

Music in Physics, Physics in Music: Making sweet sounds of Formulas

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Advance Placement Physics

Objectives:

1. Students will gain an understanding of how the harmonics, octaves, pitch, amplitude, loudness, and resonance of musical instruments are created and altered.
2. Students will be able to calculate wavelength, frequency, and velocity of wavelengths of the sound produced in a musical instrument.
3. Student will be able to calculate the harmonics and resonance of musical instruments through the use of measurements obtained in laboratory investigations.
4. Students will create their own musical instrument, calculate the harmonics and resonance of their instrument, and play a song or tune based on their instrument's ability. Student will either play the song live or create a music video to be presented to the classroom.
5. Student will be able to use technology to prove that their calculations of frequency is correct of their musical instrument.

Minnesota State Learning Standards: Students will be able to describe/perform

- A. Science 9.2.3.2.3 energy is transferred through sounds waves and how pitch and loudness are related to waves properties of frequency and amplitude. Energy can be transformed within a system or transferred to other systems or the environment, but is always conserved.
- B. Science 9P.2.3.1.1 Sound waves are generated from oscillations of objects and travel through a medium. They will be able to analyze the frequency, period and amplitude of an oscillatory system. They will be able to describe how vibrations of physical objects set up transverse and/or longitudinal waves in gases, liquids, and solid materials. They will be able to explain how interference, resonance, refraction, and reflection affect sound waves.
- C. Arts 9.3.1.3.1 Perform or present in a variety of contexts in the arts using the artistic foundations. Students will be able to rehearse and perform an existing single complex work or multiple works of music from a variety of contexts and styles and within a small or a large groups.
- D. Arts 9.2.1.3.1 Create or make in a variety of contexts in the arts using the artistic foundations.
- E. Arts 9.1.2.3.2 Demonstrate knowledge and use of the technical skills of the art form, integrating technology when applicable.

Advance Placement Physics Big Idea Standards

- A. This lesson covers part of the Advanced Placement Physics 1 Big Idea 6.
- B. Waves transfer energy and momentum from one location to another without the permanent transfer of mass and serve as a mathematical model for the description of other phenomenon.

Timing:

Sounds and Acoustics is covered in Chapter 11 of the Giancoli "Physics" 6th edition textbook. The chapter is covered in the 2nd and 3rd week of March.

Students:

The students in this course are High School seniors who have elected to take Advance Placement Physics their senior year to fulfill their 4th year of science requirement. There are several students who participate in concert band, marching band, theater, and/or choir. Typical students in this class are highly achieving students that are very studious but sometimes neglect the ability to see courses and materials across the curriculum and this lesson helps bridge the gap between theoretical and practical applications of music and science. For some students, this is also the first time manufacturing function devices that have practical applications.

Scope and Sequenc:

Day 1: Introduction to Simple Harmonic Motion Lesson. The 55 minute lesson will include notes, videos, and demonstrations the describe all objects that show simple harmonic motion. Demonstrations will include a guitar, metronome, springs, and a drinking bird. The lesson will describe factors that affect simple harmonic motion such as mass, amplitude, velocity, length, tension, and force.

Day 2: Continuation of introduction lesson from Day 1. The lesson will include more information about period of a pendulum, resonance, and types of waves including longitudinal and transvers.

Day 3: Inquiry based lab on the resonance of tuning forks and sound tubes such as a xylophone. Students will explore how a tuning fork can resonant by being placed near a xylophone's open end. At the conclusion of the investigation, the student will be able to provide calculations about the comparisons of unknown frequencies of tuning forks and xylophones to known frequencies of tuning forks and xylophones.

Day 4: Advance Placement Physics practice calculations. Students in this course take culminating exam in May on all the materials presented over the course of the year. There are two days each unit the are explicitly used to practice the previous and past exam questions related to this topic.

Day 5: Introduction of Physics Instrument project. Students will be given the rubric and project outline of the project. Students will be provided with all the necessary outcomes they must accomplish including:

- A. Construction of an instrument
- B. Calculation of the frequencies and wavelengths the instrument produces
- C. Composition of a song or research of a song that can be produced using their instrument
- D. Analysis of instruments frequencies using frequency tuner or Vernier labquest frequency probes.
- E. Presentation of song to class via video or live presentation.

Day 6: The 3rd lesson will on constructive and destructive interference. The use of this lesson will be helpful is showing students how sounds waves can interact with each other in positive or negative fashions. This will help demonstrate why musical groups and instruments have to be tuned with each other or how noise cancelling headphones work.

Day 7: Final lesson on resonance, frequency, pitch, amplitude, and wave descriptions. Students are given an opportunity to ask for clarification on any topics they might have relevant to the unit. There will also be a discussion on the Doppler effect and how velocity of the instrument or observer can change the pitch heard by the observer.

Day 8: In class opportunity to construct their musical instruments or devices.

Day 9: Advance Placement Physics practice calculations

Day 10: Assessment on Chapter 11. The assessment will be two parts which will include an individual portion and a partner portion. Each portion will consist of Advance Placement Physics style multiple choice problems and free response problems that are similar to problems practiced during the unit.

Day 11: Performance day. Each student is to perform or play their video of their instrument and song. Students will be required to talk about their instrument and how they constructed their instrument. This is a great opportunity to have fun in class, make connections with their music classes, and see how physics and music work together to create a beautiful sound.

Challenges to Lesson: Some students lack the experience on how to create objects with their hands or lack the tools to create such instruments. Most of the instruments can easily be created with PVC pipes or copper pipes. Other instruments can also be made using wood and different types of wires. All of these examples require students to purchase materials or tools they might not have due to financial reasons. If students do need assistance, I have directed them to the counseling office for financial assistance, the Tech Ed/Shop classes for tools, and I have kept other student old instrument parts to help student create a new one. Financial assistance is hard to come by for this project.

Materials Needed for Lesson by Teacher:

1. Springs of different materials, tension, and length
2. Pendulums
3. Metronome
4. Sound tubes
5. Xylophones
6. Tuning forks and mallets
7. Triangles
8. Guitar, violin, or other string instruments
9. Standing wave generator
10. Strings