UNIT STORYLINE

How can a sound make something move?

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it

LESSON 1

3 days

How does a sound source make something like this happen?

Anchoring Phenomenon

Phenomena or Design Problem

Loud music from a truck makes a window in the parking lot move. A speaker moved when it produced sound.

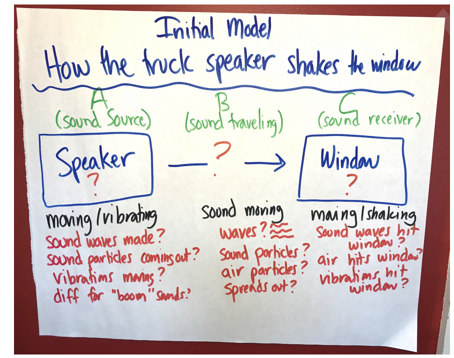
What we do and figure out

We observe a perplexing phenomenon: Sound from a truck appears to make a window move from the parking lot. We note observations of this phenomenon as well as of a speaker in the classroom. Our observations, models, and other sound-related phenomena lead us to add a broad set of questions about sound to our DQB and to list ideas for investigations to pursue.

We figure out these concepts:

- A speaker making sounds can be detected from a distance and can even cause things like a nearby window to move.
- The speaker moves back and forth when it is making sound.
- Students agree that the sound source, how sound travels, and how sounds are received are important parts of explaining how sounds can make things move.

How we represent it



⇓ **Navigation to Next Lesson:** After seeing how the speaker moves when it makes sounds, we wonder if other sound-makers show similar patterns. We decide to bring in other sound-makers to look for patterns in what each does when making sounds.

LESSON 2

2 days

What is happening when speakers and other music makers make sounds?

Investigation

Phenomena or Design Problem

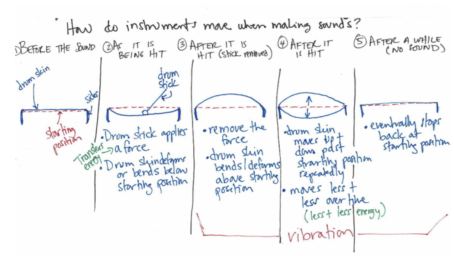
Musical instruments and speakers vibrate (move back and forth) when a force is applied.

What we do and figure out

When an instrument vibrates (makes sounds) it includes the following actions:

- A force is applied to a part of an object; that part bends or deforms and changes shape. Energy is transferred to the object.
- When the force is removed, that part of the object springs back and overshoots its starting position.
- That part of the object then repeatedly bends back and forth for a bit (we call this vibration) before stopping. When it stops vibrating, it stops making sounds

How we represent it



⇓ **Navigation to Next Lesson:** We figured out that instruments and speakers are vibrating (bending back and forth). This made us wonder whether all objects, even something solid like a table, are bending back and forth (vibrating) when they make sounds.

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<tr><th>Lesson Question</th><th>Phenomena or Design Problem</th><th>What we do and figure out</th><th>How we represent it</th></tr>
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LESSON 3

2 days

Do all objects vibrate when they make sounds?

Problematizing, Investigation

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A laser directed at a mirror on a drum, table, and speaker lets us better see the vibrations that happen when those objects make sounds.

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<td>All objects move back and forth (vibrate) when making sounds. Objects vibrate further back and forth (deform more) when a greater force is applied, creating louder sounds.</td>
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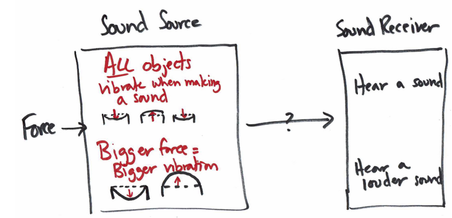

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<tr><td colspan="4">⇓ Navigation to Next Lesson: What do we mean by “more” vibrations? Is there a way we can more clearly see how a solid object vibrates more?</td></tr>
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LESSON 4

2 days

How do the vibrations of the sound source compare for louder versus softer sounds?

Investigation

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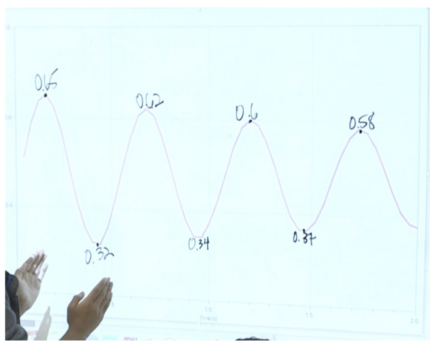

