Determining Sound Levels:

How do we make sounds and how do we hear sounds?

Grade Levels
Grades 5-6

Materials
- sound sensor
- sensor interface
- tin can, both ends open
- rubber bands
- balloons, cut open for making a drumhead
- scissors
- paper clips
- square plastic food storage container (leftover container)

Teacher Introduction
Overview
In this investigation, students use a sound sensor to determine the characteristics of sounds and their levels.

Learning Goals
Students will gain experience with both inquiry skills and content, including:
- describing sounds using drawings and verbal descriptions.
- understanding that sounds are associated with the characteristics of their source.
- presenting results to others understanding that sound travels from a source through air, solids, and liquids and that its loudness decreases with distance.
- asking a question about objects and events in the environment.
- using data to construct a reasonable explanation
- planning and conducting a simple investigation.
- understanding the process of measurement and units.
- making explanations and predictions from evidence and drawing logical conclusions.
- gaining skills and confidence in using a scientific measurement tool, the sound sensor, as well as the graphing capacity of a computer to represent and analyze data.
Vocabulary
Decibels: a unit for measuring sound level

Electronic Sensor: a device that responds to a physical stimulus and sends a resulting

Loudness: the magnitude of the sound produced

Measurement: to take a value by measuring

Sensor Interface: a device that connects an electronic sensor to a computer

Vibrate: to move back and forth in a regular way

Engage

Begin by asking students how they make sounds (vocal cords and our breath), how we hear sounds (eardrums), and how the sound gets from one to the other (vibrations that travel through the air). Students cannot observe their vocal cords and eardrums directly, but they can build a comprehensible model of each.

They can observe that the tightening of rubber bands changes the sound, as it does with vocal cords. They can observe that a balloon vibrates in response to sounds, and can make something move that touches it (a paper clip), as does the eardrum.

Make sure that all of the students locate their vocal cords and feel them vibrating. Also make sure that every student has a chance to use their voice to make a paper clip bounce around on the stretched-rubber drum. After students have completed Thinking About the Question, explain that the rubber-balloon drum and the stretched rubber bands are **models** of the eardrum and the vocal cords.

Review the ideas of vibrations and sound level based on soft and loud sounds. Then go on to the first activity that ties these features to physical actions that make different levels of sounds in decibels (dBA). For safety reasons, you should remove both ends of the tin cans and cut the balloons for the students in advance.

Students will be surprised to see the result of the voice amplified inside the can and the resulting vibrations that result from their voice. Encourage the students to verbalize the sound level (and energy) required to make the paper clip jump off the balloon.

Ask the students to provide everyday sounds that they experience on a daily basis. Based on their suggestions, they may add and test different sounds and decibel levels to the table below.

<table>
<thead>
<tr>
<th>Sound</th>
<th>Decibels</th>
<th>Sound</th>
<th>Decibels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold of human hearing</td>
<td>0</td>
<td>Heavy street traffic</td>
<td>70 - 80</td>
</tr>
<tr>
<td>Rustling leaves</td>
<td>10</td>
<td>Vacuum cleaner</td>
<td>75 - 85</td>
</tr>
<tr>
<td>Whisper</td>
<td>10 - 20</td>
<td>Hair dryer</td>
<td>85 - 90</td>
</tr>
<tr>
<td>Very soft music</td>
<td>30</td>
<td>Chain saw</td>
<td>100 - 110</td>
</tr>
<tr>
<td>Classroom</td>
<td>35</td>
<td>Threshold of pain</td>
<td>120</td>
</tr>
<tr>
<td>Average home</td>
<td>40 - 60</td>
<td>Ambulance siren</td>
<td>150</td>
</tr>
<tr>
<td>Conversation</td>
<td>60 - 70</td>
<td>Rocket engine</td>
<td>200</td>
</tr>
</tbody>
</table>

Activity adapted from Technology Enhanced Elementary and Middle School Science (NSF—Grant No. IMD0352522).
Determining Sound Levels

Teacher Introduction

Show various instruments before the second activity - actual or pictures - and have students identify what is vibrating to make the sound, how it is made to vibrate, how one changes the pitch, and how the vibration gets transmitted to the air.

All musical instruments have some part of them that vibrates and makes the musical sound. For us to hear them, they must make the air around them vibrate as well. Explain that the students will explore this by making their own musical instrument. They will test the instrument using the Sound sensor.

The building of musical instruments should cement the idea that every instrument must have a source of vibration, which students should identify in each case. There are several ways of creating the vibration - scraping a string (violin), hitting a string (piano), blowing across an opening (flute), blowing past a reed (saxophone), blowing to make the lips vibrate (trumpet), and hitting solid things, like drumheads, cymbals, or bells. The more energy is put into the vibration, the louder the sound. The Sound sensor allows students to look more analytically at musical instruments.

Instruments that make beautiful, long-lasting sounds are not easy to build! But their efforts will teach students about the mechanics of sound production. Probably the hardest part of the task is to have the sound last long enough for students to get a good graph of the sound. A drum will give a spike but no clear snapshot. Regardless, a drum or two in the class is an important addition, even if it doesn't meet all of the criteria.

