Unit Title: Music Makers **Date Developed/Last Revised:** June 7, 2013 **Unit Author(s):** Jeanine Nakakura, Leslie Hamasaki	**Grade Level:** 9-12 **Time Frame:** 8 hours **Primary Content Area:** Physics

UNIT DESCRIPTION:
Students will learn about the properties of sound and create a musical instrument (aerophone) that can play 1 octave of the C major scale.

Big Ideas (Student Insights that Will Be Developed Over the Course of the Unit):

- Sound varies in two ways: volume and pitch.
- The Engineering Design Process (EDP) is a way to organize thinking and solve problems.
- Music and musical instruments have changed over time (technology).
- Music is connected to science, technology, engineering, and mathematics.

Essential Questions (Questions that Will Prompt Students to Connect to the Big Ideas):

- What is music?
- What are the connections between music and science, technology, engineering, and mathematics?

	BENCHMARKS/STANDARDS/LEARNING GOALS
Science	HCPS III SC.PH.2.1 Explain how scientific advancements and emerging technologies have influenced society SC.PH.6.1 Analyze transverse and longitudinal waves in mechanical (e.g., springs, wave tanks) and non-mechanical media (e.g., seismic waves, sound waves) SC.PH.6.2 Solve problems involving wavelength, frequency, amplitude, speed, absorption, reflection, and refraction *SC.PS.6.5 Compare transverse and longitudinal waves and their properties* *SC.PS.6.6 Explain and provide examples of electromagnetic radiation and sound using a wave model* Note: This unit is intended for a Physics course, but Physical Science benchmarks are included in italics for teachers who may want to teach it in a Physical Science course.
Technology	(See SC.PH.2.1 above)

Engineering	HCPS III CTE Standard 1: TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems
Mathematics	CCSS.Math.Content.HSA-CED.A.1 Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions*.
English Language Arts and Literacy	CCSS.ELA-Literacy.WHST.11-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
STEM Competencies	Indicator 2.2: Collaborates with, helps, and encourages others in group situations Indicator 3.3: Generates new and creative ideas and approaches to developing solutions Indicator 4.1: Recognizes and understands what quality performances and products are GLO 5: The ability to communicate effectively Indicator 6.3: Understands the impact of technologies on individuals, family, society, and the environment

LESSON SEQUENCE

	Lesson Title/Description	Learning Goals (What Students Will Know and Be Able to Do)	Assessments	Time Frame
1	**Introduction to Sound** • Bellwork • Pre-assessment • Create a Talkie Tape amplifier • Background information: Types of waves (transverse vs. longitudinal). What is sound? What are the properties of sound?	• Students can compare and contrast transverse and longitudinal waves. • Students can describe the properties of sound that we hear (volume, pitch) and how they are related to the properties of the sound waves (amplitude, frequency).	• Pre-test: Check Your Understanding of the Model of Sound • Post-test: Check Your Understanding of the Model of Sound (given in lesson 3)	1 hour (1 class period)
2	**PHET Sound Simulation**	• Students can explain the relationship between wave speed, frequency, and wavelength. • Students can solve problems involving wavelength, frequency, and speed. • Students can describe how the properties of sound that we hear (volume, pitch) are related to the properties of the sound waves (amplitude, frequency). • Students will write informative text (scientific procedures/experiments).	• Laboratory report • Post-test: Check Your Understanding of the Model of Sound (given in lesson 3)	2 hours (2 class periods)
3	**Create a Musical Instrument** • History of instruments • Make your instrument	• Students will engage in the Engineering Design Process (EDP) to create a musical instrument that plays 1 octave of the C major scale. • Students can explain how technology has influenced music. • Student will collaborate with others. • Students will communicate the results of their project.	• Conversations with students during EDP activity • Initial sound check with students during EDP activity • Musical Instrument test • EDP Student Journal • Paper on technology and music • Post-test: Check Your Understanding of the Model of Sound	5 hours (5 class periods)

Unit Title: Music Makers Lesson Title: Introduction to Sound Date Developed/Last Revised: 6/7/13 Unit Author(s): Jeanine Nakakura, Leslie Hamasaki	Lesson #: 1 Grade Level: 9-12 Primary Content Area: Physics Time Frame: 1 hour

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks and Process Skills Assessed in this Lesson:

- SC.PH.6.1 Analyze transverse and longitudinal waves in mechanical (e.g., springs, wave tanks) and non-mechanical media (e.g., seismic waves, sound waves)
- *SC.PS.6.5 Compare transverse and longitudinal waves and their properties*
- *SC.PS.6.6 Explain and provide examples of electromagnetic radiation and sound using a wave model*

Note: This unit is intended for a Physics course, but Physical Science benchmarks are included in italics for teachers who may want to teach it in a Physical Science course.