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<td>We deform (push) a stick to represent how sound makers move differently for louder or softer sounds. We notice that motion graphs of louder sounds have higher amplitude, and softer sounds have lower amplitude, but the number of vibrations of the stick per second (we called this frequency) didn’t change whether we deformed the stick more or less.</td>
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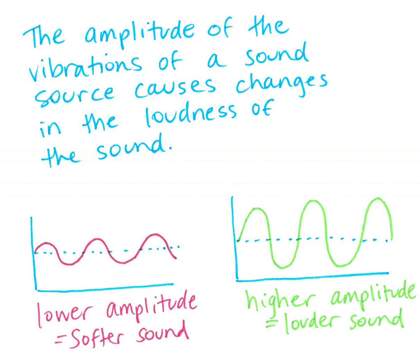

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<tr><td colspan="4">⇓ Navigation to Next Lesson: We know that pitch is another way sounds are different, and musical instruments have shorter or longer parts that create different pitches, so now we want to make our stick longer or shorter to see how it moves differently to make those different sounds.</td></tr>
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<tr><th>Lesson Question</th><th>Phenomena or Design Problem</th><th>What we do and figure out</th><th>How we represent it</th></tr>
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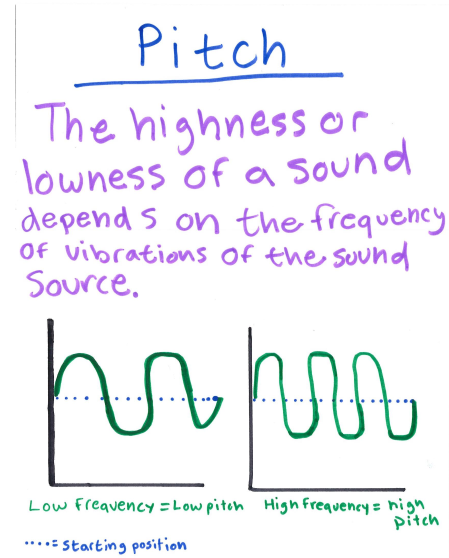
<td>LESSON 5
1 day
How do the vibrations from a sound source compare for higher-pitch versus lower-pitch sounds?
Investigation</td>
<td>
A shorter stick vibrates faster than the longer stick, and the graph of the motion of the speaker also shows faster vibrations for higher pitch.</td>
<td>We use mathematical representations of Position versus Time graphs generated from a tool used to scale up the vibrations of an object to describe wave patterns and support scientific conclusions about how objects move when they make higher-pitch and lower-pitch sounds. We figure out these ideas:
Shorter-length bars produce higher-pitch sounds when struck.
Shorter-length bars vibrate more frequently than longer-length bars when struck.
Sound sources that produce higher-pitch notes vibrate more frequently.</td>
<td>
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⇓ **Navigation to Next Lesson:** We figured out that a shorter stick vibrates faster than a longer one and the speaker vibrates faster for higher-pitch sounds. This made us wonder if we can put our ideas about frequency and amplitude together to see if we can explain how any object can make so many different sounds.

<table>
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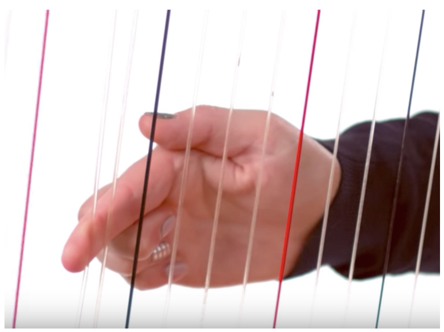
<td>LESSON 6
2 days
How can any object make so many different sounds?
Putting Pieces Together</td>
<td>
A video and graphs of the motion of a harp making sounds are used to model and argue for the different sounds being made.</td>
<td>We apply our understanding to explain different sounds coming from different objects, complete a summative mid-unit assessment, and return to our DQB.</td>
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⇓ **Navigation to Next Lesson:** We have answered many of our questions about what is happening at the sound source when it makes different sounds, but we still have many questions about how that sound is actually traveling and what happens at the receiver.

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LESSON 7

1 day

What is actually moving from the sound source to the window?

Problematizing, Investigation

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By placing a sound maker in a sealed container, we observe that we can still hear sounds coming from inside and that the mass of the container does not change before and after sounds are played.

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We test the idea that the air from the sound source is traveling to the window or our ears by placing a sound source in an airtight container and testing whether we can still hear it. We also record the mass of the container before and after the sound is produced. We use the understandings we gain from these investigations to revisit our initial models to analyze our earlier claims for what's traveling between the speaker and the window in the anchoring video.

We figure out these ideas:

- Air that is near the sound source is not moving all the way from the sound source to our ears (or window) when sounds are produced.
- We still aren't sure what is moving between the sound source and our ears, but our evidence suggests that nothing made of matter is traveling between these two points.

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⇓ **Navigation to Next Lesson:** After seeing evidence that air doesn't move from the sound source to the receiver, we wonder if air is even necessary for sound to travel.

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LESSON 8

1 day

Do we need air to hear sound?

