



*Loranger Middle School, Old Orchard Beach, Maine*

EXPLORING MUSIC *with the* PIPE ORGAN

# SOUNDWAVE ENERGY

*An integrated teaching unit for schools  
July 1, 2017*



*An educational project of*  
The Friends of the Kotzschmar Organ  
Portland, Maine • [www.foko.org](http://www.foko.org)

# ACKNOWLEDGMENTS

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# SOUNDWAVE ENERGY

An integrated teaching unit exploring

Frequency,

Amplitude,

and Pitch.

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# EXPLORING MUSIC *with the* PIPE ORGAN

## SOUNDWAVE ENERGY

The FRIENDS OF THE KOTZSCHMAR ORGAN (FOKO) is pleased to present this curriculum based on concepts found in middle school science study of sound wave energy and its relationship to the pipe organ. It is the product of ten years of active in-classroom teaching.

FOKO's Education Committee chose this concept because it:

- is a major science curriculum concepts for middle school;
- applies the scientific method during the experiments;
- provides a link from concept to a real world example of application;
- is a distinct contrast to O. Messiaen and J.S. Bach featured in another FOKO curriculum.

Central to the curriculum are the two Artist-in-Residence visits presented by an organist, demonstrating with a pipe organ. We also have included several pre-visit activities to prepare students by exploring sound wave energy concepts and functions of the pipe organ.

We include teacher resources with YouTube links, assessments, and reproduction masters.

While the unit was created for the Kotzschmar Organ in Portland, Maine and Kotzschmar Junior (our portable, demonstration organ), it can be replicated by using a local organ in a hall or church or even through the use of YouTube videos. You may wish to check with the American Guild of Organists to locate an organist or the Association of Pipe Organ Builders in America for an organ builder to assist with pipes within your local area.

The Education Committee of the *Friends of the Kotzschmar Organ*, in Portland, Maine hopes you will find these materials valuable in engaging your students in a music and arts exploration in your classroom. Please visit the FOKO website at [www.foko.org](http://www.foko.org) for more information about our education programs. If you have questions, or concerns about these materials, please contact us at [info@foko.org](mailto:info@foko.org).

## NOTES FOR THE ARTIST-IN-RESIDENCE

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This curriculum is the product of more than 10 years of bringing the pipe organ to school classrooms. I have found it to be an engaging and stimulating experience as I plant seeds of knowledge and understanding.

The more collaboration I have done with the classroom teacher before coming in to teach their students, the stronger the results. Establishing a working relationship with the teachers and functioning as a member of a collaborative team is crucial.

When using the pipe organ as a vehicle to teach sound wave energy in the science classroom, I find out what other science concepts the classes have studied and what terminology they have employed (for example: mechanical energy, laws of conservation of energy, hypothesis, data, etc.). My use of that vocabulary will reinforce the teaching that has already occurred.

I will often start my presentations to a class by asking student what they know. This allows me to discern where the class is at that time and gives me a basis on which my teaching will build.

Visual presentations can be a great asset to your teaching. Over the years I have come across many fine YouTube videos that have become effective teaching tools. The curriculum shares several links that I have found useful.

When presenting a concert following classroom instruction, I find it compelling to actively engage students in the playing. Have a child explore the highest octaves of a 2' rank, or experience the rumble of a 16' or 32' rank as they play the pedals. Have them play the low pedal D of the Bach d minor Toccata (BWV565) at the appropriate time, while I play the manual parts. A general principle is: "Do not do for students what they can do for themselves."

The curriculum ideas included here are tools for your teaching. They are meant to be freely adapted and molded to each and every individual classroom situation.

If you have questions, reactions, or responses to this curriculum, please do not hesitate to be in touch with us. As we know, the pipe organ is a marvelous instrument. It opens the doors to so many wonders of our world.



A handwritten signature in black ink that reads "Ray Cornils." The signature is written in a cursive, flowing style.

Ray Cornils  
Artist-in-residence  
Portland, Maine

# ARTIST-IN-RESIDENCE VISIT, DAY 1

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## LEARNING OBJECTIVES

Students will be able to:

- \* Discover the difference between amplitude and frequency
- \* Experience what is vibrating
- \* Learn the relationship between mass and frequency
- \* Recognize transfer of energy
- \* Experience work by pumping the bellows
- \* Recognize the role of air pressure in making sound
- \* Describe parts of the organ pipe
- \* **Discuss if sound requires a “medium” to carry it**

## MATERIALS LIST

- ◆ Pipes – wooden, metal (including a cross-sectioned pipe cut in half, if possible)
- ◆ Large slinky, small slinkies and Slink-o-matic (see pictures on pp 10 and 11)
- ◆ Ropes cut in 2', 4', 8', 16', and 32' lengths
- ◆ Portable organ for use in school

## MUSIC LIST

(links are provided if an organ is not available.)

J.S. Bach: Minuet in G (harpsichord)

<http://www.youtube.com/watch?v=KqSAGwa49MM>

**Bach: “Little” Fugue in G Minor**

<http://www.youtube.com/watch?v=PhRa3REdozw>

**Bach: “Little” Prelude in F Major**

<http://www.youtube.com/watch?v=cd4C-bKm0fk>

Bach: Toccata and Fugue in D Minor

<http://www.youtube.com/watch?v=CTVraVgzC9U> &feature=related

The Simpsons

<http://www.youtube.com/watch?v=h54ptoR9ZhY>

Benedetto Marcello: Psalm 19

<http://www.youtube.com/watch?v=Ex7epYwXI84>

**Hedwig’s Theme from Harry Potter**

<http://www.youtube.com/watch?v=ZMv5iBjMNLE>

Take Me Out to the Ball Game

<http://www.youtube.com/watch?v=i67voDrkUy8> start at .32 sec.

Somewhere Over the Rainbow (Organ with Lyrics)

<http://www.youtube.com/watch?v=yGx8yMG5yKA>

## VOCABULARY

Wave	A disturbance that transmits energy and not matter.
Wavelength	The distance between a point on one wave to the same identical point on the next wave.
Crest	Top of the wave.
Decibel	<b>The unit to measure the volume or loudness of sound; abbreviation is “dB.”</b>
Medium	The materials that the wave is passing through, such as air or water. Medium moves at a right angle to the direction of the wave.
Pitch	The way a person hears the frequency of a sound; in general, the greater the frequency, the higher the pitch.
Octave	Eight notes: do re mi fa sol la ti do.
Flue Pipe	Has no moving parts. Sound is made when wind enters the foot of the pipe through the toe hole. Wind goes through the flue, forms the wind into a sheet of air, which strikes the upper lip of the pipe and causes a sound wave to be formed.
Reed Pipe	Has moving part called the tongue that vibrates against a brass tube called a shallot. When the tongue strikes the shallot a sound is produced. The tongue and shallot are inside the boot of the pipe which is connected to the resonator which be made of either metal or wood. Type of pipe that makes a distinctive and bold sound, orchestral instrument sounds like trumpet, oboe, trombone, or clarinet.

## LESSON PLAN

### Concepts covered

- Amplitude and Frequency
- What is vibrating?
- The greater the mass, the lower the frequency
- Transfer of energy
- Work—pumping of bellows
- Air pressure
- Parts of an organ pipe

### Students may also know

- Sound requires a medium to carry it.

