The Sheldon SOLID Project

Science of Learning Instrument Design

An At-Home STEAM Project

PARENT PACKET

prepared by

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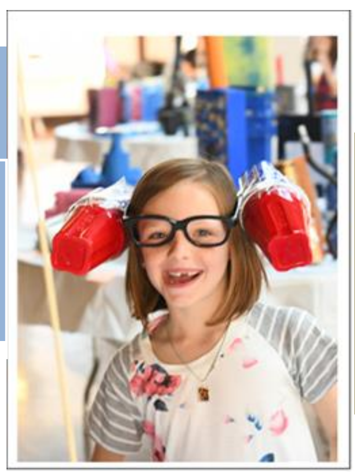

SAINT LOUIS SCIENCE CENTER

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THE SHELDON CONCERT HALL & ART GALLERIES

Letter to Parents

Dear Parents,

The *SOLID (Science of Learning Instrument Design) Music Project* is a school program that began in 2015 in collaboration with the Saint Louis Science Center and a grant from BOEING. It is designed to help children learn about how sound is made. This is achieved by engaging children in a STEAM (science, technology, engineering, arts, and math) process to build an object that can make and adjust sound.

Materials in this packet have been modified from teacher workshop resources to help you guide your child through this lesson at home. Included are the following materials.

When your child completes the project, we encourage you to share it. Take a picture and tag us on social media. Use the hashtag **#MySOLIDProject**. Also, find us on *Instagram* or *Facebook* by searching "The Sheldon Concert Hall and Art Galleries".

The *STUDENT PACKET* includes some additional materials for them to use with the STEAM process. Also, not all of the materials in the *PARENT PACKET* are provided for students, since we intend for you to guide your child through this lesson.

We hope you and your child enjoy and learn from this SOLID Challenge.

Katelyn Galenski
SOLID Program Manager

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Thank you for downloading this lesson packet. We hope that you and your child find it challenging, interesting, and educational.

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You may direct other parents to the Sheldon SOLID Music Project website SOLID Music Project so they can download the lesson packet for their children.

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Introduction & Background for Parents

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The *Science of Learning Instrument Design* (SOLID) is based on the principles of STEM education, which rely on connections between science, technology, engineering, and mathematics. The program was developed in collaboration with the *Saint Louis Science Center*, engineers from Boeing, and a team of public and private school educators.

The SOLID Music Project engages children in designing and constructing an object that will produce sound and create music. The instructional design utilizes the STEAM approach, which draws upon science, technology, engineering, the arts, and mathematics.

This lesson is based on professional development and classroom materials prepared by the Sheldon for K-12 teachers. The SOLID lesson is correlated to the ***Missouri Learning Standards*** for science, math, art, and music.

The term *lesson* does not necessarily refer to a single learning session. The SOLID Challenge can be completed in 2-3 hours. Because it involves a 6–step process, the lesson can be organized into several activities over a period of days. This depends on the complexity of the design and materials used in ways that best match your child and home situation. The more time spent with the lesson will allow for a better understanding of the STEAM Engineering Cycle.

This SOLID lesson packet was produced in response to the extended school closures resulting from the COVID-19 virus. It is intended to provide parents of elementary school children with an interesting and successful STEAM lesson they can undertake at home.

Note to Parents About the Process

Our intent is for parents and children to work together on the SOLID Music Project Challenge. To support that goal, we have prepared a packet of materials and resources for parents and another one for students.

The purpose of the *Parent Packet* is to provide you with what you need to guide your child through the project. Some of the materials are not in the *Student Packet*. It can be thought of as the "teacher edition" of a textbook that includes additional directions and explanations.

The purpose of the *Student Packet* is to provide them with the background, definitions, and step-by-step directions they will need to complete the SOLID Music Project Challenge. To achieve that, some of the student materials are written in more age-appropriate language and divided into individual steps.

If the material in the *Parent Packet* is the same as the *Student Packet*, there is an asterisk (*) following the name in the orange title banner. If there is not an asterisk, the parent version is either more detailed or it offers support for you to use in guiding your child through the project.

