Name: ____ Period: _______ Date: ________

Lesson 1: What Phenomena Did We Notice and How Would We Explain It?

Purpose: Analyze data to describe the phenomena we notice coming from a needle on a disc.

Procedure:

- Your class will operate a device that will produce some interesting phenomena. Record what you observed when the circular disc of this device was spun around under the needle in the space below.

Observations:

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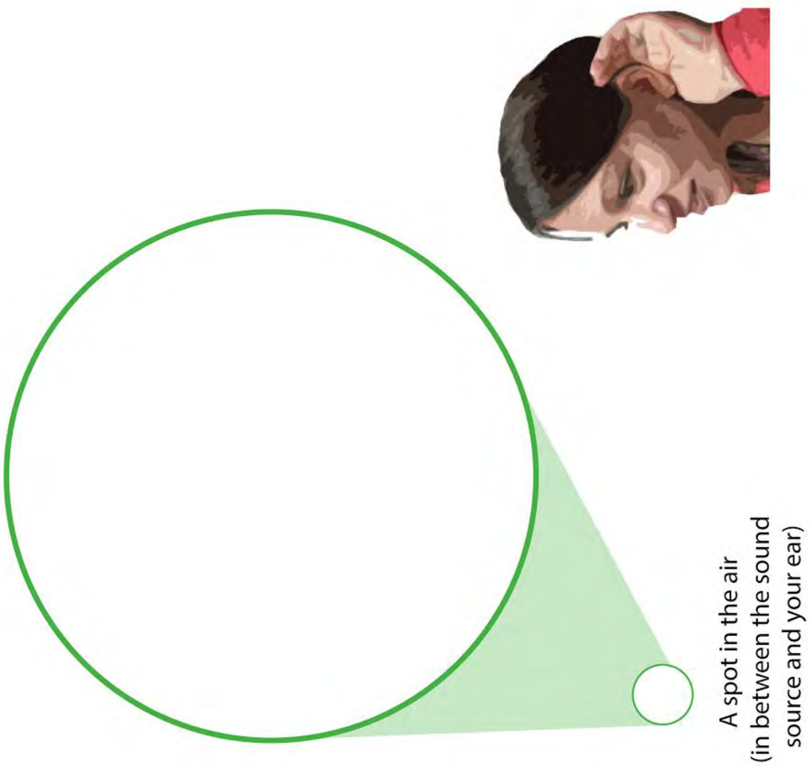
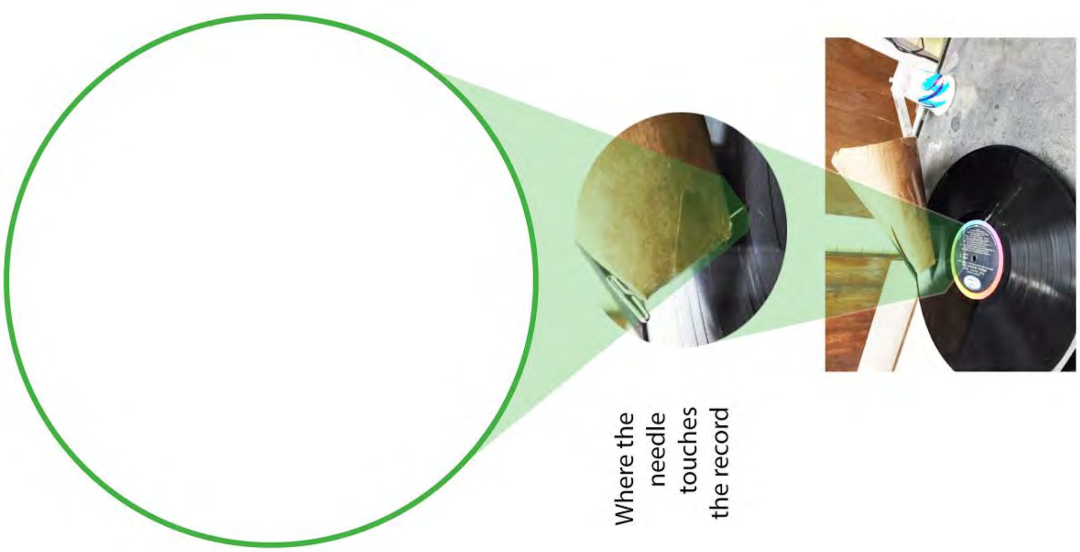
Making Sense: Draw and label a model to help you explain, "How were you able to hear the different sounds you heard from across the room?" Imagine you looked through a high powered microscope and could see stuff up close. Show a magnified view of very spot in each of these locations:

a) What would you see where the needle touched the record
b) What would you see in a spot in the air between the sound source and your ear





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1. What was similar and different between your model and your partner's model?

Similarities between our models	Differences between our models

Consensus Model:
Now, draw the consensus model the class decided on in class today to describe how we can hear the sound.

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Conclusions:

4. What did your class agree upon was needed in order to hear different sounds from across the room?

Next Steps:

5. Let's think more about some other times you have experienced hearing different sounds from a distance. Let's use these experiences, to try and generate a list of phenomena involving sound that we also want to try to explain in our unit.

6. What questions about sound do these experiences raise for you? List the questions you now have, on a sticky note, one per sticky note.

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Your class formed a driving question, “How Can I Hear So Many Different Sounds From Across The Room?

List or draw some ideas you have for possible investigations we could conduct, in order to help answer some of our questions we posted to the board. Keep track of the question that each investigation idea could help answer:

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Name: ______________________________________ Period: _______ Date: ________

Lesson 2: What Does The Record Look Like Up Close?

Purpose: Analyze data to help us figure out what causes the sound from the record and needle.

Part 1

Procedure: Record your observations for each of the data source in the space below.