### Vocabulary covered (written on the board):

- Amplitude, sound wave energy, frequency, pipe, flue, reed, hertz, manual, pedal, pitch, volume

## LESSON DEVELOPMENT

1. Play portable organ as students are entering the room.
2. Introduce self to the students giving them some of your background and give a brief summary of the objectives for today's lesson.
3. Establish **prompts used in classroom for listening and stop talking** Perhaps "Amplitude 0"
4. Opening Questions
  - a. What concepts do you know about sound wave energy? (various responses from students)  
Possible responses: amplitude, sound waves, types of waves, waves and volume.  
*You may want to put some of the comments on the board.*
  - b. Have you ever seen (heard) a pipe organ before?
5. "I love playing the organ, and I love finding out how it works?" **"Let's explore the pipe organ."**

### 6. PIPE ORGAN BASICS

Pick up a pipe, ask how do you make this work  
After discussion, demonstrate how the pipe sounds  
Ask the students to describe exactly how I did it.  
They will most likely say, "I blew into it."  
I ask them, "What did you do first before blowing in the pipe?"  
"What's your hypothesis on how the sound is produced?"

Answers:

Take a breath  
Fill my lungs with air  
Apply muscular pressure to force the air out of my lungs  
The air goes into my mouth  
(if I use my tongue to start and stop the sound, then the air is stored in my mouth)  
(my brain decides that I want the pipe to sound)  
(move my tongue)  
Air flows into foot of pipe  
And is formed into a sheet of air at the flue  
The sheet of air hits the upper lip and begins vibrating  
That frequency of its vibration is related to the length of the pipe (the mass of air vibrating)

Note how this process relates to the pipe organ

Lungs – bellows and reservoir  
Abdominal muscles – weight of the blower  
Mouth – wind chest  
Tongue – pallets  
Key action – nervous system

7. Let's look at this pipe. Actually it is a pipe cut in half.

Demonstrate how the air comes in through the toe and it splits the air and vibrates the column.

Pick up an open wooden pipe. Note the metal tuning flap end of the pipe.  
While blowing into the pipe, place your hand at end of pipe – note change of pitch.  
While blowing into the pipe, place hand at mouth – huge change of pitch – therefore this is where the sound is formed and gives a clue as to what is vibrating.  
After discussion, demonstrate how the pipe sounds. Then ask the students to describe exactly how I did it.

### 8. MANUALS, PEDAL, STOPS

- a. Note that in order for the organ to make sound, you need:
- b. To pump the bellows into the reservoir;
- c. Pull out stop – which might be better called a GO, since it allows air under the pipe
- d. Push down a key on the Manual (keyboard for the hands) or Pedal (keyboard for feet.)
- e. Note other MAN words: manuscript, mano a mano, manicure, manipulate, etc.
- f. Note other PED words: pedestrian, pedicure, etc.





EXPLORE Pipe length and its relationship to frequency.

Write Frequency and Amplitude on the board. Explain what they mean and give examples. Play two notes on the organ Do you hear a difference in amplitude or frequency? (*Both about the same loudness but different pitch.*) Frequency has to do with pitch. Amplitude with loudness or softness.

Compare two pipes. (A small wooden and a large metal.) How do you think these two pipes will sound?

Which has lower frequency (which has greater mass of air inside)? Play various notes on the organ.

Different pitches, Different amplitudes (Use Melodia and Stopped Diapason, same note, in the 2nd octave of sound.). Ask which is higher frequency.

### FREQUENCY FINDER GAME

**Organist's back is to the organ. Have student play a note on the organ. Organist listens to the note, observes if it is a high or low frequency, and then (by analyzing the interval from the previous note played) finds and plays the same note the student played. Because I spend a lot of time with sound waves I am very aware of the frequency of notes and I can find them.**

#### Variations

Give me two notes. The organist plays them back, observing which of the two notes was the higher or lower frequency.

Give me three notes, etc..

CHANGE UP: Organist plays a note. Student comes up to find the note. Was it a middle, high, or low note? If the response was too high, try lower, too low try higher, too high, try again, found it!

## 9. INFORMATION ABOUT PUMPING

The organ is a wind instrument and needs air to produce sound waves. Before electricity, someone had to pump the bellows to fill the reservoir with air.

(You may wish to note that this is an air reservoir. Cities often have water reservoirs to provide enough water for their residents).

Have a student come up and pump the bellows and fill the reservoir. Stop pumping when the reservoir is full.

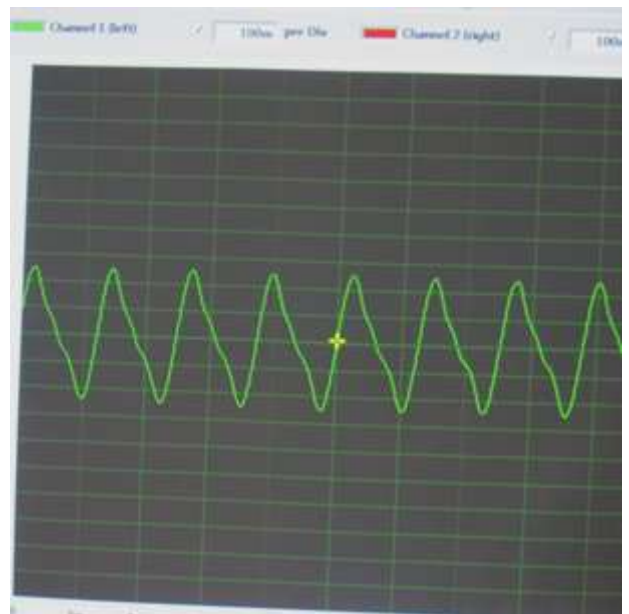
## 10. Oscilloscope

[http://www.zeitnitz.de/Christian/scope\\_en](http://www.zeitnitz.de/Christian/scope_en)  
(Download: *scope\_141.exe*, which is the application install file)

- Let me open my oscilloscope.
- Blow into a pipe and watch the waves on the screen. Blow harder into the pipe. What happens to the waves? Note frequency and amplitude. Use a shorter pipe. What happens to the waves?

## 11. Explore Amplitude

- Play a quiet piece (low amplitude) and ask a student to pump (watch reservoir, pump only when it is needed.). Note how much air is needed.
- Pull out all the stops and play Bach Toccata in d minor, ask students to pump bellows. *Note: more air is needed for great amplitude. Greater amplitude needs more energy.*



## 12. Use slinkies to show differences between pitch and amplitude

- Use the large slinky [illustrated on front cover] on the floor or on two tables. *Make one wave. Can you increase the frequency? What happens to the wave?*
- Variations : Transverse wave, half wave, full wave.