SOLID Challenge Statement

Parent Note: The purpose of the SOLID Challenge is for a child to use science to design and build a device that makes sound and can be used as a musical instrument. Below is a description of the task. The requirements listed in the description should be used to evaluate if the final product meets the challenge.

Use the STEAM Engineering Cycle to design, construct, and test a unique object that produces sound.

It must ...

- be constructed from recycled or repurposed materials;
- produce sound resulting from vibration;
- be capable of changing or modulating *volume* and *pitch* of the sound it produces;
- be comfortable and easy to use; and,
- be visually appealing.

It may be ...

- a new design (invention) OR a modified design (innovation); and,
- made of one or more parts.

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Definitions *

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You may want to know the meaning of these words before starting the challenge!

STEAM refers to Science, Technology, Engineering, Arts, and Math.
Here are the definitions for *technology* and *engineering*.

Technology – National science standards defines technology as "any modification of the natural world made to fulfill human needs or desires."

In simple terms, technology refers to anything used as a **tool.**

Engineering – National science standards defines engineering as "a systematic and often iterative [repetitive] approach to designing objects, processes, and systems to meet human needs and wants."

In simple terms, engineering is the process of designing and making objects and tools.

These are words you can find as you read the *Science of Sound.*

Sound – When vibration travels as a wave through air or matter it can be heard as sound.

Vibration – Applying a force to an object causes repeating movement called vibration. When this happens, the object produces sound.

Frequency – The number of times a sound vibrates every second is called its frequency. It can be pictured as a wave. Sound waves vibrate at different speeds. **Frequency** is how fast or slow a sound vibrates.

Pitch – Pitch is the musical term for frequency. The faster the vibration, the higher the frequency and the higher the pitch. The slower the vibration, the lower the frequency and the lower the pitch.

Amplitude – The measure of the strength or intensity of a sound wave is called amplitude.

Volume – Volume is the musical term for amplitude. In music, volume is defined as the loudness or softness of a sound.

Percussion – A *percussion* instrument produces sound when it is struck, shaken, or scraped.

String – A *string* instrument produces sound by causing the strings to vibrate.

Wind – A *wind* instrument produces sound by passing air through a cylinder.

Acoustic – Acoustic is the name given to the scientific study of how sound travels in a space

Science of Sound *

The Science of Sound

Have you ever thought about how sound is created?

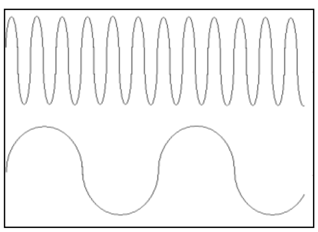
An object produces sound when it vibrates in some kind of material. These vibrations travel as sound waves through the air to your ears. The human eardrum is a stretched membrane, like the skin of a drum. When the sound waves hit your eardrum, it vibrates and the brain interprets these vibrations as sound!

The sound a vibration makes depends on the size, shape, and material creating it. These three factors can affect the *volume*, *pitch*, and *tone* quality of the sound.

Frequency & Pitch

It turns out that sound waves vibrate at different speeds. The number of times a sound vibrates per second is called its **frequency**. Frequency is the scientific name for the musical term **pitch**.

The faster a sound vibrates, the higher the frequency and higher the pitch. The slower a sound vibrates, the lower the frequency and lower the pitch.



Fast Frequency / High Pitch

Slow Frequency/ Low Pitch

Consider the Size!

Will a large drum and a small drum make the same sound?

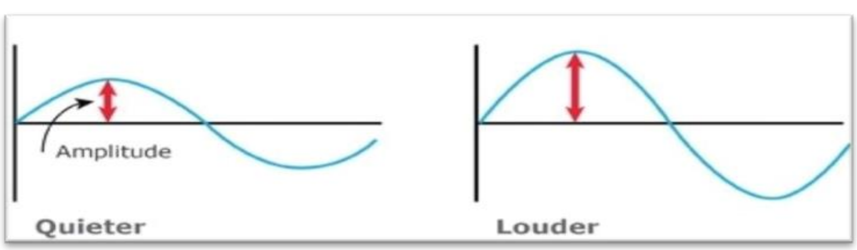
No. The body of a large instrument has more air to vibrate. That makes the pitch lower! A smaller instrument has less air to vibrate and that makes the pitch higher. The more air there is inside an object, the slower the sound vibrates, creating a lower frequency. The opposite is true for smaller instruments.

