**The Science of Sound**

1. Purpose of Activity:
   - The purpose of this lesson is to give students the opportunity to explore and demonstrate the science behind how sound is made and heard. Students will perform these demonstrations in paired groups. The lesson culminates with students designing a musical instrument that can play at least two different pitches.
   - Misconceptions→ This lesson will clarify the following common misconceptions about sound:
     - *Loudness and pitch of sounds are confused with each other.* Students will learn that pitch is how high or low a sound is and depends on the frequency of a sound wave, while loudness is determined by the amplitude (height) of a sound wave.
     - *Sounds moves faster in air than in solids, because air is thinner and allows the waves to travel more freely.* Sounds travel much faster in solids than in gas because sound travels through vibrating the molecules in matter.
     - *Sound moves between particles of matter (in empty space) rather than matter.* Sound waves need to travel through a medium such as a solid, liquid, or gas. The sound waves move through each of these mediums by vibrating the molecules in the matter.
   - Inquiry question: How can we modify the volume, pitch, and quality of sound?
   - Understandings and Objectives:
     - Students will be able to conduct a series of demonstrations that illustrate properties of sound.
     - Students will be able to describe the movement of sounds through various mediums and how different sounds produce different waves.
     - Students will be able to manipulate sound waves to produce at least two different pitches.
     - Students will understand that scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
     - Students will understand that scientists use different kinds of investigations depending on the questions they are trying to answer.
     - Students will understand that scientists develop explanations using observations, evidence from investigations, and scientific knowledge.

2. Target Learning Group:

   - Fourth grade

3. Approximate Time Involved:

   - Teacher Preparation:
     - Day one: 15-20 minutes
     - Day two: 10-15 minutes
   - Student Participation:
     - Day one: 45-60 minutes

- Day two: 45-60 minutes
- Day three: 30 minutes

4. Background information:

- Every sound is created by a vibration. The air is alternately squeezed and stretched to create waves that spread out in all directions. When these sound waves reach you, the sensitive mechanisms in your ears respond to the air vibrations, and so you hear sound. (Science Encyclopedia, p. 32)
- Sound waves radiate in all directions from the sound source. Sound can travel through liquids, such as water, and many hard solids too. But a vacuum—completely empty space—is completely silent, because there is nothing to transmit the sound waves. (Science Encyclopedia, p. 32)
- The three characteristics of sounds are: pitch, loudness (volume), and quality (timbre). Pitch is a term used to describe how high or low a note a being played by a musical instrument or sung seems to be. The pitch of a note depends on the frequency of the source of the sound. Frequency is the number of waves produced in a given time. Frequency is measured in Hertz (Hz), with one vibration per second being equal to one hertz (1 Hz). A high frequency produces a high pitched note and a low frequency produces a low pitched note.
- Loudness depends on the amplitude of the sound wave.
- The larger the amplitude the more energy the sound wave contains therefore the louder the sound. This is used to describe the quality of the waveform as it appears to the listener; Therefore the quality of a note depends upon the waveform. Two notes of the same pitch and loudness, played from different instruments do not sound the same because the waveforms are different and therefore differ in quality or tone. (http://www.passmyexams.co.uk/GCSE/physics/pitch-loudness-quality-of-musical-notes.html)
- Loudness and pitch are not related. A high-pitched sound can be soft and a low-pitched sound can be loud. (Sciencesaurus, p. 313)
- Sound travels at different speeds through different materials. In general, sound travels faster through liquids than through gases. Sound waves also travel faster through a warmer medium than through a cooler medium. (Sciencesaurus, p. 312)

5. Next Generation Science Standards/Science Frameworks Involved:

- Cross-Cutting Concepts:
  - Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. (MS-PS4-2)
  - Patterns of change can be used to make predictions. (3-LS1-1)
- Disciplinary Core Idea:
  - Sound can make matter vibrate, and vibrating matter can make sound. (PS4.A)
- Interdisciplinary Standards:

- SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-PS4-2)