Data Source	Observations
A) The surface of a record under a magnifying glass.	
B) A video of a needle on a record player as it plays a 3 minute song.	

Making Sense for Part 1:

Share your ideas with a partner: How might what you observed about the surface of the record be related to the sounds that it makes when spun?

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Part 2

Procedure: Record your observations for each of the phenomena below.

Data Source	Observations
C) A photo of the surface of the record from under a microscope	
D) A slow motion video of a needle moving along the surface of the record as it is spun.	

Making Sense for Part 2:

How might what you observed about the surface of the record be related to the sounds that it makes when spun?

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Conclusions: What ideas did the class come up with for what might be causing the record and the needle to make different sounds as it is spun?

Next Steps….

What are new questions does this raise for your class to investigate?

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Name: ____ Period: _______ Date: ________

Lesson 3: What Can I Observe Other Objects Doing When They Are Making Sounds?

Purpose: Analyze data from observations of other objects when they are making sounds to describe patterns between what you feel and what you see.

Predict: What causes a drum, guitar string, or a xylophone to make a sound?

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Observations

Data Source	Observations
A) Touching the instruments after or as they were making a sound.	
B) Slow motion videos of instruments after being played or strings plucked.	

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Making Sense: Discuss with a partner: How is what you observed with your fingers related to what you observed with your eyes (in slow motion)? How is it related to what you heard?

Part 1: Conclusions - as a class:

- How did your class decide to represent what was happening to in one of the instruments over time? Show your class model in the space below:

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Part 2: Conclusions - continued:

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Next Steps…..

- Is everything your explanation for what is causing the instruments to make sounds also the explanation for what happens when anything makes a sound?

- How could we investigate this question further?

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Name: ____ Period: _______ Date: _______

Lesson 4: What do we need to figure out next?

Our Next Question:
What new question is your class investigating?

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Predict:
What is your prediction in answer to this question? Why?

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Procedure:

- Observe the setup that your class built with your teacher.
- Discuss with a partner: How will the setup that your class built, help you investigate this question?
- Record your observations from the experiment below.

Observations:

Object	What happens when it is struck softly?	What happens when it is struck harder?

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Making Sense: Make a claim based on the results of this investigation to answer the question that your class wrote above.

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Conclusions: What discoveries did your class make about what happens to any object when it becomes a sound source?

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How could we use these discoveries to help explain: **"Why does the needle makes sounds when it touches the record as it spins underneath it?"** Construct an outline of an explanation together as a class.

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Name: ____ Period: _______ Date: ________

Lesson 5: How do the vibrations of the sound source compare for louder vs. softer sounds?

Purpose: Analyze data and use mathematical thinking to determine how the vibrations of the sound source change when it is struck or plucked to make a loud vs. a soft sound.

Planning Our Investigation:

Describe some of the ways that the behavior of the long wooden stick would be similar to a guitar string or tuning fork when you strike it or pluck it (push or pull on it and release it)?

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How could studying the vibrations in a larger scale object, like the wooden stick, help us understand the vibrations occurring in smaller scale objects like a tuning fork or a record needle?

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Procedure:

The range finder probe can detect and record the distance from an object to the probe many times a second. Describe how the graph changed during the demonstration.

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When the wooden rod is at rest, how far is it from the detector? ____________________

What was the shape of the graph when the wooden rod is at rest?

____

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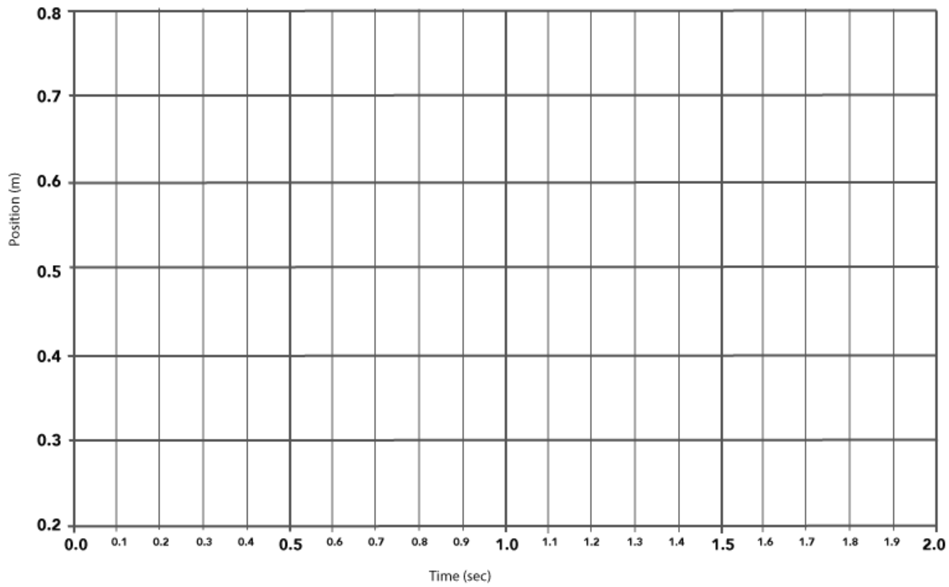
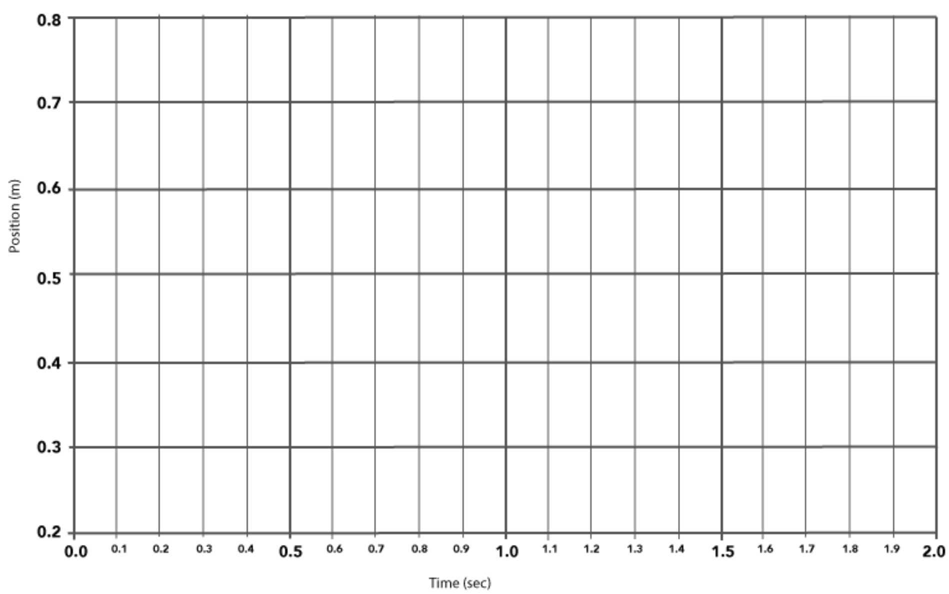
Predict: First draw in the straight line showing the position of the wooden rod when is at rest, in both graphs. Then use a different color pen or pencil to sketch your prediction of what the the shape of the graph would look like after pulling back the end the wooden rod and releasing it for both conditions after if you pulled back the wooden rooden a small amount and released it, or if it was struck softly.

