Unit 2

Sound Waves:

How can a sound make something move?

Student Work Pages

GRADE 8 Core Knowledge Science®

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Sound Waves

How can a sound make something move?

Table of Contents

Science Literacy Exercise Pages

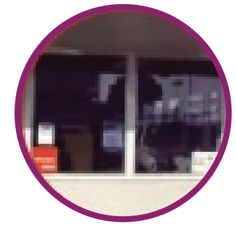
Name: ______________________ Date: ______________________

Initial model: Draw and label a model that will help you explain your thoughts about this question: *How does the sound coming from one thing (like the speaker) make another thing far away (like the window) move?* For each location on your model, show a zoomed-in view of what is happening. Then, explain your model in words below.

Zoom in on what is happening at the spot where the sound is coming from.

Zoom in on what is happening in the space between the truck and the building window.

Zoom in on what is happening at the window to make the window move.



Name: ______________________ Date: ________________

How do instruments move when making sounds (vibrating)?

Name: ____________________ Date: ____________________

Progress Tracker

Question	Source of evidence

What we figured out (in words/pictures)

Progress Tracker

Question	Source of evidence

What we figured out (in words/pictures)

Name: ______________________ Date: ______________________

How do insects make sounds?

We live in a noisy world. One of the noisiest inhabitants on Earth are insects. No matter where you go, you can't escape them. It is estimated that 75% of the over 8 million different species of life on Earth are insects. No wonder it's impossible to escape their constant, noisy chatter.

But how do insects make sounds? As you read, think about what is similar between how sound is produced in all these insects and what you have figured out in your investigations in class about how instruments produce sound.

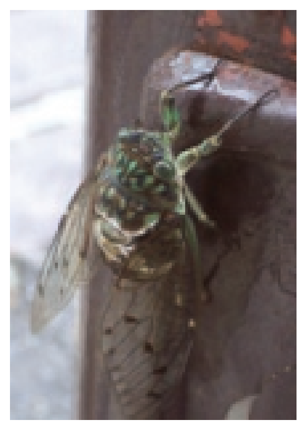
Crickets. Among the noisiest of insects are crickets. Only the male crickets make sounds, and surprisingly, not all species of crickets produce sound. Crickets make sounds for many reasons, but one of the main reasons is for male crickets to attract female mates.

When a male cricket wants to attract a mate, he lifts up his wings and rubs them together. Each wing has "teeth," much like a comb does. The chirping sound is created by running the top of one wing along the teeth at the bottom of the other wing. When the cricket does this, the teeth strike each other, and thin portions of the wing deform, change shape, and vibrate to make the sound.

http://www.birdphotos.com

Grasshoppers. Grasshoppers are another group of insects that use sound in their everyday life. One way they make sounds is by rubbing one of their hind legs, which has rows of pegs on the inside, against the stiff outer edge of their wing. These sounds are produced in order to find a mate and protect their territory. Grasshoppers can also make loud snapping or cracking sounds with their wings as they fly. They "pop" their wings by causing the membranes between the veins to stiffen, leading them to change shape and vibrate. This is another way to get attention when they are trying to court another grasshopper for mating.

Cicadas. Another noisy insect is the cicada. Cicadas make the loudest mating song of any insect or animal. Some species can produce songs as loud as the sound from a car's speakers at maximum volume.



The male cicada makes sounds by changing the shape of two membranes in his ribs called tymbals. By contracting a muscle, the cicada bends the membrane inward, producing a loud click. As the membrane snaps back, it clicks again. This produces vibrations that move through his abdomen to make the sound louder. Cicadas also make sounds to attract mates and protect territories.

Questions

Q1: What are some similarities in the way these insects produce sounds and the way instruments produce sounds?

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Q2: Think about the sound that a bee, mosquito, or fly makes as it flies near your ear. Each produces a buzzing sound as they fly. Then, go to the links provided and analyze one of the slow motion videos below of one insect flying to figure out what might be producing these sounds as they are doing this. Both videos are posted on youtube. The web addresses listed here are shortcuts to the original videos:

- Mosquitos: https://youtu.be/4lVymwokIpA
- Bees: https://youtu.be/LXmsFQV6q5s

After watching the videos, draw and annotate a "comic strip" view that shows the way that the wings are moving and changing shape over time. If you don't have access to the videos, then create a comic strip that is a prediction of what you think you would see.

Q3: How does the way the wings of these insects make sounds compare to the way that instruments make sounds?

Name: ______________________ Date: ______________

How do objects move when they make sounds?

Part 1. What are possible outcomes of our investigation, and what do they mean?	
When we ____________________, we might observe ________________.	That would make us think _____________.

Part 2. What did you observe?	
Sound source	**Observations**

Part 3. Make a claim from evidence, day 1: How do solid objects move when making sounds?	
Claim:	
Evidence to support your claim	**Reasoning:** Why does this evidence support your claim?
Drum	
Rock	

Part 4. Make a claim from evidence, day 2: How does changing the force affect the sound?	
Claim:	
Evidence to support your claim	**Reasoning:** Why does this evidence support your claim?
Speaker	A bigger force on an object causes the object to ______________.
Drum, Rock	When that happens more ______________ is being transferred. This means that louder sounds ______________.

Name: ______________________ Date: ______________

Where else are lasers used to detect vibrations?

Directions: Read the following two articles to explore how scientists are using lasers to detect vibrations, then answer the questions to help you connect their work to ours.

Reading 1: Engineers measure Big Ben's bong
February 28, 2017
Used with permission from University of Leicester

A team from our Department of Engineering has, for the first time ever, vibration-mapped the famous London bell Big Ben in order to reveal why it produces its distinct harmonious tone.

The group, from the Advanced Structural Dynamics Evaluation Centre (ASDEC), measured four of Big Ben's chimes, taking place at 9AM, 10AM, 11AM and 12 noon.

The ASDEC team used a measurement technique called 'laser Doppler vibrometry'. This involved creating a 3D computer model of Big Ben and then using lasers to map the vibrations in the metal of the bell as it chimed.

ASDEC, working with the BBC, measured the structural dynamics of Big Ben in an unprecedented level of detail after being given exclusive access to the iconic structure.

Using two Scanning Laser Doppler Vibrometers, the team was able to characterise Big Ben without touching it, providing high-density vibration measurements without any loss of accuracy or precision.

The findings of the mapping project will be revealed during a BBC documentary entitled 'Sound Waves: The Symphony of Physics', which was broadcast at 9:00PM on Thursday 2 March on BBC4 and was hosted by Dr Helen Czerski.

Martin Cockrill, a Technical Specialist from the Department of Engineering, who leads ASDEC's measurement team and appears in the documentary, said: "Aside from the technical aspects one of the most challenging parts of the job was carrying all of our equipment up the 334 steps of the spiral staircase to the belfry. Then to get everything set up before the first chime, we were literally working against the clock.

"Many of the vibrations in the metal of Big Ben are too tiny to be seen by the naked eye. But this is what we were able to map using the lasers and not just one or two points on the surface; we were able to get over 500 measurements across the surface which just wouldn't have been possible with previous technologies."

Martin Cockrill and Max Chowanietz led the team from a technical point of view undertaking the measurements with two other members of the team, Chris Howe and Amy Stubbs.

Max is a graduate engineer with ASDEC who completed a General Engineering Degree at the University of Leicester in 2014 and has since followed his passion.

Max said: "It was a privilege to be part of such a unique project, especially so early in my career."

Q1: How was the Big Ben project similar to the investigation you conducted in class to determine if the table was vibrating? How is it different?

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Reading 2: The Vibrating Moon
June 15, 2008
Used with permission from A Moment of Science, WFIU

On our last program we mentioned the startling experience of five British monks from the twelfth century who saw an enormous explosion occur on the moon.

In their records they wrote that the upper horn of the new moon split in two and emitted a pillar of flame. Modern astronomers, working on the assumption that the monks witnessed an asteroid collision, have found a crater of recent origin in the spot where the monks said the explosion occurred.

There is also more evidence to support the theory that the moon was struck by a passing object that night in June. In fact, the moon may still be vibrating from the impact.

When the Apollo astronauts traveled to the moon, they placed instruments on its surface called "laser retro reflectors." These instruments are essentially sophisticated mirrors that allows us to shine laser beams at the moon and receive the bounced-back light. Multiply the amount of time it takes to get the signal back by the speed of light and you have a highly accurate measurement of the distance to the moon.

This method of measurement has revealed that the moon is, in fact, vibrating, like a bell that has been struck by a rock. The vibration makes the moon move back and forth by about ten feet every three years.

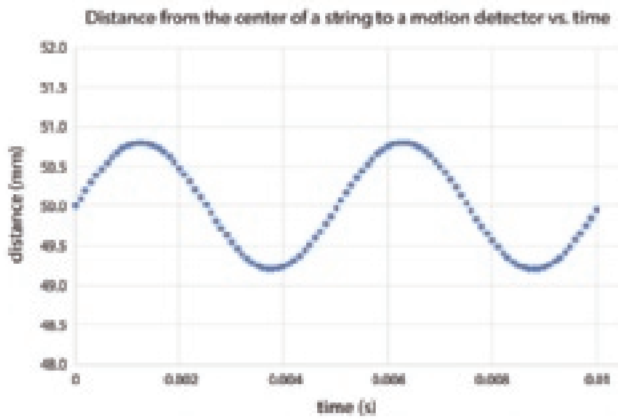
Not all astronomers agree that an asteroid strike set the moon vibrating; some argue that it is a natural effect of the earth's gravitational pull. However, if the asteroid hypothesis is correct, it seems likely that the British monks of eight hundred years ago saw the blow that left the moon shaking even today.

Q2: What pattern would you expect to see in the motion of the laser dot over three years that was reflected back to Earth from the mirrors that astronauts left on the Moon?

Q3: What pattern would you expect to see in the motion of the laser dot over six years?

Name: ______________________ Date: ______________

Harp String Graph Handout



This is a position versus time graph for one of the strings on a harp, collected from a motion detector. Draw a line to connect the dots to help you visualize the shape of the graph.

1. Sketch a straight line showing the distance of the harp string from the motion detector *when it was at rest.*

2. Sketch another graph on top of this one to show what the graph would look like if you played the same note (*same pitch)* but *louder.*

3. What things did you change in the graph that you sketched? Did you change the amplitude, the frequency, or something else?