13. Use the Slinky-o-Matic.  
 Demonstrate compression or longitude waves)  
 Pull the string. The return is an echo wave. It sends a wave to the wood and it returns.  
*Can you increase the frequency? Pull more often.*

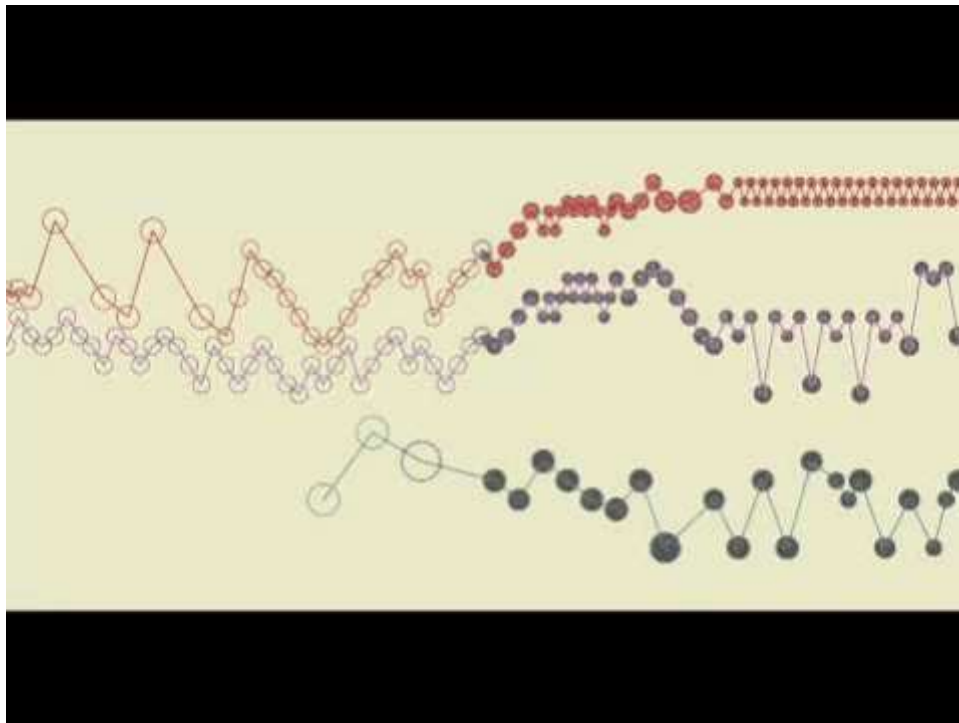


14. Range of Frequencies  
 The frequency we can hear is 20 to 20000 times/second.  
 Play A0440. “I’m going to play something whose frequency is 440 waves per second.”  
 Then play the A an octave higher. “This pipe’s frequency is 880 times per second.”  
 Then play the highest note on the keyboard .

13. Ask student to speak or sing with different frequency or amplitude

15. Watch video of “dots” of the J. S. Bach “Little” Fugue in G Minor

[http://www.youtube.com/watch?v=p1XD1MSES\\_8](http://www.youtube.com/watch?v=p1XD1MSES_8)



Point out the higher frequency (red, notice trill section), lower frequency (purple), then green, then light blue (pedal board).  
 Point out the nine fugue repetitions.

Mnemonic for fugue subject

“J.S. Bach composed this little melody.”



## ARTIST-IN-RESIDENCE VISIT, DAY 2

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### LEARNING OBJECTIVES

The student will be able to:

- \* Explain characteristic of Amplitude and Frequency
- \* Explain how an organ works
- \* Define what is an octave
- \* Exploration of 2:1 relationship (geometric, not arithmetic relationship)
- \* **Explore Pipe lengths 2', 4', 8', 16', 32', 64'**
- \* Use the Scientific method in their discussion
- \* Practice Listening skills
- \* Learn how a reed pipe works (vibrating tongue as opposed to the flue pipe, vibrating column of air)

### MATERIALS LIST

- ◆ Reed and Flue Pipes
- ◆ Measuring stick
- ◆ **Rope lengths 2', 4', 8', 16', 32', 64'**
- ◆ Portable organ for use in school

### MUSIC LIST

(links are provided if an organ is not available.)

Debussy *Premiere Arabesque*

<http://www.youtube.com/watch?v=iv1jLyD4Pv8&feature=fvwrrel>

<http://www.youtube.com/watch?v=Xiq3gHL83f8>

Somewhere Over the Rainbow

(see previous day for links)

Take Me Out to the Ball Game

<http://www.youtube.com/watch?v=i67voDrkUy8>

start at .32 sec. Organ music with lyrics

Star Wars Theme

<http://www.youtube.com/watch?v=p5AHLqi62eQ>

two students playing a duet

<http://www.youtube.com/watch?v=fKDWi8Q4THk>

shows hands playing on manuals on a theatre organ

**Organ failure 128' pipe, just for fun**

<http://www.youtube.com/watch?v=jaSfOx43ykQ>

## LESSON DEVELOPMENT

1. Play the organ as students enter the room.
2. Review from lesson one  
Ask class about physics terms  
Ask class about pipe organ terms
3. Premiere Arabesque  
Set up video with dots.  
Ask class to hypothesize about what the dots will represent  
Then listen to the Arabesque and review concepts
4. Flue and Reed Pipes  
Give 4 flue pipes of different lengths to 4 different students. Have them line themselves up in front of the class in order of low to high frequency.  
Give a reed pipe boot (of a low-pitched reed pipe) to a student and have the student stand where they think they will fit into the frequency line. Ask each student to blow into the pipe. The students will be shocked to hear reed pipe.
  - Dissect the reed pipe. (remove resonator boot)
  - Show what is vibrating.
  - Compare to clarinet, saxophone, bassoon and oboe.
  - Get other reed pipes and explore reed lengths, The greater the mass the lower the frequency
5. Show tuning slide—note what happens when you move it. Note similarity to slide whistle or slide trombone.  
Explore the reed lengths.  
Show the tuning slide.
5. More Mass = lower frequency; longer ruler or reed = more mass = lower frequency.
  - Place a ruler over the edge of a table. Have student flick the end of the ruler. Observe frequency.
  - Change length of ruler over the edge of table and note change of frequency.
6. Octave Exploration—note geometric doubling, not arithmetic addition of octave ratios.  
Discuss octave  
Do, re, me, fa, sol, la, ti, do  
Songs that students know that represent the octave:  
*Take Me Out To The Ballgame* or *Somewhere Over the Rainbow*
7. Find 4 C open flue pipes in the organ. Let students measure them. (from mouth to tuning slide).
  - Measure shortest (answer: 5 ½ inches or 14 cm)
  - Next C (11 inches or 28 cm)
  - Hypothesize next C (most students will answer 16 ½ inches or 42 cm)
  - Measure it. (answer is 22 inches or 56 cm) Note this is a geometric, not arithmetic ratio.
  - An octave lower would be 44 inches or 112 cm.

Put chart on the board and have student fill in data

DATA CHART	
Short C	_____ (5.5 inches or 14 cm)
Medium C	_____ (11 inches or 28 cm)
Long C	_____ (22 inches or 56 cm)
Very Long C	_____ (44 inches or 112 cm)

*Exploring 2' 4' 8' 16' 32' and 64' ropes at Merrill Auditorium:*



**8. So let's explore the wavelengths of various pipes (2', 4', 8', 16', 32', 64')**

Hand out ropes of 2', 4', 8', 16', 32' and 64' lengths to teams of two students each. Place students holding one end of the ropes all at the same spot in the hallway of the school. Stretch out the ropes in the hall. Try to get a single wave to travel through each rope. Which one requires more energy???

Note: the longest pipe at First Parish Church 16'  
the longest pipe in Kotschmar Organ 32'  
the longest pipe in world 64' can't hear it – only feel it (Sydney Australia)  
Imagine a 128' pipe – what would it sound like?

Watch hypothetical video 128' pipe <http://www.youtube.com/watch?v=jaSfOx43ykQ>

**9. Wrap up Questions**

What is the difference between amplitude and frequency?

How are decibels and hertz related?

How does sound wave energy happen in a pipe?

**10. Complete assessment.**



# A FIELDTRIP TO A LOCAL PIPE ORGAN

Ideally, every project will culminate in a field trip to a pipe organ in the community. Not only will students have an “ears on” experience of live music (*growing rare in these days of digital media*), but they will have an “eyes on” experience as well. Their interest and excitement will be evident as they gather around the console to see “how it all works.”