Have the students demonstrate their instruments to the class and explain the patterns that they make on the Sound sensor. Ask them how the instrument could be improved. Which standard musical instrument does it most resemble?

If there are any musicians in the class, have them demonstrate their instruments and show the snapshots of their sounds with the Sound sensor.

Background Information

Humans hear sound when their ears convert air vibrations into nerve signals that travel to the brain. The outer visible part of the ear is called the pinna. The shape, size, and orientation of your pinna affect how you hear the world around you. The sound vibrations travel down the ear canal and cause the eardrum to vibrate. The eardrum is a thin membrane connected to the ossicles. These tiny bones transmit the vibrations at the eardrum to the auditory nerves that send the signal onto the brain.

Anatomy of the Human Ear:
Activity adapted from Technology Enhanced Elementary and Middle School Science (NSF–Grant No. IMD0352522).
Sound is created when energy is transformed into vibrations. The initial vibration spreads out as pressure variations or oscillations and is often transformed by the mechanical properties and shape of the instrument that produces it.

Consider a very simple one-string guitar consisting of a hollow wooden box with a wire stretched tightly across one side.

A small amount of the energy in the vibrating wire is transferred to the air as sound, but much more of the energy is transferred to the sides of the wooden box through the points where the wire is attached. Various parts of the side of the box will vibrate in resonance with the string. The vibrating sides of the box will transfer much more sound energy to the air than the wire itself because they are much larger. Students may have noticed that the sides of stringed instruments - guitars, violins, cellos -- are very light. If the wooden box is made of thin stiff wood the sides will resonate more and transfer more sound energy to the air than if the sides were thicker and heavier.

Another way in which musical instruments make sound is by resonating a column of air with a simple buzzing sound. The buzzing input of energy to the column of air is transformed by the size and length of the air cavity beyond to produce different pitches.

In reed instruments, like clarinets and saxophones, one blows air past a stiff reed to make a buzzing sound. The reed flaps back and forth quickly, opening and closing the air passage. To change the pitch, musicians shorten or lengthen the resonant air cavity by opening and closing holes in the body of the instrument. The initial buzzing sound in horn instruments like the trumpet and trombone is produced by vibration of the player's tightly pursed lips. In a trumpet the length of the air column is changed by the player opening and closing valves. Each valve connects to a loop of pipe that is a different length. In a trombone, the column length is changed by sliding.

In instruments like flutes and recorders the sound energy is produced when by regular oscillating turbulence in air blown across the sharp edge at the mouthpiece.

The way some reed instruments make sound is similar to how humans make sound. The vibrating reed is analogous to our vocal cords that are located in the larynx between the throat and the lungs.
Time Required:

The amount of time you spend on introductory discussions, data collection, and analysis, will determine your overall timeline. The following represents a possible timeline.

- **One-half class period** Introductory Discussion
- **One class period** Activity 1: Describing Sound Levels
- **Two class periods** Activity 2: Building a Musical Instrument
- **One class period** Analysis: Summary

Additional days can be used for further investigations.

Extensions for Students

- Use the sound sensor to determine the locations in your school that are the noisiest. How does the classroom compare to the hallways between classes?
- Use the sound sensor to investigate noise levels outside. Are there certain times during a day that are louder than others?
Determining Sound Levels:
How do we make sounds and how do we hear sounds?

Name

Materials
- tin can, both ends open
- rubber bands
- balloon, cut open
- paper clip

In the 2 activities you will look at how sound causes things to vibrate as measured by a sound sensor.

Thinking About the Question
In the activities, you will use an electronic sensor to measure sound level.

Sounds come from things that vibrate. A vibration is something moving back and forth in a regular way. Some things vibrate and make sounds that we can hear. All musical instruments have some part of them that vibrates and makes the musical sound.

You can see how sounds are vibrations by building a model. Build a balloon drum by stretching a balloon over one end of a tin can that has both ends open as shown above. Stretch the balloon tight and hold it in place by putting a rubber band around the edge.

1. Talk into the open bottom of the tin can while touching the balloon.
   a. What does your voice do to the stretched balloon?

b. Can you feel the vibrations coming from your voice?

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c. How do you think the vibrations get from your mouth to the drum?

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2. Talk into the open bottom of the tin can after placing a paper clip on the drumhead. Can you make the paper clip move? Can you make the paper clip jump off the drum?

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3. Your voice makes the drumhead vibrate up and down. These vibrations are very fast, and they make sounds that we can hear. How do you think the sound of your voice moves the paper clip?

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Making and Hearing Sounds

Introduction

New Words

Decibels

Electronic Sensor

Loudness

Measurement

Sensor Interface

Vibrate

Investigating the Question

Do the 2 activities in this section

Activity 1: Describing Sound Levels

Activity 2: Building a Musical Instrument
Activity 1: Describing Sound Levels

Name _______________________

Materials
- sound sensor
- sensor interface
- square plastic food storage container
- rubber bands

Steps
1. Stretch two rubber bands around a plastic box as shown above. If the rubber band is very long, go around the plastic box twice to make two bands across the top.

