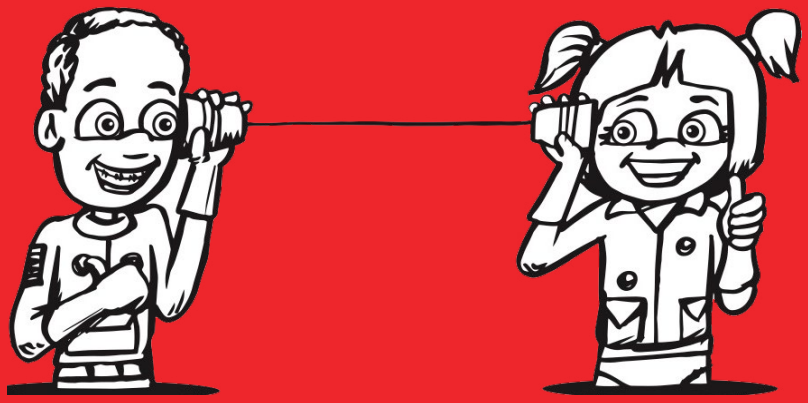
National Aeronautics and Space Administration

NEXT GEN STEM

COMMERCIAL CREW



The Astro-Not-Yets: Sound on a String! **Educator Guide**

www.nasa.gov

For more about Next Gen STEM visit http://www.nasa.gov/stem/ccp.

Grade Level: **K-2**

Suggested Time: **5 days - (30 min each day)**

Day 1 – Inquiry Discussion & Inquiry Activity 1 – Type of String
Day 2 – Inquiry Activity 2 – String Length
Day 3 – Inquiry Activity 3 – Type of Cup
Day 4 – Inquiry Activity 4 – Cup Size
Day 5 – Final Discussion

The Astro-Not-Yets

Sound on a String

Objectives:

Following this activity, students will be able to:

- Explain how sound travels.
- Demonstrate the affect different materials have on the transmission of sound waves.

Materials:

- ☐ Multiple types of string: 2m each (examples: cotton twine, polyester kite string, nylon monofilament, yarn, waxed shoemakers thread, carpet or button thread, etc.)
- ☐ Multiple lengths of one type of string (examples: 2m, 5m, and 10m of cotton twine)
- ☐ Multiple pairs of various types of cups (examples: plastic, paper, Styrofoam, tin can, etc.)
- ☐ Pairs of various sizes of one type of cup (2 small, 2 medium, and 2 large cups)
- ☐ Buttons, paper clips, metal washers, toothpicks, glue, or sealing wax (various methods for attaching the string to the cup)
- ☐ Nail or screw for the teacher to punch holes in the cups
- ☐ Optional: Beeswax, shoemakers wax, paraffin wax, or surfboard wax to wax the string
- ☐ Photocopies of Inquiry Activity Sheet (or create one appropriate for your class)
- ☐ Large plastic baggies and stickers for distributing materials
- ☐ Chart paper
- ☐ Crayons
- ☐ Computer (optional)

Next Generation Science Standards (NGSS):

1-PS4-1. Waves and Their Applications in Technologies for Information Transfer: *Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. Grade: K-2*

1-PS4-4. Waves and Their Applications in Technologies for Information Transfer: *Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance. Grade: K-2*

Common Core Standards for Mathematics (CCSS):

CCSS.MATH.CONTENT.1.MD.C.4. Represent and interpret data: *Organize, represent, and interpret data with up to three categories: ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another.*

Teacher Background:

How is a rocket launch like a rock concert? If you have ever witnessed a rocket launch in person, then you know the roar from the engines during launch can be heard and felt miles from the launch pad. Sound is a form of energy caused by vibration. Place a ruler on the edge of a table or desk so about half of the ruler sticks out over the edge. Use one hand to anchor the ruler to the desk and gently push down or pull up and release the other end of the ruler. Listen to the sound made by the vibration. Now extend the ruler another inch off the table and strum it again. Repeat this several times extending the ruler further over the edge each time. What do you hear? Notice how the length of the ruler affects the pitch (how high or low the note).