____

____

4. Describe in words what you would see the *actual harp string* doing differently if it were producing the *same-pitch* note but *louder.*

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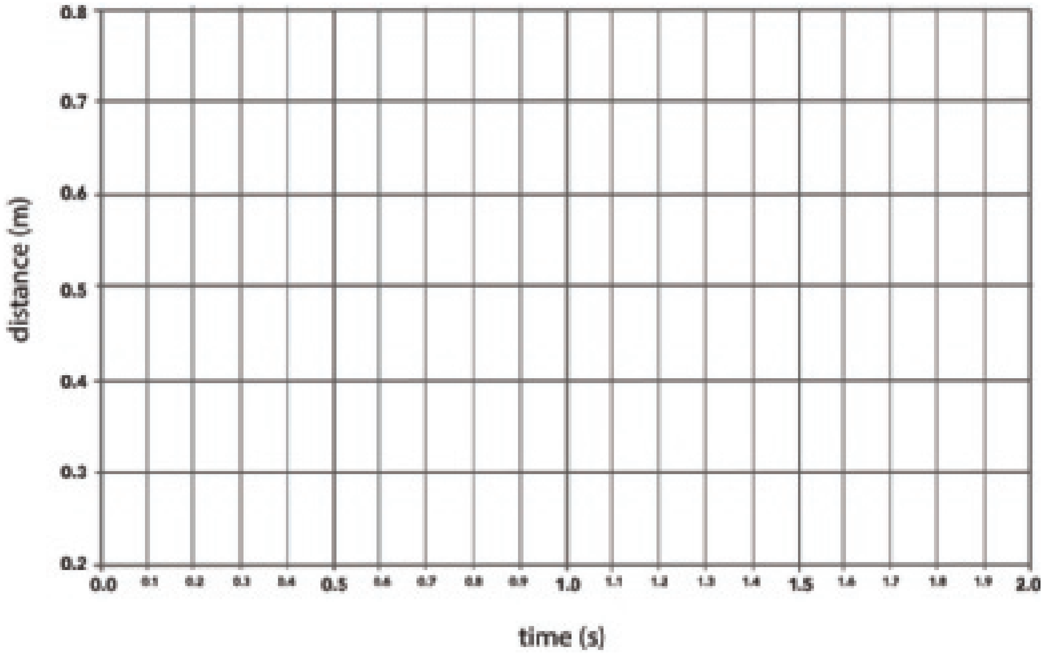
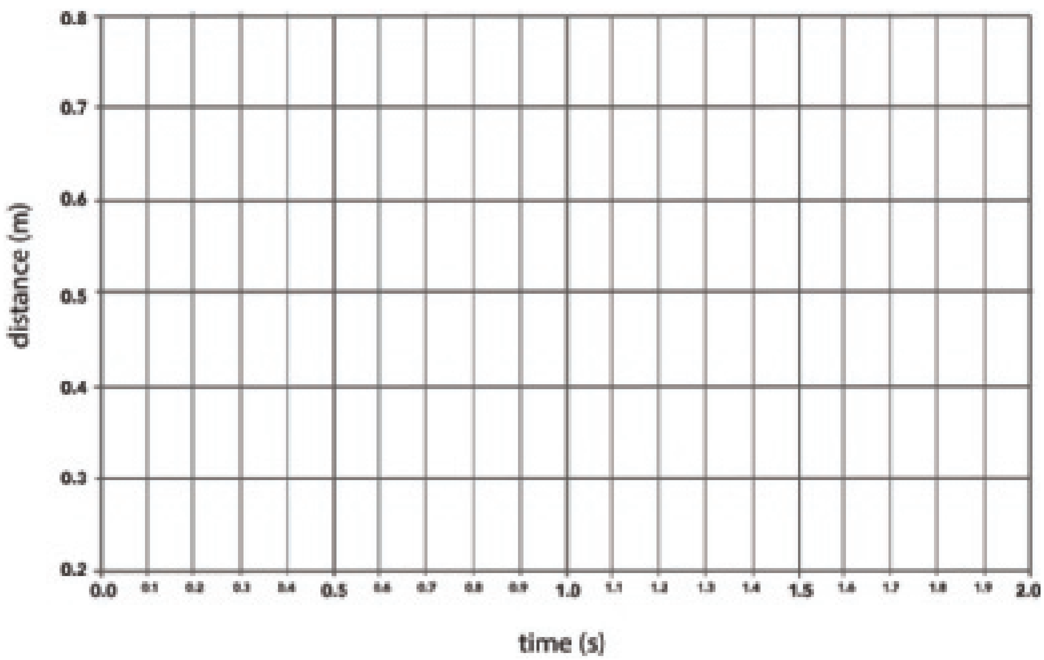
Name: ______________________ Date: ______________________

L4 Motion Graphs

Condition 1: Light Push



Condition 2: Harder Push



Name: ______________________ Date: ________________

Discussion Self Assessment

1. Read each statement and mark YES or NO for whole-class discussions and small-group discussions.

Today, I . . .	In whole-class discussions		In small-group or partner discussions	
	YES	NO	YES	NO
Shared my thinking by sharing new ideas, asking new questions, or asking for clarification from others.				
Listened actively to others by rephrasing, repeating, and/or reusing the ideas of others and/or by asking others to repeat their statements or to clarify ideas when they are difficult to hear or understand.				
Respectfully gave critiques to others about their explanations, models, investigation plans, or questions by using observations, data, or evidence and asking questions.				
Invited others to share their thinking.				

2. Choose one statement that you checked NO for or that you think you can improve on. Write down 2 ideas for what you can do to improve in the next discussion.

Name: ____________________ Date: ____________

How does the motion detector work?

In Lesson 4 we had the opportunity to *visualize* vibrations at the sound source by using a motion detector. The motion detector generated graphs of the motion of the stick to help us see how the distance of the end of the stick changed over time. But how does this motion detector make these graphs?

When a motion detector gathers motion data, it is recording the position of the stick over time. Each position it detects and records is called a *sample*.

The motion detector we used in class has a maximum sampling rate of 25 frames per second, which means that every 1/25th of a second it records a new position, or new sample. Another way to think about this is that every second it can record another 25 samples. And in two seconds it can record 50 samples. The table to the right shows all samples that the motion detector recorded in one second for the vibrating stick.

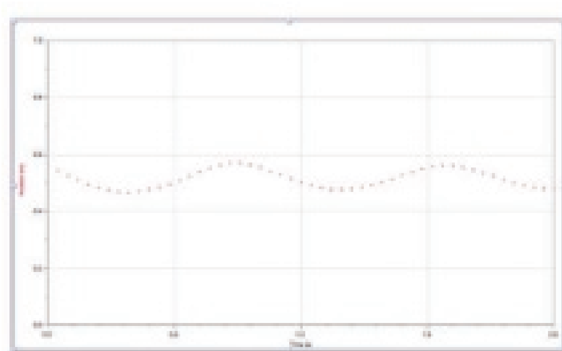
Notice that the record of these samples is a bunch of digits in a table. One group of digits represents time, another group of digits represents position. So for example, at a time of 0.96 seconds, the distance from the end of the detector to the end of the stick is 0.514 meters. And at 1.00 second, the distance from the end of the detector to the end of the stick is 0.500 meters.

	Time (s)	**Position (m)**
1	0.04	0.543
2	0.08	0.524
3	0.12	0.508
4	0.16	0.494
5	0.20	0.483
6	0.24	0.475
7	0.28	0.470
8	0.32	0.468
9	0.36	0.470
10	0.40	0.476
11	0.44	0.484
12	0.48	0.494
13	0.52	0.507
14	0.56	0.522
15	0.60	0.537
16	0.64	0.551
17	0.68	0.562
18	0.72	0.569
19	0.76	0.569
20	0.80	0.563
21	0.84	0.553
22	0.88	0.540
23	0.92	0.526
24	0.96	0.514
25	1.00	0.500

Q1: At 0.76 seconds, how far away was the stick from end of the detector?

Q2: At what time was the stick at 0.470 meters?

Here is a Position vs. Time graph for the data (samples #1 through #50) that the motion detector sampled and recorded.



Q3: The software for the motion detector has the option to draw a line to connect one sample to the next when it creates the graph of position vs. time. Draw a straight, horizontal line on the graph to show the starting position of the stick before it began vibrating. Then connect the dots to help you visualize the shape of the graph.

Q4: How many times does the vibration repeat in the 2 seconds shown above?

Q5: Sketch another graph on top of this one to show how the graph would look if you pulled the stick back further.

Q6: How often should the pattern in the graph you sketched repeat?

a. Just as frequently (as often) as the pattern in the original graph on this page

b. Less frequently (less often) than the pattern in the original graph on this page

c. More frequently (more often) than the pattern in the original graph on this page

How does your prediction compare to what you discovered in class?

Notice that in Q3, the shape of the graph came from connecting the dots. And notice that the dots are coordinates on the graph. The values for these coordinates are based on number values for time and distance that were sampled and stored in a data table.

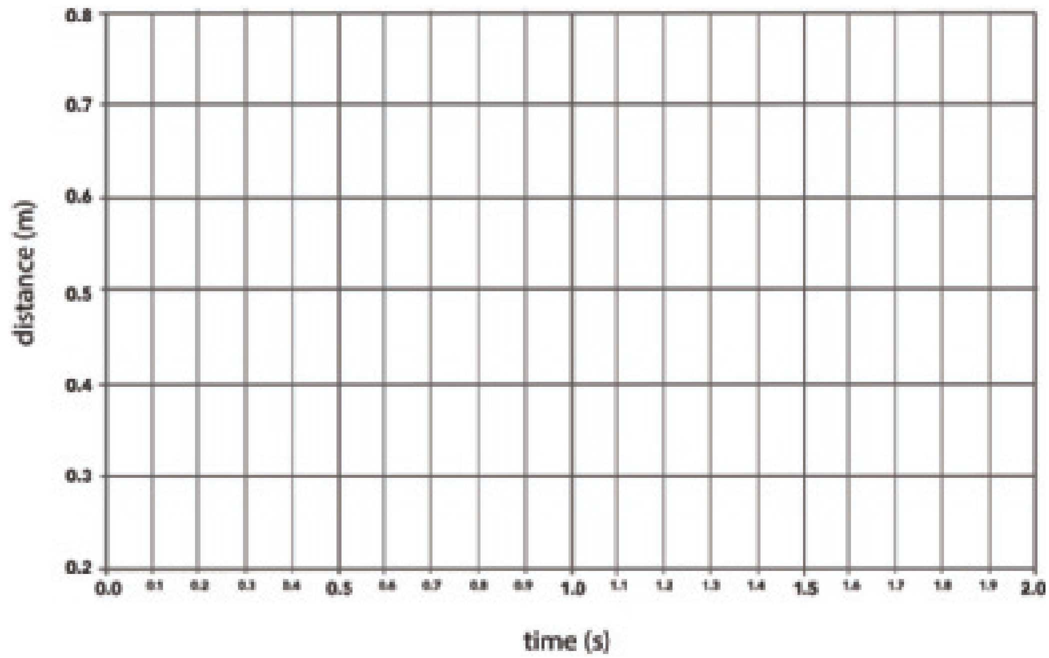
This type of record of information is called a **digital** record. It is referred to as a digital recording because the information that is recorded by the electronic device is just a long series of numbers (or digits), nothing more.

Q7: Where else have you heard the terms *digital* or *digital record* or *digital recording*?