Whenever possible, young organ or piano students are encouraged to have a “hands on” experience as well. The thrill of playing a pipe organ for the first time is never forgotten!

During the times that a church is used small groups of 6-7 students go on the tour of the windchest and preview architectural highlights of the church such as stained glass windows.

Another group of 6-7 students is working on scavenger questions as the organist continues to perform. Students receive a question such as:

- ◆ Who built this organ?  
(Hint: look for the nameplate on the console)
- ◆ What city did the organ builder work in?  
(Hint: look for the nameplate on the console)
- ◆ How many pipes are in the façade?  
(A façade are the pipes that you can see – they are painted beautifully)
- ◆ How many manuals does this organ have?  
(Remember: a manual is a keyboard played by the hands)
- ◆ How many pedals does this organ have?  
(Remember: a pedal is a key played by the feet)
- ◆ Do you think this organ was ever pumped by hand?  
(Hint: What year was the organ built? Look on the console.)
- ◆ How many stops does this organ have?
- ◆ What year was the organ built?  
(Hint: look for the nameplate on the console)



This allows students a close up view of the console and the artist-in-residence playing. During this time the rest of the students work on a word search puzzle about component pieces of an organ.

# A SAMPLE PROGRAM

## Introduction

*Trumpet Tune*

David German

## Exploration of Frequency

*Les Fifres* (flue pipes)

*Toccata in d minor*

*Dancing Feet*

Louis Dandrieu

J. S. Bach

Noel Rawsthorne

## Exploration of Amplitude

*Chorale* (use of swell box)

*The Imperial March* (reed pipes)

Leon Boëllmann

John Williams

## Listening for many things happening at the same time

*The Leviathan March*

Hermann Kotzschmar

## Exploring the inside of the organ (played softly while students go through organ chamber)

*Fountain Reverie*

*Canon in D*

*Hedwig's Theme*

Percy Fletcher

Johann Pachelbel

John Williams

## Closing

*Toccata from Symphonie V*

Charles Marie Widor

# MEET THE KING OF INSTRUMENTS

## The Kotzschmar Organ

Upon completion of the artist-in-residence visits on the sounds of the pipe organ the students attend a concert at Merrill Auditorium in Portland, Maine with the mighty Kotzschmar Organ. Ray Cornils, the Municipal Organist for the City of Portland revisits the concepts taught in the classroom.

The program presents classical compositions as well as familiar movie themes that are quickly recognized by the students. A concert in a large concert hall is often a first experience for many students. When time and distance prohibit a school to come to Portland an organ in a local church may be substituted.

The concert program is about 40 to 50 minutes in length. Since the Kotzschmar Organ was built by Austin Organ Company, students can walk inside the organ to see the inner workings of the instrument. Students proceed through the various chambers of the windchest looking at the various pipes, swell boxes, blower reservoir, wiring, and movement of the pneumatic actions as docents explain the component pieces. An up-close view of the five-manual console with many stops impresses the students with all the different sounds that can be sounded. If the concert is in a church and there is a possibility of viewing the windchest, small groups of students can walk through or look into this space.





This experience has been a highlight of the students' exploration of the pipe organ and its sounds. As partnerships are established between FOKO and the schools, the new class of students is always asking, **“When do we get to go to see the big organ?”**



## BASIC SCIENTIFIC CONCEPTS

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### **What is “sound”?**

Sound is a form of *energy*.

### **What is “energy”?**

Scientists define energy as “the ability to do work”. A good definition for students is “energy makes things happen.” Scientists admit that they do not know what energy “is” ... they can only describe its presence, forms, and effects. Energy remains one of the “great mysteries of the “universe.”

### **What types of energy exist?**

Scientists recognize two state of energy

Potential Energy: Potential energy is stored energy. That is, energy that hasn't been used yet. Energy can be stored in many ways. Gasoline is an example of potential energy: when it burns, it creates heat, light, and mechanical force.

Kinetic Energy: Kinetic Energy is energy in motion. Scientists say “work is done” when potential energy is converted into kinetic energy.

### **What forms can energy take:**

Other forms of energy include:

Light energy

Electrical energy

Electromagnet energy

Heat energy

Mechanical energy

### **What is “Mechanical energy”?**

Mechanical energy is the energy related to the position and motion of objects, and how forces affect those objects.

### **How is Sound Energy related to these other forms?**

Sound is a form of kinetic energy because the energy is in motion.

Sound is a form of mechanical energy because the energy moves through and affects objects.

Some examples are:

Solid = a bell, a guitar string, the human voice

Liquid = water

Air = (the most common “something.”)

### **What is a “sound source”?**

A sound source is anything that creates a mechanical pressure wave that travels through a medium by setting the medium's molecules into motion. Scientist call that motion “vibration.”

Sound is usually created by converting mechanical energy into acoustic energy. These vibrations are transmitted (carried) by a medium to our ears.

Sound energy is produced when an object vibrates. The sound vibrations cause waves of pressure that travel through a medium such as air, water, wood, or metal. Sound energy is a form of mechanical energy.

**Vibration** is a mechanical phenomenon where by oscillations occur about an equilibrium point.

**What is a “medium”?**

The word medium comes from Latin and has the meaning “in between”. In physics, a “medium” is anything made of molecules. “Sound can travel through anything made of molecules. Unlike light energy or electromagnetic energy, sound cannot travel through a vacuum. Therefore, there is no sound in outer space.

**What is a “pressure wave”?**

The motion of sound energy through the medium is called a pressure wave.

**How fast does sound travel?**

Sound travels much more slowly than light. Light energy does not need a medium through which to travel. Sound travels at different speeds in different media. Such as, lightning flashes but later you hear the thunder depending on how far away the lightning is.

**WAVES****Compression Waves**

A sound wave consists of alternating cycles of compression and expansion of the medium.

**Compression:** The molecules of the medium are forced together. This results in increased density and pressure.

**Expansion:** The molecules of the medium are forced apart. This results in decreased pressure and density.

## PHYSICS AND THE ORGAN WEB SITES — ADDITIONAL RESOURCES

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### **Elementary Grades**

<http://www.physicsclassroom.com/class/sound>

The physics classroom on sound provides a number of lessons about waves and sound along with animation. There are resources for teachers and students.

### **Waves**

The nature, properties and behaviors of waves are discussed and illustrated; the unique nature of a standing wave is introduced and explained.

### **Sound Waves and Music**

The nature of sound as a longitudinal, mechanical pressure wave is explained and the properties of sound are discussed. Wave principles of resonance and standing waves are applied in an effort to analyze the physics of musical instruments.

<http://www.youtube.com/watch?v=irqfGYD2UKw&feature=related>

Sound Frequency Pitch and Amplitude using Instruments 3.19 min.

Examples of tuning forks, sound whistles, and boomwackers are used to illustrate the difference between pitch, frequency, and amplitude. Good visuals of the sound waves created by the different amplitudes.

<http://www.youtube.com/watch?v=IsfPzrSFKO4>

Physics and the Pipe Organ 5:35 min

A good tutorial of open and closed pipes, actions, interior picture of tuning, and listening to a pipe organ.

<http://www.youtube.com/watch?v=rhakZPMjPKE&NR=1>

Physics of the Pipe Organ – animation sequence 3.29 min.

<http://www.youtube.com/watch?v=MFLeGJclQiI&feature=related>

Sound is Vibrations – animated cartoon 0.37 sec. elementary

One of the pipes takes you on a tour of various components of the pipe organ. Good explanation of how the blower assists the reservoir and eventually the sound. Good explanation of how the sound wave is operating within the pipe.

