

2008  
Winning Lesson Plan  
from Bellevue,  
Washington

*The Sound of Music*  
(Physics-style)

by Laura Baumgartner  
Robinswood High School

Subject: Introductory  
Physics

Grade Level: 10

Duration: 1 Week

## Overview and Purpose

Students learn about sound waves by investigating a musical instrument of their choice, home-made or pre-made. They record the sound waves produced by their instrument using Vernier probes on a computer, and analyze the wavelength, frequency, and amplitude. They vary one variable and design an investigation to test its effect on another variable of their choice. During their investigation, they capture screen shots of their work as part of the recording and reporting process. The computer assists in the measurement of frequency, and students need to convert that to pitch. Students work together to solve problems, analyze unexpected data, and refine their data collection strategy until they can explain what is happening. Finally, each group presents its results to the class and writes a report.

## Innovation

My contribution to the study of sound waves in a beginning level physics class is to use the computer to record waves generated by students so they can analyze what they create and design an investigation around it. In addition, the use of screen shots to report their work is something that I have done in a variety of ways as this project has improved over the years. Originally, I worked with researchers at Northwestern University and a technology tool called Progress Portfolio that would allow students to do annotated screen capture as part of their project. Since then, I've found that the Smartboard Notebook software provides most of the same tools and is a more robust program already in my classroom, so we use it instead.

## Description of the Larger Context

The project falls within a unit on waves, including earthquake waves, light waves, and sound waves. The unit begins with students using slinkies to investigate longitudinal and transverse waves and what factors affect wave speed. They find that only the medium affects the speed of the wave. The wavelength, frequency, and amplitude are all independent of wave speed. They also use the slinkies to investigate waves that interact with each other by sending two waves down the slinky from either end, either causing constructive or destructive interference. Then, they move on to using wave tanks to observe circular vs. plane waves. In the wave tanks, students observe again the effects of constructive and destructive interference. The sound of music project gets students to begin to apply their knowledge of waves in general and investigate something of interest to them within the context of waves. After the sound section of the unit, students will study light waves and other electromagnetic radiation.

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## Objectives

As a result of this lesson, students should know:

- The variables that can be measured when studying waves change in relationship to each other. As the pitch of a note goes up, the sound wave frequency also goes up and its wavelength goes down. The amplitude of a wave determines how loud the note sounds, but does not affect its pitch. None of these variables affects the wave's speed in a given medium.
- There are three basic types of musical instruments: open-ended pipe (both ends open, like an organ pipe), closed-ended pipe (one end closed, like a flute), and string (like a guitar). The type of musical instrument determines where the nodes and anti-nodes will occur and also determines the fundamental frequency (lowest note) of each instrument.
- The design of a scientific investigation involves manipulating one variable, measuring the response in another, and reporting the relationship or lack thereof that was observed.

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## Educational Standards Addressed

### Essential Academic Learning Requirements (Washington State)

- 1.1.3 Analyze sound waves, water waves, and light waves, using wave properties including frequency and energy. Understand wave interference.
- 2.1.1 Understand how to generate and evaluate questions that can be answered through scientific investigations.
- 2.1.2 Understand how to plan and conduct systematic and complex scientific investigations.
- 2.1.3 Apply understanding of how to construct and revise a scientific explanation using evidence and inferential logic.
- 2.1.5 Apply understanding of how to report complex scientific investigations and explanations of objects, events, systems, and processes, and how to evaluate scientific reports.
- 2.2.3 Evaluate inconsistent or unexpected results from scientific investigations using scientific explanations.

### National Science Educational Standards

#### Content Standard D:

Interactions of Energy and Matter. Waves, including sound and seismic waves, waves on water, and light waves, have energy and can transfer energy when they interact with matter.

#### Content Standard A:

Science as Inquiry. Identify Questions and Concepts that Guide Scientific Investigations, Design and Conduct Scientific Investigations, and Formulate and Revise Scientific Explanations and Models using Evidence.