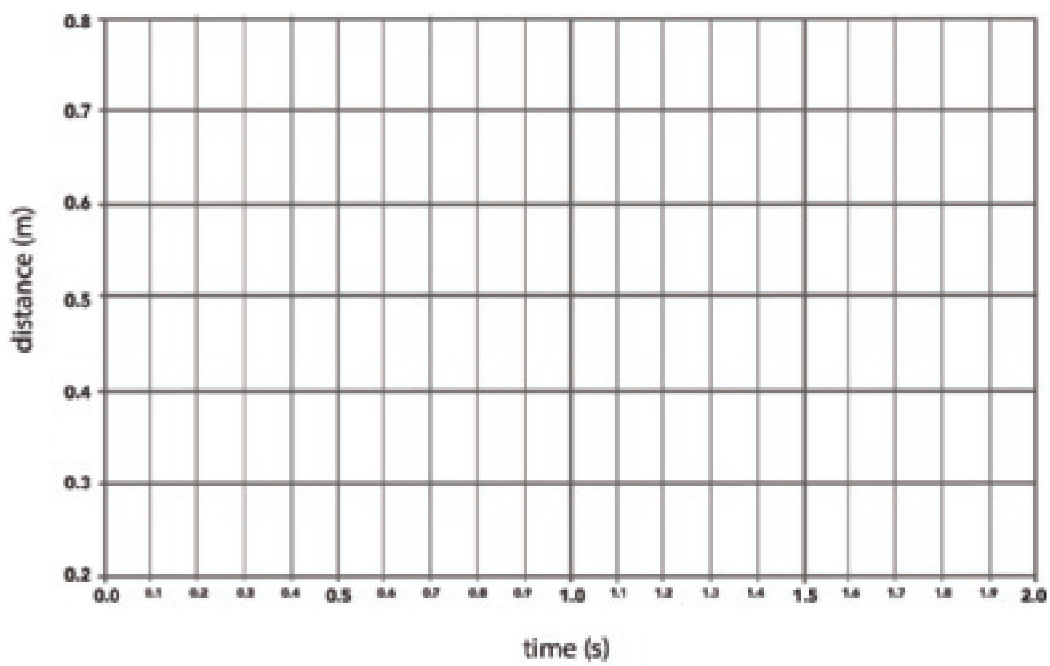
Name: ______________________ Date: ______________________

Pitch Graphs

Condition 1: Long stick (represents low pitch)



Condition 2: Short stick (represents high pitch)



Name: ____________________ Date: ____________________

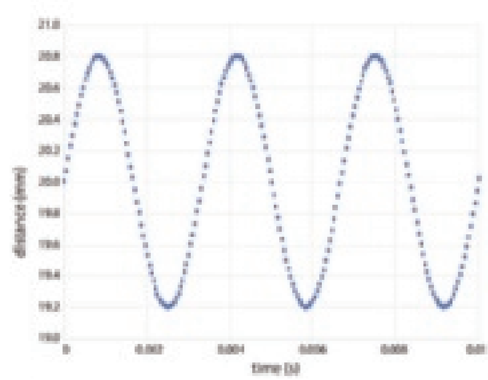
Analyzing Graphs of Sound Source Vibrations

Exit Ticket: The graphs to the right represent the position of a sound source that is vibrating. The sound source in each case is a xylophone that was struck with a mallet three different times to create the three different graphs.

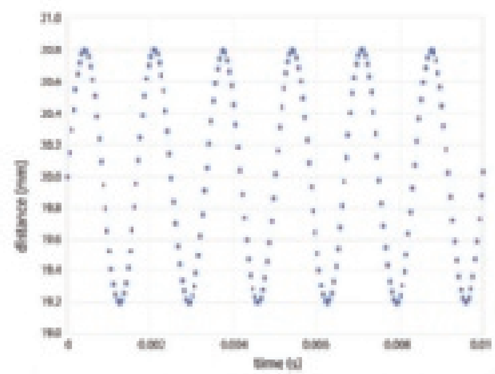
1. Based on the three graphs, what can you claim about each instance that sound that was made by hitting a xylophone? Why do you think that?

2. Which of the graphs has the highest frequency? Which of the graphs has the lowest frequency? What is your mathematical evidence?

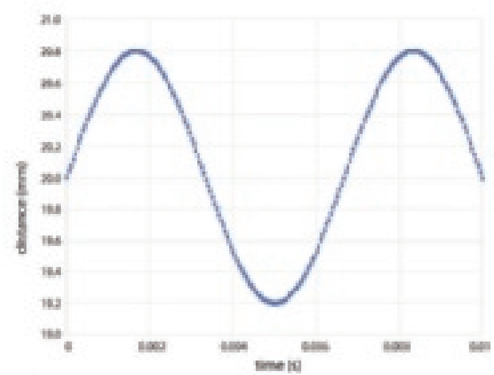
Graph A



Graph B



Graph C



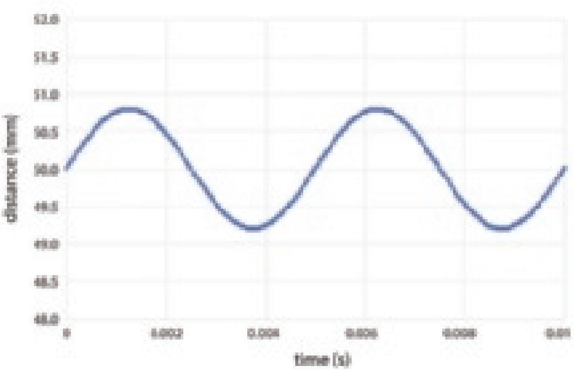
Name: ______________________ Date: ______________

Connecting Graphical Representations to the Sounds Made

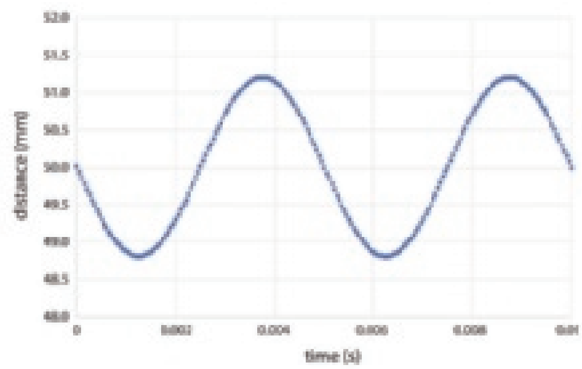
Data for each question set:

The graphs below represent the position of a vibrating sound source. In this case, the sound source was a xylophone that was struck with a mallet six different times to create the six different graphs.

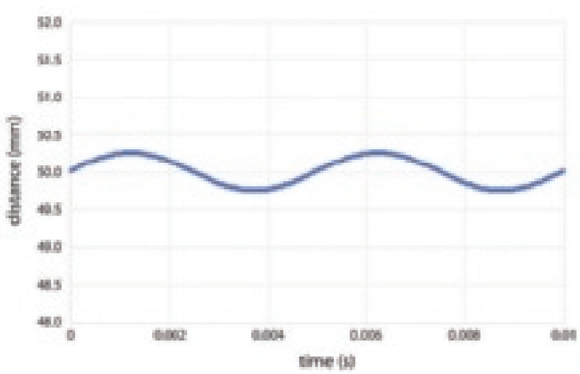
Graph A



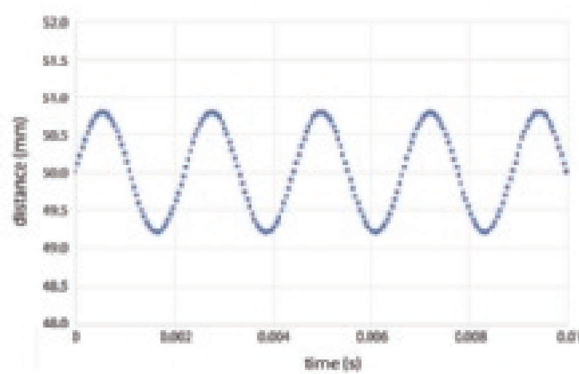
Graph B



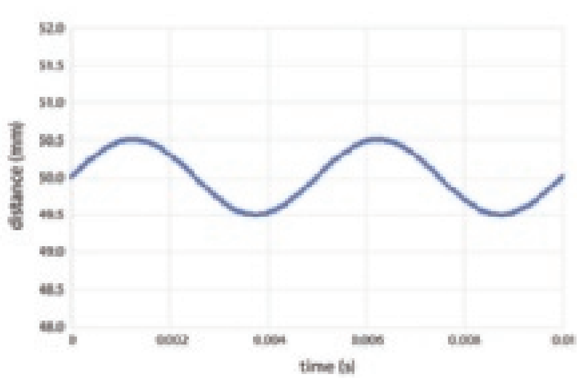
Graph C



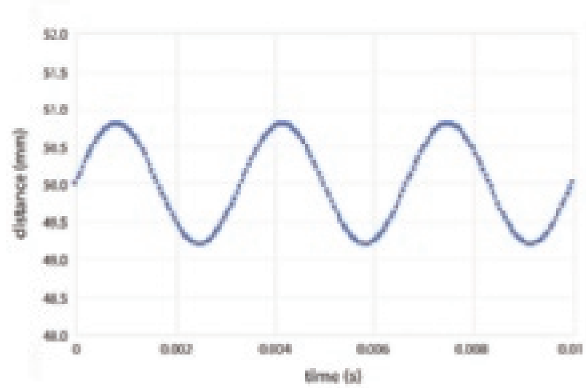
Graph D



Graph E



Graph F



Connecting Graphical Representations to the Sounds Made

Question Set 1

1a. Make two claims:

Which graph represents vibrations that are producing the quietest sound? ____________

Which graph represents vibrations that are producing the loudest sound? ____________

1b. What is your **evidence** from the graphs (use the words *amplitude* and *frequency*)?

____

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1c. How does the evidence support your claim (reasoning)? How does the movement of the object relate to how loud the sound is?