<http://www.youtube.com/watch?v=Bg4gDRAjdeE>

Pipe Organ Sound powered by waves 0.38 sec.

A unique pipe organ that is sounded by waves in Croatia, fun to view

[http://www.ptg.org/concentration\\_notes/concen.html](http://www.ptg.org/concentration_notes/concen.html)

Music notation concentration game, your responses are timed

<http://www.youtube.com/watch?v=Xu6hbS2TlSw>

What is Frequency and Wavelength (hertz) 2.30 min. Elementary

### **SCIENCE WEBSITES**

<http://www.youtube.com/watch?v=irqfGYD2UKw&feature=related>

Sound Frequency Pitch and Amplitude using Instruments

<http://www.youtube.com/watch?v=IsfPzrSFKO4>

Physics and the Pipe Organ

<http://www.youtube.com/watch?v=Bg4gDRAjdeE>

Pipe Organ Sound powered by waves, Croatia 0.38 sec.

<http://www.youtube.com/watch?v=RcdDRVt8lhA>

Dubrow Physics Final – PVC Percussive Organ, High School 6.37 min.

<http://www.youtube.com/watch?v=3sCz1R5ttpk&feature=related>

What Bach would know and not know about today's organs 6.59 min

[http://www.youtube.com/watch?v=fID89ijdM\\_Y](http://www.youtube.com/watch?v=fID89ijdM_Y)

Learning Series Pipe Organs – Windchest 7.15 min

[http://www.youtube.com/watch?v=usHtqr0\\_HXU&feature=related](http://www.youtube.com/watch?v=usHtqr0_HXU&feature=related)

Sound – High School Physics Project presentation 9.13 min.

### **Wave Lengths**

<http://hyperphysics.phy-astr.gsu.edu/hbase/music/saxw.html#c1>

This link provides pictures of various musical instruments and the wave length produced by playing the instrument. This link is the saxophone. Grades 5-8

<http://hyperphysics.phy-astr.gsu.edu/hbase/music/clarw.html#c1>

clarinet wave form

<http://hyperphysics.phy-astr.gsu.edu/hbase/music/flutew.html#c1>

flute wave form

<http://hyperphysics.phy-astr.gsu.edu/hbase/music/basoon.html#c2>

bassoon wave form

### **Physics Web Sites**

<http://video.answers.com/how-to-build-a-pipe-organ-chair-37477132>

How to Build a Pipe Organ Chair Grades 8 - 12

<http://www.worthingtondirect.com/blog/band-chair/build-a-wooden-chair-pipe-organ/>

School Furniture Blog on how to build a pipe organ chair – Grades 8 - 12

<http://www.youtube.com/watch?v=irqfGYD2UKw&feature=related>

Sound Frequency Pitch and Amplitude using Instruments and Tuning forks

<http://www.youtube.com/watch?v=IsfPzrSFKO4>

Physics and the Pipe Organ – video, good background information 5.25 min.

<http://www.youtube.com/watch?v=rhakZPMjPKE&NR=1>

Physics of the Pipe Organ – animation sequence 3.29 min.

<http://www.youtube.com/watch?v=Bg4gDRAjdeE>

Pipe Organ Sound powered by waves, Croatia 0.38 sec.

<http://www.youtube.com/watch?v=RcdDRVt8lhA>

Dubrow Physics Final – PVC Percussive Organ, High School 6.37 min.

<http://www.youtube.com/watch?v=3sCz1R5tptk&feature=related>

What Bach would know and not know about today's organs 6.59 min

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Sound – High School Physics Project presentation 9.13 min.

[http://www.ptg.org/concentration\\_notes/concen.html](http://www.ptg.org/concentration_notes/concen.html)

## Sound Card Scope

### “Scope”

Scope is an application that creates an oscilloscope for ‘seeing’ sound waves. Application also includes a two-channel signal generator that can be sent to the scope. Also has a spectrum analyzer for looking at harmonic content.

[http://www.zeitnitz.de/Christian/scope\\_en](http://www.zeitnitz.de/Christian/scope_en)

Download: **scope 141.exe** which is the application install file

[http://www.zeitnitz.eu/scope/manual\\_scope\\_v141.pdf](http://www.zeitnitz.eu/scope/manual_scope_v141.pdf)

Download: PDF Manual for Sound Card Scope 1.4.1

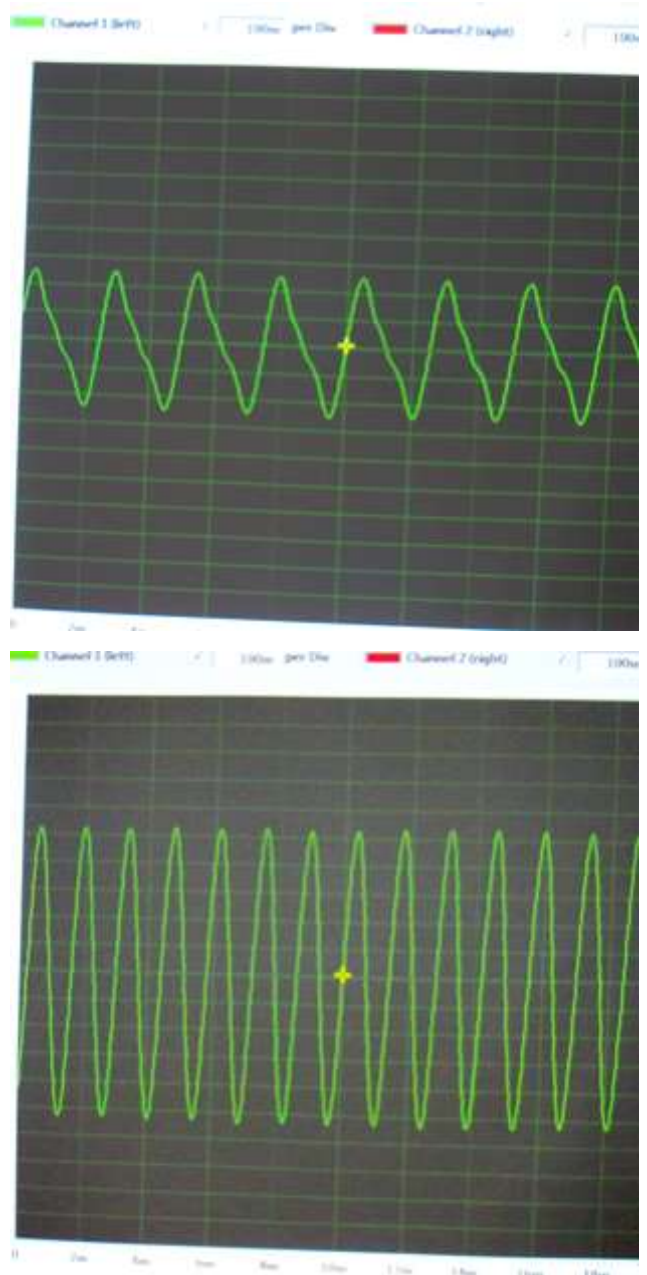
Possible place to research similar applications for Mac:

*Note “VST “= Virtual Studio Technology*

<http://bedroomproducersblog.com/2011/07/05/bpb-freeware-studio-best-free-oscilloscope-vstau-plugins/>

Another possible:

<http://www.hitsquad.com/smm/programs/AudioXplorer/>



HERTZ

DON'T

HURT!