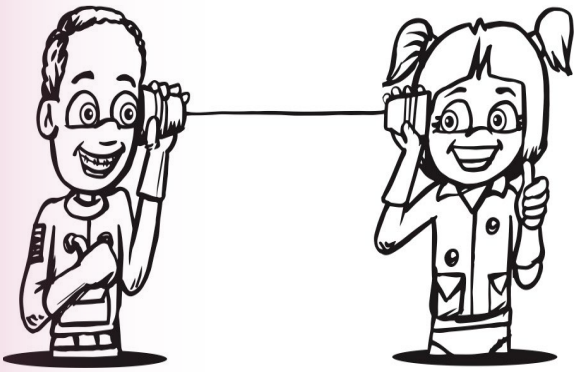
The tuning keys on a guitar adjust the tension on each string and thus change the pitch or frequency of vibration. Like a ruler, the guitar string vibrates more slowly when it is longer resulting in a lower frequency or lower pitch. Pressing the string against a fret (raised metal strip on the neck of the guitar) reduces the length of string vibrating, resulting in a higher note.

When an object such as a guitar string, rocket engine, or speaker vibrates, it causes the molecules in the object to move back-and-forth. Neighboring particles push into each other and then return to their initial position. Think of a Slinky stretched out across a table. With one end fixed, give the other end a small push or pull and watch the disturbance travel along the length of the Slinky. This exercise demonstrates a compression wave and illustrates how sound energy travels. This chain reaction causes surrounding molecules to vibrate. Sound is not only transmitted by vibration; it is also detected by vibration. Sound waves traveling through air enter the outer ear causing a thin membrane called the “eardrum” to vibrate. The vibration travels through the middle ear to the liquid-filled inner ear. There it is channeled to the cochlea where specialized cells convert the compression waves into electric impulses transmitted to the brain via nerve fibers.

How does tuning a guitar relate to rocket science? Like a guitar, every sound and vibration reverberates through the body of a rocket. The difference between them is the musician wants to sustain these vibrations and amplify the sound while the engineer works to reduce them. By blasting the rocket or spacecraft with sound levels past 140 decibels, engineers can verify the structural integrity of a rocket and measure its ability to withstand the powerful sound-induced shaking of launch and other stages of flight.

Sound waves travel at different speeds through different mediums: solid, liquid, or gas (air). Sound waves travel faster through materials in which the molecules are tightly packed (greater density) and quickly return to their initial position (higher elasticity). Insulating materials absorb different amounts of energy at different frequencies, so these materials are used to dampen vibration and contain sound. Sound depends on vibration to transmit energy from particle to particle. Consequently, sound cannot travel through the vacuum of space. The molecules are so widely spaced the compression wave has no medium to travel through.

In this activity, pairs of students work together to develop a hypothesis for how sound travels and then experiment with different types of cups, cup sizes, types of string and string lengths to determine the best method to transmit sound on a string cup phone.



Preparation and Tips

This activity is spread out over a period of four days with a fifth day to summarize the results. For best results, students should work in pairs. Each day the students test one variable and document their findings on the "Sound on a String" Inquiry Activity Sheet. The teacher or student pairs can then combine the individual findings on large chart paper to create a class graph for each variable and discuss any similarities or differences upon completion of the activity each day. On the following day, review the whole class results and create a new chart to record the results for the new variable being tested. Save the charts to compare the results from all four days at the end of the week. On the fifth day, you may also incorporate one of the Extensions as a culminating activity. Instead of using chart paper, consider using a spreadsheet with graphing capabilities.

Each pair of students will need materials to construct one string cup phone each day. Prepare the sets of materials ahead of time and distribute to students in large plastic baggies. Prepare an extra set of materials to demonstrate how to construct and use a string cup phone.

Precut the string to desired lengths. Thoroughly wash the cups and make sure there are no sharp edges. Use a thumbtack or the tip of a nail or screw to pre-punch holes in the bottoms of all cups/cans. Do not make the holes too large or the cups will fall off the string. You may also tie the string to a button, paperclip, metal washer, or toothpick inside the cup to keep the string from pulling through the hole; or punch two holes, loop the string through both holes, and tie the knot. Glue or sealing wax is another method for securing the string to the cup. You may want to recruit parent volunteers or older students to help younger students construct their string cup phones and troubleshoot problems.