6. Materials: For a class of 24 students, or 12 groups of 2 students

• Index cards: 1 per group
• Sound Test activity sheet: 1 per student
• Music source (iPod, radio, record player, or computer will work): 1
• Access to Internet
• Slinky: 1
• Wire hangers: 3 per group
• Metal spoons: 3 per group
• Rulers: 1 per student
• Yarn: 3 pieces per group
• String: 3 pieces per group
• Pieces of bell wire: 3 pieces per group
• Several glass bottles: 3 bottles
• Water: 1 large cup/jug
• KWL handout: 1 per student

For Student with ADHD:

• Modified Sound Test activity sheet

7. Safety Considerations:

- Students should be reminded to handle wire hangers with care
- Students should be reminded to hold the pieces of wire safely, never point or jab the wire at other students
- Students should be reminded to keep the glass bottles on the desk at all times

8. Lesson References:


- Rainford, J. (2004). Sound. In *Science encyclopedia* (First ed., Vol. 1, pp. 32-33). Great Bardfield: Bardfield Press.
- *Sciencesaurus: A student handbook*. (Student ed., pp. 312-313). (2005). Physical Science. Wilmington, MA: Great Source Education Group/Houghton Mifflin.
- The Everyday Science of Sound. (2012, January 1). Retrieved February 27, 2015, from http://scienceofeverydaylife.com/teachers/pdfs/3_5_MUSIC.pdf
- Intervention and Strategies for Students with Attention Deficit Hyperactivity Disorder. (2010, January 1). Retrieved March 6, 2015, from http://www.northbranfordschools.org/images/customer-files/adhdbooklet.pdf

**SCIENCE INSTRUCTION**

Step-by-Step

1. Teacher Preparation: Teacher will distribute materials for the sound experiments before students enter class.

2. Pre-Assessment:

- Students will be pre-assessed using the K-W-L. Students will be directed to complete the What I Know column and the What I Want to Learn column.
- Students will fill out the What I Know column according to what they know about sound properties and sound waves. Students are required to fill out at least three items for the first column and three items for the second column. Acceptable responses must be related to sound waves and/or properties of sound.
- Each item is worth one point, for a total of 6 possible points.
- Grading Scale:
    - 5-6 points +
    - 3-4 points
    - 1-2 points —
    - 0 points ☹

The teacher will use the pre-assessment to gauge the level of the students' understanding about sound waves. This pre-assessment can be used to pinpoint any misconceptions about sound. The teacher can use this information to guide their instructions and dispel misconceptions during the slinky demonstration. When students are conducting their investigations at the sound stations, the teacher can use the student answer from the K-W-L to further clarify certain concepts.

**♦ Provide Lucas with a modified K-W-L sheet that features a numbered list in each column. This small adjustment makes it easier for him to keep track of his thoughts.**

3.. Inquiry Procedures:

**Engage**

- Introduction: As students enter the room, have music playing in the background (see materials list). Additionally, this lesson requires students to conduct a series of demonstrations. Ensure that all materials are available and organized. A list of materials can be found above.

**♦ Seat Lucas at a front-row desk near the demonstration table**

- Divide students into partners and distribute an index card to each partner group. Ask students to write a sentence or draw a picture that describes how they think the sound from the iPod or radio gets to their ears.

**♦ Pair Lucas with his Study Buddy, a designated student who helps Lucas stay on task**

- Ask each group to share what is on their card. Which group's answer seems most reasonable? Encourage discussion.
- Distribute K-W-L handouts to students. Allow 15 minutes for completion before collecting them.

**Explore**

- Hold up a Slinky and pass it around. Ask students if they have any ideas about how the Slinky relates to how they hear music.
- Direct two volunteers to stretch the Slinky out on the floor or on a table as far as they can, with one volunteer firmly holding each end. Direct the student at one end to stroke or pluck the Slinky.

  Ask: Do the two ends of the Slinky move toward each other? (No.)
  What is moving from one end of the Slinky to the other? (A pulse of energy.)