____

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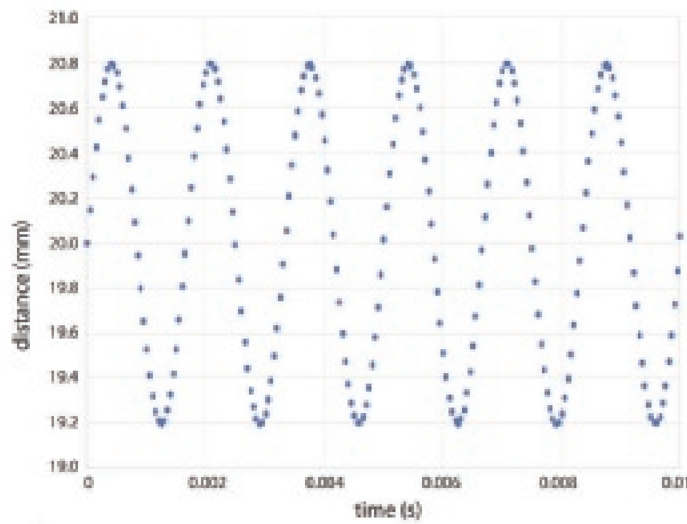
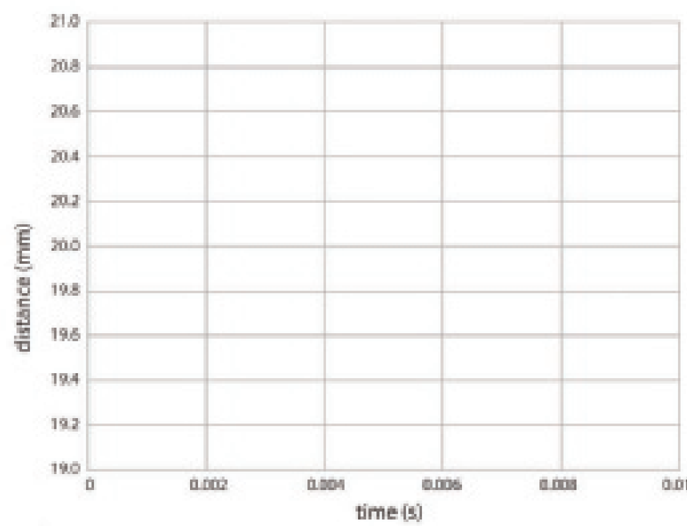
Additional practice:

The graph to the right represents the position of a sound source that is vibrating. The sound source is a guitar string that was plucked. The time frame depicted is 0.01 second.



Graph G

1d. Draw a new version of **graph G** that represents the vibrations of a sound source from an instrument that is deformed with just as much amplitude as the one above but is vibrating with a frequency that produces four back-and-forth motions (four waves) in 0.01 second.



1e. If a sound source is producing sound with a steady pitch and is vibrating with a frequency of 2 waves per 2 seconds, then how many times would it move back and forth in 10 seconds?

Connecting Graphical Representations to the Sounds Made

Question Set 2

2a. Make claims:

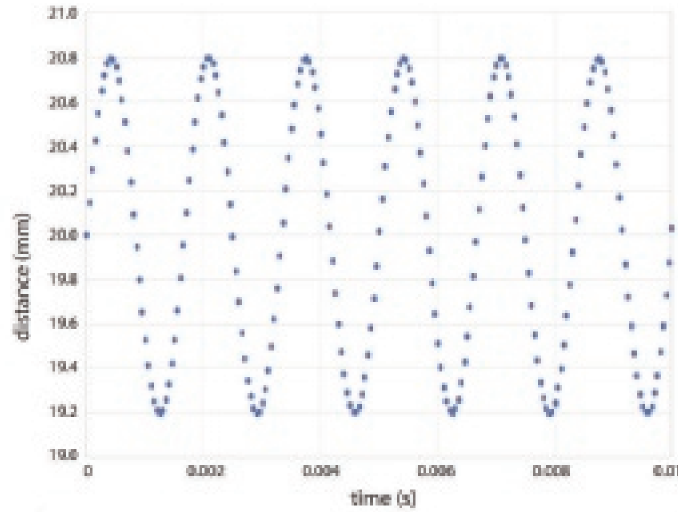
- Which graph represents vibrations that are producing the lowest pitch sound? ___________
- Which graph represents vibrations that are producing the highest pitch sound? ___________
- Which graph represents vibrations that are producing a sound with a pitch that is not the lowest and is not the highest of the three? ___________

2b. What is your **evidence** from the graphs (use the words *amplitude* and *frequency*)?

2c. How does the evidence support your claim (reasoning)? How does the movement of the object relate to the pitch of the sound?

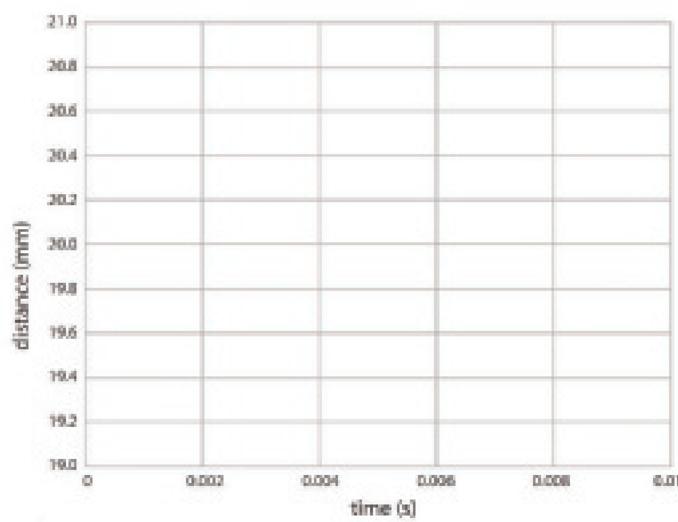
Additional practice:

The graph to the right represents the position of a sound source that is vibrating. The sound source is a guitar string that was plucked. The time frame depicted is 0.01 second.



2d. Draw a new version of **graph G** that represents the vibration of a sound source from the same instrument, which is producing a sound at the same frequency but with a smaller amplitude.

Graph G

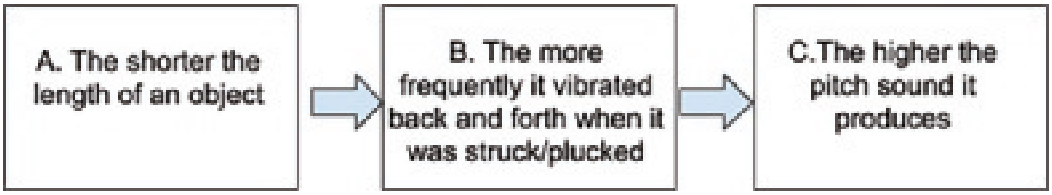


2e. If a sound source is producing sound with a steady pitch, and is vibrating with a frequency of one wave per 2 seconds, then how many times would it move back and forth in 20 seconds?

Name: ______________________ Date: ______________

Supplemental Investigation 6A: What Else Besides an Object's Length Affects the Frequency It Vibrates at When Struck or Plucked?

In class, you saw examples of instruments that had bars, boards, or tines with different lengths that produced different pitch sounds. You also saw how differences in length led to the chain of cause and effect represented by the system model below.



However, changing the length of an object is not the only way to affect the vibration and pitch listed in B and C of the system model.

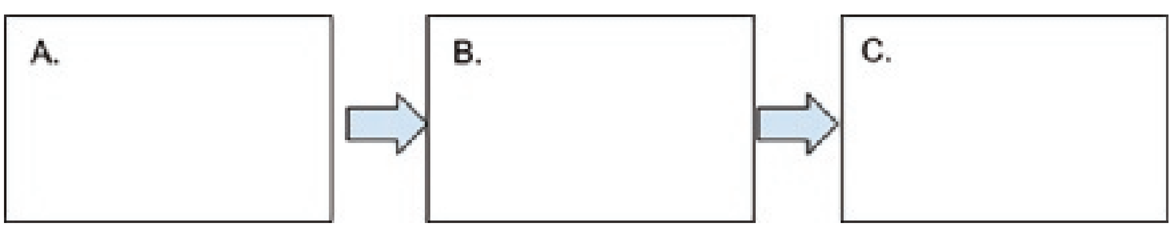
Pick one of these two possible investigations to conduct. You may need a helper to capture the data you collect:

1. Explore how variations in how tightly stretched a material is in part A of the system model might affect the vibration and pitch observed in parts B and C.
   a. Materials needed: 1 rubber band
   b. Optional material: Slow-motion camera on a smartphone
2. Explore how variations in the thickness of an object might affect the vibration and pitch observed in parts B and C.
   a. Materials needed: 6 coffee stirrers
   b. Optional material: Slow-motion camera on a smartphone

If you conduct investigation A, try stretching the rubber band a greater amount and comparing what happens each time you pluck it.

If you conduct investigation B, tape a bundle of three coffee stirrers tightly together and tape a second bundle of two coffee stirrers tightly together. Save one coffee stirrer to test on its own. Hold down the ends of each bundle so that the majority of each bundle is hanging over the edge of a counter. Pluck the end of each.

If you have a slow motion camera on your smartphone, record video of the object you are investigating and compare how frequently the object vibrates to the pitch of sound it produces. If you don't have a slow motion camera to use, simply record what you hear in box C and summarize what you know must be happening to the frequency of the vibrations of each object in part B of the system model. Record what you discovered in the boxes below, which correspond to the same elements in the system model outlined above:

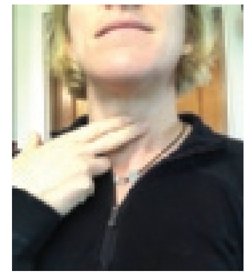


Name: ______________________________ Date: ______________________

Supplemental Investigation 6B: How Do People Force Their Voice to Make Different Kinds of Sounds?

We rely on our voices every day to interact with others. We usually speak without thinking about how our body makes it happen. However, figuring out how we make sound is useful to maintaining the health and effectiveness of our voices.

To explore these ideas further, you will conduct a few investigations. The third investigation will require that you have a deflated balloon to experiment with.



Investigation 1 – What do you feel when you sing a note?

Q1: If you held your fingers lightly against your throat (as shown in the photo), sang a note, and held that note for a couple seconds, what do you think you would feel?

____

____

Q2: Take a deep breath and try to do this. Then try again, singing more quietly. Try it a third time, singing more loudly. How did what you felt compare?

____

____

____

Q3: How does what you felt relate to what you figured out about vibrations and amplitude?

____

____

____

____

Investigation 2 – How Can You Use a Balloon to Simulate the Function of the Vocal Cords?

The part of your throat you felt vibrating in the previous investigation is called the **vocal folds** (also called vocal cords). When we talk, sing, laugh, cry, or scream, those sounds are produced by the movement of these vocal folds. These sounds made by the human voice are the result of three main parts working together: 1). **the lungs,** 2). **the vocal folds,** and 3). **the articulators**.

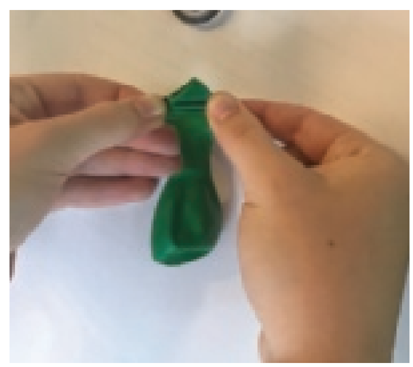
1. **The lungs.** It is the air passing over the vocal folds that makes them vibrate. This air comes from the lungs as you exhale and pushes on the vocal folds with different amounts of force. Bigger pushes of air (bigger exhalations) cause louder sounds because the vocal cords are deformed more (just like with our drum!).

2. **The vocal folds:** The larynx, often called the voice box, has two vocal folds that vibrate to produce sound. These vocal folds open during breathing and close during swallowing and when we produce sounds like speaking. In order to produce those sounds, air is pushed between the vocal folds that have been pushed together. The speed of the vibrations can be controlled by the muscles in the larynx, which pull and stretch the vocal folds, resulting in different pitch sounds.

