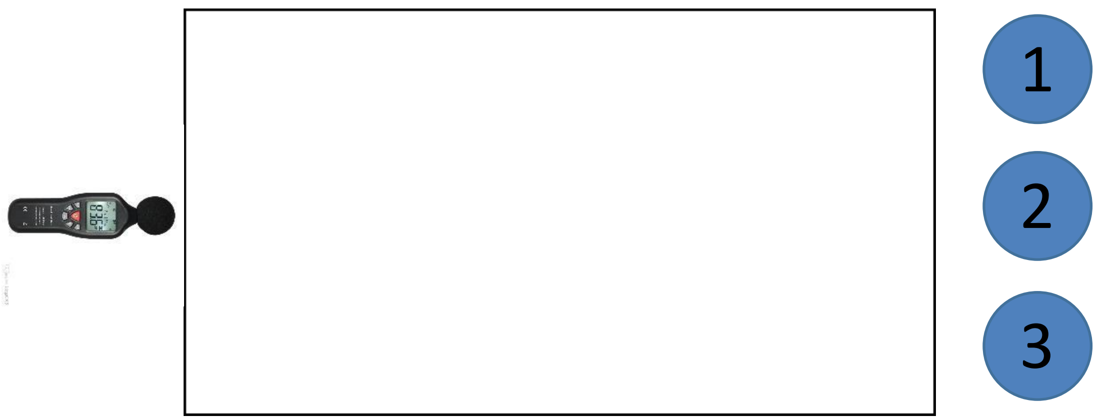
Day 5 The Final Experiment + Optimization

Directions for the teacher: This is the final day where the students should finish up testing all their variables. After finishing all of their tests, each group will have 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 to look like this…

Choosing your second variable:

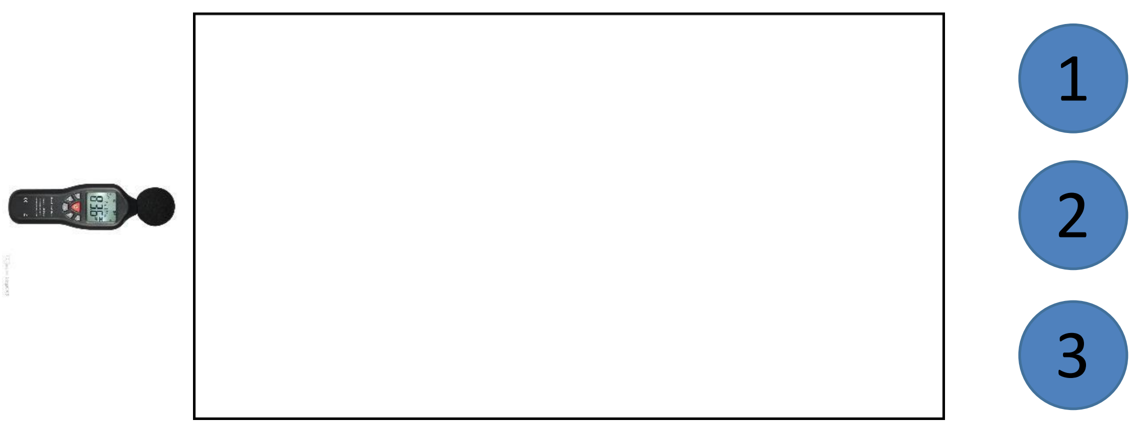
Test #3

Material Used	Frequency Used	Orientation of Pieces	Location of Speaker	Volume Recorded
	300 Hz	*(Draw Below)*		