2A. Criteria- What Students Should Know and Be Able to Do:

Students can-

- compare and contrast transverse and longitudinal waves.
- describe the properties of sound that we hear (volume, pitch).

2B. Assessment Tools/Evidence:

Formative:

- Pre-test: Check Your Understanding of the Model of Sound
- Talkie Tape: quick EDP activity to see if students understand process

Summative:

- Post-test: Check Your Understanding of the Model of Sound (given in lesson 3)

3. Learning Experiences (Lesson Plan)

Materials:

- Slinky

For each group of 2-3 students:

- 1 Talkie Tape (3 different types of sayings on the Talkie Tapes works well), available from https://www.talkietapes.com/
- Variety of containers to amplify sound (milk cartons, yogurt containers, etc)
- Something to poke holes, such as scissors or safety pins

Handouts/Other Resources:

- Pre-test (see attached)
- Bellwork questions (see attached)
- PowerPoint on sound (see attached)
- LiveBinder on sound: http://www.livebinders.com/play/play?id=367835

Prerequisite Knowledge:

- SC.3.6.2 Explain how things make sound through vibrations
- SC.6.6.4 Describe and give examples of different types of energy waves
- SC.6.6.10 Explain how vibrations in materials set up wavelike disturbances that spread away from the source
- SC.8.6.3 Identify the characteristics and properties of mechanical and electromagnetic waves

Procedure:

1. Bellwork: Ask the students, "What is the difference between noise and music?" Students may have written or verbal responses. (5-10 min)
2. Have students take the pretest. (5-10 min)
3. Background info—PowerPoint. Discuss the properties of sound, longitudinal vs. transverse waves. Review terminology as needed, including amplitude, wavelength, and frequency. (10-15 min)
    - Demonstrate longitudinal vs. transverse waves with a slinky
4. Amplify Talkie Tape Activity (20-25 min)
    - Give each group 1 Talkie Tape, 1 or more containers, and a scissors.
    - Show students that running your fingernail over the Talkie Tape produces the sound.
    - Ask students to figure out a way to amplify the sound produced by the Talkie Tape using the materials provided so that they can understand what it is saying.
    - If students are having difficulty, give hints (tie a knot in the Talkie Tape to secure it to the container, or tell them the 3 possible sayings that their Talkie Tape could be saying).
    - Briefly have each group share how they amplified the sound from their Talkie Tape.

Homework Activity (Optional):

-

TEACHING & ASSESSMENT (Steps 4, 5, 6, &7) **Completed by teacher after instruction has taken place**
4. Teaching and Collecting of Evidence of Student Learning: Teacher Notes:
5. Analysis of Student Products/Performances - Formative: Teacher Notes:
6. Evaluation of Student Products/Performances – Summative (Not necessary for every lesson): Teacher Notes:
7. Teacher Reflection: Replanning, Reteaching, Next Steps: Teacher Notes:

Bellwork questions: Sound Unit

1. What is the difference between noise and music?
2. What are 3 ways you could change the sound of your voice?
3. If a tree fell in a forest and no living creatures were there to hear it, would the tree make a sound?
4. What animals hear the lowest/highest frequency sounds?
5. How many octaves can you sing? How could you find out?
6. What concert halls are famous for their acoustics? Why? How could you improve the acoustics of this room?
7. Why do singers sound different when they sing live compared to their recordings?
8. Sort sounds from soft to loud, or, high to low frequency.

Check Your Understanding of the Model of Sound

Purpose: To evaluate your understanding of the fundamentals of the model of sound.

Background:
Each of the following drawings indicates a model of a sound. The frequency of each sound is the number of vibrations occurring each second, or, f = vibrations/sec.

Procedure:
For each sound count the number of waves, determine the time for those waves to pass a given point, and calculate the frequency of each sound.
Note: Although sound waves are longitudinal, they are often represented as transverse waves (for example on an oscilloscope).

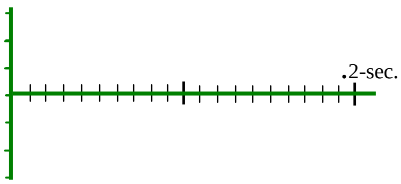
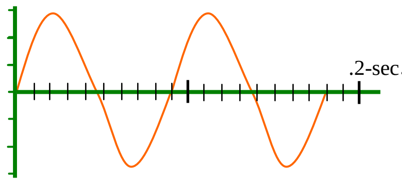


Figure 1



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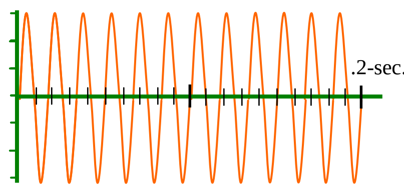