- Share with students that the Slinky is modeling the way energy in the form of a sound wave travels through a solid, liquid or gas.
  - *Explain: substances, known as mediums, are made up of molecules, more or less regularly spaced from each other, like the coils of the Slinky. When one of these molecules is moved as the result of a sound source's energy, it pushes against the molecules next to it before returning to its original position; the process is repeated as the sound wave passes through the molecular structure of the medium.*

- Have students practice modeling a sound wave with the Slinky.

♦ **Provide Lucas with a ball chair during the lecture portion of the lesson**

- Now tell groups that they will be conducting a series of sound tests that illustrate properties of sound and how sound travels through mediums.

- Distribute the following materials to each group: Sound Test activity sheet, one wire hanger, one ruler, several pieces of string, several pieces of yarn, and several pieces of bell wire. Review the directions for each demonstration and direct students to write observations/answer the questions on the activity sheet as they go.

♦ **Check in with Lucas to make sure he understood the directions**

<u>Sound Test 1</u>
Materials: Wire hanger, ruler
Directions: Have one group member hold the wire hanger while another group member taps it with the ruler. Describe the sound you hear on the activity sheet.

<u>Sound Test 2</u>
Materials: Several pieces of string, wire hanger, ruler Directions: Have each group member wrap a few inches of string around a finger on each hand. Place the string wrapped fingers gently into each ear. Suspend the hanger from the string so that it does not touch anything else. Have another group member tap the hanger with the ruler. How is the sound different than in the first demonstration? Answer the questions on the activity sheet.

Sound Test 3

Materials: Several pieces of yarn, wire hanger, ruler Directions: Have each group member repeat Sound Test 2 using yarn instead of string. How is the sound different from the string? Answer the questions on the activity sheet.

Sound Test 4

Materials: Several pieces of wire, wire hanger, ruler

Directions: Have each group member repeat Sound Test 3 using wire instead of yarn. How is the sound different from the yarn? Answer the questions on the activity sheet.

**Explain**

- Have each group take turns reporting their findings as recorded on the activity sheet. Ask them to explain why the sound may have been louder or softer in different sound tests, even though the same hanger was used in all.
  *Note for teacher clarification: the speed at which sound travels depends on the medium (yarn, string, etc) in which it is traveling and how the molecules are packed in that medium. The closer together the molecules, the better sound travels (so the better they would be able to hear). Molecules are packed most densely in solids and least densely in gases. When the string and fingers were plugged into the ears, the sound traveled better than just through the air. Solid wire is denser and a better conductor of sound than tightly woven string, which is in turn a better conductor of sound than loosely woven yarn.*

**♦ Place Lucas and his Study Buddy in a designated corner of the classroom, away from other students and distractions to ensure that their materials will not be intermixed with another group's and to allow Lucas to interact one-on-one with his Buddy.**

- Collect K-W-L sheets and activity sheets

Day Two

**Engage**

- Teacher Preparation: Set up sound test five demonstration
  - Review K-W-L sheets, address/clarify common misunderstandings in demonstration
- Another aspect of sound, in addition to volume, is pitch. Ask students if they know the difference between a high sound and a low sound.
  - Ask: What are some examples of high and low sounds?

- Using their pencils, challenge students to find an object in the classroom they can tap against that will produce a high sound, and an object they can tap against that will produce a lower sound.
- After a few minutes, allow students to share their objects.

