PHYSICAL SCIENCE FAX!

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Thundering Tube

Demonstration Kit

Introduction

When a tree falls in a forest and no one is around to hear it, does it make a sound? The same question can be asked of a vibrating spring. Does a vibrating spring produce sounds even though they cannot be heard? Use the Thundering Tube amplifier to find out!

Concepts

- Sound pitch
- Resonance
- Amplification

Background

Many musical instruments work because air is vibrated in an air column and then the length of the air column is varied to change the sound produced. The length of the air column determines the pitch of the sound that is heard from the vibrating air. A mixture of different frequencies and the resonation of air columns on a particular set of frequencies can turn noise into music. The sound produced is the loudest when the air column is in resonance (in tune) with the vibrational source.

How does resonance occur? A vibrating source produces a sound wave. This wave of alternating high- and low-pressure variations moves through the air column. Sound waves are often depicted as a sine wave as shown in Figure 1. The sound wave is ultimately reflected back toward the vibrational source. It is either reflected back off a closed end of the column or as a low-pressure reflection off the open end of the column. If the reflected wave reaches the vibrational source at the same moment another wave is produced, then the leaving and returning waves reinforce each other. This reinforcement, known as resonance, produces a special wave—a standing wave. A standing wave is a wave pattern that results when two waves of the same frequency, wavelength, and amplitude travel in opposite directions and interfere with each other. A node is a point in a standing wave that always undergoes complete destructive interference and therefore is stationary. An antinode is a point in the standing wave, half-way between two nodes, where the largest amplitude occurs.

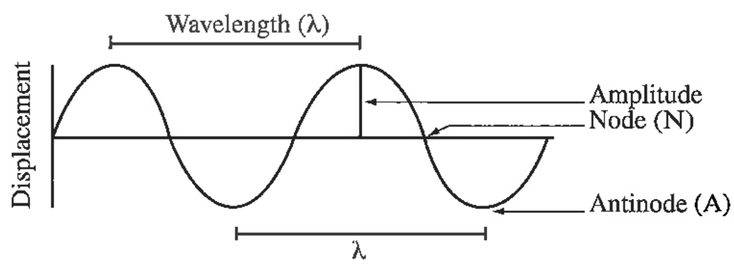

Figure 1.

The Thundering Tube acts as an open-closed-end air column. One end is open while the other end is covered by a latex sheet. Therefore, the sound frequencies that resonate inside the column are equal to $nv/4L$, where n is an odd harmonic number (i.e., 1, 3, 5, etc.), v is the speed of sound in the air column, and L is the length of the column. As the length of the air column increases, the sound frequency, also known as the *pitch,* that resonates within the column decreases. An example of an instrument that generates small sound frequencies, or low-pitched sound, is a tuba. High frequency sound is generated by a flute. A tuba is composed of a very long air column, whereas a flute is very short in comparison.

The vibrating spring, by itself, produces very faint sounds. However, when one end of the spring is attached to a flexible latex sheet (a "drum") that is placed over the end of an air column, the vibrating sound frequencies of the spring become amplified. The sound frequencies that become the loudest are the ones that are in resonance (in tune) with the air column. The long tube will resonate the low-frequency sound and a short tube will resonate the high-frequency sound. It is important to note that all the original sound frequencies of the vibrating spring are still present in the air column. However, only the sound frequencies that are in tune with the air column become amplified. As the length of the Thundering Tube changes, different sound frequencies resonate and the pitch changes.