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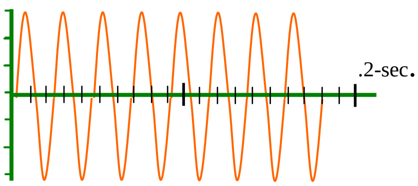

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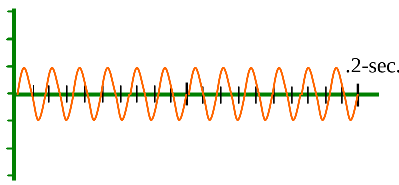

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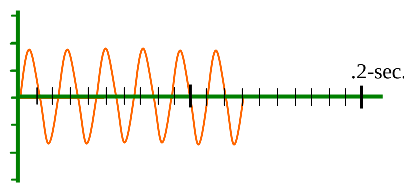

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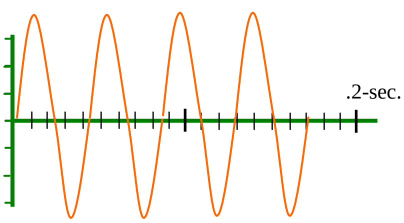

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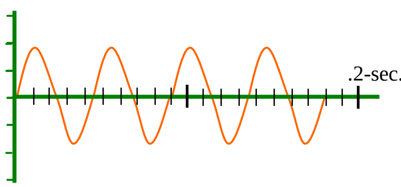

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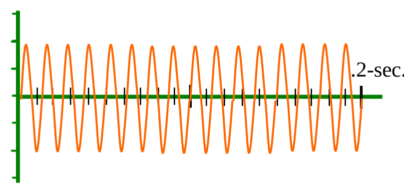


Figure 9

10. According to the model which sound is the loudest? ______

11. Which sound is the softest? ______

12. Which sounds have the same frequency but different loudness? ______ and ______

13. Which sound is the highest frequency? ______

14. Which sound is the lowest frequency? ______

Modified from Data Sheet at:
http://www.sciencescene.com/PhysicalScience/05sound/topic05.htm

Name_____ ____________________Date___________Period______

Pre-test

Figure	Number of Waves	Time (sec)	Frequency (waves per sec)
1			
2			
3			
4			
5			
6			
7			
8			
9			

10)

11)

12)

13)

14)

Total Correct = ________/14

Name_____ ____________________Date___________Period______

Post-test

Figure	Number of Waves	Time (sec)	Frequency (waves per sec)
1			
2			
3			
4			
5			
6			
7			
8			
9			

10)

11)

12)

13)

14)

Total Correct = ________/14

Answers

Figure	Number of Waves	Time (sec)	Frequency (waves per sec)
1	0.0	0.0	0.0
2	2.0	0.18	11.11
3	12.0	0.20	60.0
4	8.0	0.18	44.44
5	12.0	0.20	60.0
6	6.0	0.13	46.15
7	4.0	0.17	23.53
8	4.0	0.18	22.22
9	16.0	0.20	80.0

10) 7

11) 5

12) 3 and 5

13) 9

14) 2

Modified from Data Sheet at:
http://www.sciencescene.com/PhysicalScience/05sound/topic05.htm

SOUND

STEM Lesson

Lesson 1 Introduction to Sound

MUSIC MAKERS

Bellwork Question

In your Science notebook, please answer the following question:

- What is the difference between noise and music?

Pre-test

Test Your Understanding of the Model of Sound

Introduction to Sound

Benchmarks

- SC.PH.6.1 Analyze transverse and longitudinal waves in mechanical (e.g., springs, wave tanks) and non-mechanical media (e.g., seismic waves, sound waves)
- *SC.PS.6.5 Compare transverse and longitudinal waves and their properties*
- *SC.PS.6.6 Explain and provide examples of electromagnetic radiation and sound using a wave model*

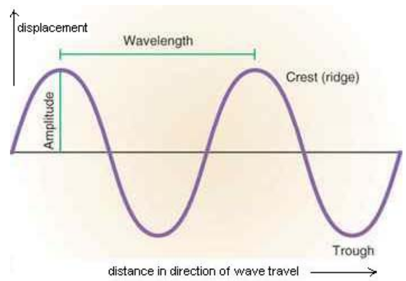
Essential questions

- What is music?
- What are the relationships between music and science, technology, engineering, and mathematics?

Background information

- Sound is a form of energy and travels in waves, causing molecules to move and vibrate
- Sound is a longitudinal wave and requires a medium to travel (slinky demo)
- Sound travels fastest through solids, slowest through gases

Vocabulary



http://www.frankswebspace.org.uk/ScienceAndMaths/physics/physicsGCSE/amplitudeWavelengthFrequency.htm

Talky tapes

- Use recycled materials to make sound louder to hear messages.