**BUT DECIBELS DO!**



# MUSIC AND SCIENCE WORD-SEARCH

AMPLITUDE  
 FLUE  
 SCIENCE  
 BELLOWS  
 REED  
 SOUNDWAVE ENERGY  
 FREQUENCY  
 DECIBEL

RESERVOIR  
 WIND  
 LOW  
 HERTZ  
 OCTAVE  
 HIGH  
 FEET  
 PITCH

CREST  
 HANDS  
 PIPEORGAN  
 TROUGH  
 MUSIC  
 PUMP  
 SCALE  
 STOPS

Q	W	E	W	N	Y	Z	G	I	Y	J	P	L	Y	T	C	U	I	O
M	P	A	S	D	F	T	H	J	K	L	Z	X	C	H	A	N	D	S
U	X	C	Q	F	A	R	M	F	L	U	E	R	J	E	D	U	E	T
S	C	A	L	E	S	E	N	L	R	E	R	E	H	D	E	Y	T	O
I	H	Q	D	E	D	H	B	K	O	E	F	F	P	F	H	T	F	P
C	R	E	S	T	F	D	V	Z	I	F	Q	T	I	V	I	R	V	S
V	F	E	G	W	O	F	C	Y	U	P	M	U	P	S	I	E	B	T
B	D	R	H	E	C	G	R	L	Y	B	B	B	E	W	O	W	G	G
A	M	P	L	I	T	U	D	E	T	N	V	V	O	N	S	E	T	Y
N	D	I	J	R	A	H	Z	H	E	M	C	F	R	Y	C	D	E	H
M	S	T	K	T	V	J	A	G	E	D	X	D	G	U	I	Y	D	U
N	A	C	L	Y	E	W	S	F	W	H	Z	S	A	J	E	T	C	G
B	S	H	Q	U	G	E	D	B	Q	G	S	W	N	M	N	G	A	T
V	D	T	W	I	H	R	F	E	A	F	D	Q	Y	I	C	F	S	R
C	F	D	E	C	I	B	E	L	Q	E	R	T	Y	R	E	R	W	F
X	J	U	R	Q	J	T	G	L	Z	D	W	T	R	E	O	H	D	E
Z	K	I	T	L	K	Y	H	O	W	S	F	I	F	T	I	I	E	D
L	N	O	S	O	U	N	D	W	A	V	E	E	N	E	R	G	Y	T
K	I	P	Y	W	Z	A	J	S	S	W	G	H	V	D	U	H	R	W
J	O	A	U	W	X	E	K	D	X	E	H	G	C	E	Y	E	T	U
L	I	N	G	R	D	S	W	A	Z	C	T	F	D	T	T	T	Y	J
H	G	S	I	E	C	X	L	A	C	C	E	T	R	O	U	G	H	I



# MUSIC AND SCIENCE WORD-SEARCH

AMPLITUDE  
 FLUE  
 SCIENCE  
 BELLOWS  
 REED  
 SOUNDWAVE ENERGY  
 FREQUENCY  
 DECIBEL

RESERVOIR  
 WIND  
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CREST  
 HANDS  
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 MUSIC  
 PUMP  
 SCALE  
 STOPS

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U			F		R		F	L	U	E							T
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					C		R						E				
A	M	P	L	I	T	U	D	E					O	N	S		
		I			A				E				R		C		
		T			V					D			G	I	Y		
		C			E								A		E		
		H						B					N		N		
								E							C		
		D	E	C	I	B	E	L							E		
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			S	O	U	N	D	W	A	V	E	E	N	E	R	G	Y
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													H				

# MAINE LEARNING GOALS

Maine Learning Results: ART

**A1 Artist's Purpose:** PreK-2: Students recognize a variety of purposes for making art, including communicating emotion.

B3 Making Meaning:

*PreK-2:* Students create art works that communicate ideas and feelings and demonstrate skill in the use of media, tools, and techniques.

*Grades 3-5:* Students create art works that communicate ideas, feelings, and meanings and demonstrate skill in the use of media, tools, techniques, and processes.

*Grades 6-8:* Students create art works that communicate an individual point of view.

- a. Demonstrate skills in the use of media, tools, techniques, and processes.
- b. Demonstrate knowledge of visual art concepts.
- c. Communicate a variety of ideas, feelings, and meanings.

C1 Application of Creative Process

Students identify and demonstrate creative problem-solving skills.

*Pre-K-2:* a. Improvise to solve problems in the performing arts. b. Imagine and share possible solutions to apply to challenges in creating art. Students describe and apply steps of creative problem solving.

*Grades 3-5* a. Identify problem; b. Define problem; c. Generate a variety of solutions; d. Implement solution(s); e. Evaluate solution(s). Students describe and apply creative-thinking skills that are part of the creative problem-solving process.

*Grades 6-8:* a. Fluency; b. Flexibility; c. Elaboration; d. Originality; e. Analysis

E2 The Arts and Other Disciplines

*PreK-2:* Students identify connections between and among the arts and other disciplines.

*Grades 3-5:* Students describe characteristics shared between and among the arts and other disciplines.

*Grades 6-8:* Students explain skills and concepts that are similar across disciplines.

Maine Learning Results: MUSIC

A-3 Listening and Describing

Students listened to and described simple examples of the elements of music including pitch, rhythm, tempo, dynamics, harmony, and texture.

D-1 Aesthetics and Criticism

Students asked questions about an art form to further understand the concepts, skills, and processes used to create the work of art. Students explained purposes for making music in different times and places, including cultural traditions, personal expression, and communication of beliefs.

## Maine Learning Goals: SCIENCE

### B1 Skills and Traits of Scientific Inquiry

*PreK-2:* Students conduct and communicate results of simple investigations.

*Grades 3-5:* Students plan, conduct, analyze data from and communicate results of investigations, including fair tests.

*Grades 6-8:* Students plan, conduct, analyze data from and communicate results of investigations, including simple experiments.

### D4 Force and Motion

*PreK-2:* Students describe how objects move in different way

*Grades 3-5:* Students summarize how various forces affect the motion of objects, the properties of waves and the wavelike property of energy.

*Grades 6-8:* Students describe the force of gravity, the motion of objects, the properties of waves, and the wavelike property of energy in light waves.

**For more information on Maine's Learning Goals, please see:**

<https://www.maine.gov/doe/proficiency/standards/maine-learning-results.html>



## FRIENDS OF THE KOTZSCHMAR ORGAN

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Founded in 1981, the Friends of the Kotschmar Organ (FOKO), a non-profit organization, supports the Kotschmar Organ. Each year the organization presents 16 to 18 concerts, engaging renowned organists and guest artists from around the world. FOKO is responsible for the care and maintenance of the organ and provides funds to produce and promote concerts, maintain, repair, and enhance the organ, sponsor lectures and organ demonstrations and tours and supports a growing education program to bring awareness and understanding of this musical

## THE KOTZSCHMAR ORGAN

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In August 1912 the City of Portland dedicated its new City Hall, replacing the building destroyed by fire in 1908. The new building included a large public auditorium whose stage was dominated by a magnificent organ built by the Austin Organ Company of Hartford, Connecticut. The instrument was the gift of Cyrus H.K. Curtis, born in Portland in 1850, founder of the Curtis Publishing Company of Philadelphia, renowned for such magazines as The Saturday Evening Post, and Ladies Home Journal.