2. Pluck the rubber band. You can see it vibrate. Describe the sound that it makes.

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3. Put the plastic box next to the sound sensor and pluck one of the rubber bands. Start recording with the sound sensor. Is it a smooth sound, or a rough sound?

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4. Try pulling one rubber band tighter than the other as shown below. What happens to the graph?

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5. Use words to describe the different patterns on the graph.

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6. Make one rubber band tighter than the other. Pluck each rubber band starting with the loose rubber band first while the sound sensor is recording. Compare the difference between the two rubber band sounds.

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7. A scale has been developed to measure the level of different sounds. The loudness of a sound is measured in units called decibels (dBA). A sound with the intensity level of 0 decibels is so soft that it can barely be heard. Thunder has an intensity of 120 decibels. Sounds with intensities louder than 120 decibels can actually cause pain to humans.

Using your sound sensor, fill in the decibel level for each sound in the table below.

<table>
<thead>
<tr>
<th>Sound</th>
<th>Decibels (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rustling leaves</td>
<td></td>
</tr>
<tr>
<td>Whisper</td>
<td></td>
</tr>
<tr>
<td>Very soft music</td>
<td></td>
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<tr>
<td>Classroom</td>
<td></td>
</tr>
<tr>
<td>Conversation</td>
<td></td>
</tr>
<tr>
<td>Heavy street traffic</td>
<td></td>
</tr>
</tbody>
</table>

8. As the amount of decibels increases, explain how this affects your ears?

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Activty 2: Building a Musical Instrument

Name

Materials
- sound sensor
- sensor interface

Talk to your teacher about materials for making musical instruments.
- String bass - Long pole or meter stick, string (fishing line), resonator box
- Rubber-band banjo - Piece of wood, plastic container with top, rubber bands, cardboard
- Box harp - Open box, rubber bands, cardboard bridge, pencil
- Fishing-line guitar - Wood board, screws, eyelet screws, fishing line
- Hose horn - Garden hose, funnel
- Bottle organ - Soda bottles
- Bottle xylophone - Glass bottles or glasses
- Double reed oboe - Rolled-up paper tube, straw (cut end), tape
- Shakers - Bottles filled with small things like beans
- Triangle - Bolts, string

Banjo:

Bottle xylophone:
Making and Hearing Sounds

**Box harp:**
- Rubber bands
- Pencil to make different string lengths
- Cardboard box

**Another box harp:**
- Rubber bands, different thickness
- Cardboard bridge with notches

**Fishing line guitar:**
- Bridge
- Fishing line
- Softwood
- Screw for tightening

**Hose horn:**
- Funnel
- Hose

**Oboe:**
- Straw reed
- Seal joint with tape
- Air vibrates
- Reed
- Tips vibrate
- Paper roll

**String bass:**
- String or fishing line
- Meter stick
- Tin can
Making and Hearing Sounds

Triangle:

Steps

1. Your job is to build a musical instrument and test it using the sound sensor. Each group should make a different instrument. Your teacher will supply you with a set of materials or you can bring things from elsewhere, if you discuss it first with your teacher.

2. The following is a list of goals you should meet with your instrument.
   a. It has a sound that lasts long enough so that you can record it with the sound sensor.
   b. You can play both soft and loud sounds.
   c. You can play a melody (such as "Mary had a little lamb").
   Some groups may make additional drums that don't meet all of these goals.

3. When you have a design, draw your instrument.

[Blank space for drawing]
4. Using the sound sensor record a picture of your instrument’s sound. How do you change the loudness?

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5. How can you get the sound to last longer?

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6. Describe the quality of your instrument's sound. Quality is hard to put into words, but try it. What does it sound like? (examples: buzzy, tinny, like a bird, like a bell) How does it feel? (Examples might include harsh, clear, fuzzy, soft, sharp, raw, gentle.) How do you change the quality of the sound (if you can)?

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
Making and Hearing Sounds:  
*How do we make sounds and how do we hear sounds?*

Name __________________

**Answering the Question**
In these 2 activities you looked at how sound causes things to vibrate as measured by a sound level sensor.

1. Your eardrum is a piece of skin just like a stretched balloon. It vibrates when sounds reach your ear. Bones that touch the eardrum carry the vibrations to your inner ear, where they are detected and translated into signals to the brain. Here is a diagram of the ear.

Can you explain why sounds aren't as loud when you cover your ear?

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
2. Here is diagram of a musical instrument. What vibrates to make the sound? How does the player make it vibrate? How does the player control the loudness of the sound? How does the player control loudness?

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3. Here is another diagram of a musical instrument. What vibrates to make the sound? How does the player make it vibrate? How does the player control the loudness of the sound? How does the player control loudness?

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____________________________________________________________________

4. Here is another diagram of a musical instrument. What vibrates to make the sound. How does the player make it vibrate? How does the player control the loudness of the sound? How does the player control loudness?

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________
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