("Aloha", "Science is Fun", "You're the Greatest")

- Share how your group accomplished the task.

Lesson 2: PHET Sound Simulation

MUSIC MAKERS

PHET Sound Simulation

Benchmarks

- SC.PH.6.2 Solve problems involving wavelength, frequency, amplitude, speed, absorption, reflection, and refraction
- CCSS.Math.Content.HSA-CED.A.1 Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions*.
- CCSS.ELA-Literacy.WHST.11-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

PHET Sound Simulation

- Open up PHET Sound Simulation.
- Go to the first tab titled, "Listen to a Single Sound Source." Play with the simulation to determine the answers to the following questions. (5 minutes)
  - How does frequency affect sound?
  - How does amplitude affect sound?
- Discuss your findings.

PHET Sound Simulation

- Go to the second tab, titled "Measure."
- How are the wavelengths and frequencies of sound waves are related? Play with the simulation to find out. (Recommendation: test 200, 400, 600, 800, and 1000 Hz waves).
- Fill out the data sheet as you run your test.
- Graph your data.
- Generate an equation relating wavelength and frequency (optional).
- Share results via discussion and then write up a laboratory report.

Lesson 3: Create a Musical Instrument

MUSIC MAKERS

Create a Musical Instrument

Benchmarks

- CTE Standard 1: TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems
- SC.PH.2.1 Explain how scientific advancements and emerging technologies have influenced society
- GLO Indicator 2.2: Collaborates with, helps, and encourages others in group situations
- GLO Indicator 3.3: Generates new and creative ideas and approaches to developing solutions
- GLO Indicator 4.1: Recognizes and understands what quality performances and products are
- GLO 5: The ability to communicate effectively
- GLO Indicator 6.3: Understands the impact of technologies on individuals, family, society, and the environment

Criteria

- Create a musical instrument that can play one octave of a scale in C major
- Musical Instrument must be an aerophone (sound generated by a column of air vibrating)

Assessment

- Check notes (pitch) with **n-Track tuner** app OR **Audacity** (download from Internet)

[**both are FREE**!]

- Engineering Design Process Student Journal
- Rubric—for final design

ProTuner

17

C major scale

Note	Frequency (Hz)
Middle C	262
D	294
E	330
F	349
G	392
A	440
B	495
C (1 octave higher)	524

From Spigot Science Sound p. 14

What do you think was the first musical instrument played?

Music Through History

- Earliest forms of music were probably **drum-based, percussion instruments** (rocks and sticks)
  --used in religious ceremonies as representations of animals
- 35,000 years ago—flute made from vulture bone
- 4000 BCE—Egypt—**harps and flutes**
- 3500 BCE—Egypt—**lyres and doubled-reeded clarinets**
- 3000 years ago—Peru—**conch shells** (pututus)

History (continued)

- 2500 BCE—Denmark—**trumpet**
- 1500 BCE—Hittites—**guitar**
- 600 BCE—Greece—Pythagoras developed the **Octave Scale**
- Middle Ages—**harps, rebec, violin, lute, cello, viola, double bass, bagpipes, triangle, harpischord, trombone, xylophone**
- 1700 – 1800s—**French horn, oboe, bassoon, clarinet, piano, banjo, mandolin, ukulele, harmonica, tuba, accordion, saxophone**
- 1900s to present—**Electric guitars, synthesizer**

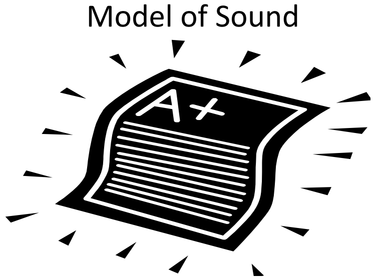
Career Connections

http://www.thefutureschannel.com/dockets/realworld/the_rhythm_track/

- Video Clip (6min 35sec)
- Drummer, Ndugu Chancler
- Why is math essential for music?

Post-test

Check Your Understanding of the Model of Sound



Unit Title: Music Makers **Lesson Title:** PHET Sound Simulation **Date Developed/Last Revised:** 6/10/13 **Unit Author(s):** Jeanine Nakakura, Leslie Hamasaki	**Lesson #:** 2 **Grade Level:** 9-12 **Primary Content Area:** Science **Time Frame:** 2 hours

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks and Process Skills Assessed in this Lesson:

- SC.PH.6.2 Solve problems involving wavelength, frequency, amplitude, speed, absorption, reflection, and refraction
- CCSS.Math.Content.HSA-CED.A.1 Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions.*
- CCSS.ELA-Literacy.WHST.11-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

2A. Criteria- What Students Should Know and Be Able to Do:

Students can-

- explain the relationship between wave speed, frequency, and wavelength.
- solve problems involving wavelength, frequency, and speed.
- describe how the properties of sound that we hear (volume, pitch) are related to the properties of the sound waves (amplitude, frequency).
- write informative text (scientific procedures/experiments).