3. **Articulators:** Other structures above the larynx like the lips, tongue, teeth, palate, and cheek help form additional sounds. For example, when the tip of your tongue touches just behind your top teeth, you can make the "d" sound.

Q4: If you filled up a balloon with air and pinched the neck of the balloon, how might you use it to simulate this cause and effect relationship? – *Bigger pushes of air (bigger exhalations) cause louder sounds because the vocal cords are deformed more.*

Q5: Use the photograph to plan how you will adjust the neck of the balloon to simulate this cause and effect relationship. – *These folds vibrate very fast (from 100 to 1,000 times per second), depending on the length and tension of the vocal folds as the air pushes past them. The speed of the vibrations can be controlled by the muscles in the larynx, which pull and stretch the vocal folds, resulting in different pitch sounds.*



Procedure

1. Try some of the ideas you came up with using the balloon your teacher gave you.
2. Record your observations below.

Observations

For producing sounds of different volume	For producing sounds of different pitch

Investigation 3 – How Do the Articulators Help Us Say So Many Words?

Procedure

1. Say the first six letters of the alphabet out loud.
2. Pay attention to which of the structures in your mouth were pushing against each other to help form each letter. Repeat if necessary.
3. Record your observations with a check mark in the table below.

Letter spoken	Which structures were pushing against each other?				
	tongue	palate	cheek	lip	teeth
A					
B					
C					
D					
E					
F					

Q6: Which spoken letter(s), provided the strongest evidence that something you did forced your tongue, palate, cheek, and/or lips to vibrate as you said that letter?

Q7: Construct a scientific explanation, using evidence from these three investigations, to answer the question, How do people force their voice to make different kinds of sounds?

Name: ______________________ Date: ______________

Investigation Plan

1: What question are we going to investigate?	
2: How will we investigate this?	
3: What are some possible outcomes for our investigation?	**4: What would each of these outcomes tell us?**
5: What did you observe? What claims can you make?	

Name: ______________________ Date: ______________

Lesson 7: Exit Ticket

1. List at least 2 important pieces of feedback that you received from your partner. What could you add or change on your model to address these pieces of feedback?

Feedback from your partner about your initial model	What can you change on your model to address this feedback?

2. After collecting new evidence in our investigations and getting feedback from your partner, do you still support the claim you made in your initial model? If not, what new claim would you make about what is traveling between the speaker and the window?

(For example: In my initial model, my claim was that ________. After today's work, my claim is ________.)

3. What did you see in the evidence we collected today that makes you think your claim from Q2 is correct? How does that evidence support the claim you chose?

Name: ______________________ Date: ______________________

Sound and States of Matter

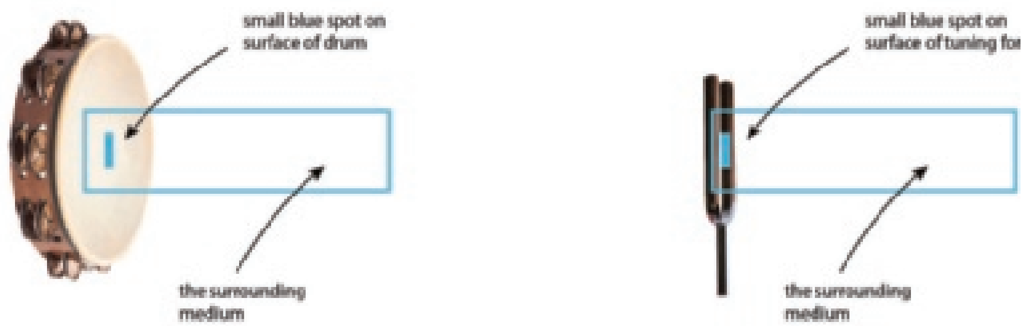
In our last lesson, we did an investigation where we made a sound underwater inside of a tank and then heard the sound through the air, a gas, after it traveled through the liquid water and solid glass. Develop a model to represent the different states of matter that the sound traveled through after it was made.

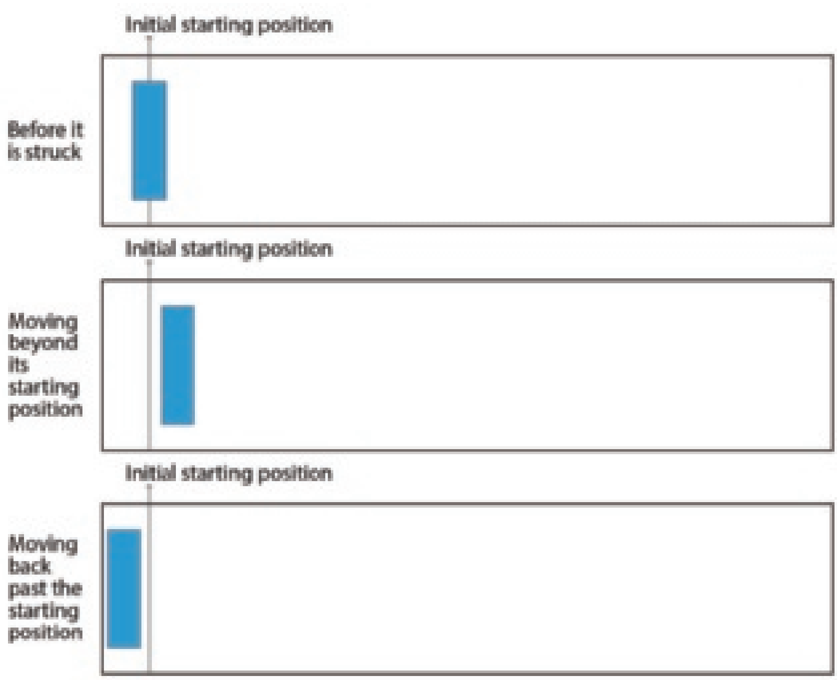
Models of Different States of Matter		
Water in the tank (liquid)	Glass wall of tank (solid)	Air in between the tank and our ears (gas)

Name: ______________________ Date: ______________________

Modeling the Matter around the Sound Source

Develop a model to show the state of matter (liquid or gas) that would be next to the small spots (shown as rectangles in the diagrams below) on the surface of either object producing sound (drum or tuning fork). At each point in time, show what you predict would happen to the matter in the medium when the tuning fork and drum are vibrating.





Name: ____________________ Date: ______________

Self Assessment for Classroom Discussions

1. Read each statement and mark YES or NO for whole-class discussions and/or small-group discussions.

Today, I . . .	In whole-class discussions		In small-group or partner discussions	
	YES	NO	YES	NO
. . . **shared my thinking** by sharing new ideas, asking new questions, or asking for clarification from others.				
. . . **listened actively to others** by rephrasing, repeating and/or reusing the ideas of others, and/or by asking others to repeat their statements or to clarify ideas when they are difficult to hear or understand.				
. . . **respectfully gave critiques** to others about their explanations, models, investigation plans, or questions by using observations, data, or evidence and asking questions.				
. . . **invited others to share** their thinking.				

2. Choose one statement for which you checked NO – or a statement that you think you can improve on – and write down 2 ideas for what you can do to improve in the next discussion.

Name: ____________________ Date: ____________________

Visualizing Sound in a Medium Investigations

Part 1: Predict

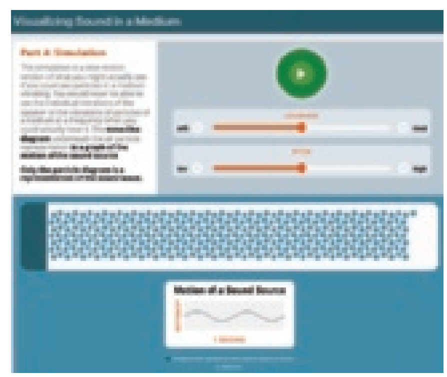
1. What, if anything, do you expect to see moving across the medium as sound travels away from a sound source?

2. If you could watch the motion of a single particle in the medium, what would you expect to see it doing as sound travels across the medium?

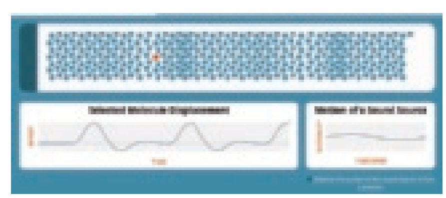
Part 2: Investigation 1: What is happening at a spot in space in the medium?

1. You will be working with one device. Open a web browser and go to the web address for the https://openscied.org/sound-in-a-medium/ simulation. Make sure the sound is on for your device.

2. Click on the green play button. Adjust the loudness and pitch sliders so you can see a clear pattern in the movement of the particles.



3. Click on a single blue particle to make it red so it is easier to track. Pay attention to the pattern in the whole medium and the motion of this single particle.



4. Record your observations.

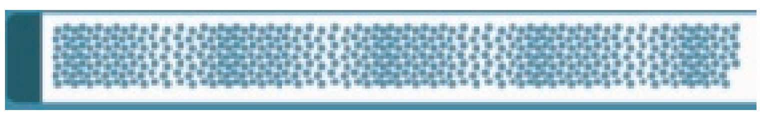
Visualizing Sound in a Medium Simulation: Observations for Investigation 1	
What patterns do you notice in the motion of a single particle in the medium?	What patterns do you notice in what appears to be happening across the entire medium?

Part 3: Investigation 2: How will the patterns you see moving across the medium change?

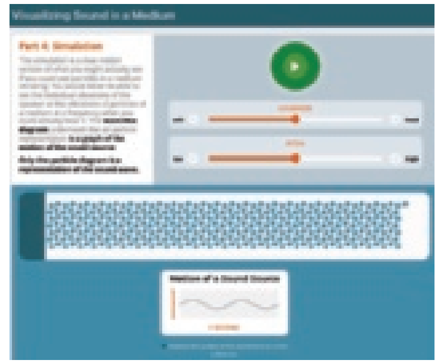
1. **Design an experiment:** Decide with a partner which variable (pitch or loudness) you want to change and how you will change it. Record the name of the variable you decide to test in the space below.

---

2. **Predict:** How do you think the patterns you see moving across the medium will be affected by these changes? Sketch the pattern you think you will see in the box below.

Pitch and loudness set in the middle: This image shows the simulation when the pitch and loudness are both set in the middle.	
Predict: What do you predict the medium will look like when you change your variable? In the box to the right, sketch the pattern you think you will see.	
Why do you think the pattern would look this way?	