Test #4

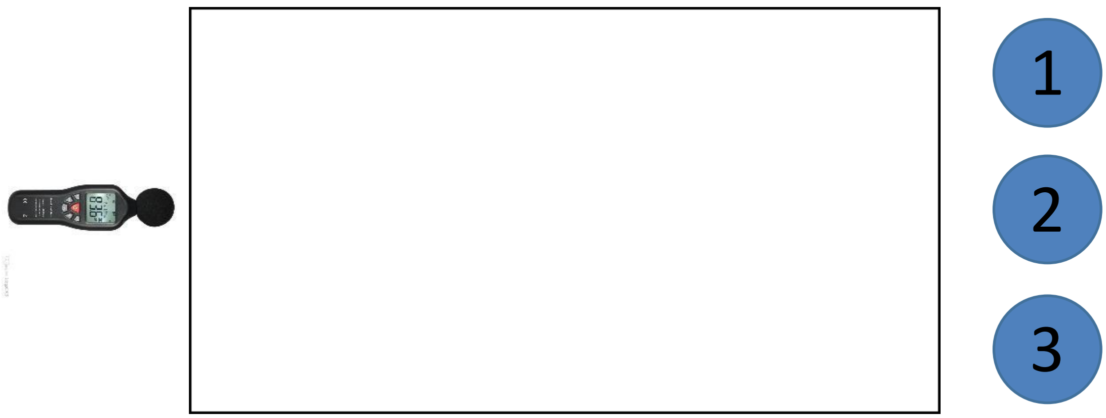
Material Used	Frequency Used	Orientation of Pieces	Location of Speaker	Volume Recorded
	300 Hz	*(Draw Below)*		



Choosing your third variable: ____.

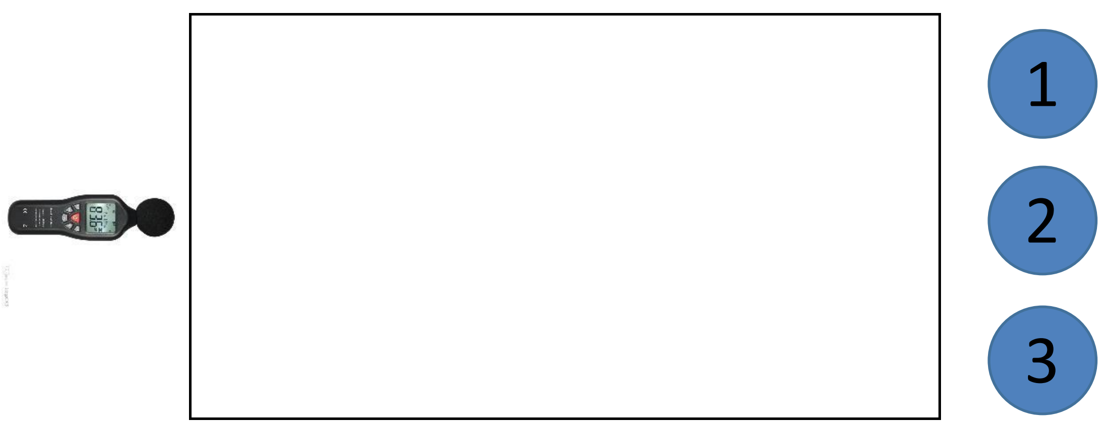
Test #5

Material Used	Frequency Used	Orientation of Pieces	Location of Speaker	Volume Recorded
	300 Hz	*(Draw Below)*		



Test #6

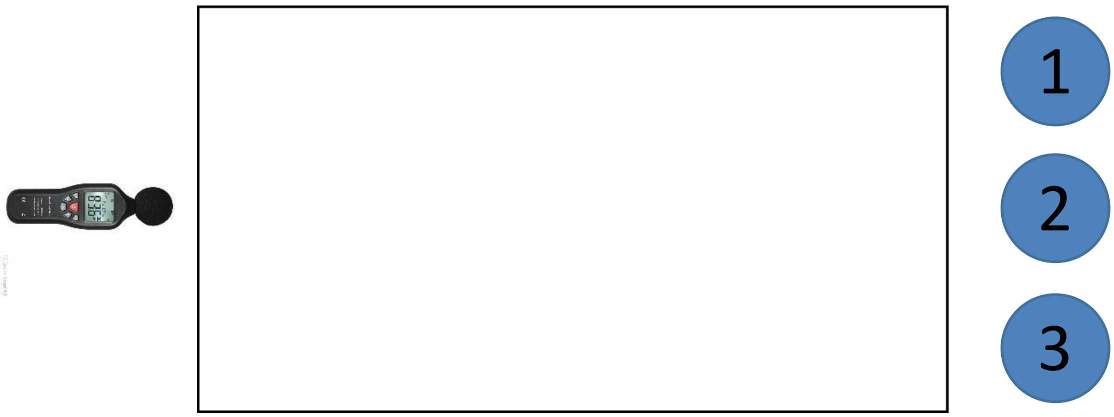
Material Used	Frequency Used	Orientation of Pieces	Location of Speaker	Volume Recorded
	300 Hz	*(Draw Below)*		