2B. Assessment Tools/Evidence:

Formative:

- Discussion of laboratory results

Summative:

- Laboratory report
- Post-test: Check Your Understanding of the Model of Sound (given in lesson 3)

3. Learning Experiences (Lesson Plan)

Materials:

- Access to computers with the PHET Sound Simulation downloaded from http://phet.colorado.edu/en/simulation/sound
- Graph paper, graphing calculator, or computer with graphing program such as Excel

Handouts/Other Resources:

- Data Sheet: PHET Simulation on Sound (see attached)
- LiveBinder on sound: http://www.livebinders.com/play/play?id=367835

Procedure:

1. Have students open up PHET Sound Simulation. Instruct students to go to the first tab titled, "Listen to a Single Sound Source." Have students play around with the simulation to determine the answers to the following questions. Discuss student findings. (15-20 min)
   - How does frequency affect sound?
   - How does amplitude affect sound?
2. Direct students to the second tab titled, "Measure." Have students play around with the simulation to determine how the wavelength and frequency of sound waves are related. Suggested frequencies to use are 200, 400, 600, 800, and 1000 Hz waves. Instruct students to write out a laboratory report for this part of the activity, including a data table. You may want to provide a data sheet for students to use during the simulation to help them write the laboratory report. (40 min)
3. Assist students with graphing their data as needed. Guide students towards creating a mathematical equation that expresses the relationship between wavelength and frequency (optional). Have groups share their findings with the class and work on their laboratory reports. (60 min)

Homework Activity (Optional):

- Finish laboratory report, if needed.
- Practice problems on wavelength, frequency, and speed.
- Ask students to write down how the volume and pitch of a sound is related to the properties of the sound waves.

TEACHING & ASSESSMENT (Steps 4, 5, 6, &7)
Completed by teacher after instruction has taken place

4. Teaching and Collecting of Evidence of Student Learning:
Teacher Notes:

5. Analysis of Student Products/Performances - Formative:
Teacher Notes:

6. Evaluation of Student Products/Performances – Summative (Not necessary for every lesson):
Teacher Notes:

7. Teacher Reflection: Replanning, Reteaching, Next Steps:
Teacher Notes:

Data Sheet: PHET Simulation on Sound

Observations	
Questions	
Background Information	
Hypothesis	
Variables	Independent: Dependent: Controlled: Unable to control:
Methods	
Data/Results	
Conclusion	Be sure to address the following question: What is the relationship between wavelength and frequency of a sound wave?