Procedure

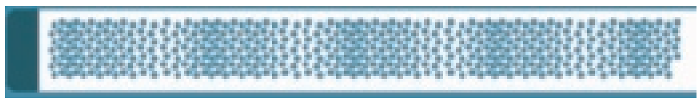


3. You will test your predictions using 2 computers—your computer and your partner's computer. Adjust the sliders on both computers to have these values:

4. On only one computer, adjust the value of the slider for the one variable you want to change.

5. Press the green play button on both computers and watch the simulations develop.

6. Record your observations in the table below.

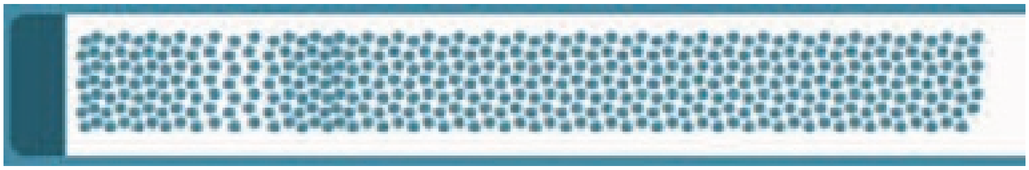
Visualizing Sound in a Medium Simulation: Observations for Investigation 2	
Pitch and loudness set in the middle: This image shows the simulation when the pitch and loudness are both set in the middle.	
Observe: What did you see when you changed your variable? Record your observations in the box to the right.	

Making Sense: What is happening to the particles in the medium that led to the results you observed?

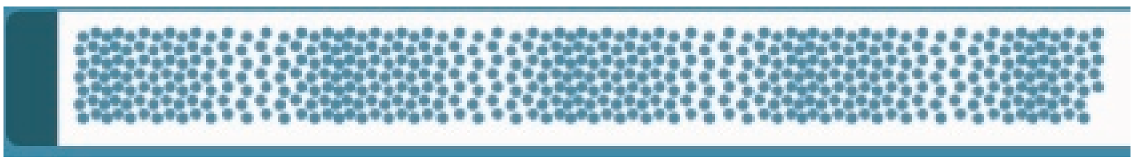
Name: ______________________ Date: ______________________

Analyzing Sound in a Medium Simulation Data

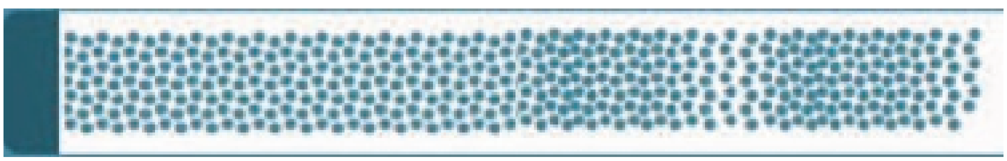
Frame 1: Start of the motion



Frame 2: Later (source has been vibrating a while)



Frame 3: After pausing source



Home learning: Use the ideas in this lesson to explain how music produced from the speaker in the truck caused the window in a building in the parking lot to move. Make a sketch of what is happening and be sure to include the following in your model:

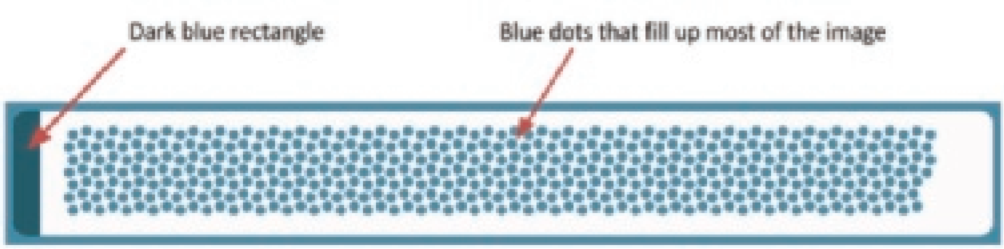
- vibrations of the sound source
- collisions between particles
- energy transfer
- changes that happen in the particle density across the medium

Name: ______________________________ Date: ______________________

Visualizing Sound Analogy Map

Tape this sheet in your science notebook and work in a group to complete the analogy map below for the Visualizing Sound in a Medium simulation. The first row is done for you.

Analogy Map: Visualizing Sound in a Medium Simulation		
Feature of the simulation . . .	***. . . is like feature of the real world . . .***	***. . . because . . .***
Dark blue rectangle on the left edge of the image . . .	. . . is like a tiny piece of the surface of a drum, or a tuning fork, or any vibrating object . . .	. . . because the blue rectangle can move back and forth in a regular pattern just as a vibrating object does.
Blue dots that fill up most of the space in the image . . .		
Making the dark blue rectangle move faster . . .		
Making the dark blue rectangle move farther left and right . . .		

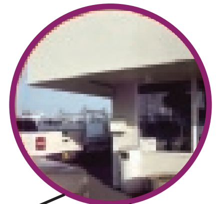


Name: ____________________ Date: ____________________

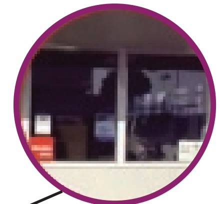
Revising your model: Look back at your initial model and your Progress Tracker and consider how your understanding of this question has changed: *How does the sound coming from one thing (like the speaker) make another thing (like the window) move?* Draw and label a revised model to explain your answer to this question. For each location on your model, show a zoomed-in view of what is happening. Then, explain your model in words below.

Zoom in on what is happening at the spot where the sound is coming from.

Zoom in on what is happening in the space between the truck and the building window.



Zoom in on what is happening at the window to make the window move.



Name: ______________________ Date: ______________________

Gotta-Have-It Checklist

Part 1: Use your Progress Tracker and your science notebook to make a checklist of the most important ideas you need when explaining this question.

What our model needs to have to answer the question, *"How are sounds caused, and how can they make something move?"*	***Check off pieces of the model as you use them.***	
	used	***did not use***

Part 2: When your teacher tells you to, use your checklist to make a model to answer our question. As you use ideas from your checklist, put a check in the "used" column for the idea. If you do not use an idea after all, place a check in the "did not use" column.

Peer Feedback Self Assessment

Giving Feedback

How well did you give feedback today?

Today, I . . .	YES	NO
. . . gave feedback that was **specific** and about **science ideas.**		
. . . **shared a suggestion** to help improve my peer's work.		
. . . **used evidence from** investigations, observations, activities, or readings to support the feedback or suggestions I gave.		

One thing I can do better the next time I give feedback is:

Receiving Feedback

How well did you receive feedback today?

Today, I . . .	YES	NO
. . . read the feedback I received carefully.		
. . . asked follow up questions to better understand the feedback I received.		
. . . said or wrote why I agreed or disagreed with the feedback.		
. . . revised my work based on the feedback.		

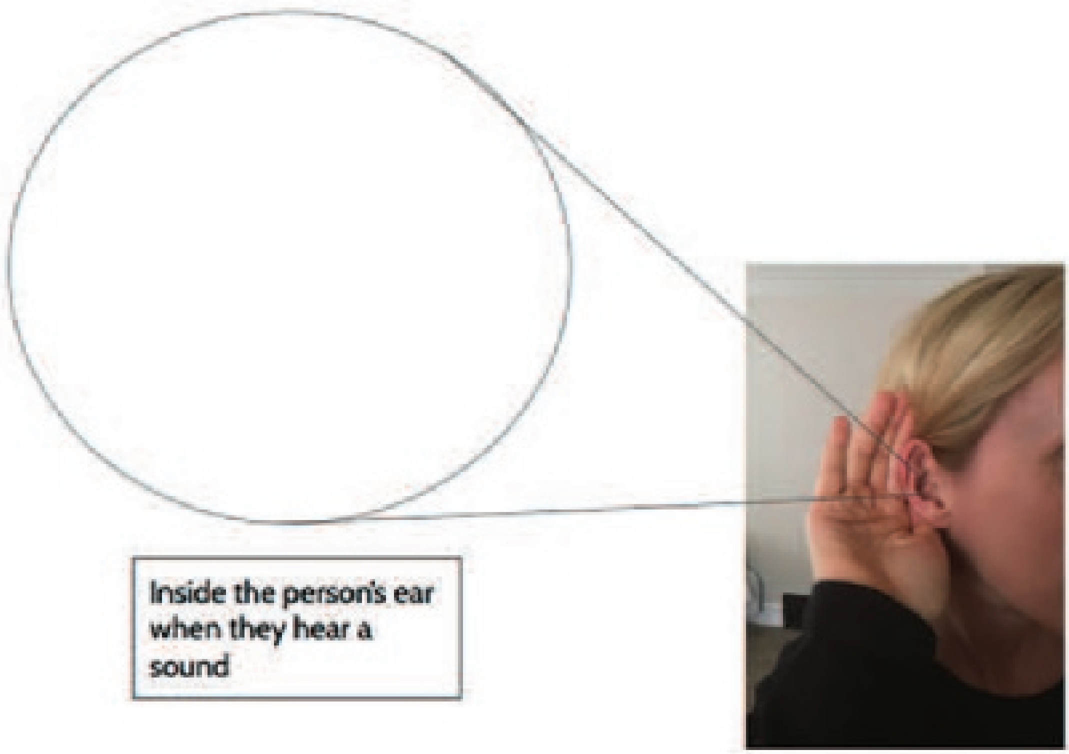
What is one piece of feedback you received?

What did you add or change to address this feedback?

Name: ______________________ Date: ______________________

Model Inside an Ear

What do you think is happening inside people's ears that allows them to detect different sounds? Use words and pictures to model your thinking.



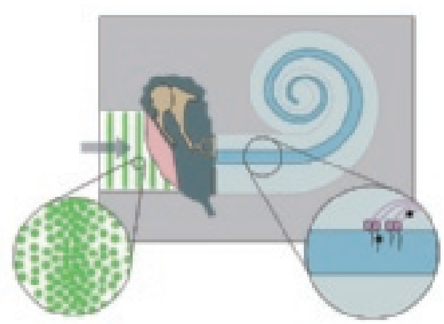
Name: ______________________ Date: ______________________

Information from the Experts

The information summarized from these interview questions was compiled with the help of Dr. Keith Lertsburapa (an otolaryngologist with Amita Health in Downers Grove, Illinois) and Dr. Jon Seigel (a neurobiologist and associate professor at Northwestern University).

What happens to the vibrations in human ears after they get to the eardrum?

After sounds cause the eardrums to vibrate, they pass those vibrations along a series of bones in the inner ear. This transmits the vibrations into the fluid of the cochlea, where the sound wave travels along the basilar membrane (the darker blue line in the diagram to the right) which allows people to detect the variety of pitch in the sounds they hear. You can view an animation showing how sound is transferred through the parts of the ear here: http://www.neuroreille.com/promenade/english/ear/fear.htm



How do people hear different pitches and volumes of sound?

When the vibrations enter the cochlea, different pitches will vibrate different areas of the cochlea more. Basically, the basilar membrane (represented above as the darker blue coil in the cochlea) has different areas that react more strongly to each pitch. When a sound of a certain pitch goes into the cochlea, the corresponding area of the basilar membrane vibrates more strongly. You can see an animation of what this looks like here: https://www.youtube.com/watch?v=fuEswszwFRg&t=2s Every different pitch that vibrates the basilar membrane also causes some of the hair cells in a particular area to vibrate, and this is the final step of the process. Different hair cells vibrate in response to different pitches of sounds. When those hair cells vibrate, they send an electrical impulse to the brain, and finally that sound can be heard. To see a hair cell up close, watch this video: https://youtu.be/xf2MRsBYAvE

Why do people lose their hearing as they get older?