Investigation

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When a sound source is placed in a solid container with liquid or gas inside, we hear sounds coming from inside. When it is placed in a container with no matter inside, we do not hear any sounds coming from inside.

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We test, through two investigations, whether air is even needed to hear sound. One investigation provides evidence that sound moves through any type of matter, while the other investigation provides evidence that sound can't move across empty space that has no matter in it (a vacuum).

Sound can travel through all different kinds of matter (solids, liquids, and gasses), not just air. Sound cannot travel through an empty space with no matter; sound needs matter to travel.

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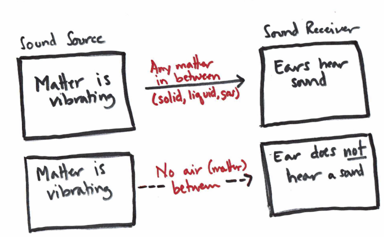

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⇓ **Navigation to Next Lesson:** We know that sound needs matter to travel, but we don't know yet how to represent sound going through matter. We decide we need to make models to see how matter allows sounds to travel to our ears.

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Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it

LESSON 9

1 day

How can we model sound traveling through a solid, liquid, or gas?

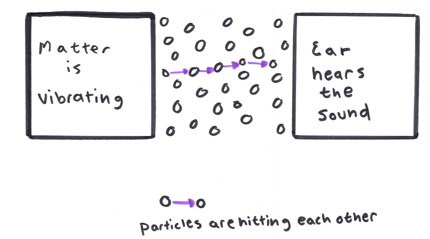
Investigation

We use our bodies to simulate a sound source hitting a particle, causing it to collide into the particle next to it, transferring energy to the next particle and so on.

We recall that models of all states of matter have particles, empty space, and motion. We simulate what happens in the surrounding matter as a vibrating object is interacting with it. This model suggests that motion (or energy) might be transferred through the medium from one end to another through particle collisions.

We figure out these concepts:

- Solids, liquids, and gases are made of particles moving through empty space, with different spacing in each state of matter.
- Particles can collide with other particles in a gas and bump into neighboring particles in a solid or a liquid.
- If a push is transferred into the particles at one place in the medium (any state of matter that sound travels through), it might result in a series of collisions among neighboring bands of particles across the medium.



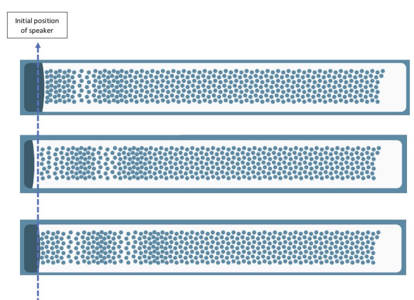
⇓ **Navigation to Next Lesson:** We figured out that particles collide into one another as sound moves through a medium. This made us wonder if we could better see the interactions among particles by using a computer simulation that shows more particles, repeated vibrations of particles, and vibrations of different amplitude and frequencies.

LESSON 10

2 days

What exactly is traveling across the medium?

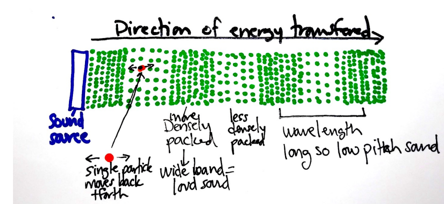
Investigation



Vibrations of a sound source cause particle bands to push against the particles next to them, creating dark and light bands where there are areas of densely and loosely packed particles.

We manipulate a computer simulation by changing either the pitch or loudness of the sound produced to see how the motion of the particles in the medium is affected. We figure out these ideas:

- When an object moves back and forth, it produces bands of compressed and expanded particles that move through the medium (bands of compression travel, but particles do not).
- The density of particle compression gets greater when the amplitude of vibration at the sound source increases.
- The distance between compression bands appears to change when we change the frequency of vibration.
- Collisions between the particles in the medium result in compression bands moving away from a sound source.
- Collisions transfer energy across the medium.



⇓ **Navigation to Next Lesson:** We figured out that vibrating objects produce bands of compressed particles in the medium in which the sound is traveling. The particles do not travel from the sound source to the sound detector but collide with the particles next to them, transferring energy through the medium. This makes us wonder if we can use our model to explain other sound phenomena.

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LESSON 11

2 days

How does sound make matter around us move?

Putting Pieces Together

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Salt on plastic wrap stretched over a bowl jumps up and down when a drum nearby is hit.