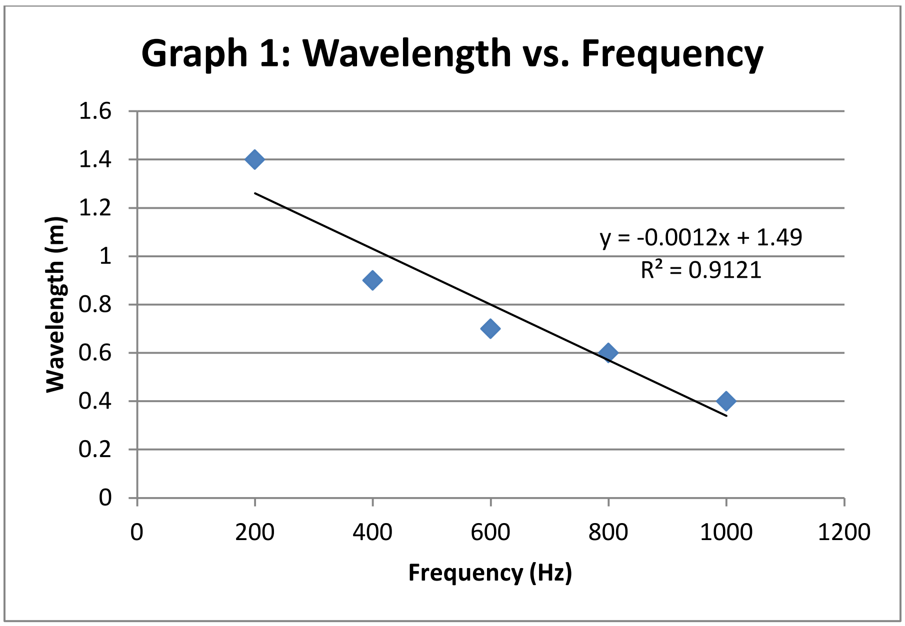
Sample PHET Sound Simulation Data

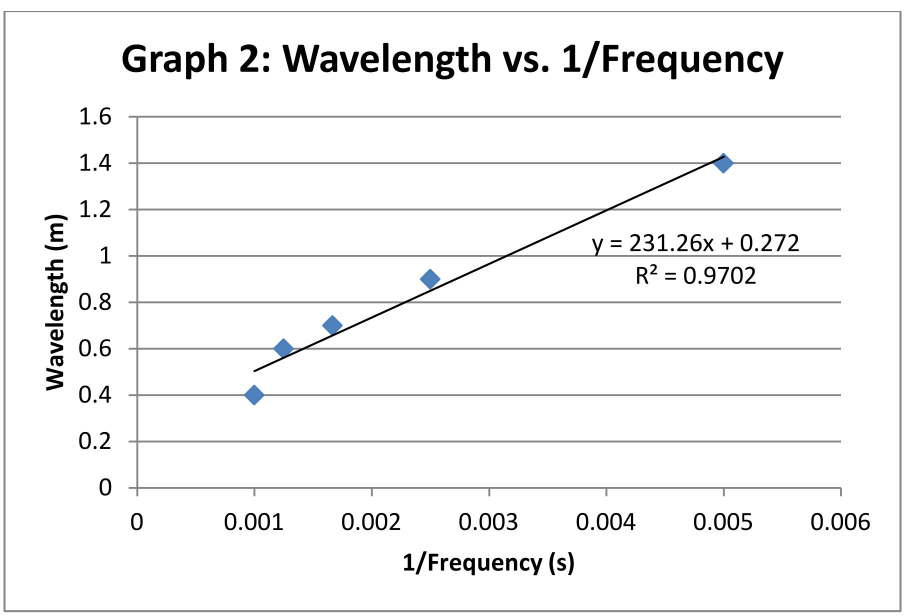
Table 1

Frequency (Hz)	Wavelength (m)
200	1.4
400	0.9
600	0.7
800	0.6
1000	0.4

Table 2

1/frequency (s)	Wavelength (m)
0.005	1.4
0.0025	0.9
0.001666667	0.7
0.00125	0.6
0.001	0.4





Unit Title: Music Makers **Lesson Title:** Create a Musical Instrument **Date Developed/Last Revised:** 6/10/13 **Unit Author(s):** Jeanine Nakakura, Leslie Hamasaki	**Lesson #:** 3 **Grade Level:** 9-12 **Primary Content Area:** Science **Time Frame:** 5 hours

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks and Process Skills Assessed in this Lesson:

- CTE Standard 1: TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems
- SC.PH.2.1 Explain how scientific advancements and emerging technologies have influenced society
- GLO Indicator 2.2: Collaborates with, helps, and encourages others in group situations
- GLO Indicator 3.3: Generates new and creative ideas and approaches to developing solutions
- GLO Indicator 4.1: Recognizes and understands what quality performances and products are
- GLO 5: The ability to communicate effectively
- GLO Indicator 6.3: Understands the impact of technologies on individuals, family, society, and the environment

2A. Criteria- What Students Should Know and Be Able to Do:

Students can-

- engage in the Engineering Design Process to create a musical instrument that plays 1 octave of the C major scale.
- explain how technology has influenced music.
- collaborate with others.
- communicate the results of their project.

2B. Assessment Tools/Evidence:

Formative:

- Conversations with students during the design and creation of musical instruments
- Initial sound check using a tuner or sound analyzer with students as they create their musical instruments

Summative:

- Musical Instrument test (instrument can play 1 octave of the C major scale)
- Engineering Design Process Student Journal
- Paper on technology and music
- Post-test: Check Your Understanding of the Model of Sound

3. Learning Experiences (Lesson Plan)

Materials:

- A variety of materials to make a musical instrument (aerophone), such as:
  - Hollow tubes that can be cut/adjusted to different lengths (PVC pipe, test tubes, bamboo, plastic tubing—PVC pipe works well)
  - Scissors/PVC cutter/saw
  - Rulers/meter sticks
  - Materials to adjust the length of the tubes, such as cork, plastic wrap, water, drill
  - String/modeling clay
- Tuner or sound analyzer such as n-Track tuner on the iPad or Audacity on the computer
- Chart or PowerPoint slide showing frequencies of the notes in the C major scale
- Computer, internet, and projector for video clip

Handouts/Other Resources:

- Engineering Design Process Student Journal (fold pages in half to create a booklet)
- Rubric: Making a Musical Instrument
- PowerPoint on the history of musical instruments
- Rubric: Technology & Music
- Livebinder on sound: http://www.livebinders.com/play/play?id=367835