Condition 1: ______________________________________



What do you predict the graph would look like if pulled the wooden rod back further (or struck it harder)?

Condition 2: ______________________________________



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Procedure: As a class collect data and generate graphs to observe and analyze for the two conditions.

Observations:

Graph 1:	Graph 2:

Making Sense

- What patterns did you notice between both graphs?

Conclusions

- How does what we see in the graphs, help us answer our original question, "How do the vibrations of the sound source compare for louder and softer sounds?"

- What new questions did these discoveries raise for your class? What new ideas do you have for what we should investigate next time?

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Lesson 6: What's different about the vibrations produced from sound sources producing different pitch notes?

Brainstorm: What are some types musical instruments that we could look at more closely to see how they make different pitch sounds?

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Procedure: Record you observations of the devices as they make different pitch sounds.

Observations

Device A:	Device B:	Device C:

Making Sense:
What patterns did you notice between how the instrument(s) you observed in class and the music box make different pitched sounds?

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Do you think there was any differences in the vibrations that were being made as different notes were being produced by the music box? Explain

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Next Steps: What would we need to change about the rod we used in the last investigation, if we wanted to (re)use it to represent the different structures that were producing different notes in the music box?

____

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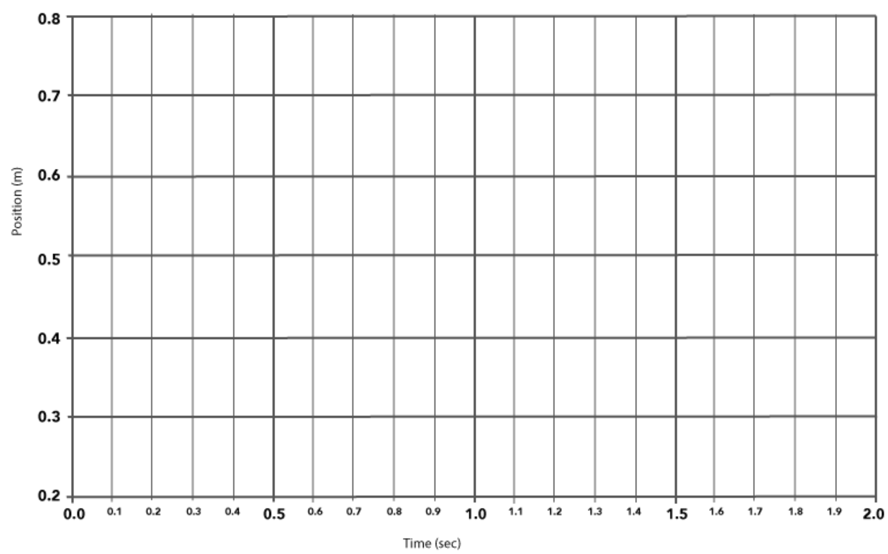
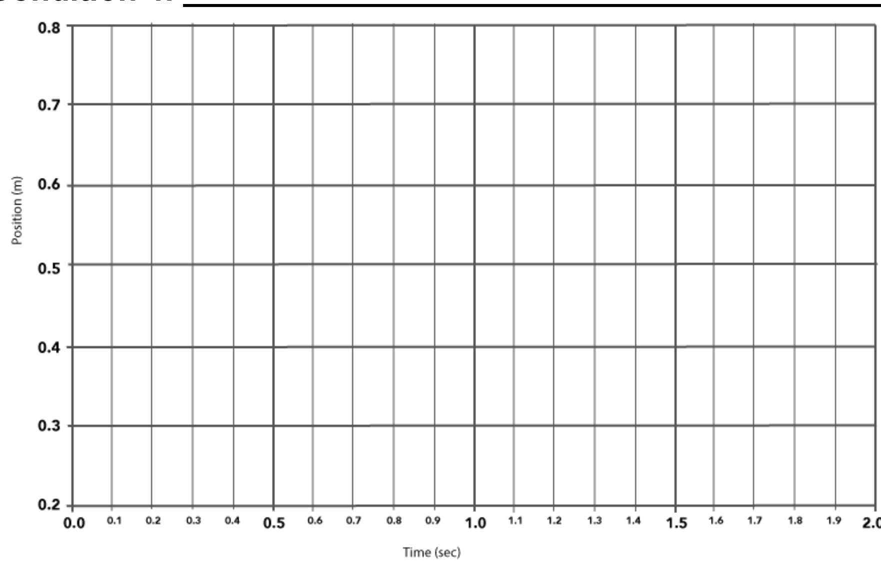
Predict: What do you predict the graph of the vibrations of the end of the rod will look like for these two different conditions you class wanted to test?