Final Test #1

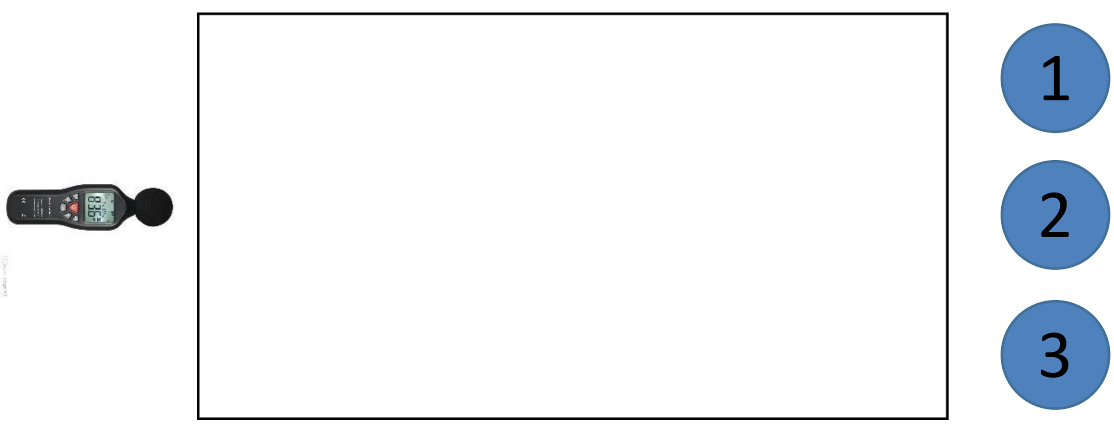
This is it. The final test where you take the best of all the variables you tested and put them all together in one final experiment. Refer to the previous experiments performed today and the ones performed two days ago if you are not sure what variables to use!

Material Used	Frequency Used	Orientation of Pieces	Location of Speaker	Volume Recorded
	300 Hz	*(Draw Below)*		