  - *Ask: What do you think makes these sounds different?* Allow students to share their ideas.
  - *Explain: Sound waves reach the eardrum causing them to vibrate. Then the brain perceives these vibrating sound waves as sound The pitch of a sound (how high or*

*low a sound is) depends upon the frequency of the sound wave, meaning how many× a sound wave vibrates in one second. Faster vibration = higher pitch.*

**♦ Provide Lucas with a stress ball and/or ball chair during the lecture portion of the lesson**

**Explore**

- To help students investigate the science behind pitch differences, conduct the demonstration below using student volunteers to help you fill the bottles and blow on them. Encourage students to answer the questions about this demonstration on the bottom of their Sound Test activity sheet.
    - *Note: Since multiple children may blow on the same bottles in this demonstration, you will want to ensure that students do not put their mouths directly on the bottles. Additionally, since glass bottles are used, be sure to review the importance of being careful around glass. If students hit the glass too hard, the bottle can tip over and break. Be sure that students do not substitute any other object than the pencil to tap the glass.*

<u>Sound Test 5</u>
Materials: Eight empty glass bottles of the same size, water, pencil
Directions: Arrange the bottles in a row and first fill one close to the top with water. Blow across the top of the bottle and observe the sound (pitch) coming from the bottle. Fill the second bottle with a little less water than the first and blow across it, observing its sound. Continue to fill each bottle with a little less water than before and blow on them. What differences can you hear in the pitch of the bottles? Then tap on the first bottle with a pencil. Observe the sound (pitch) coming from that bottle. Tap on the remaining bottles and observe the sounds coming from each. Write down your observations on the activity sheet.

**Explain**

- Ask students which bottle produced the highest pitch and to explain why bottles that were filled with more water produced different sounds than those filled with less water.
  *For teacher clarification: Different sounds are produced by changing the length of the object or air volume through which the air vibrates. Shorter air columns produce higher pitches than longer air columns. Students can see demonstrations of how different instruments produce different sounds*

**Elaborate**

4. Assessment

- Challenge student groups to combine all of the information they have learned about sound in the design of their own musical instrument.
- Distribute the Design a Musical Instrument activity sheet. The sheet directs students to design an instrument using materials from home that will (a) make sound; and (b) be played in at least two different pitches.
- Discuss features of their instrument that could be manipulated to change pitch: length, mass, liquid, volume, etc.
  **♦ Break down the project into smaller chunks so it is more accessible for Lucas. He can focus on one task at a time.**

Day Three

**Evaluate**

- Ask each group to present their instrument explaining why they used the materials they did, how sound is heard through their medium, and how they planned and executed different pitches.

**♦ Provide Lucas with ball chair during student presentations**

- Pass back K-W-L sheets, let students fill in the What I Learned column
- Distribute post-assessment activity sheet

**♦ Allow Lucas to periodically take breaks jumping on a mini-trampoline once he has finished a section of the activity sheet**

Scoring Key for Evaluation

1. Instruments should make sound.
2. Instruments should be able to be played in at least two pitches.
3. Students should be able to explain why they chose the materials they did.
4. Students should be able to explain the reasons why their instruments can make sound and why they can play in at least two pitches.

5. Post-Assessments

- Distribute the post-assessments.
- Ask students for any further questions/comments about sound waves

**♦ Provide Lucas with a quiet work space near the teacher's desk**

• The post-assessment will be evaluated according to the following scale:

- Question 1: One point will be given for the correct answer.
- Question 2: One point will be given for each correct answer.
- Question 3: Two points will be given for the correct diagram.
- Question 4: One point will be given for the correct answer.
- Question 5: One point will be given for the correct answer.

- Grading Scale:
  - 5-6 points □+
  - 3-4 points □
  - 1-2 points —
  - 0 points ☹

Topic: _____ Name: _____

| K What I Know | W What I Wonder | L What I Learned |
| --- | --- | --- |
| | | |

# Sound Test Student Activity Sheet

Sounds fill our lives. But how often do we think about how we hear sound or why some sounds are louder or higher than others? Ready to find out? The demonstrations described below can help you learn the science behind sound Follow the directions for each demonstration and answer the questions that follow.

## Sound Test 1

Materials: Wire hanger, ruler
Directions: Have one group member hold the wire hanger while another group member taps it with the ruler. Describe the sound you hear in the space below.

## Sound Test 2

Materials: Several pieces of string, wire hanger, ruler
Directions: Have each group member wrap a few inches of string around a finger on each hand. Place the string wrapped fingers gently into each ear. Have another group member tap the hanger with the ruler. How is the sound different than in the first demonstration? Is it louder or softer than the sound made when the hanger was held by hand and the sound passed through the air? What conclusions can you draw about sound from this demonstration?