Condition 3: ____



Condition 4: ____



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Observations:

Graph 3:	Graph 4:

Making Sense - of Lesson 3b

- What patterns did you notice between both of graphs?

Making Sense - of the results from this lesson and the last lesson.

- How were the vibrations changing between these two conditions (3 & 4)?

- How were the vibrations changing between the two conditions from the previous lesson (1 & 2)?

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Conclusions

- What discoveries did your class make?

Next Steps

- Now that you have made these discoveries, how might they help you answer the question, “how does a sound get from a sound source to my ear?”

- How might we go about investigating this question or testing different ideas related to how that might work?

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Name: ______________________ **Period: ______ Date: ________**

Checkpoint

Using what you saw in the video, and what we've learned so far about sound, answer the questions below:

1. **What is the sound source in this phenomena?**

2. **If you could zoom into the sound source, what would you expect to see it doing anytime it produced a sound?**

3. **If you could zoom into the sound source, what would you see it doing differently when it produced a louder sound?**

4. **What would you see the sound source doing as it produced higher pitched sounds/notes?**

5. **What would you see the sound source doing as it played lower pitched sounds/notes?**

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Lesson 8a: How can one object (a stereo speaker) make all these different sounds anyway?

Q1: Describe the motion you noticed in the slow motion videos of the stereo speaker:

Video 1:	**Video 2:**

Q2: How does these observations provide evidence that a speaker can be made to vibrate lots of different ways to produce lots of different kinds of sounds?

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Q3: What do you think is making the speaker vibrate in these different ways?

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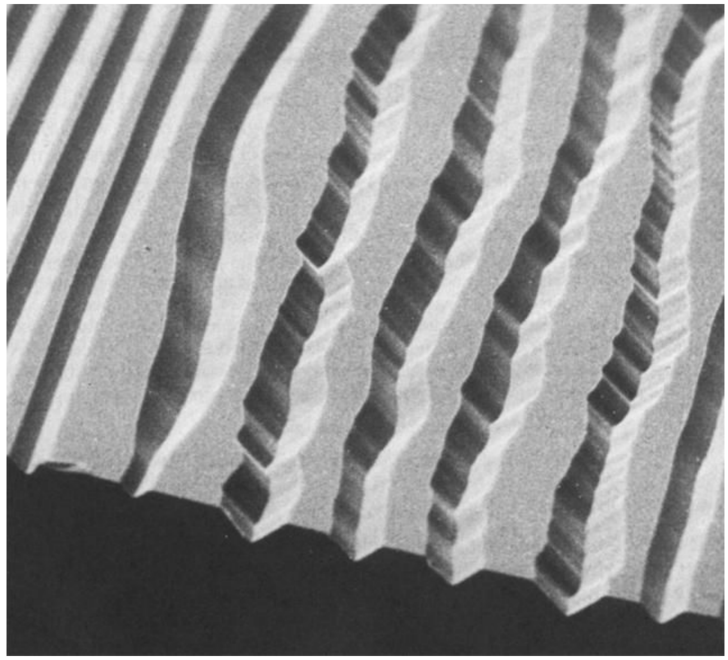
Q4: Analyze the image of the grooves on this record. Use a highlighter or marker to indicate the following.



- **No Sound (NS):** highlight and label (as NS) the part(s) of the record where it appears no sound would be produced
- **Loud Sounds (LS):** highlight and label (as LS) the part(s) of the record where a really loud sound is produced
- **Lower Pitch (LP)** highlight and label (as LP) the part(s) of the record where it appears a low pitch notes or sound would be produced.
- **Higher Pitch (HP)** highlight and label (as HP) the part(s) of the record where it appears a high pitch notes or sound would be produced.

Q5: How does the structure of the record, force the needle to produce sounds of different loudness and different pitches as the record is spun under it?

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Q6: What should happen to the pitch of the sounds produced if you spun the record faster?

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Next Steps: Q7: What new questions do you have now about the speaker or the record?

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Lesson 8b: What makes a speaker vibrate and produce sound?

Planning your investigation: What are the three main parts of the speaker you will be putting together to try to build a functioning speaker?

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The directions you will follow will show you how to attach the coil of wire to a plastic cups.   But you can also try attaching it to other objects too, and see if they make sounds too.

In step 1 you can glue the coils of the wire to a different material, or different shaped object.

Work with a group to plan on trying at least two different objects to try to attach the coil of wires to test if the object vibrates and produces sounds.

1. Hot glue the coils of electromagnet wire to the surface of the object you want to make vibrate

3. Bring a strong magnet close to the center of the wire coils. You should hear the song coming from the surface of the object. You may need to get closer to the object and/or hold it to your ear.

2. Hook each end of the wire coil to the two ends of a stripped aux. audio cord; you may want to use alligator clips to attach it together. Plug the aux. cord into an electronic device that is playing music.

What is the 1st object your group wants to try to attach the coils of wire to?	What is the 2nd object your group wants to try to attach the coils of wire to?

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Now that you know what the 3 main parts of a speaker's are, you will need to follow a more detailed procedure to build your 1st speaker.

Work in teams of 4-5 people. Have one pair of students try your 1st object (in place of the plastic cup shown above), and have the other pair of students try your 2nd object. Each pair students should try to build their own speaker, so that the group can compare results from both objects they tested.