This is not actually the case for all people as they get older. Hearing loss due to aging (presbycusis) affects only 30% of people over the age of 65. The loss of ability to hear sounds of a higher pitch can be related to the structure of the cochlea. Higher-pitch sounds are detected by the hair cells at the base of the cochlea (where all sounds first enter the cochlea). So as a result of being the first to receive those vibrations, these hair cells take the biggest beating over time and eventually wear out.

So how does hearing loss work?

As you can now understand, hearing is a very complex mechanism. In order for humans to detect sound, the vibrations need to be transmitted many times: from the eardrum, to the bones of the inner ear, to the fluid of the cochlea, to the part of the basilar membrane that detects that pitch, and finally to the hair cells, which send the electric signals to the brain. You can imagine this like a line of dominoes. If any of those mechanisms is broken or has a defect, then hearing will be impaired. This can be especially true for the hair cells because of their structure. These hair cells have tiny detectors, called stereocilia, that respond to vibrations. Exposure to sounds that are too loud or too high pitch can damage the stereocilia, causing the hair cells to stop working. This can mean temporary damage (causing ringing in our ears) or permanent damage leading to hearing loss. To see stereocilia that have been permanently damaged from exposure to sound, visit http://www.dangerousdecibels.org/virtualexhibit/2howdowehear.html.

Name: ______________________ Date: ______________________

Hearing in Elephants, Dogs, and Humans

In class, you explored some of the structures found in human ears that help humans detect and understand sounds. We know, for example, that humans are able to hear sounds with different pitches because the human cochlea and the basilar membrane inside it have different areas that detect different pitches.

The ability of humans to hear a wide range of sounds depends on the structures in the inner ear. Some of the key structures that affect hearing range are (1) the ratio of the width of the cochlea at the base (bottom) compared to the apex (top), (2) the stiffness of the basilar membrane, and (3) the structure and organization of the hair cells.

Both elephants and dogs also have a cochlea, but as you can see in the chart below, they are able to hear a different range of pitches of sound than humans. The chart below shows the range of hearing in hertz (Hz), which is the number of waves per second.

Animal	Lowest frequency sound they can hear	Highest frequency sound they can hear
Elephant	17 Hz	10,500 Hz
Human	31 Hz	19,000 Hz
Dog	64 Hz	44,000 Hz

A dog whistle, also known as silent whistle or Galton's whistle, is a type of whistle that emits sound in a higher range of frequencies than humans can hear. Some other animals, including dogs and domestic cats, can hear these higher frequency sounds so this whistle is used in their training. It was invented in 1876 by Francis Galton and is mentioned in his book *Inquiries into Human Faculty and Its Development.* In the book, he describes experiments to test the range of frequencies that could be heard by various animals, such as a house cat.

The maximum upper range of human hearing is about 19,000 Hz for children, declining to around 16,000 Hz for middle-aged adults. The top end of a dog's hearing range is about 44,000 Hz, while a cat's is 64,000 Hz. These data suggest that there are some high-pitch sounds that children can hear that adults cannot. Most people do not have whistles they can use at home to test whether or not the people or pets in their families can hear certain pitches. However, there are computer apps available online that produce sounds of different frequencies. You might consider trying the Online Tone Generator found at http://onlinetonegenerator.com/with friends or people in your family.

Q1: Based on the information in the table above, which of these three animals—an elephant, a human, or a dog—can hear the lowest pitch sounds? ______________________

Q2: If you are able to try the Online Tone Generator with others, summarize your results in the space below.

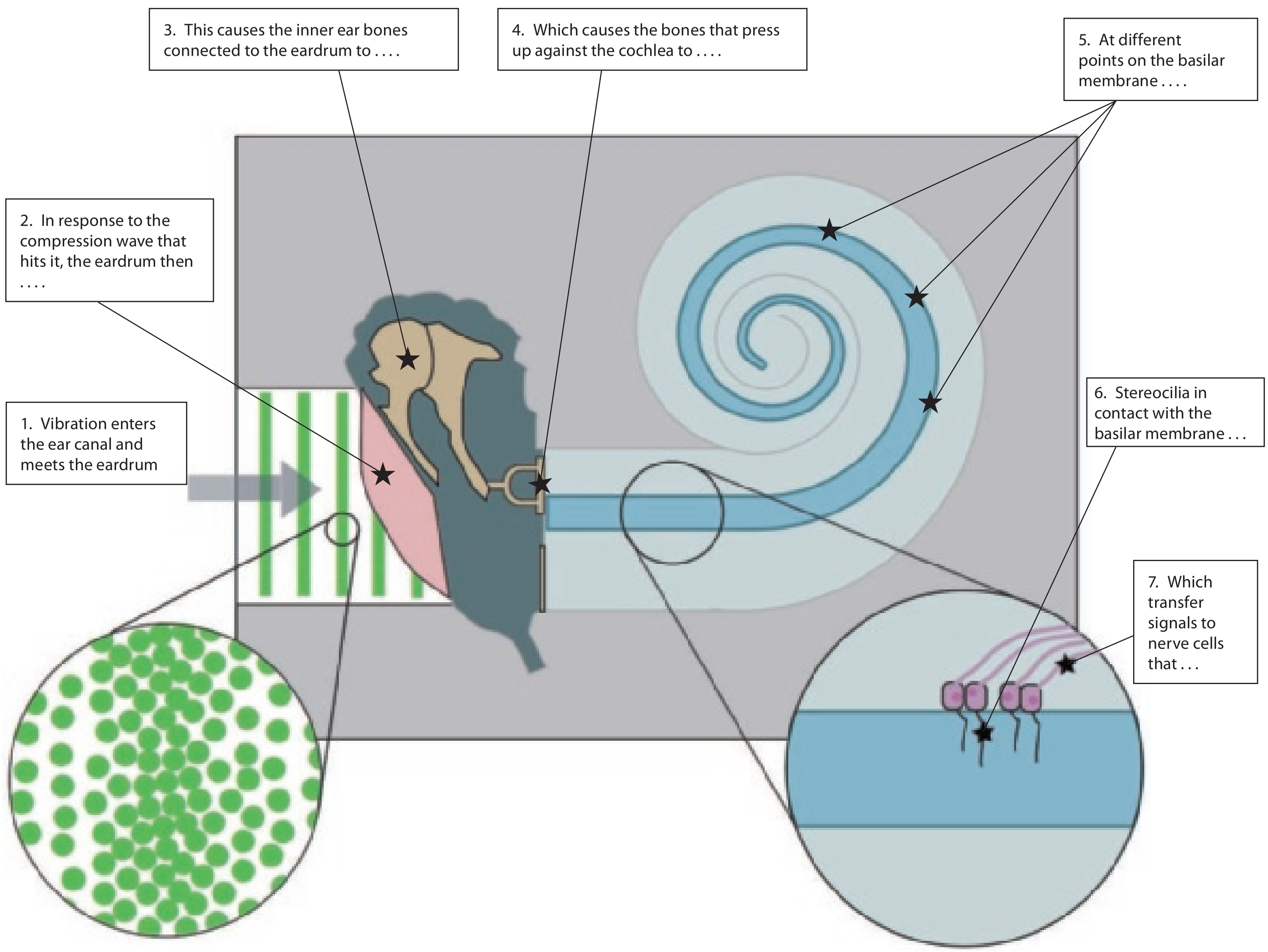
Name: ______________________ Date: ______________

Lesson 12 Activity Sheet

Responding to the reading and video and animation links: As you read *Information from the Experts,* use the space below to take notes on anything you found that could help us answer our questions about how the structure and function of the ear allow humans to detect different sounds.

Questions we are still trying to answer: • What is happening inside the human ear that allows it to detect different sounds? • What else is happening in the human body that allows it to hear sounds?
Notes from the reading and video and animation links:

Constructing Explanations: Use what you learned from the article and links to show how energy from sounds is transmitted through the inner ear and detected by different sensory cells. Track your findings on the diagram below.



Name: ______________________ Date: ______________

Analogy Map for Energy Transfer Investigation

This thing from our investigation . . .	. . . is like (feature of the real world)	Because . . .
	sound source	
	particles in the medium around sound source	
	sound detector	
	sound source vibrating with greater amplitude	
	sound source vibrating with greater frequency	

Name: ______________________ Date: ______________

Data Tables for Energy Transfer Investigation

Investigation 1 – Frequency: For each trial, record the final position of the marker in column C. Then, calculate how far the marker moved and record that number in column D.

A. Number of waves in a second	B. Initial position of the target (cm)	C. Final position of the target after being hit by the waves	D. How far did the target move?
1	20		
2	20		
3	20		
4	20		

1. Making sense of your data for investigation 1: Compare the distances the marker moved (shown in column D). What patterns do you notice?

Investigation 2 – Amplitude: For each trial, record the final position of the marker in column G below. Then, calculate how far the marker moved and record that number in column H.

E. How far you pulled back the ruler (cm)	F. Initial position of the target (cm)	G. Final position of target after being hit by these waves	H. How far did the target move?
1	20		
2	20		
3	20		
4	20		

2. Making sense of your data for investigation 2: Compare the distances the marker moved (shown in column H). What patterns do you notice?

Name: ______________________ Date: ______________

Energy Transfer Investigation Class Results

Group	Investigation 1: Frequency versus Energy			
	How far the target moved after 1 wave (cm)	How far the target moved after 2 waves (cm)	How far the target moved after 3 waves (cm)	How far the target moved after 4 waves (cm)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
Typical value for our class:				

Group	Investigation 2: Amplitude versus Energy			
	How far the target moved after 1 cm (cm)	How far the target moved after 2 cm (cm)	How far the target moved after 3 cm (cm)	How far the target moved after 4 cm (cm)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
Typical value for our class:				

Stop and jot in your notebook:

1. What patterns did you notice in how changing the amplitude of the vibration changed the amount of energy transferred?

2. What patterns did you notice in how changing the frequency of the vibration changed the amount of energy transferred?

3. Using the table and graphs of our data, which do you think transferred more energy: waves of bigger amplitude or waves of greater frequency? How did you arrive at your claim?

Name: ______________________ Date: ______________

Science Literacy Exercise Page 1 Use with Reading Collection 1

Roadmap for Reading

"Collection 1: Musical Instruments" consists of four selections.

1 Music Makers
2 Anatomy of an Acoustic Guitar
3 An Analysis of Resonance of Sitka Spruce (*Picea sitchensis*) from Graham Island, British Columbia
4 Vintage Vibes for Sale!

As you read:

- Consider the general purpose of each part:
  - Is it a description or definition of something?
  - Is it an explanation of how something works or why it is the way it is?
  - Is it a procedure, instructions, or steps in an event or process?
  - Is it an argument of a point or attempt to persuade?
- Consider how each part of the reading relates to knowledge you gained from the previous part.
- Consider what you can tell about the source of information, the writer.