Curtis stipulated that his gift should be a memorial to Hermann Kotschmar, a family friend, his first music teacher, and the leading **figure in Portland's musical life from the 1850s** until his death in 1908. When installed, the Kotschmar Memorial Organ was the second largest pipe organ in the world. In 1918, it was provided with a new console incorporating **Austin's improved combination action. Enlarged** in 1927 with a new Antiphonal Division and additions to the Swell, it was also provided with a

second new console.

Although municipal organs were once common in America, only two such instruments are known to survive in regular use. (The other is the Spreckels Organ in Balboa Park, San Diego, California.)

The first Municipal Organist was Will C. Macfarlane; Edwin H. Lemare held the position from 1921 to 1923. Incumbent Ray Cornils has served since 1990.

The Kotschmar Organ celebrated its 100th Anniversary on August 22, 1912. **Immediately following that evening's concert, a two-year** renovation began. The entire organ has been removed from Merrill Auditorium, and every pipe and action component restored to original condition at the shop of Foley-Baker, Inc. in Tolland, Connecticut.

The renovated Kotschmar Organ made its debut on Saturday evening, September 27, 2014. Performers included Municipal Organist Ray Cornils, Pe-



Name: \_\_\_\_\_

*Music & Sound Wave Energy*

Teacher: \_\_\_\_\_

Please circle the correct response to the following questions.

1. What type of frequency will a long pipe produce?  
a. high      b. highest possible      c. low      d. medium
2. What type of frequency will a short pipe produce?  
a. high      b. highest possible      c. low      d. medium
3. What number on a pipe organ stop would have the highest frequency?  
a. 2'      b. 4'      c. 8'      d. 16'      e. 32'
4. What number on a pipe organ stop would have the lowest frequency?  
a. 2'      b. 4'      c. 8'      d. 16'      e. 32'
5. How many notes are in an octave?  
a. 2      b. 4      c. 8      d. 16      e. 32
6. A manual is a collection of \_\_\_\_\_ played by the hands.  
a. notes      b. pipes      c. keys      d. elephants
7. Amplitude is about \_\_\_\_\_.  
a. volume      b. pitch      c. stops      d. notes
8. You can change the amplitude on the organ by changing the \_\_\_\_\_.  
a. music      b. stops      c. frequency
9. The section of the organ played by your feet is called the \_\_\_\_\_.  
a. manual      b. stops      c. pedal board      d. pipes

Please write a response to these prompts.

1. The most important learning that I remember from our music and sound wave energy lessons on frequency is
  
  
  
  
  
  
  
  
  
  
2. The most important learning that I remember from our music and sound wave energy lessons on amplitude is

# Lab Stations for Sound Wave Experiments

Lab Station #1: Drum with paper clips on the top.

Set the paper clips on the table. Tap on the drum. What do you see? What do you hear?

Set the paper clips on the drum, and tap again. What do you see? What do you hear?

**Lab Station #2: Touch side of your throat and say “ahh.”**

What do you feel as you say ahh? What do you hear? Say “ahh” in a very deep voice, and then in a high-pitched voice. Does it feel different?

Lab Station #3: Tuning fork in water.

Gently strike the tuning fork on the heel of your shoe and then place it in the water.

Describe what you observe. What do you see? What do you hear?

Lab Station #4: Rubber band strung between two pegs or nails.

Pluck the rubber band. What do you see? What do you hear?

Lab Station #5: Fork on a string and spoon.

Take the string attached to the fork – hold one end of the string in each hand, partially wrapped around your index fingers.

Place your index fingers gently on your ear lobes.

Swing the fork until it hits the spoon. What do you hear? What do you see?

Lab Station #6: Meter stick or ruler on edge of a table.

Hold one end of the ruler firmly against the top of the table.

Snap the other end. What do you see? What do you hear?

Snap it again, and then while it is vibrating, slide it so less of the ruler hangs off the table.

Try again with your ear pressed against the table. What do you notice now?

Lab Station #7: Straw

Using a paper straw, flatten first centimeter of a straw.

Cut 1 Cm long triangle from both sides of straw so that it comes to a point.

Blow through the straw, and cut off 1 cm from the far end of the straw.

Repeat until straw is too short to continue.

What do you hear? What do you see? How does the sound change as the straw gets shorter?

## SOUND WAVE LAB REPORT FORM

Name:

Sound station # \_\_\_\_\_

Draw your Diagram and label appropriate sections.

1. What do you see?

2. What do you hear?

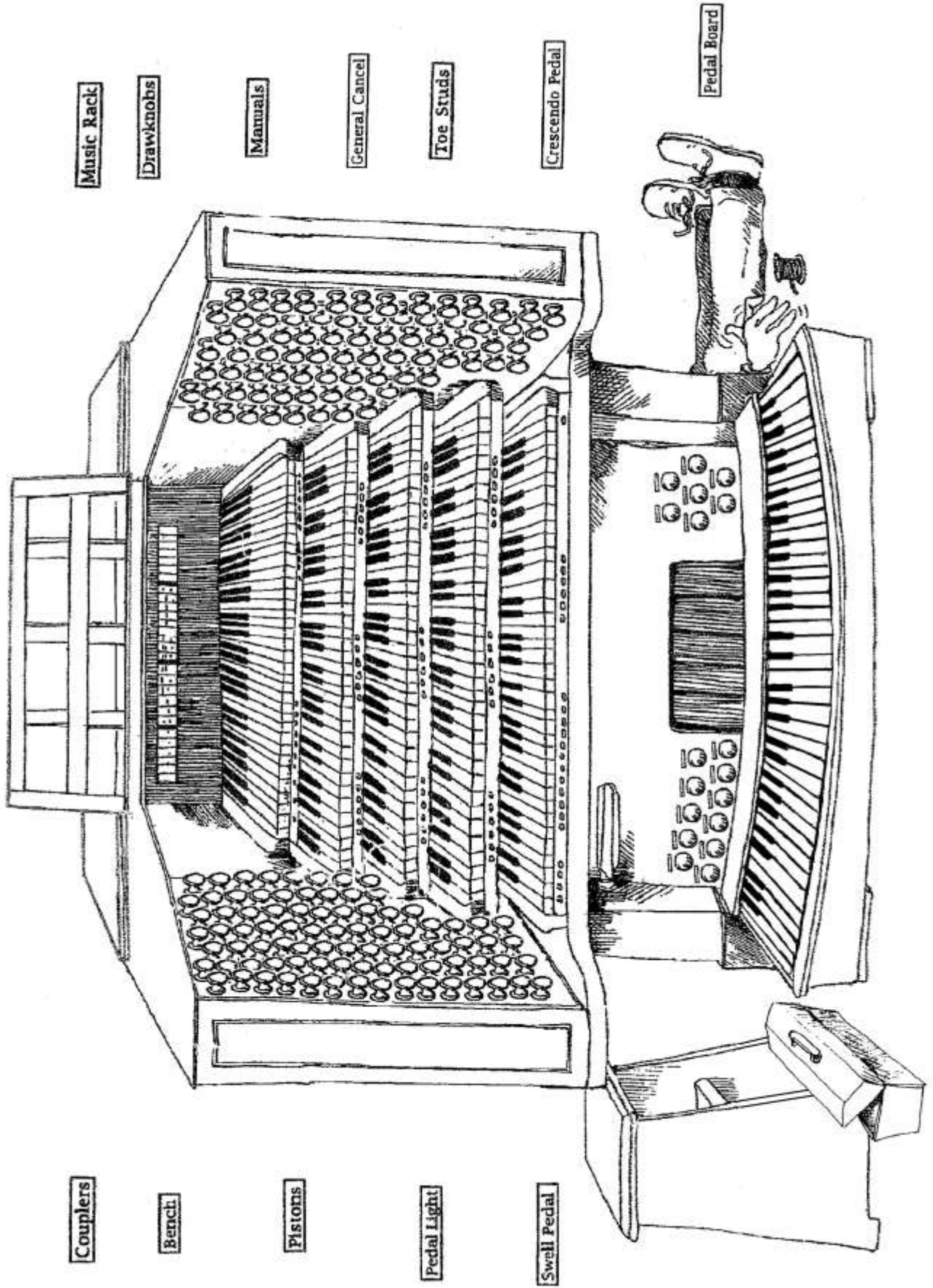
**3. What is the source of the vibration? Label it as the “source” on your diagram.**

4. What type of medium is the wave traveling through? (For example, solid, liquid or gas.)  
***Label this as the “medium” on your diagram.***

5. In what direction does the wave appear to travel? Draw its path on your diagram using a line and an arrow to represent the sound wave.