## Equipment

- Musical instruments (guitar, flute, recorder, trombone, harmonica, etc.)
- Materials to make new instruments (comb, wax paper, clay, tubes, dowels, string, etc.)
- Vernier microphone probes and LoggerPro software
- Smart Notebook software

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## Procedures

1. After the class has worked through standard slinky labs, water table labs, and learned some of the vocabulary associated with waves, I introduce the project. I usually start by bringing in some instruments that students may have experience playing or ask students to bring instruments that they play to class with them. I use the computer to record a wave form for each of the instruments that we have in class today. I project these on the smartboard so we can all look at them together. We review the vocabulary words, wavelength, amplitude, crest, trough by drawing on the wave forms we have created and labeling the parts.
2. We start to look at differences between the wave forms. Students quickly mention that the instruments were playing different notes, they are different sizes, different students were playing them so some were not as loud as the others, and more. I use their comments to generate a list of possible variables that could be changed or measured in a laboratory setting.
3. I ask students to meet in their small groups and begin to plan what sort of investigation they would like to carry out. I explain that they can use instruments that are in the classroom or that they can make or bring their own. I circulate among the groups to clarify and assist.
4. The second day usually is devoted to answering questions that groups have and exploring how to use the software and what measurements it will facilitate. Usually by the end of the second day, students have identified their variables and created a data table.
5. When students arrive the third day, I ask each group to share their plan. I like to give all groups the opportunity to know what others are doing, learn from it, and share thoughts early in the process when plans are still flexible. Most of the data collection occurs the third and fourth days of the project. I visit each group during data collection to ensure that everyone in each group can explain their procedures and make sense of their data.
6. Finally, when data is collected, each group reports back to the whole class about their results and prepares a final report detailing their investigation.

## Extensions Beyond the Classroom

High school students are typically very interested in music, and many play a musical instrument. When I encourage them to bring in an instrument they play or try out a new one, they are immediately interested in learning the physics of why it works.

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## The Sound of Music Student Sheet

### Objective

To explore a student generated question about how a musical instrument works, including analyzing graphs of the frequency of sound generated by the instrument. Discuss what question you and your group would like to investigate, make sure that it will fulfill the requirements for the project, then check with your teacher. Each person in your group will write their own final lab report about the project with the sections listed on this overview sheet.

### Hypothesis

When writing your hypothesis, consider these questions:

- Which variable will you manipulate (independent) and which variable will you measure (dependent)?
- How do you think they are related? Why do you think so? What data will you collect to find out?

### Background Information

For your final lab report in this project, describe out how your instrument works. Include:

- a diagram showing your instrument in action and explanation of the diagram,
- your assessment of whether your instrument has open or closed ends and how this affects
- its sound.

### Procedure

1. You will gather data to answer the question you proposed. In the process, you will need to collect some information about the fundamental and harmonic waves for your instrument's lowest pitch.
2. Use LoggerPro software and the microphone probe to record the waves from the lowest pitch you can produce with your instrument. Save each graph as a file in your My Documents folder on the server.
3. Using the graph from the lowest note you made, measure the period (time between 1<sup>st</sup> peak and 2<sup>nd</sup> peak) and calculate the frequency of the fundamental wave. Remember frequency = 1 / period. Record your results in a data table.

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## The Sound of Music Student Sheet (Cont'd)

### Procedure (Cont'd)

4. Measure the period and calculate the frequency for each harmonic that is visible as well. Record this information in your data table.
5. Convert the frequencies into note names that a musician would recognize. For example the tuning forks we used in class had a frequency of 256, but a musician would call that a "C". Record in your data table.

### Data Table

Design and complete a table where you can record all the data you collected. Make sure you include room for period, frequency, and note value for each fundamental and harmonic shown in your graphs.

### Analysis

1. Get from your teacher the lowest predicted frequency for your instrument. Compare the actual lowest frequency you measured and explain any possible differences.
2. Explain how your instrument is similar in how it produces sound to one other instrument,
3. Explain how your instrument is different in how it produces sound from one other instrument.

### Conclusion

Review your hypothesis and state the relationship between variables you investigated.