Written Response

After completing this week's reading selections, produce a T-chart to compare and contrast the two advertisements on the "Vintage Vibes for Sale!" pages. Each column of the T-chart contains details for the same ad; each row of the T-chart contains a detail being compared or contrasted for the two ads. Set it up like this:

Diva Ad	Delphi Ad
Year of guitar, 1975 assumed based on some characteristics	Year of guitar, 1975 confirmed by serial number

- Record your chart on a separate sheet of paper; attach this page to the front of it when you turn it in.
- Base your analysis on what you've learned about acoustic guitars and what you can perceive or infer about the two guitars for sale and their sellers.
- Below the chart, determine which of the ads is more trustworthy. Identify the guitar that you think would be the best investment for a guitar player or collector, and summarize in a single sentence why you think so.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.

Evaluation Guidelines

Element	1	2	3	Feedback
Chart structure	Chart structure is unclear; is more like a list of observations of both ads.	Chart structure is generally functional, but direct comparisons or contrasts are hard to track.	Set up to compare and contrast the two ads and the products by similar or analogous features	
Chart details	Scant details are provided to help with analysis.	Lists details about ads, but points across rows are not clearly related in comparisons or contrasts.	Thorough gathering of details that show contrast between the two ads, as well as some similarities	
Conclusion	Concludes that the less-reputable seller and their suspicious ad is more trustworthy	Correctly identifies the guitar promoted in the more credible ad, but reasoning is missing or faulty	Identifies the guitar promoted in the more credible ad and supplies a thoughtfully reasoned explanation	

Additional Feedback Notes:

Name: ____________________ Date: ____________________

Roadmap for Reading

"Collection 2: Sounds in Nature" consists of five selections.

1 Sound in Air Versus Water
2 Whale Sounds
3 What Is *Loud*?
4 AMAZING Animal Sounds!
5 Noise Pollution

As you read:

- Consider the general purpose of each part:
    - Is it a description or definition of something?
    - Is it an explanation of how something works or why it is the way it is?
    - Is it a procedure, instructions, or steps in an event or process?
    - Is it an argument of a point or attempt to persuade?
- Consider how each part of the reading relates to knowledge you gained from the previous part.
- Consider what you can tell about the source of information, the writer.

Written Response

After completing this week's reading selections, produce an infographic to compare and contrast animal sounds. Think of an infographic as a small poster (the size of a sheet of notebook paper). It should include sketched pictures and blocks of text to add visual meaning on top of a chart or graph.

- Sketch your infographic on a separate sheet of paper; attach this page to the front of it when you turn it in.
- Your infographic should summarize the properties of sounds, including frequency and decibel ranges, that are produced by a few different animals.
- Be sure to show data related to different species and the sounds they emit on some kind of graph or other visual that displays one or more axes to show frequency and intensity of sounds. An important criterion for your work is that your visual arrangement of information logically relates to the data. Place the animals and data about their sounds in the appropriate places so the comparison and contrast of their sounds is supported visually.
- Focus on the animals that are described in the reading, not other animals you might know about or research on your own time. Don't worry about comparing underwater decibels with regular (in air) decibels in the visual.
- Somewhere on the infographic, include a few sentences to describe what might happen to one of the animals if the sound it emits is disrupted by noise pollution from human activities.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.

Evaluation Guidelines

Element	1	2	3	Feedback
Infographic structure	Infographic structure is incoherent.	Structure is somewhat clear but there is no rhyme or reason to the axes or scales applied.	Coherent structure with axes for loudness/intensity and frequency, and examples are placed at appropriate points.	
Infographic details	Just a few examples from the reading are included; details are inaccurate.	Some details from the reading are included, but more helpful details were available.	Most of the example organisms from the reading are featured, and the details are accurate.	
Noise pollution disruption statement, content	Example cited is not relevant, and connection with a threat of noise pollution is not explained.	Correct selection of an organism, but explanation of connection to a threat from noise pollution is unclear.	Correct selection of an organism whose communication would be disrupted by noise pollution; cause and effect are clearly described and logical.	
Grammar and mechanics	Six or more errors in punctuation, capitalization, and spelling	Three to five errors in punctuation, capitalization, and spelling	Fewer than three errors in punctuation, capitalization, and spelling	

Additional Feedback Notes:

Name: ______________________ Date: ______________________

Roadmap for Reading

This week's reading selection focuses on how sound travels through media. The articles include a number of data tables and graphics. The data reveal patterns in how sound waves transmit through matter according to various properties.

"Collection 3: Sound and Media" consists of five parts.

1. The Matter Matters
2. Breaking the Sound Barrier
3. The Acoustic Soundscape
4. Using Sound to Measure the World
5. Seismic Waves

As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, or an attempt to persuade?
- Consider how data and graphics support the narrative text and how narrative text clarifies the data and graphics.
- Consider how each part of the reading relates to knowledge you gained from the previous part.

Written Response

Your writing exercise is to complete a thoughtful paragraph that refers to patterns revealed in the selections' data and graphics.

- Compose your paragraph on a separate sheet of paper; attach this page to the front of it when you turn it in.
- Choose one of the following topic sentences.
  - *Density affects the transmission of sound waves through different media.*
  - *Soundscapes, both natural and designed, differ because sound waves bend or bounce back when they move through one medium and encounter another.*
  - *It's much more achievable to break the sound barrier high in the atmosphere than it is beneath the ocean's surface.*
  - *Knowing the speed at which sound waves travel through different media makes sound waves useful for measurement, imaging, and determining Earth's makeup beneath the surface.*
- Build on the topic sentence to complete a well-constructed paragraph. Use details from data and/or graphics in the reading selection in your paragraph's supporting sentences.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.

Evaluation Guidelines

Element	1	2	3	Feedback
Content	Inadequate summary of a pattern of sound wave transmission through media as set up by the topic sentence	Adequate completion of a structured paragraph about sound wave transmission in media but weak in alignment with the topic sentence	Thorough support of the topic sentence, citing specific, relevant details from the reading selection and summarizing key points from data tables and/or graphics	
Supporting sentences (details)	Incomplete sentences or details irrelevant to the paragraph topic	Complete sentences but too few, lacking in support from the reading, or unclear relationship with the topic sentence	At least six complete sentences, encompassing three major points from the reading that support the topic sentence	
Organization and transitions	Statements with little clear relationship to the topic sentence or each other	Key supporting details present but absent or choppy transitions	Ideas in an order that helps the topic make increasingly more sense	
Grammar and mechanics	Six or more errors in punctuation, capitalization, and spelling	Three to five errors in punctuation, capitalization, and spelling	Fewer than three errors in punctuation, capitalization, and spelling	

Additional Feedback Notes:

Name: ______________________ Date: ______________

Science Literacy Exercise Page 4 Use with Reading Collection 4

Roadmap for Reading

"Collection 4: Compression Waves" consists of five selections.

1 The Loudest Sound on Record
2 Compression Wave Action
3 Sound Waves Versus Shockwaves
4 Sound in 3-D
5 The Doppler Effect

As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, or an attempt to persuade?
- Consider how data and graphics support the narrative text and how narrative text clarifies the data and graphics.
- Consider how each part of the reading relates to knowledge you gained from the previous part.

Written Response

After completing this week's reading selections, produce illustrated summary notes that compare and contrast sound waves of different intensities and compare and contrast sound waves with shockwaves. Think of your illustrated summary notes as a small informational poster (the size of a sheet of notebook paper). Include blocks of text and sketched pictures to add visual meaning. Arrange elements being compared and contrasted on the page in a logical way.

- Sketch your summary notes on a separate sheet of paper; attach this page to the front of it when you turn it in.
- Your page should illustrate and summarize the similarities and differences between sound waves and shockwaves.
- Your page should also illustrate and summarize the similarities and differences between sound waves of different intensities.
- Be sure to label parts of the diagrams that you sketch.
- Write captions that express the contrasts and comparisons among the diagrams. Mentioning specific examples in your captions helps make them memorable.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.

Evaluation Guidelines

Element	1	2	3	Feedback
Summary notes structure	Summary notes don't have any organized structure.	Elements themselves are clear, but contrasts and comparisons are difficult to draw.	Elements are organized on the page in a way that makes it logical to compare and contrast them.	
Sketched elements	Sketches don't effectively model longitudinal waves.	Sketches fairly represent longitudinal waves, but comparisons and contrasts are difficult to make between them.	Sketches model sound waves of both high and low intensity and shockwaves of appropriately differentiated intensity.	
Text elements	Diagrams are lacking in discernible text explanations.	Present labels and captions are accurate but could use more detail for clarity.	Labels and captions concisely explain aspects of the sketched elements and make comparisons and contrasts between them clear.	
Ties to examples	Examples are not mentioned.	Examples are mentioned but do not improve the ability to understand the contrasts or comparisons among elements.	Examples make comparisons and contrasts among elements more understandable.	

Additional Feedback Notes:

Name: ______________________ Date: ______________________

Science Literacy Exercise Page 5 Use with Reading Collection 5

Roadmap for Reading

This week's reading collection focuses on how wind produces and interacts with sound. Three of the selections relate specifically to wind turbines.

"Collection 5: Air, Wind, and Sound" consists of five parts.

1. A Windy Vancouver Vacation
2. A Whisper or a Shriek?
3. Wind Turbines
4. A Survey of Wind Turbine Syndrome Victims
5. Wind Turbine Health Impact Study

As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, or an attempt to persuade?
- Consider how each part of the reading relates to knowledge you gained from the previous part.
- Consider how what you have learned about sound waves prepares you to interpret what you are reading.

Written Response

Your writing exercise is to script a mock social media post expressing a position about the hypothetical wind farm discussed in the reading selection. Compose your post as a thoughtful paragraph that provides reasoning and evidence.

- Compose your paragraph on a separate sheet of paper; attach this page to the front of it when you turn it in.
- Build on a topic sentence to complete a well-constructed paragraph. Use details from the reading selections in your paragraph's supporting sentences.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.

Evaluation Guidelines

Element	1	2	3	Feedback
Content	Inadequate support of a position using information from the reading	Adequate completion of a structured paragraph about sound and wind turbines but weak in alignment with the topic sentence or a position	Thorough support of the position declared in the topic sentence, citing specific, relevant details from the reading selection	
Supporting sentences (details)	Incomplete sentences or details irrelevant to the paragraph topic	Complete sentences but too few, lacking in support from the reading, or unclear relationship with the topic sentence	At least six complete sentences, encompassing three major points from the reading that support the topic sentence position	
Organization and transitions	Statements with little clear relationship to the topic sentence or each other	Key supporting details present but absent or choppy transitions	Ideas in an order that helps the topic make increasingly more sense	
Grammar and mechanics	Six or more errors in punctuation, capitalization, and spelling	Three to five errors in punctuation, capitalization, and spelling	Fewer than three errors in punctuation, capitalization, and spelling	

Additional Feedback Notes:

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