Consider using different sized materials when you design your sound device to make different pitches!

Amplitude & Volume

Sound waves also vary in intensity. The strength or intensity of a sound wave is called **amplitude**.

To understand this, imagine waves like an ocean. Sometimes the water is still. Other times waves rise well above the surface of the water. The distance between the highest point of the wave and the calm surface of water is called amplitude. When the amplitude is higher, the sound wave it creates a **louder volume**. When the amplitude is lower, the sound wave creates a **softer volume**.



Instrument Classification

Instruments can be classified into three musical families based on the way they create vibrations. The three families are **percussion**, **wind**, and **string**.

Percussion instruments produce sound through vibration by being struck, shaken, or scraped. Percussion instruments can be made from a variety of materials, including wood, metal, and plastic. Drums often have animal skin or a similar synthetic material stretched over the top. Marimbas, steel drums, maracas, gongs, and tambourines are all examples of percussion instruments.

Wind instruments produce sound through air being blown through a cylinder or reed. Wind instruments can easily be created from various sized cardboard or plastic tubes, PVC pipe, glass bottles, or even rolled up paper! Many traditional wind instruments are made from wood or metal. You may be familiar with wind instruments like the flute, tuba, and bassoon. The size and material of those instruments are different and this produces very different sounds!

String instruments produce sound by strings being plucked or struck OR by the friction of a bow pulled across the strings causing sustained vibration. Stringed instruments are most commonly made from wood, but the only requirement for it to be a stringed instrument is for it to have … strings! The violin, cello, and guitar are a few common string instruments.

Follow these links to learn more about the science of sound!

- What Is Sound
- Physics of Sound
- Sound Waves

Follow these links to learn more about instrument design and get inspired!

- The Recycled Orchestra
- Recycled Percussive Band
- Ted Talk on Making a Clarinet out of Paper
- Ted Talk on the Saxophone Carrot

Elements of Acoustic Design

We learned that sound is a result of an object vibrating, but what makes each vibration sound different to our ears? A car honking sounds very different from leaves rustling in the wind. A violin sounds very different from a tuba. Why is that? It turns out that the ***material***, ***size***, ***shape***, and ***texture*** are just a few of many design elements that have a great impact on sound.

If one of these design elements is changed, it will create a completely different sound. Think of two drums – one is made from wood and the other is made from metal. Can you imagine how both will sound when they are hit? The different materials produce dramatically different sounds!

We also know that size matters in creating different pitches. For example, a violin and cello are both stringed instruments with similar shapes, but a cello is much larger. The size of the cello produces a lower sound because there is more air vibrating inside the instrument. This creates a lower frequency.

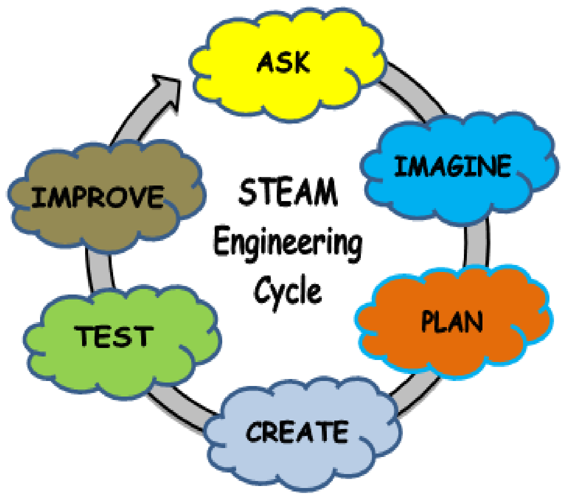
What about the shape and texture? As you begin working on your device, experiment to see how these design elements might change the quality of sound.

