

Acoustic Resonance

Requirements

- Time required: 75 minutes
- Group size: 2-3 (preferably 2)
- Target grade level: rising sophomores and juniors

Summary of activity

Students will complete a self-guided lab to explain acoustic waves in a tube, in particular:

How different wavelengths can “fit” in a tube due to boundary conditions and wavelengths

- How the physical dimensions of a tube can support certain wavelengths of tube and therefore resonate

Pre-requisite knowledge requirements

- Math: students should know how to solve a simple algebraic equation for one variable
- Science: have some background knowledge on waves, but not much required
- Music: none

Dependencies on other SMT activities

Should follow waves and sound or allot extra time to briefly go over the material.

Learning objectives

- After this activity, students should understand how tubes with different properties (lengths, open/closed ends, etc) can support only certain wavelengths of acoustic pressure waves and therefore resonate.
- Students should be able to experimentally determine resonance frequencies using electronic equipment (speaker, function generator).
- Students should be able to correlate and verify. experimentally determined resonance frequencies with theoretical calculations.
- Ultimately, students should understand that an acoustic wave must be generated to produce sound and the medium generating the sound affects how it sounds.
- Connections
- Math: Sinusoids, algebra, trigonometry
- Physics: waves - period, frequency, wavelength

Relevant educational standards

- Math: 2.8 Algebra and Functions
- Science: 3.4 Physical Science

List of materials

Each group needs:

- Adjustable PVC tube with speaker (3.5" and 4.5" diameter PVC tube at least 24" long with speaker attached)
- 2 iPads with the SMT apps
- Amplifier
- iRig Pre-Amp
- XLR cable
- 1/8" audio cable (or whatever cable will convert your amplifier output to 1/8" audio)
- Tape measure (metric)
- Microphone
- Pair of Alligator clips
- Two pieces of speaker wire

Detailed description of the activity

Introduction / motivation

What causes instruments to make different pitched notes? How do we control the pitch of an instrument? These questions both deal with the concept of resonance and are important in the study of instrument acoustics.

Background

Acoustics is a term that generally means "having to do with the properties of sound" and in this activity we'll be analyzing Acoustics as they pertain to musical instruments. By the end of the activity you should be able to explain what resonance is, what causes it, and how it relates to instruments..

New Vocabulary / Definitions

These terms will not be treated in the strict pedagogical sense, but introduced as needed in the activity

- **Acoustics:** the science that deals with the study of sound.
- **Waves:** a disturbance that propagates through space and time (i.e. a water wave, or a sound pressure wave)
- **Frequency:** the number of times a wave cycles for a given unit of time (i.e. Hz = cycles per second)
- **Period:** the amount of time it takes to complete one cycle of a wave.
- **Wavelength:** The distance between repeating section of a propagating wave.

- **Standing Wave:** a wave that remains in a constant position. Occurs as a result of interference between two waves traveling in opposite directions
- **Acoustic Resonance:** the tendency of a system to absorb more energy when it is excited by a frequency that matches the systems natural frequency of vibration(s)

Procedure

- Introduce the objectives of the activity (to understand resonance and how it relates to musical instruments) (5 minutes);
- Break Students up into small groups of 2-3 and hand out/set up equipment (Total time 10-20 minutes)
- Have the students follow the instructions on the provided worksheet. This is a self-guided lab, and instructors should help students figure out the answer for themselves.

Safety issues

Make sure students don't mis-use electronic equipment (e.g. connecting amplifier output wires together)

Investigating question(s)

- Explain what "resonance" is and why is this important for musical instruments?
- When a sound is applied to an open-ended tube and the frequency of the sound is adjusted, why will you hear certain frequencies "louder" than others?
- What enables a bass to produce lower pitched sounds than a guitar or violin?

Assessments

- There is no formal pre-activity assessment. Questions will be posed to the group, informally, at the start of the session in order to get a feel for how familiar they are with musical instruments and to get their brains going.
- The students are asked to fill out a worksheet as they proceed, which will indicate whether or not they were participating in the activity.
- No post activity assessment.