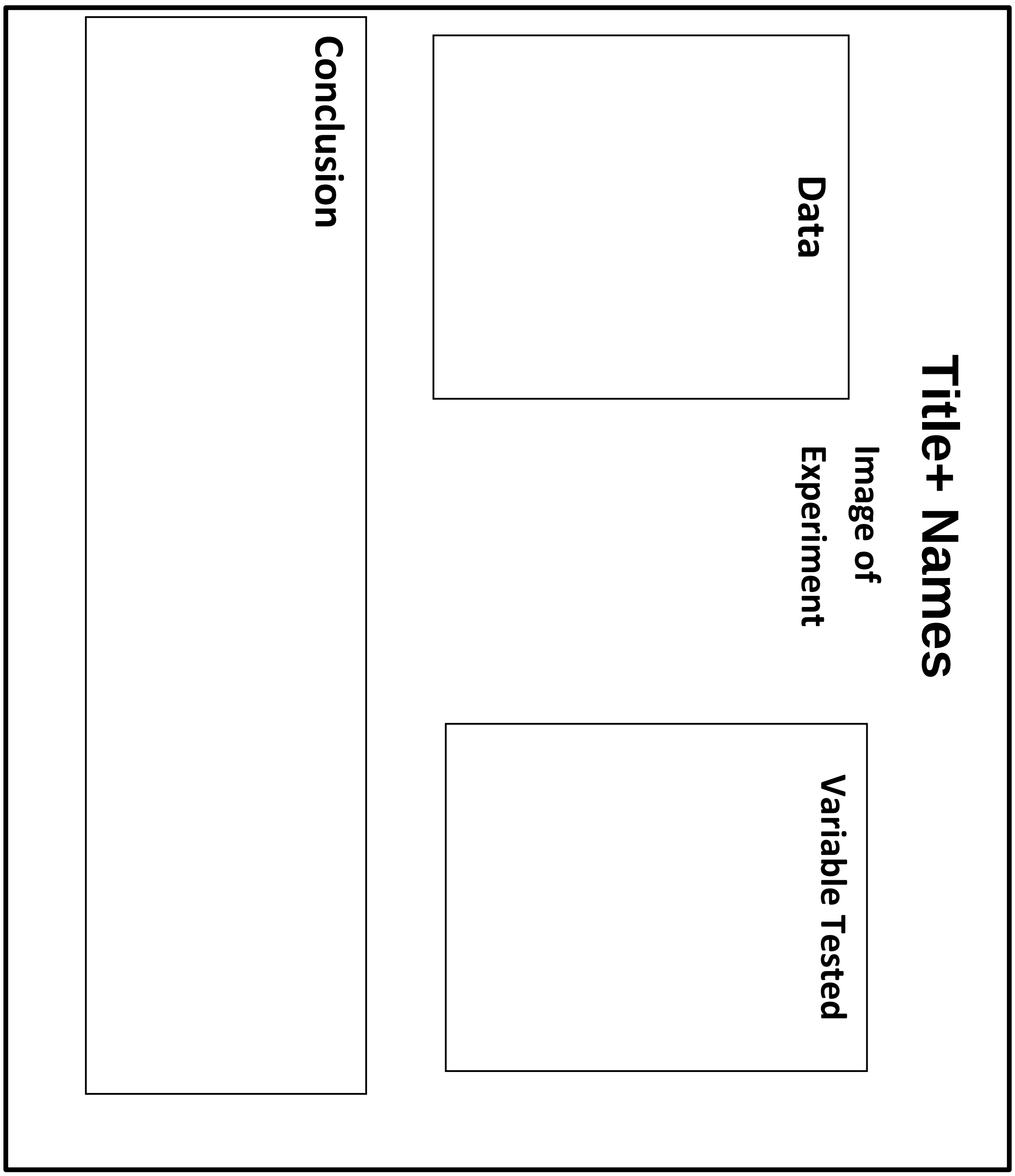
Final Test #2

Material Used	Frequency Used	Orientation of Pieces	Location of Speaker	Volume Recorded
	300 Hz	*(Draw Below)*		



Day 6 Poster Presentations

Today the students will break up into the same groups they had for the final experiment and they will begin to work on their poster presentations. Each poster should have all of the data that they collected and the results of their hard work. If there is still time at the end of the day, the students will present their posters with their volunteers. Below is a template for how the students could set up their poster!



Glossary

Mechanical Wave: Any wave that requires a medium to travel through. Mechanical waves have the following important properties: Amplitude, frequency, wavelength.

Longitudinal Wave: A type of mechanical wave that travels in the up and down motion. This type of wave is most commonly seen in all sound waves!

Transverse Wave: A type of mechanical wave that travels in a back and forth horizontal motion!

Surface Waves: This is a type of mechanical wave that travels in a rolling motion. It is extraordinarily hard to find this type of wave in nature, mostly all cases being found in waves created by the ocean.

Amplitude: This is the height of the wave. A larger amplitude usually causes more energy to create.

Wavelength: This is the length of the wave. The wavelength is described as the length of one repeating unit of a wave!

Frequency: This is the amount of wavelengths that travel past a certain distance in a given amount of time. Higher frequencies require higher amounts of energy but small wavelengths while lower frequencies require little energy and have longer wavelengths.

Medium: Any matter that a sound wave can propagate through. In the presence of no medium, mechanical waves cannot exist.

Hertz: Another word for frequency! Represented by the two letters **Hz**

Decibel Meter: A tool used by scientists to measure the frequency of any sound wave!