3M Young Scientist Lab

in partnership with: Discovery Education

3-5

Lesson Plan

The Everyday Science of Sound

Sound and music are important parts of our everyday sensory experience. But how often do we think about the behaviors of sound or how it is produced, reproduced and detected? The basis for an understanding of sound, music and hearing is the physics of waves. In this lesson, students will conduct a series of demonstrations that illustrate the science behind how sound is made and heard. The lesson culminates with students designing a musical instrument that can play at least two different pitches.

Learning Objectives:
Students will be able to:

- Conduct a series of demonstrations that illustrate properties of sound.
- Describe the movement of sound waves through various mediums and how different sounds produce different waves.
- Design a musical instrument that produces at least two different pitches.

Academic Standards:

National Science Education Standards (SCES)

- Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world. (p. 123)
- Scientists use different kinds of investigations depending on the questions they are trying to answer. Types of investigations include describing objects, events, and organisms; classifying them, and doing a fair test (experimenting). (p. 123)
- Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations. (p. 123)
- Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances. Those properties can be measured using tools, such as rulers, balances, and thermometers. (p. 127)

Benchmarks for Science Literacy

- Sometimes similar investigations give different results because of differences in the things being investigated, the methods used, or the circumstances in which the investigation is carried out, and sometimes just because of uncertainties in observations. It is not always easy to tell which. 1A/E1*
- Science is a process of trying to figure out how the world works by making careful observations and trying to make sense of those observations. 1A/E2**
- Because we expect science investigations that are done the same way to produce the same results, when they do not, it is important to try to figure out why. 1B/E2a*

- One reason for following directions carefully and for keeping records of one's work is to provide information on what might have caused differences in investigations. 1B/E2b
- Scientists' explanations about what happens in the world come partly from what they observe, partly from what they think. 1B/E3a

Time Frame:
This lesson can be completed in two to three class periods.

Materials:

- Index cards
- “Sound Test” activity sheet
- Music source (iPod, radio, record player, or computer will work)
- Access to Internet
- Slinky
- Wire hangers
- Metal spoons
- Rulers
- Yarn
- String
- Pieces of bell wire
- Several glass bottles
- Water
- Pencils

Classroom Activities:

Engage
Note: 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.

1. 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. At this point, this will probably just be a guess and that’s okay!

2. Ask each group to share what is on their card. Which group’s answer seems most reasonable? Encourage discussion.

Explore

3. 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. What happens? 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 that those 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. Students can see an online demonstration of the movement and energy of a sound wave at *http://www.fearofphysics.com/Sound/dist.html*.

4. 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. Younger students should do each demonstration at the same time as you model, while older students can move through the demonstrations at their own pace.

   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 on the activity sheet.

   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. 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

5. 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.)

Engage

6. 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. What high and low sounds can they name? 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. What do they think makes these sounds different? Allow students to share their ideas. Then share the following:

   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 times a sound wave vibrates in one second. Faster vibration = higher pitch. To see an online diagram of both a high frequency wave and a low frequency wave go to http://www.physicsclassroom.com/Class/sound/U11l2a.cfm.

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.

Sound Test 5
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; have students visit: http://www.flickr.com/photos/physicsclassroom/galleries/72157625462682584/.

Elaborate

7. Finally, 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. You may want to first discuss features of their instrument that could be manipulated to change pitch: length, mass, liquid, volume, etc.

Evaluate

8. 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.

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.

Home Connections

Parent Background Information:
In addition to music, stethoscopes are a great way to study the science behind sound. Did you know that the first stethoscope was invented in 1819 by French physician Rene Laennec? He used a long, rolled paper tube to funnel the sound. Since then, the stethoscope has gone through many changes. It has gotten better with each change. George P. Cammann of New York developed the first stethoscope with an earpiece for each ear. This model would be used for more than 100 years with very few modifications. It wasn't until the early 1960s that Dr. David Littmann, a Harvard Medical School professor and cardiologist, patented a revolutionary new stethoscope with vastly improved acoustical performance. He helped to transform a simple listening device into a powerful diagnostic tool.

Did you ever wonder how a stethoscope works? An acoustic stethoscope works by enhancing the sounds made within the human body and transmitting those sounds to the listener's ear. A doctor places the chest piece, which is either flat or bell-shaped, against the patient's skin. If the chest piece is flat it will have a thin, tightly stretched membrane over the end of the device, which is called a diaphragm. This membrane will vibrate much like the bones of the inner ear when sounds occur. The sound waves travel up the hollow plastic tubing into the metal earpieces, which are also hollow. Thus the doctor can hear what is happening inside the patient's body without an invasive surgical procedure. If the chest piece is shaped like a bell it will be hollow, with no diaphragm and work by transmitting the vibrations from the patient's skin. The bell chest piece transmits only the low frequency sounds while the flat diaphragm piece transmits only the higher frequency sounds.

Electronic stethoscopes are battery powered and have interchangeable frequencies that enable doctors to hear both high frequency and low frequency sounds with the same device. This type of stethoscope contains a microphone that picks up the sounds and amplifies them electronically before sending the sounds to the ear pieces. These stethoscopes pick up many sounds.

Next time you go to the doctor, ask which type of stethoscope he or she uses and how it helps amplify sound. Your doctor may even let you listen to your own heartbeat!

"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.