STEAM Engineering Cycle

Engineering Cycle

The ***engineering cycle*** is a design process made up of a series of steps that engineers follow to develop a solution to a problem.

The SOLID Music Project uses a 6–step process. They are – defining the problem, brainstorming solutions, selecting and designing the best solution, building a prototype, testing and evaluating its performance, and redesigning it to improve its function and performance.



ASK	**What is the problem?**
	What have others done to solve this problem?
	What are the requirements and constraints for the problem?
IMAGINE	**Brainstorm possible ideas.**
	Consider several solutions.
	Choose the best ideas.
PLAN	**Develop a plan.**
	Draw a design.
	List the materials needed.
	Describe how it will work.
CREATE	**Build a model or a prototype based on the design and using the available materials.**
TEST	**Test the model.**
	Evaluate the results based on the challenge statement.
	Determine how well it functions.
IMPROVE	**Redesign the model to improve how it functions, feels, and looks.**

Tools

As you and your child prepare for the SOLID Challenge, you will need to think about what tools might be needed. You can also have conversation about this with your child. The best time would probably be during the PLAN step of the engineering cycle, but it will be helpful to be prepared in advance.

Here are some things you might need for your child to build, assemble, and decorate the project.

ruler	small hand saw	glue stick
scissors	masking tape	liquid glue
hole-punch	cellophane tape	paint brush
drill	duct tape	pencil or marking pen

NOTE TO PARENTS: Consider your child's age and skills before beginning the CREATE step. Allow your child to only use appropriate tools and supervise them as they work. For some tools and construction elements, it may be necessary for you to help them or do certain things for them, so this exercise is SAFE!

Materials

As you and your child prepare for the SOLID Challenge, you will need to think about what materials are available to use. Your child will need to select materials during the PLAN step of the engineering cycle, but it would be good to talk about during the IMAGINE step.

The best things to use are ordinary materials you have at home. Many of these materials are usually recycled, like different kinds of boxes or plastic containers.

Here are suggestions of materials that could be used to make different kinds of sound.

STRING or PERCUSSION
Coffee or oatmeal cans
Shoe boxes or cereal boxes
Cardboard boxes of any shape and size
Tin cans or soda cans
Rubber bands of various sizes
String, fishing line, or wire
Broom sticks or wooden dowel rods
Plastic or styrofoam bowls or boxes
Paper or plastic straws or funnels

RATTLES
Beads or metal washers
Dried beans, corn, or other seeds
Plastic soda bottles or condiment bottles
Plastic jars or small containers with lids
Paper roll tubes

WIND
PVC pipe or rubber hoses

DECORATIVE MATERIALS – For decoration consider these materials.

marking pens of different colors	tempera or water color paint
yarn	feathers
glitter	decorative tape stickers

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Video Links

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These videos can expand your child's understanding of how sound is made and controlled. They can also provide many different examples of objects that make sound and create music. It would be beneficial to view some of these before beginning the STEAM Engineering Cycle during the ASK step. They could also be viewed after successfully completing the cycle to expand your child's understanding of creating sound in a variety of ways.

Understanding the science of sound

- What Is Sound
- Physics of Sound
- Sound Waves
- Science of Sound Demonstrations

Cymatics demonstration – The study of visible sound and vibration:

- Incredible Cymatics Performance
- Chladni Plates Showing Frequency

Creating sound through repurposed materials:

- The Recycled Orchestra
- Recycled Percussive Band
- Ted Talk on Making a Clarinet out of Paper
- Ted Talk on the Saxophone Carrot
- Incredible Handmade Guitars

Sound sculpture examples:

- Singing Tree
- "The Wing" Sound Sculpture
- Waterphone Instrument
- Yaybahar Instrument

Learn more about world music!

- Grindell World Music Collection

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Directions

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Parent Note: There are 6 steps to the *STEAM Engineering Cycle*. Ask your child to follow the directions to complete each step of the cycle. The *Student Packet* has a separate page for each step that includes directions and questions.