Materials needed

For plugging into a headphone jack on a computer or phone

A. Aux. cord with one end cut off and the end of the wires exposed

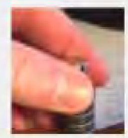
For connecting the aux. cord to the speaker

B. Two alligator clips

For building the speaker

C. A 30 to 40 ft. piece of electromagnet wire coiled in loops, with both ends stripped.

D. A strong magnet that is smaller than the diameter of the loops in the coils of the wire shown above.



E. Any object that you want to try to make vibrate (and turn into a speaker).

F. A glue gun

G.You also will need an electronic music device (computer, tablet, smartphone) to hook this all up to, to test it.

In step 1

Use a hot glue Gun to attach the coils of wire to the object you want to try to make vibrate. You can peel the glue off and try a different object with the same coil of wire later.

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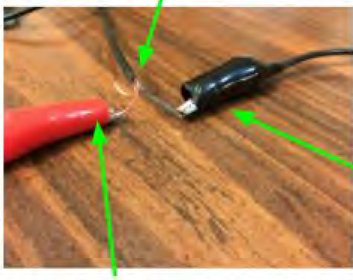
Keep a gap between these
The 2 different wires to prevent a short circuit.

In step 2



B. Clip the other alligator clip to the copper end of the black wire on the aux. cord.

A. Clip one the alligator clips to the copper end of the red wire on the aux. Cord.

C. Clip the other ends of the alligator clips to the copper ends of your coil of speaker wire (which will be glued onto the object that you want to make vibrate)

D. Start a song playing on your electronic device with the volume turned up. Plug in the aux cord to it. The sound will go away for now.

E. Make sure the black and red wires aren't touching (this would cause a short circuit) and the electricity won't flow through the coil.

Step 3

A. Bring one or more magnets close to the center of the coils of the wire. Listen closely. Bring the object that has the coil on it close to your ear. You should hear music coming from it! You should also be able to feel it vibrating!

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Observations: After you have assembled and tested it, record observations you notice in the space below about how each object you tested functions.

	1st object tested	2nd object tested
Describe the object you tested. You can include a sketch and labels too if you wish.		
Did it vibrate?		
Did it produce sound?		
If both produced sound, how did the sound produced from the two objects compare? Was there any differences in sound quality?		

Brainstorming new ideas: Q1: Why would attaching ends of the coil of wire in your device, to wires coming out of an electronic device like a smartphone or a computer get it play songs?

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Q2: How is the music in an electronic devices like smartphones or computer stored inside of it so that it can play it back later?

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Name: ________________________________ Period: ____________

Reading 8b: How do speakers work?

What parts make up an electric speaker?

You built an electric speaker in class. The diagram below shows a cutaway of another electric speaker.   Compare the structures you noticed in class to those shown in the diagram below.

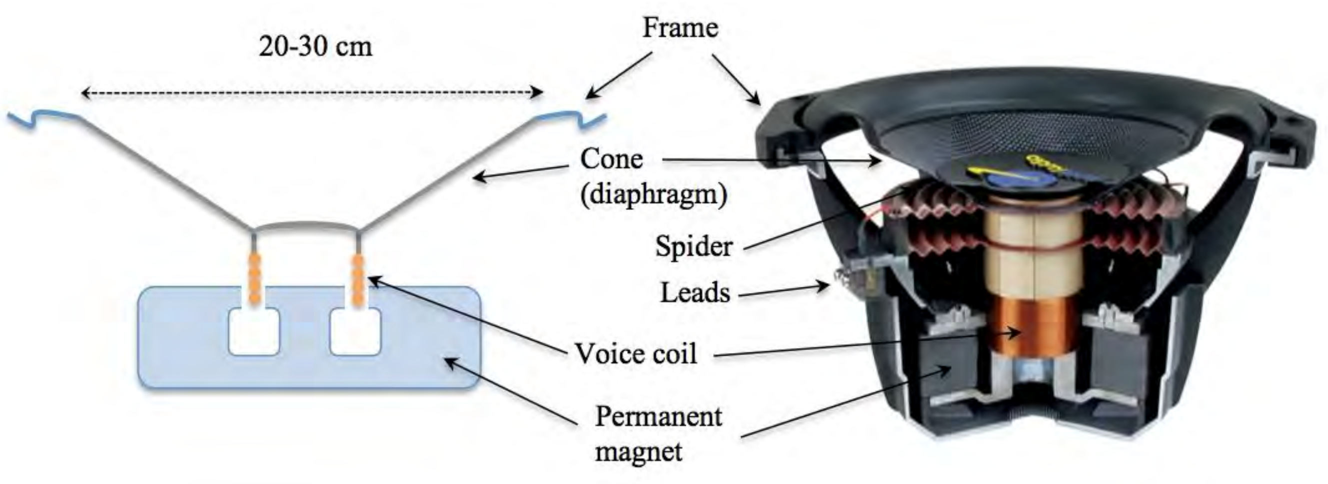

Image is from soundphysics.ius.edu/wp-content/uploads/2014/01/speaker1.jpg

Q1 What structures do you see in the diagram above that are similar to the ones in the speaker you built?

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You may have noticed some different structures in this diagram compared to the speaker you built.   For example the **leads** shown in the diagram are the locations where you would clip the wires from the electronic music player to the speaker.   And the **spider** is a structure made of material like paper, that is often folded to make a flexible lightweight spring for the top of the speaker so it can move up and down more easily.

How does the wire coil interact with the magnet?

The more electrical energy sent through the coil, the stronger the magnetic force that is produced.   By changing the amount of electrical energy sent through the wire coil over, the push and pull from the coil on the magnet also changes over time.

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In a electric speaker, the different pushes back and forth on the cone are due to changes in the force between the magnet and the coil over time. And this changing force is due to a changing amount of electricity sent through the wire.

Q2 How is this similar to how the record causes the needle to move back and forth?

Q3 How is this different?