Students may color or decorate their string cup phone to personalize them. Include a numbered and color-coded sticker in each baggie to place on the phones to differentiate the day/variable of the phones (e.g., 1-red sticker for kite string, 1-blue sticker for cotton twine, 1-yellow sticker for nylon fishing line, 2-red sticker for 2m, 2-blue sticker for 5m, etc.). All phones with stickers marked 1 indicate these phones were constructed on Day 1 to experiment with string type. The colors of the sticker will indicate the specific type of string (length of string, type of cup, or cup size depending on which day) to make it easier to compare results. Students can then use crayons with the same colors to record their findings. Remember to change only one variable each day and be consistent with all other materials for each phone. For example, it is important when you are testing various types of cups that all of the phones use the same type and length of string.

It may be helpful to model the proper use of a string cup phone before students test their phones. Demonstrate how the string must be pulled tightly for the vibration to travel through it. Your hand will dampen the vibration and diminish the sound, so attempt to hold the cup with as little of your hand touching the surface as possible. Remind students how they should whisper into the phone to allow everybody to hear their own partner. Have students practice soft talking with their partner before the activity begins.

After student pairs complete the construction of their string cup phone, set up tables around the room for conducting the experiment. Assign three or four pairs of students to each table depending on how many types of phones will be tested. Include a station for each type of phone (red station, blue station, yellow station, etc.). Each pair of students will then rotate through the stations at their table recording their observations to determine which variable is being tested that day (type of string, string length, type of cup, or cup size), create a hypothesis about how the variable will affect the sound transmitted (loudness or clarity), experiment by talking into each string cup phone, and then record their findings.

For a condensed approach to this check out the activity Sound on a String: Center Activity lesson.

Procedure for Inquiry Activity

You can demonstrate the procedure below for students prior to engaging in the inquiry activities. Depending on the student level, you may want to display this sequence in a sequential picture diagram on the board or print the written instructions for your students.

1. Thread string up through the hole in the bottom of cup.
2. Tie a knot on the end of the string inside the cup. You may need to tie several knots on the end to make the knot large enough and prevent the string from slipping out of the hole. (See paragraph 3 in the Preparation and Tips section above for other suggestions for attaching the string).
3. Repeat steps 1 and 2 with the second cup.
4. Stand far enough apart so the string is pulled tightly and whisper into the cup while your partner places his or her ear near the opening of the other cup.
5. Rotate through each station and record your results on the Inquiry Activity Sheet.
6. Post your results from the Inquiry Activity Sheet onto the class graph.

Inquiry Discussion:

Inquiry Activity 1 (Day 1):

- Types of string (must use the same length of string and use identical cups)
  - 2m of polyester kite string
  - 2m of cotton twine
  - 2m of nylon monofilament (fishing line)
  - Use whatever you have available including different material/fibers (natural and synthetic) as well as different thickness/weight.

- Discussion questions to follow the activity: Did the type of string affect the loudness or clarity of your partner's voice? Which string would you select? Why?

Inquiry Activity 2 (Day 2):

- String length (must use the same type of string and use identical cups)
  - 2m
  - 5m
  - 10m
  - Experiment with whatever lengths are convenient for your space. If you have a long straight hallway, then you may try an even longer string.

- Discussion questions to follow the activity: Did the length of the string affect the loudness or clarity

Inquiry Activity 3 (Day 3):

- Types of cups (must use the same length and type of string)
  - Plastic
  - Paper
  - Styrofoam
  - Tin can (or any type of metal)
  - Try to find cups as close to the same shape and size as possible.

- Discussion questions to follow the activity: Did the type of cup affect the loudness or clarity of your partner's voice? Which cup would you select? Why?

Inquiry Activity 4 (Day 4):

- Cup sizes (must use the same length and type of string and use the same type of cup)
  - 8 oz
  - 10 oz
  - 16 oz
  - Use whatever sizes are available as long as you have a small, medium, and large for one of the following: plastic, paper, Styrofoam, or metal

- Discussion questions to follow the activity: Did the size of the cup affect the loudness or clarity of your partner's voice? Which size would you select? Why?

Final Discussion:
Use the Background Information and class chart to guide the following discussion questions and stimulate interest in further investigation.

- What is sound?
- How does sound get from one place to another?
- Why is vibration important?
- How do we make sound?
- How do we hear sound?

Assessment

Have students explain how they determined which variable was being tested each day or at each center. Discuss how the materials affected the sound and conduct a class debate about creating the "best" string cup phone with the given materials. Collect and review completed "Sound on a String" Inquiry Activity Sheets.