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<td>We develop a model to explain a new phenomenon: salt jumping on plastic wrap when a drum is hit. We develop a checklist that includes the key ideas we have developed about how sounds are caused and how sound can cause other things to move. Then, we apply that checklist to revising the model that explains why a window near the parking lot moved when a truck speaker was blasting music.</td>
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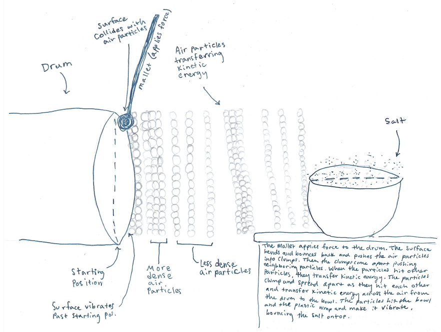

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⇓ **Navigation to Next Lesson:** We have a good idea about how sound travels, but we still have a lot of questions about how we actually hear things and what is happening at the sound receiver. We've heard that there's a body part called the eardrum, so we wonder how that might fit in with what we already know about sound.

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LESSON 12

1 day

What goes on in people's ears so they can detect certain sounds?

Investigation

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An otoscope video of an eardrum examination, an animated diagram, and a reading show the structures in the ear canal and vibrations entering the inner ear.

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<td>In order to find answers to their questions about how our ears detect sounds, students read an interview with experts and watch several videos and animations about the structures of the ear and how hearing loss can occur. They synthesize that information to annotate a model showing how energy is transferred through the parts of the ear to the nerve cells that send signals to the brain.</td>
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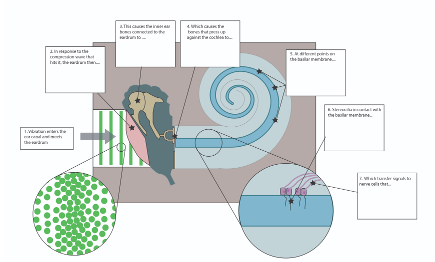

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⇓ **Navigation to Next Lesson:** Since we've learned that both loud sounds (high-amplitude waves) and high-pitched sounds (high-frequency waves) can damage our ears, we want to know which is worse. So, we want to investigate which type of sound wave (higher amplitude or higher frequency) transfers more energy.

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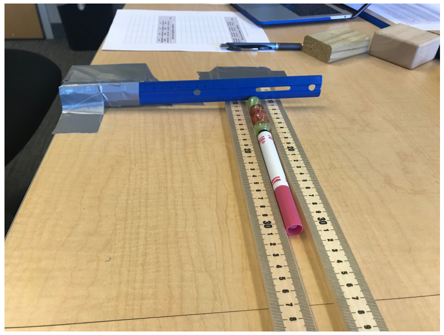
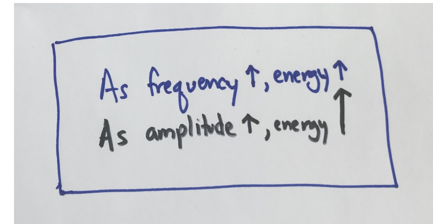
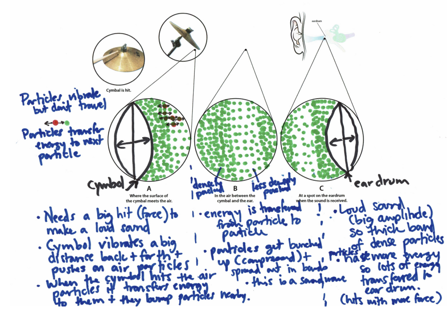
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 13 2 days **What transfers more energy, waves of bigger amplitude or waves of greater frequency?** Investigation	 *A ruler (representing a vibrating object) pushes marbles (representing nearby particles) with greater energy when we increase the amplitude or frequency of the ruler's vibrations. Increasing amplitude has a proportionally greater effect on energy transfer than increasing frequency.*	We conduct two investigations to measure "What transfers more energy, waves of bigger amplitude or waves of greater frequency?" First, we change how many times a marker representing the sound detector is hit by marbles in a given time period (the frequency) and measure the total distance the marker moved (the amount of energy transferred to the detector). Next, we change the force acting upon the marbles (changing the amplitude) and measure how this changes the distance the marker moves. We figure out these ideas: • Waves with bigger amplitude transfer more energy than waves with less amplitude. • Waves with higher frequency transfer more energy than waves with less frequency. • Proportional increases in amplitude have a bigger effect on the energy transferred than increases in frequency.	

⇓ **Navigation to Next Lesson:** In this lesson, we figured out that when the frequency of a vibration doubles, the energy transferred doubles, but when the amplitude of the vibration doubles, the energy transferred quadruples. We've figured out so much! Now we are ready to revisit our DQB to show what we have learned by answering many of our questions.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 14 2 days **How can we explain our anchoring phenomenon, and which of our questions can we now answer?** Putting Pieces Together	 *Hitting a cymbal loudly can damage a musician's ears.*	We revisit the Driving Question Board and discuss all of our questions that we have now answered. Then we demonstrate our understanding by individually taking an assessment. Finally, we reflect on our experiences in the unit.	

LESSONS 1-14
24 days total