How does an electronic device know how to produce different sounds?

If an electronic device always sent the same amount of electricity through the wire, the coil of the wire would always pull on the magnet with the same strength. This would be like pulling on a guitar string or pushing on a needle and not letting go. In all these case, no sound would be produced.

In order to produce different sounds, the pull between the magnet and the coil must change over time. To make this happen, the amount electrical energy sent through the wire must change over time.

In an electronic device, the information about how much electrical energy to send through the speaker wires is stored in a **digital file** within the device. That file, stores that information as a series of numbers.

You looked at the type of data that motion detector records too. That is also a digital file.

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Let’s think back to the numbers in the table that you looked at in your Lesson 5 Home-learning assignment again.

Those numbers were the time and position of the stick end from that the detector **recorded**.

Now let’s imagine that those same numbers were used to provide information that described how much to move the stick back and forth at different times.

That is what a digital electronic device does when it produces sounds from a digital sound file. It uses the numbers in the file as information that tell it how much to move the speaker (not the stick) back and forth at different times.

It uses these numbers to send different amounts of electricity through the wire at different points in time. This creates a different amount of magnetic push or pull, which moves the speaker cone back and forth so that it vibrates at different frequencies and different amplitudes to produce different sounds.

While the table to the left has only 25 samples recorded in it per second, most digital sound files have 44,100 samples of information recorded in it for every second of sound recorded in the file.

	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

Digital music files didn’t become a popular way to record, copy, and play back music until people started using computers to store and exchange music files. And this didn’t become common until around 1998 to 2001.   By 2001, the cost of hard drive storage space had dropped to a level that allowed pocket-sized computers (like ipods, smartphones, and tablets) to store large libraries of music for relatively little cost. At that point, because using computers allow people to easily copy files and share information over the internet, digital files became the way that most people began to record, store, and share music.

Q4 Before hard drives on computers and the internet were used to store, share, and play back songs and audio recordings, what are some other technologies that you think people might have used?

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Lesson 9: What else can happen when a sound sources produces different sounds?

Background: Let's revisit the video of the truck playing the music from their stereo. This time you will observe a longer video clip from the same event. The camera will pan away from the truck in the later part of the video.

Observations

1. Record your observations in the space below, describing any new phenomena you notice

2. Let's revisit our models from Lesson 1. **"How is it possible that a wiggle/vibration at the sound source could be causing this to happen in the building across from the truck?"** How do the models between your classmates compare?

Similarities in the models	Differences in the models

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Conclusions

3. What did your class agree upon must be happening?

Next Steps

4. What new questions did this raise?

5. How might we go about investigating what is happening in the air between the sound source and the window or the sound source and our ear?

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Lesson 10 and 11- Student Activity Sheets: Our Investigations

What are we wondering?	How will we test it?	What did we figure out from how we tested it?
1.		
2.		

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3.		
4.		
5.		

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Q1. Argue from Evidence: How do the results of these investigations help us understand more about how sound travels from the sound source to the sound detector?

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Q2. Our Revised Model: Draw a revised class model, summarizing what you know about how sound travels from a sound source to your ear, based on your observations today.

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Lesson 12- Part 1: Student Activity Sheets

Brainstorm: What did you hear your classmates say is similar about the three states of matter: solids, liquids, and gasses?

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Model: In the space below, work with your team to develop a model of the state of matter that your teacher has assigned you.

State of Matter:	State of Matter:
Our Model:	Our Model:

Model: Now that you've compared your model to your teammates, what should similar and different between representing different states of matter, such as solid water (ice), liquid water, and water vapor (gas state).

Representing two different states of matter using two different models?	What should included in both models?	What should be different in both models?
Gas vs. a liquid		
Gas vs. a solid		

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Home Learning: We know that somehow the sound is moving across the matter. We know from our modeling that matter is made of small particles, and we have a pretty good idea of what that looks like. What we still don't know is how the sound is actually moving across the matter. To prepare for tomorrow's lesson, re-draw one of your team's models of a state of matter below. Then **add sound to your model to show how you think sound moves across the matter shown in your model.** We will share our ideas tomorrow in class.

State of Matter:
My model showing how sound travels across this medium:

Making Sense:
How did you choose to show the sound in your model? Why did you choose to show it that way?

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What do you think might be a limitation of your model (something that your model might be missing)?

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Lesson 12 - Part 1: Student Activity Sheets

Class Model #1: Now that we've had a chance to model how we think sound moves in class, model what that looks like in the space below.

State of Matter:
My Updated Model with Sound:

What was the limitation of this model that we discussed? ______________________________

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Class Model #2: Now that we've tried another way of representing how the sound moves, model that in the space below.

State of Matter:
My Updated Model with Sound:

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What are the advantages of this model over the previous one ?________________________

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Conclusions: Today we modeled what the system looks like with air particles in it, would we see similar interactions between particles if we simulated sound traveling through a liquid? Or a solid? How would those compare?

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How does this model help us understand why we couldn't hear any sound when we sucked the air out of the system?

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Next Steps: Scientists often build computer simulations to help investigate and visualize systems that have parts (or particles) in them that are too small to see. Computer simulations are programmed to have the objects, interactions, and visualization tools that the user wants or needs. Think about what you would want to see included in such computer simulation that would help you understand more how across sound travels across a medium.

- What sort of things would you want to be able to adjust about the sound source in that simulation?

- What sort of particle interactions would you need included in the simulation?

- What sort of things would you want to be able to visualize?

- How might running a computer simulation that includes all the things you listed above help us better understand what exactly is traveling across the medium, when a sound moves from sound source to my ear or from a truck stereo to a window in a building across the parking lot?

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Name: ____ Period: _______ Date: ________

Lesson 13: What exactly is traveling across the medium?

Purpose: Use a computational model to conduct an investigation to determine what exactly is traveling across the medium.

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

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

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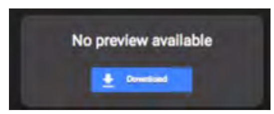
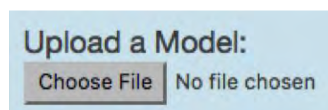
Procedure for loading the model:

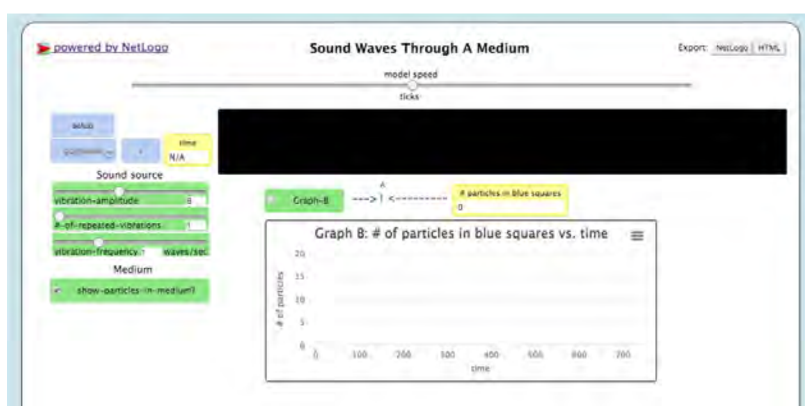
1. **Type this url into chrome:** http://goo.gl/mTPUZp
2. **Press Download on this blue button shown here:---------->**



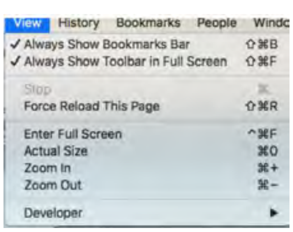
3. **You may be prompted to save the file to your google drive or to your desktop (it may automatically save to your downloads folder or your google drive). Keep track of where the model is saved**
4. **Type this url into chrome: http://www.netlogoweb.org/launch**
5. **Click on this Choose File button:------------------------------------>**



6. **This will allow you upload a file from your computer. Select the Sound Waves Through A Medium.nlogo file from wherever it was saved to in step 3.**
7. **This is what you should see:------>**



8. **You may have to zoom out to get it all to fit on your screen. Use this menu to zoom in and out:**



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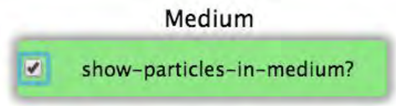
Procedure for Part A :

1. Switch SHOW-PARTICLES-IN-MEDIUM to “on”



2. Press the SETUP button to initialize the model ----------->

3. Then press GO/PAUSE to run the model ----------->

4. Pay attention to the motion of a single green particle in the medium.
5. Pause the model by pressing the GO/PAUSE button again.
6. Repeat the last 4 steps.
7. Record your observations on the next page

Observations (from 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?

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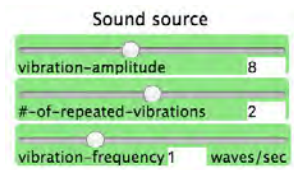
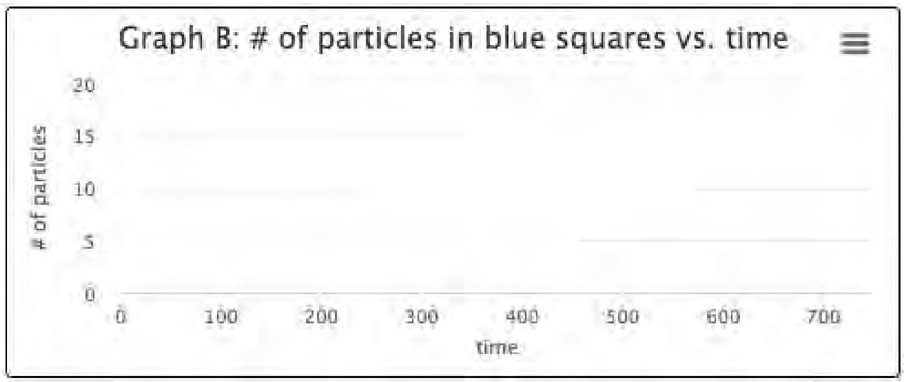
Investigation 2: How will the concentration of particles at a spot in space change over time?

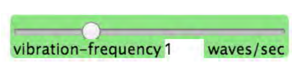
Predict. What pattern will you see in the number of particles at a spot in space (the blue detector) over time? For these slider settings. Sketch your prediction. The simulation always starts with 9 particles at each detector (see image to the right)



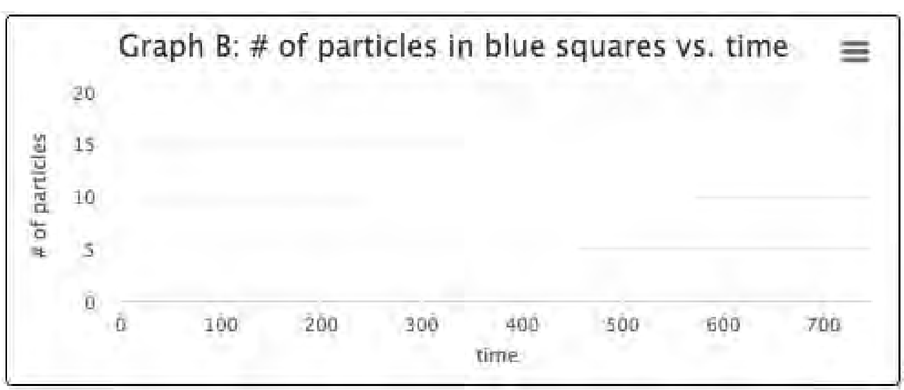


Design an investigation for Part B

In addition to the values assigned to the sliders shown above, what new values for these sliders do you want to test?

Sliders	What value do you want to set these to?
	
	
	

Predict. For these adjusted slider values, what pattern do expect you will see in the number of particles at a spot in space (the blue detector) over time? Sketch your prediction. The simulation always starts with 9 particles at each detector



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Procedure

1. Turn the GRAPH B switch on: 

2. Press the SETUP button to initialize the model -----------> 

3. Then press GO/PAUSE to run the model - ----------> 

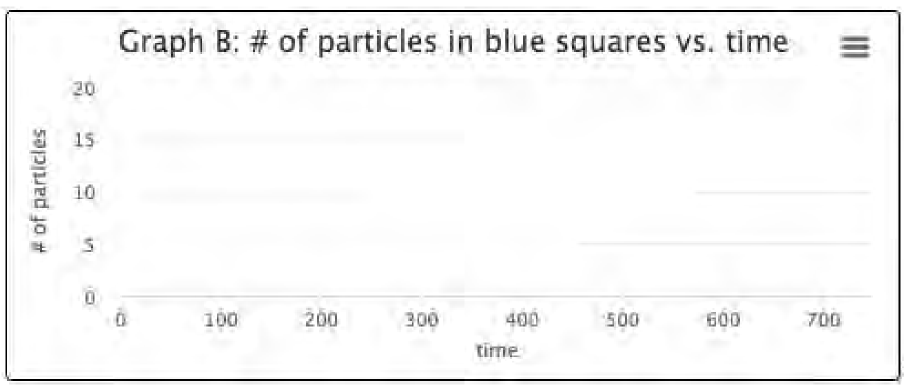
4. Record a sketch of the graph in the space for the 1st graph below

5. Repeat steps 1-4, but change the slider values in step 2, to the values you wanted to test from the previous page.

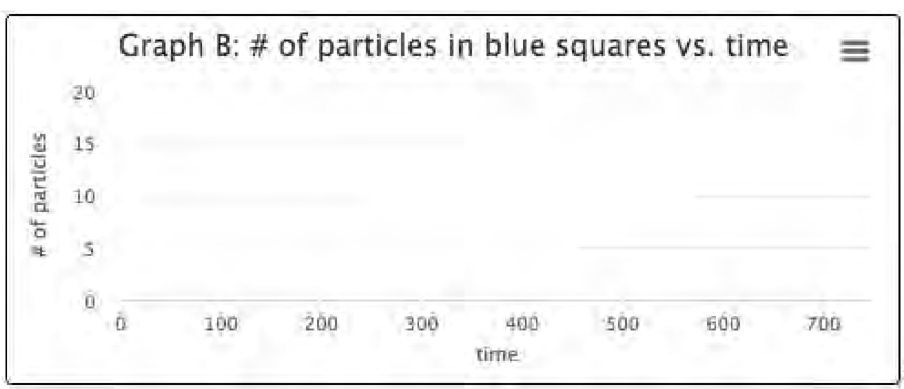
6. Record a sketch of the new graph in the space for the 2nd graph below

Observations (from Investigation 1)

1st graph



2nd graph



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7. How do all the observations from the last two investigations help you explain what exactly is moving across the medium?

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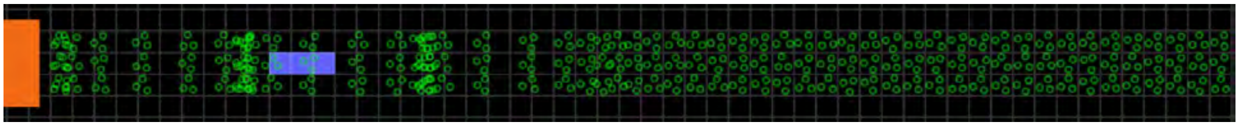
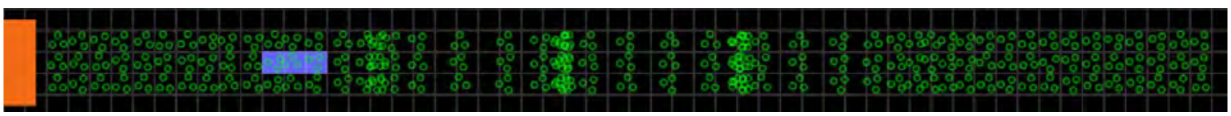
Conclusions As a class construct a simplified model showing how particle density changes across the medium as a sound travels through it.

Frame 1



Frame 2



Frame 3

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Getting Ready to Apply and Assess Your Understanding How could you use the model on the previous page to explain how you heard the sound of the two ball bearings colliding together through the water of the fish tank? Include the following in your explanation: vibrations of the source source, collisions between water particles, energy transfer, and changes in that happen in particle density across the medium.

How could you use a similar model to explain why when a stereo speaker in a truck produces sounds it can cause the window across the parking lot to shake?

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Lesson 14- Check point

Reviewing the phenomena: In an earlier video you saw that when the truck stereo played music at a certain pitch and at a really loud volume, the windows in a building across the parking lot began to shake.

Q1 Explain: As the speaker vibrates, what does it do the particles in the air surrounding it?

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Q2 Explain and model: What is happening to the particles in the medium, that would would explain, How does this end up causing the window to vibrate across the parking lot? Provide a model with labels to support your thinking.

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Q3 Explain: What would be different about your model of the particles in the medium for a loud vs. sound sound traveling through it?

Q4 Explain: Why is matter needed to transmit sound from the sound source to the window?

Q5 Explain: If you could see the motion of air particles surrounding the window, how would they be moving, when they are making the window move?

Q6 Explain: What is making the stereo speaker move back and forth in the first place?

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