Extensions:

- Allow students to demonstrate and/or present their findings with the class as part of the final discussion.
- Give each student the opportunity to create the optimal string cup phone by selecting a string length, type of string, cup size, and type of cup. Assemble the phone and allow students to take it home to teach their family about sound waves.
- Have students brainstorm ideas to improve the design of the string cup phone using the same or different materials. Then have students test their designs.
- Test other variables such as the method for attaching the string to the cup or waxed string versus unwaxed string.
- Use the web resources below, or demos described in the Background Information to research more about sound and find additional sound activities such as the Shoebox Guitar, Musical Tube, or Super Sound Cone.
- Team up with a music teacher to let students investigate how different instruments produce sounds.

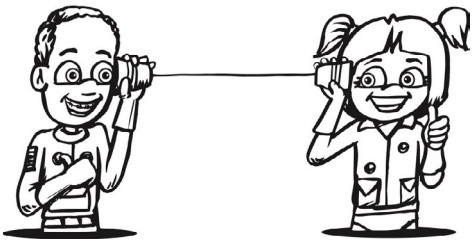
Web Resources:

www.grc.nasa.gov/WWW/K-12/TRC/Aeronautics/Musical_Tube.html
(Musical tube activity)

www.philharmonia.co.uk/thesoundexchange/sound_samples/sample_libraries/
(Collection of samples from single notes to full orchestra)

https://spaceplace.nasa.gov/sound-cone/en/
(Directions for constructing a Super Sound Cone)

Web sites may provide teachers and students with background information and extensions. Inclusion of a resource does not constitute an endorsement, either expressed or implied, by the National Aeronautics and Space Administration.



The Astro-Not-Yets:

Sound on a String!

Student Name: _____ **Date:**_____

Directions: Fill in the blank and draw what you saw during your experiment.

Day 1:

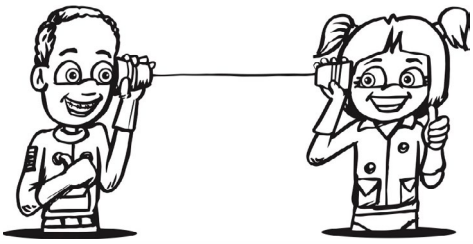
Before:

1. I think the string made of _____ will make the loudest sound.

After:

1. The string made of _____ made the loudest sound.
2. The string made of _____ sounded the clearest.

This is what our experiment today looked like:



The Astro-Not-Yets:

Sound on a String!

Student Name: _____ **Date:**_____

Directions: Fill in the blank and draw what you saw during your experiment.

Day 2:

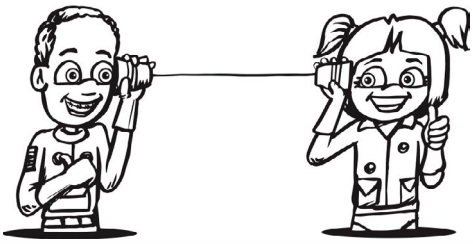
Before:

1. I think the string that is _____ long will make the loudest sound.

After:

1. The string that was _____ long made the loudest sound.
2. The string that was _____ long sounded the clearest.

This is what our experiment today looked like:



The Astro-Not-Yets:

Sound on a String!

Student Name: _____ **Date:**_____

Directions: Fill in the blank and draw what you saw during your experiment.

Day 3:

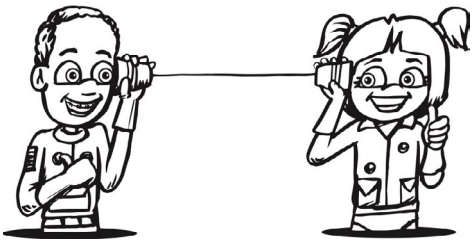
Before:

1. I think the cup made of _____ will make the loudest sound.

After:

1. The cup made of _____ made the loudest sound.
2. The cup made of _____ sounded the clearest.

This is what our experiment today looked like:



The Astro-Not-Yets:

Sound on a String!

Student Name: _____ **Date:**_____

Directions: Fill in the blank and draw what you saw during your experiment.

Day 4:

Before:

1. I think the _____ size cup will make the loudest sound.

After:

1. The _____ size cup made the loudest sound.
2. The _____ size cup sounded the clearest.

This is what our experiment today looked like: