The Sheldon SOLID Project

Science of Learning Instrument Design

An At-Home STEAM Project

STUDENT PACKET

prepared by

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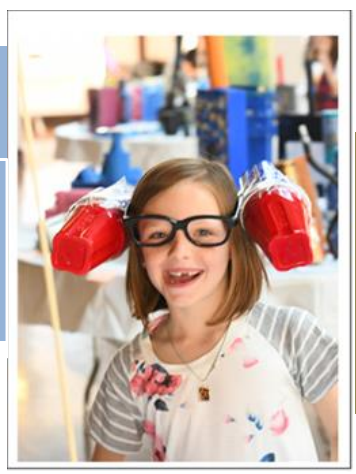

SAINT LOUIS SCIENCE CENTER

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THE SHELDON CONCERT HALL & ART GALLERIES

Letter to Students

Dear Student,

Welcome to this at-home guide on the **Science of Learning Instrument Design** (SOLID). I hope you are excited to experiment with the science of sound and tap into your creativity!

In this project, you will be challenged to design and construct a device that creates sound through vibration and is able to change pitch and volume. As part of the design process, you will be given the creative liberty to make your sound device into a decorative piece of art.

Take a picture of your finished project and tag us on social media with the hashtag ***#MySOLIDProject***. Find us on Instagram or Facebook by searching *The Sheldon Concert Hall and Art Galleries*.

This packet includes materials to guide you through the process. There is also a PARENT PACKET that includes more information about this challenge, because we want you to work on this project together.

Your packet includes these materials.

We hope you find this project interesting. We want you to enjoy and learn from the SOLID Challenge.

Katelyn Galenski
SOLID Program Manager

Science of Sound

The Science of Sound

Have you ever thought about how sound is created?

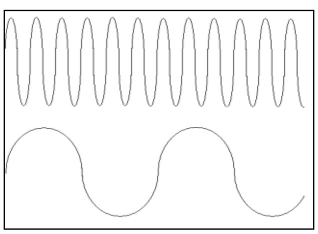
An object produces sound when it vibrates in some kind of material. These vibrations travel as <u>sound</u> <u>waves</u> through the air to your ears. The human eardrum is a stretched membrane, like the skin of a drum. When the sound waves hit your eardrum, it vibrates and the brain interprets these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

Amplitude & Volume

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

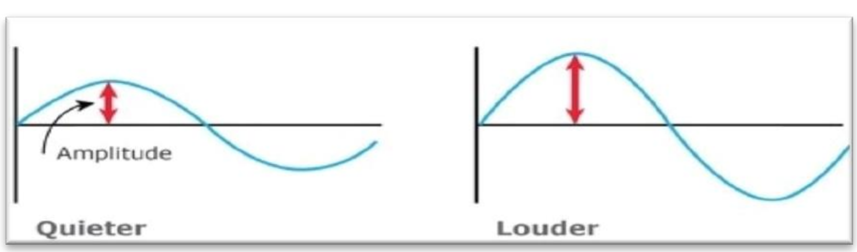
To understand this, imagine waves like an ocean. Sometimes the water is still. Other times waves rise well above the surface of the water. The distance between the highest point of the wave and the calm surface of water is called amplitude. When the amplitude is higher, the sound wave creates a **<u>louder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

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!



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.

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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

STEAM Engineering Cycle

Are you ready to put your engineering cap on?

The SOLID music project uses the 6 steps of the STEAM Engineering Cycle. These are the steps that engineers follow to develop a solution to a problem.

Step 1: ***Ask*** questions to understand the SOLID challenge

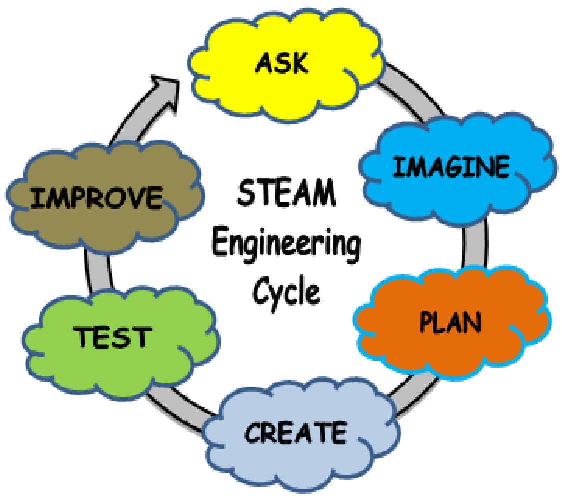
Step 2: ***Imagine*** possible solutions to the challenge and choose the best solution

Step 3: ***Plan*** the details of your sound device

Step 4: ***Create*** your sound device based off your plan

Step 5: ***Test*** that your creation meets the requirements listed in the challenge

Step 6: ***Improve*** your sound device to perform better or look more artistic!



Directions

Worksheets were prepared to guide you through the STEAM engineering cycle for this challenge. There is one worksheet for each of the six steps.

In each worksheet you will find directions and a set of questions to guide you through each step of the engineering cycle.

There is no time limit for the STEAM engineering cycle. You can take as much time as you need for each step and for the entire cycle. Your parent can help you decide what is the right amount of time for you to finish each step of the engineering cycle.

Be creative!

The Final Step

By completing the STEAM engineering cycle, you have met the SOLID Challenge and successfully designed and built a musical instrument! Congratulations!

Your final step is to think about your experience and what you learned from the project. Go to the ***What I Learned*** sheet to write your thoughts.

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STEP 1

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ASK — In this step we will define the challenge, ask questions, and look at what others have done to solve the problem.