## Sound Test 3

Materials: Several pieces of yarn, wire hanger, ruler
Directions: Have each group member repeat Demonstration 2 using yarn instead of string. How is the sound different from the string? Is it louder or softer than with the string? What conclusions can you draw about sound from this demonstration?

**Sound Test 4**

Materials: Several pieces of wire, wire hanger, ruler

Directions: Have each group member repeat Demonstration 3 using wire instead of yarn. How is the sound different from the yarn? Is it louder or softer? What conclusions can you draw about sound from this exercise? Which of the mediums above (air, string, yarn or wire) helped you hear the sound of the wire being tapped best?

**Sound Test 5**

Materials: Eight empty glass bottles of the same size, water, pencil

Directions: Arrange the bottles in a row and fill first one close to the top with water. Blow across the top of the bottle and observe the sound (pitch) coming from the bottle. Fill the second bottle with a little less water than the first and blow across it, observing its sound. Continue to fill each bottle with a little less water than before and blow on them. Write your observations on the activity sheet. Then tap on the first bottle with a pencil. Observe the sound (pitch) coming from that bottle. Tap on the remaining bottles and observe the sounds coming from each. Write all observations below. In what bottle is the sound loudest? Softest? Highest? Lowest? What conclusions can you draw about sound from this demonstration?

**Design a Musical Instrument Student Activity Sheet**

Throughout this lesson you have learned about the principles of sound, how sound waves move through various mediums, and how frequency, tone and pitch play a role. Now it's time to use what you have learned to design a musical instrument that will play in at least two different pitches.

**Step 1:** Decide what type of instrument you would like to make. Draw a sketch of it below:

**Step 2:** Determine what materials you will need to make your instrument. Think about how you can adapt or change materials to change pitch through length, mass, volume, etc. Use materials from home such as cans, cups, tubes, paper, plastic, metal, rubber bands, tape, combs, balloons, hangers, yarn, string, floss, bottles, dowel rods, rulers, boxes, straws, etc.

**Step 3:** Work with your group to build your instrument. You may have to change your original plan and that's okay!

**Step 4:** Present and play your instrument, explaining why you chose the materials you did, how sound is heard through your medium, and how you planned and played different pitches with your design.

**Sound Waves Assessment**

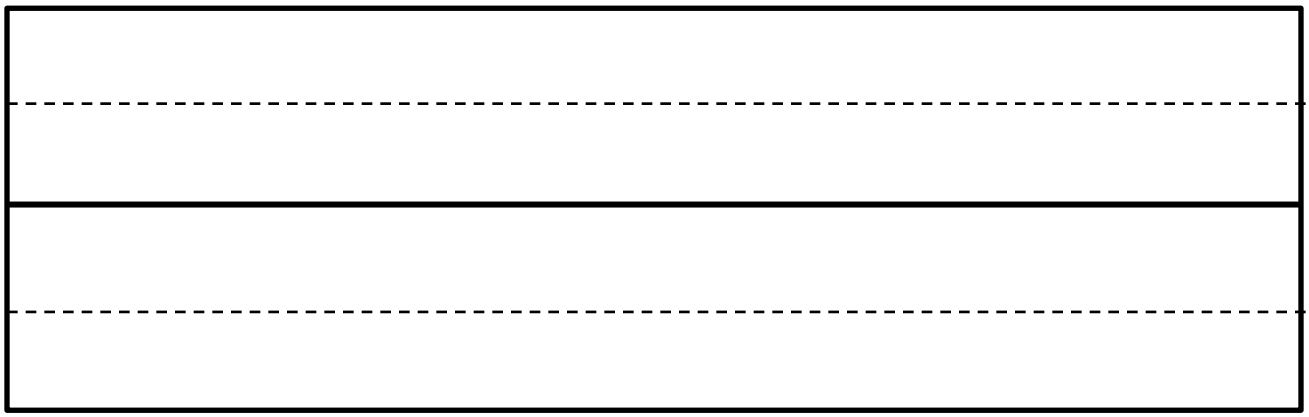
1. Sound waves travel at different speeds through different materials. Through which of the following materials will sound waves travel the **fastest**?