The directions for you in this section are more detailed than those in the *Student Packet*. This additional information will enable you to provide guidance and support to your child as needed.

As children work through the engineering cycle, sometimes they may be uncertain about what to do or that they may need to be redirected. Questions can prompt them, without telling them what to do next. For each step, we have provided some questions you can use to stimulate your child's ideas and work.

Each step could be completed separately OR be grouped together with other steps. We have made some suggestions about organizing the six steps. Make a schedule that is best for your child and home setting. All six steps could be completed in a single block of a few hours or divided into several work periods over a number of days.

Finally, we have provided some suggestions about the about the amount of time to consider for each step. Again, you decision about the time allocated for each cycle will be influenced by your child's age, development level, interest, and attention.

Step 1 – ASK

- Present the SOLID Challenge to your child.
- Provide your child with the opportunity to ask questions about the challenge.

  Be sure your child understands what to build and what it will do.

  Make sure your child understands the requirements of the challenge. One way to do this is to ask your child to repeat the challenge in his or her own words.
- View the two links with your child to see how others have used recycled materials to create sound devices. These links appear in the Student Packet directions.
- Have your child review the *Science of Sound* background information.

Stimulating Questions:

What is the problem or challenge?
Can you tell me the problem in your own words?
What are the requirements?
Is this problem similar to another you know about?
Do you know what others have done to solve this problem?
How could we find out more about this problem and possible solutions to it?

Suggested time: 10-15 minutes, plus time to review the on-line links

Step 2 – IMAGINE

- Ask your child to think about some examples that meet the requirements of this challenge.
- After a few minutes, ask your child to suggest several different ideas for objects that might satisfy the challenge.

  Encourage your child to offer at least **3** unique ideas.
- Have your child provide a brief description of each one on the Step 2 worksheet.
- Have your child review the ideas and select the best one or the best features from two or more ideas.
- Review descriptions of musical instrument families (see *Science of Sound* and *Definitions*) and ask your child to answer the questions about creating vibration and changing **volume** and **pitch** on the Step 2 worksheet.
- Ask your child to suggest what tools and materials might be needed for their sound device.

Stimulating Questions:

What could be a solution for this challenge? [Encourage 3 unique solutions.]
Do you know anything you could use as models for this challenge?
What do you think your object might look like?
When other people look at it, do you think they will know how to use it?
What are you doing to make it feel comfortable to use?
What are you doing to make it look attractive and appealing?

Suggested time: 15-30 minutes

Schedule Note: If your plan is to spread the SOLID Challenge over several days, it would work well to complete the **Ask** step and the **Imagine** step in one time block.

Step3 – PLAN

- Ask your child to review the requirements of the challenge.
- Before beginning the plan, show your child all of the materials and tools you have that they could use to construct their sound device.
- Have your child use the ***Design Sheet*** or plain paper to prepare a plan for what their sound device will look like and how it will work.

  Note 1: It is important that the design and materials be committed to paper. It needs to be used to guide the construction of the sound device. It is also a way to evaluate how the plan was followed. Think of it as a blueprint that a builder would use to construct a house.

  Note 2: Based on your child's math skills, you could have the design include measurements for each part and draw the design to scale.
- Ask your child to follow the directions and answer the questions on the Step 2 worksheet.

Stimulating Questions:

Which materials do think would be the best to use?
Are there some materials that you should <u>not</u> use? Why not?
How do you think it will work?
Why did you choose to use (X) in your design?

Suggested time: 30 – 45 minutes

Schedule Note: If your plan is to spread the SOLID Challenge over several days, the **Plan** step could either be grouped with the **Ask** and **Imagine** steps in one time block OR it could stand alone in a separate time block.

Step 4 – CREATE

- Have your child use the drawing, description, and list materials to build the sound device.

  Note 1: Monitor your child's work. Be sure the design, description, and list of materials are followed. Changes are allowed after the **Test** step.

  Note 2: Feel free to assist with construction when tools are used or an "extra" pair of hands is needed to hold things. However, remember this is your child's project, not yours. They will only learn from the process if they are doing the work on their own.

- Ask your child to answer the questions on the Step 4 worksheet after construction is completed.

Stimulating Questions:

What is the purpose or function of (X)?
What does (X) do?
How does (X)work?
Why did you put (X) here?
What do you think would happen if you moved (X) to another place?

Suggested time: 1 hour or as needed for your child

Schedule Note: If your plan is to spread the SOLID Challenge over several days, the **Create** step is best in a separate time block.

Step 5 – TEST

- Ask your child to follow the directions on the Step 5 worksheet to make sound and change the volume and pitch of the sound.

  Note: Have your child attempt each task **3 times**. This makes sure the result is not by chance, but truly demonstrates how the sound device functions.

- After each test, ask your child what is working and what is not. This helps to identify what might need to be improved.

- After your child has completed all 3 tests, ask your child to answer the questions on the Step 5 worksheet. The answers will identify what improvements may need to be made.

Stimulating Questions:

When you tested it, what happened?
Did it work like you thought it would? If not, why not?
Is it easy and comfortable to use? If not, what could you do to improve it?
How easy is it to make it vibrate and create a sound?
How easy is it to change the volume?
How easy is it to change the pitch?
If these were not easy to change, what can you do to make it easier?
What can you do to make it more visually appealing?

Suggested time: 30 minutes

Schedule Note: If your plan is to spread the SOLID Challenge over several days, the **Test** step could be paired with the **Create** step, if time and interest permits. However, since additional thought, planning, and work may be needed, the **Improve** step should stand alone in a separate time block.

Step 6 – IMPROVE

- Before beginning any changes or improvements, have your child follow the directions on the Step 6 worksheet.
- Ask your child to make a change on the *Design Sheet*. Make the adjustment on the sound device and try it again.

  Note: Since only a small change may be necessary, it is important to make **only one change at a time**, rather than making several changes all at once. Make as many separate changes and tests as necessary until all of the SOLID Challenge requirements are met.

Stimulating Questions:

What could you change to improve how it works?
What other materials could you use?
What changes did you make?
After you made the changes, how well did it work?

Suggested time: 30 minutes or as needed for your child

FINAL STEP

The final step is to ask your child to think about what they learned from this project. The **What I Learned** page that follows is also included in the *Student Packet*. It poses several questions to help your child reflect on what they learned.

How this is used depends on the age and development level of your child. It could be completed as a writing exercise. It also could be an oral exercise in the form of a conversation between you and your child. You might also consider some combination of these approaches.

Regardless of how you decide to use **What I Learned,** we believe it is important that every learning episode end with the opportunity for a child to reflect on the experience.

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What I Learned *

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Answer these questions after you have completed all 6 steps of the challenge.

1. Was I successful with this challenge? Why or why not?

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2. What was the most difficult part of this challenge? Why?

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3. What part did science play in my design? (Review *Science of Sound* on pages 2 and 3)

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4. What did I learn about designing and engineering during this challenge?

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5. What questions do I still have about this challenge?

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Extension Activities

Parent Note: Once your child has successfully designed and constructed a sound device that meets all of the SOLID Challenge requirements, that experience could be a springboard for exploring related topics.

Your child could investigate how sound devices and musical instruments are used around the world and in various cultures and civilizations throughout history. Here are a few suggestions for extension activities.

- Explore how various musical instruments have changed over time.
- Investigate how various percussion, wind, or string instruments are used in different civilizations, countries, social groups, or cultures.
- Create a composition which, when played, will feature the sound-making device.
- Identify percussion, wind, and string instruments used in various types of contemporary music.
- Investigate the use of different instruments in several types of musical genre.
- Explore the history and origins of those instruments and genre.
- Investigate how various musical instruments are constructed. Give attention to artistic design, decoration, and performance comfort.
- Examine instruments to learn how each one makes the sound it does and how its volume and/or pitch is altered when being played.
- Identify where else vibration, volume, and pitch are found in everyday life and the role and importance of these sound devices in our lives.
- Review what they learned about vibration and consider how those science and math principles apply to other sound devices found in everyday life.