6. What happens to the medium as the wave travels? Be specific.

Can you match the name with the part?  
Draw a line from each box to the correct part of the console.





# **Further Investigations in Sound Quality & Making Music**

## **Part 1: Percussion Instruments**

**Capturing Interest:** Play a drum, xylophone or other percussion instrument. What makes the differences in the sound? How can we change this instrument to alter its sound?

**Objectives:** To explain how overtones effect sound, how tone, timbre, and pitch are effected by rubber band “strings” of different sizes and stretch and finally, contrasting music and noise.

### **Related words:**

***fundamental tone:*** the lowest pitched sound produced when air vibrates.

***overtone:*** the high pitched sounds produced when this instrument causes a vibration

***timbre:*** also called tone is the sound quality or color of a note: warm, dark, shrill are examples

***music:*** sound that is combined in a pleasing way that includes rhythm, melody, and harmony

***rhythm:*** the basic beat in music

***melody:*** the combination of musical notes making up a tune

***harmony:*** the combination of many different notes heard together-from many instruments

***noise:*** a jumble of unpleasant sounds with no pattern of vibration

***note:*** musical symbol that indicates the location of a pitch or frequency of vibration

***chord:*** two or more musical notes play together

***sound chamber:*** the part of the wind instrument whose vibrations resonate with the *sound* created by blowing into the opening of the instrument

**Background:** Musical instruments have different sound qualities. Music is made when a combination of vibrations are played in a pattern that produces a pleasing sound. These sounds include rhythm, melody and harmony. Percussion instruments are played by tapping or hitting. Drum, xylophone and cymbals are examples of percussion instruments. The act of hitting or tapping the instrument creates vibrations that resonate inside the instrument as in the drum and Xylophone and outside into the air as in the cymbals. The opposite of music is noise. It is an unpleasant sound with irregular patterns of vibrations. Noise does not usually have any sort of rhythm, but more importantly it has no melody or harmony. It is unorganized vibration. When music is played we call the individual sound a chord when several musical vibrations are played together.

### **Materials:**

A variety of small glass jars, bottles or tubes (*test tubes work well held in a stand*)  
water, rubber mallet made from a chopstick and pencil gripper or large eraser  
(*using metal or wood objects may be too noisy for a whole class experiment*)

### **Procedures/Directions:**

1. Select three or four different sizes of jars, all the same style.
2. Tap them each and note the sound vibration they create.

# **Further Investigations in Sound Quality & Making Music**

## **Part 2: String Instruments**

**Capturing Interest:** Play a stringed instrument like a Ukulele or Guitar. What makes the differences in the sound of each string? How can we change the strings to alter their sound?

**Objectives:** To explain how overtones affect sound, how tone, timbre and pitch are effected by rubber band “strings” of different sizes and stretch and finally, contrasting music and noise.

### **Related words:**

***fundamental tone:*** the lowest pitched sound produced when air vibrates.

***overtone:*** the high pitched sounds produced when this instrument causes a vibration

***timbre:*** also called tone is the sound quality or color of a note: warm, dark, shrill are examples

***music:*** sound that is combined in a pleasing way that includes rhythm, melody, and harmony

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***chord:*** two or more musical notes play together

***sound chamber:*** the part of the wind instrument whose vibrations resonate with the *sound* created by blowing into the opening of the instrument

**Background:** Musical instruments have different sound qualities. Music is made when a combination of vibrations are played in a pattern that produces a pleasing sound. These sounds include rhythm, melody and harmony. Stringed instruments make music through a variety of vibrating strings. Guitar, banjo, cello, violin and ukulele are all stringed instruments. String instruments are played by plucking or bowing. Noise does not usually have any sort of rhythm, but more importantly it has no melody or harmony. It is unorganized vibration. When music is played we call the individual sound a chord when several musical vibrations are played together.

**Materials:** Many different sizes of rubber bands, all at least two to three inches in diameter. A stack of cardboard, foam core or thin wooden rectangles.

### **Procedures/Directions:**

1. Select four different sizes of rubber bands.
2. Stretch them over the frame (rectangle) you were given lengthwise.
3. Add two pencils, one at each end to hold the rubber bands above the board.
4. Hold them up to your ear and pluck each one to hear its pitch or vibration. Try to find the fundamental note which is the lowest pitch sound of each rubber band string.
5. Move the rubber bands so that they are in order from lowest pitch to highest pitch.

## **Further Investigations in Sound Quality & Making Music**

### **Part 3: Wind Instruments**

**Capturing Interest:** Play a penny whistle, recorder or other wind instrument. What makes the differences in the sounds? How can we change this instrument to alter its sound?

**Objectives:** To experience and explain the different pitches of notes produced when air is blown across bottle tops and how a flexible tube containing water can alter the pitch of sound when air is blown across its opening as the water is moved within it. Also, how does amplitude (volume) change when blowing with more force?

#### **Related words:**

***fundamental tone:*** the lowest pitched sound produced when air vibrates.

***overtone:*** the high pitched sounds produced when this instrument causes a vibration

***timbre:*** also called tone is the sound quality or color of a note: warm, dark, shrill are examples

***music:*** sound that is combined in a pleasing way that includes rhythm, melody, and harmony

***rhythm:*** the basic beat in music

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***noise:*** a jumble of unpleasant sounds with no pattern of vibration

***note:*** musical symbol that indicates the location of a pitch or frequency of vibration

***chord:*** two or more musical notes play together

***sound chamber:*** the part of the wind instrument whose vibrations resonate with the *sound* created by blowing into the opening of the instrument

#### **Background:**

Musical instruments have different sound qualities. Music is made when a combination of vibrations are played in a pattern that produces a pleasing sound. These sounds include rhythm, melody and harmony. Wind instruments make music when air is blown through them. A flute, recorder, trumpet, bagpipes and the Pipe Organ are examples of wind instruments. Blowing through the wind instrument causes a column of air to vibrate within. This causes the air near the opening to vibrate and as it travels out of the instrument we hear the note. The pitch is different depending on the length of the tube or instrument and whether it has holes that are covered or open. Be aware that there are many ways that wind instruments vibrate columns of air inside them. A Trombone changes its length by sliding one tube in and out of another. Horns change their length by opening and closing valves and holes. One can also blow in different ways to change harmonics.

#### **Materials:**

If the students have already done the extension of the percussion activity with bottles that are the same, they might want to do this one with different bottles. *If not, they can skip the next steps and go directly to the **Water Trombone** described below.*

# Education

[www.foko.org/education](http://www.foko.org/education)