A. copper pipe
B. swimming pool
C. air on a cold day
D. sauna filled with steam

2. While Melinda was at the beach, she decided to go swimming. While she was in the water, she saw a motorboat in the distance. When Melinda put her head under the water, she discovered that the sound of the motorboat was louder. The next day, she asked her science teacher why this happened. What explanation did Melinda's science teacher provide?

A. The motorboat moved closer to Melinda.
B. Sounds travel fastest through the air.
C. Sounds travel faster through liquids than through gases.
D. Melinda's sense of hearing is better under water than on land.

3. A piano play is playing a high, quiet note. Draw a picture of the sound wave at a high pitch and low volume.



4. Sound waves with higher frequencies are _____ (higher, lower, louder, quieter).

5. Sound waves with higher amplitudes are _____ (higher, lower, louder, quieter).

Sound Waves Assessment Answer Key

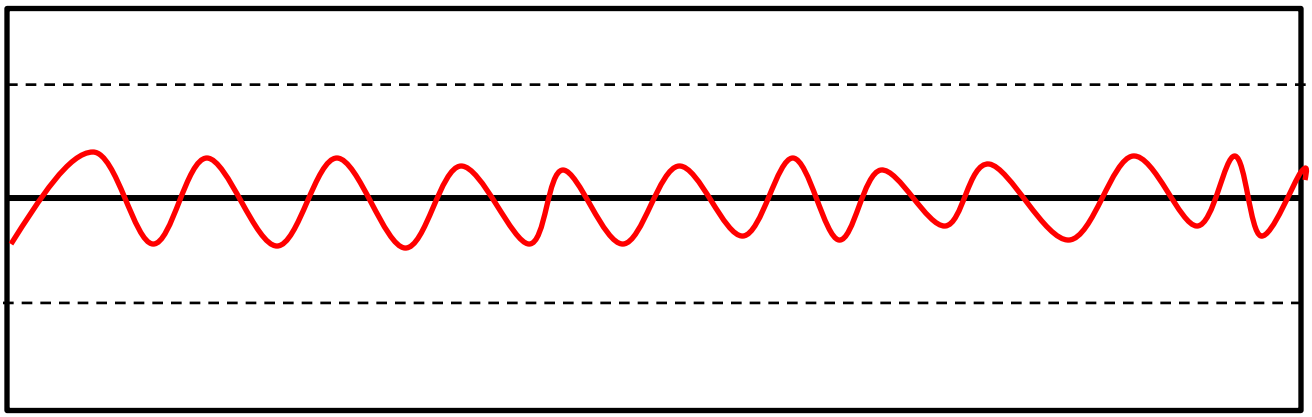
1. Sound waves travel at different speeds through different materials. Through which of the following materials will sound waves travel the **fastest**?

E. copper pipe
F. swimming pool
G. air on a cold day
H. sauna filled with steam

2. While Melinda was at the beach, she decided to go swimming. While she was in the water, she saw a motorboat in the distance. When Melinda put her head under the water, she discovered that the sound of the motorboat was louder. The next day, she asked her science teacher why this happened. What explanation did Melinda's science teacher provide?

E. The motorboat moved closer to Melinda.
F. Sounds travel fastest through the air.
G. Sounds travel faster through liquids than through gases.
H. Melinda's sense of hearing is better underwater than on land.

3. A piano play is playing a high, quiet note. Draw a picture of the sound wave at a high pitch and low volume.



4. Sound waves with higher frequencies are __higher_____ (higher, lower, louder, quieter).

5. Sound waves with higher amplitudes are ___louder_____ (higher, lower, louder, quieter).