Procedure:

1. Explain the task to students: In groups of 2-3 students, create an instrument that can play 1 octave of the C major scale. The musical instrument must be an aerophone, which generates sound by producing a column of vibrating air.
2. Show students a chart or PowerPoint slide showing the frequencies of the notes in the C major scale and tell them the information might help them with their task.
3. Explain what materials are available and any safety issues, especially with tools such as a saw.
4. A sound check can be conducted for each note as students work on their instrument. Demonstrate the use of the tuner.
5. Give students time to work. Instruct students to complete the Engineering Design Process Student Journal as they work. You may want to require that students complete Steps 1-3 in the journal before they are allowed to actually start building their instrument.
6. Go over the history of musical instruments (PowerPoint). Discuss the role of technology and engineering in the development of music. Also discuss the connections between music and math.
7. Have students write about whether they think technology has impacted society in the realm of music. To assess student work, use Rubric: Technology & Music. You may want to have students use a template to plan their writing. See an example at http://www.readwritethink.org/files/resources/interactives/persuasion_map/
8. Have students share their musical instruments and the process they went through to create them with the class.
9. Have students self-assess their musical instrument project with Rubric: Making a Musical

Instrument.

10. Give students the post-test on sound.
11. Possible extension activities:
    - Devise a way to tune the instrument
    - Increase range to more than one octave
    - Amplify the sound
    - Determine the mathematical equation that expresses the relationship between the frequencies of the notes in the chromatic scale
    - Improve aesthetics of instrument
    - Improve the timbre of the instrument
    - Make fruit or vegetable instruments (See ***Spigot*** magazine on Sound, p. 13)
    - Are all school bells the same pitch?
    - Introduce students to cymatics (study of visible sound) by showing a video like ***Making Sound Visible Through Cymatics: Evan Grant onTED.com***
        - http://blog.ted.com/2009/09/03/making_sound_vi/
    - Make your own Talkie Tape
    - Show ***Honda Musical Road*** or ***Duck Calls*** video
        - http://parkpictures.com/index.php/category/view/45/type:3/#/page:1
        - http://abcnews.go.com/Nightline/video/duck-dynastys-swamp-millionaires-15967157
    - Find sound recordings and imitate
    - Form a class orchestra and play a simple song with the instruments the students made

Homework Activity (Optional):

-

TEACHING & ASSESSMENT (Steps 4, 5, 6, &7)
Completed by teacher after instruction has taken place

4. Teaching and Collecting of Evidence of Student Learning:
Teacher Notes:

5. Analysis of Student Products/Performances - Formative:
Teacher Notes:

6. Evaluation of Student Products/Performances – Summative (Not necessary for every lesson):
Teacher Notes:

7. Teacher Reflection: Replanning, Reteaching, Next Steps:
Teacher Notes:

Information Sheet: Explain how the sound produced by the instrument is related to the frequency of the sound waves and the length of the air column. You may also provide any other background information that a potential customer may be interested in.

Making a Musical Instrument

______________________________'s

Engineering Design Process Student Journal

Step 1 ASK: *Understand the problem clearly, state the conditions and limitations, and obtain information from prior knowledge.*

Problem: You are a wannabe rock star trying to make some extra money. A company that sells science toys has contracted you to help them create a kit for an activity on sound. Your job is to create a musical instrument that can play 1 octave of a C scale. The instrument must be an aerophone (sound is created by a vibrating column of air). You need to design the instrument, create a prototype, and test the pitch of the notes. Then you will optimize the prototype for accurate pitch. You will submit a report explaining the prototype trial results, optimization process, and why your final design is the best choice (or not). You will also create an information sheet for the kit explaining how the sound produced by the instrument is related to the frequency of the sound waves and the length of the air column.

Materials: You will be given certain materials to choose from.

- Various types of tubes: straws, PVC, bamboo, steel, bottles, etc.
- Various tools: scissors, pruner, pipe cutter, etc.
- Misc. supplies: tape, glue, sandpaper, paper, ruler, etc.
- Other materials that you could bring from home

ASK: Ask questions about the project that you want to know more about. Remember to clearly define the *criteria* and *constraints* of the project.

List criteria and questions to clarify criteria.

Conclusion:

- What changes were made to your prototype, and what effect did they have on the final instrument performance?
- What design do you recommend for the instrument? Provide data and reasoning to support your recommendation.

EXPERIMENT: Test out your final instrument!

Table 2: Final trials for pitch frequency (Hz)

Expected Musical Note	Length of Air Column	Expected Frequency (Hz)	Measured Frequency (Hz)	Frequency % error	Measured Musical note
C					
D					
E					
F					
G					
A					
B					
C					

Graph your final data

List constraints and questions to clarify constraints.

