72 Mach One

Purpose

To determine the speed of sound using the concept of resonance

Required Equipment/Supplies

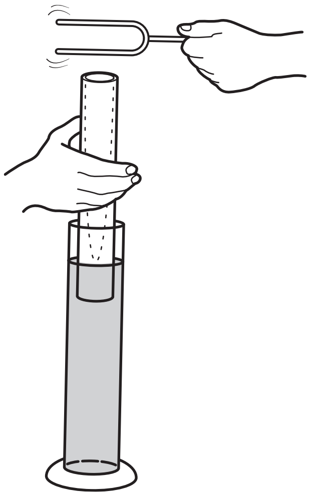
resonance tube approximately 50 cm long or golf club tube cut in half
1-L plastic graduated cylinder
meterstick
1 or 2 different tuning forks of 256 Hz or more
rubber band
Alka-Seltzer® antacid tablet (optional)

Discussion

You are familiar with many applications of *resonance*. You may have heard a vase across the room rattle when a particular note on a piano was played. The frequency of that note was the same as the natural vibration frequency of the vase. Your textbook has other examples of resonating objects.

Gases can resonate as well. A vibrating tuning fork held over an open tube can cause the air column to vibrate at a natural frequency that matches the frequency of the tuning fork. This is resonance. The length of the air column can be shortened by adding water to the tube. The sound is loudest when the natural vibration frequency of the air column is the same as (resonates with) the frequency of the tuning fork. For a tube open at one end and closed at the other, the lowest frequency of natural vibration is one for which the length of the air column is one fourth the wavelength of the sound wave.

In this experiment, you'll use the concept of resonance to determine the wavelength of a sound wave of known frequency. You can then compute the speed of sound by multiplying the frequency by the wavelength.



Procedure

Step 1: Fill the cylinder with water to about two thirds of its capacity. Place the resonance tube in the cylinder. You can vary the length of the air column in the tube by moving the tube up or down.

Step 2: Select a tuning fork, and record the frequency that is imprinted on it.

frequency = _________ Hz

Strike the tuning fork on the heel of your shoe (NOT on the cylinder). Hold the tuning fork about 1 cm above the open end of the tube, horizontally, with its tines one above the other. Move both the fork and the tube up and down to find the air column length that gives the loudest sound. (There are several loud spots.) Mark the water level on the tube for this loudest sound with a rubber band stretched around the cylinder.

Measure air column length.

Step 3: Measure the distance from the top of the resonance tube to the water-level mark.

length of air column = ________ m

Measure the diameter.

Step 4: Measure the diameter of the resonance tube.

diameter of the resonance tube = _______ m

Compute corrected length.

Step 5: Make a corrected length by adding 0.4 times the diameter of the tube to the measured length of the air column. This corrected length accounts for the air just above the tube that also vibrates.

corrected length = __________ m

Compute the wavelength.

Step 6: The corrected length is one fourth of the wavelength of the sound vibrating in the air column. Compute the wavelength of that sound.

wavelength = __________ m

Compute the speed of sound.

Step 7: Using the frequency and the wavelength of the sound, compute the speed of sound in air. Show your work.

speed of sound in air = _______ m/s

Repeat using different tuning fork.

Step 8: If time permits, repeat Steps 2 to 7 using a different tuning fork.

frequency = ________ Hz   length of air column = _________ m

corrected length = _______ m   wavelength = _______ m

speed of sound in air = _________ m/s

Analysis

1. The accepted value for the speed of sound in dry air is 331 m/s at 0°C. This speed increases by 0.6 m/s for each additional degree Celsius above zero. Compute the accepted value for the speed of sound in dry air at the temperature of your room.

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2. How does your computed speed of sound compare with the accepted value? Compute the percentage difference.

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