FOLLOW THESE DIRECTIONS

1. **Read the challenge carefully. Think about how you might create a solution.**

> **The SOLID Challenge**
>
> Design and construct a unique object that produces sound.
>
> It must …
>
> - be constructed from recycled or repurposed materials;
> - produce sound resulting from vibration;
> - be capable of changing the *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.

2. **Follow these links for inspiration and to see what others have done to address this problem!**

> The Recycled Orchestra
> World Instruments Made from Recycled Materials

3. **Answer these questions.**

Do you understand the challenge? ___ Yes ___ No

If not, what questions do you have about the SOLID Challenge?

____

____

____

____

4. **Before beginning Step 2, review *Science of Sound* on pages 2 and 3 about creating sound and changing volume and pitch.**

STEP 2

IMAGINE Brainstorm possible solutions. Think outside the box! Don't copy a musical instrument you know, but create something that is uniquely yours!

FOLLOW THESE DIRECTIONS

1. **What ideas can you come up with to meet this challenge? List 3 ideas below for your sound device. How do you think it will look and how do you expect it to make sound?**
   - ____________________
     ____
   - ____________________
     ____
   - ____________________
     ____

2. **Choose the best idea for your design. Circle one idea OR the best parts of several ideas.**

3. **Review how each musical family creates vibration on page 3 and then answer these questions.**

   How do you think your device will create vibrations – friction by rubbing OR blowing air OR plucking or striking with your hand or another object?

   ____

   How do you think the **volume** and the **pitch** of the sound can be changed by your device?

   ____

   ____

There are so many different **materials** you can use for this project! Here are some you might use.

- General: cardboard boxes, plastic bottles, containers of various sizes, tin cans, popsicle sticks
- String: rubber bands, wire, fishing line
- Percussion: beans, rice, other rattling material
- Wind: paper towel tubes, toilet paper rolls, PVC pipe, plastic bottles, straws
- Construction: strong tape, hot glue gun, scissors, string
- Decoration: color markers, paint, beads, feathers, yarn, glitter, decorative tape

MOST importantly, you will need your own creativity!

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STEP 3

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PLAN **Make a detailed plan for the sound device.**

FOLLOW THESE DIRECTIONS

1. **Use the *Design Sheet* or a blank piece of paper to sketch your sound device. Include as much detail as you can!**

2. **Answer the questions about the materials that can be used.**

   Will your sound device be in the ***percussion***, ***wind***, or ***string*** family OR will it have parts in more than one of these three families?

   ____

   ____

   What materials will you use to build the device, create vibration, and change volume and pitch?

   ____

   ____

   What materials will you use for decorating the device?

   ____

   ____

3. **Label each part of the design with the name of the material you will use.**

4. **Review the *Definitions* on page 4 and answer these questions about *sound* and *pitch*.**

   How do you think the size and shape of the device could affect the sound quality and the pitch?

   ____

   ____

5. **Describe how your device will make sound. Explain how you will create vibration, change volume, and change pitch.**

   ____

   ____

   ____

   ____

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STEP 4
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CREATE **Use the design plan to build a physical model of the sound device.**

FOLLOW THESE DIRECTIONS

1. **Use the plan from Step 3 to build your sound device.**

2. **As you build the device, be sure to use the materials listed in the plan.**

3. **Try not to make any changes to your design until AFTER you test it.**

4. **After you have finished building your sound device, answer these questions.**

Does the model look similar to my drawing? ___ Yes ___ No

Have I used the materials listed on my *Design Sheet*? ___ Yes ___ No

Did I have any problem following the design and building the device? If so, what was it?

____

____

____

____

Do I expect any problems when I test my device?

____

____

____

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STEP 5

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TEST **Test the model. Evaluate how it performs and meets the SOLID Challenge requirements.**

FOLLOW THESE DIRECTIONS

1. **Test the device to see if it creates sound through vibration.**

2. **Test the device to see if it can change volume.**

3. **Test the device to see if it can create two or more pitches.**

4. **Answer these questions about how the model performs and looks.**

   Does the device create sound through **vibrations** like you planned? ___ Yes ___ No
   If not, what part is not working and what change can improve it ?

   ____

   ____

   Can you change the **volume** as planned? ___ Yes ___ No
   If not, what part is not working and what change can improve it ?

   ____

   ____

   Can you change the **pitch** as planned? ___ Yes ___ No
   If not, what part is not working and what change can improve it ?

   ____

   ____

   Is the device colorful and artistic? ___ Yes ___ No
   If not, what can you do to add more visual interest?

   ____

   ____

   Is there any other part of the device you hoped would work differently? ___ Yes ___ No
   If so, what can you do to solve that problem?

   ____

   ____

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STEP 6

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IMPROVE **Redesign the model if needed to improve the way it performs, feels, or looks.**

FOLLOW THESE DIRECTIONS

1. **Identify each problem found during the *Test* step. (Add more lines if needed.)**

   Problem 1 ____

   Problem 2 ____

   Problem 3 ____

2. **For each problem, go back to the original design and make changes to the plan. Make only <u>one</u> change at a time.**

3. **Change the device according to the new plan and the test it again.**

4. **Briefly tell what you did for each problem or improvement. (Add more lines if needed.)**

   Solution 1 ____

   ____

   Solution 2 ____

   ____

   Solution 3 ____

   ____

After making all of the changes, did your device look and perform like you planned? ___ Yes ___ No

After making all of the changes, did the device meet all of the requirement of the SOLID Challenge? ___ Yes ___ No

Design Sheet

What I Learned

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

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

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

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

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

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