List any other questions about the project that you have.

Step 2 IMAGINE: Draw and/or write out your ideas for possible designs.

IMAGINE/PLAN: Draw a diagram of your final design, label the possible measurements for each dimension of the instrument, and write down what materials you plan to use in order to make your final instrument.

Diagram

Materials

CREATE: Build your final instrument following your plan. If you make any changes from your plan, write it down here↓.

Step 4 CREATE: Build your prototype instrument following your plan. You may test one note before creating the rest to make sure you're on track. If you make any changes from your plan, write it down here↓.

Changes to plan: Initial test results:

Step 5 EXPERIMENT: Measure the pitch frequencies that your prototype produces.

Table 1: Prototype trials for pitch frequencies (in Hz)

Expected Musical Note	Length of Air Column	Expected Frequency (Hz)	Measured Frequency (Hz)	Frequency % error	Measured Musical note
C					
D					
E					
F					
G					
A					
B					
C					

Temperature of room:

Speed of sound in air at _____________:

Graph your prototype data:

Step 6 IMPROVE: Make it better!

ASK: What worked and what didn't work for you design? Why?

What worked? Why?

What didn't work? Why?

Suggested changes to try? Why?

Step 3 PLAN: Think about which design would work best and make a choice. Draw a diagram of your prototype design, label the possible measurements for each dimension of the instrument, and write down what materials you plan to use in order to make your prototype.

Diagram

Materials

Rubric: Making a Musical Instrument

	Advanced	Proficient	Developing	Beginning
Product Quality (Musical Instrument)	Product meets all criteria within the given constraints. Product exceeds criteria in one or more areas.	Product meets all criteria within the given constraints.	A product is created. Most or all constraints are followed. Most or all criteria are met.	Product does not meet most or all criteria. Some or all constraints may be overlooked.
Engineering Design Process	Student persists in the engineering design process until all criteria are met. Creativity is utilized during problem-solving. Design decisions are made with a reasonable rationale.	Student persists in the engineering design process until all criteria are met. Design decisions are made with a rationale.	Students engage in the engineering design process and attempt to improve the product, but stop before all criteria are met. Design decisions may be made randomly.	Students engage in parts of the engineering design process. Product does not meet all criteria and no attempt is made to improve the design. Design decisions may be made randomly.
Communication (Engineering Journal)	Journal clearly documents the engineering design process and the results. Information is accurate. Content is relevant and complete, adequately addressing potential questions a reader may have. Writing is clear and organized. Flow of information is logical.	Journal documents the engineering design process. Information is generally accurate and complete. May include some content that is only tangentially related to the topic. Most of the writing is clear. There is some organizational structure to the information.	Journal documents most of the engineering design process. Some information is unclear, questionable or inaccurate. Irrelevant content may be included. Some important information may be missing. Writing is unclear and/or unorganized. Flow of information is confusing.	Journal documents some of the engineering design process. Much information is unclear, questionable, inaccurate, irrelevant, or missing.
Collaboration/ Teamwork	Student respectfully contributes ideas and feedback to the team. He/she listens to and acknowledges the contributions of others, as well as encourages others to share their ideas.	Student contributes ideas and feedback to the team. He/she listens to the contributions of others.	Student contributes ideas and/or feedback to the team. He/she sometimes listens to the contributions of others. May either become passive or dominate the group at times.	Behaviors may include one or more of the following: Rarely contributes ideas or feedback to the team. Rarely listens to others. Is mostly passive or does the entire project alone. Is distracted and not focused on the project.

Rubric: Technology & Music

Learning Goal:
I can explain how technology has influenced society in the area of music.

Category	3 (Exceeds standard)	2 (Meets standard)	1 (Approaching standard)
Introduction	Stance is clearly stated.	Stance is stated.	Topic is mentioned, but no stance is taken.
Main Reasons	Three or more substantially different and important reasons are provided for stance.	Two substantially different reasons are provided for stance.	0-1 reasons are provided for stance.
Facts/Examples	Facts and/or examples are provided for each reason. Information is accurate. Information logically supports each reason. An ample amount of information is provided, so that the reader generally does not have unanswered questions.	Facts and/or examples are provided for each reason. Information is accurate. Information logically supports each reason.	Facts and/or examples are lacking, inaccurate, or do not logically match the reason provided.
Conclusion	Summarizes main points and/or provides suggestions for next steps in a powerful, memorable, and/or effective way.	Summarizes main points and/or provides suggestions for next steps.	Does not summarize main points or provide suggestions for next steps. Ideas are scattered or irrelevant.