Lab 4

Speed of Sound in a Cardboard Tube

Experimental Objectives

- The purpose of this experiment is to determine the speed of sound in an air column, both from an open and a closed tube. Data should be taken at a number of different resonant frequencies.

Longitudinal sound waves can be produced by any vibrating source. The frequency of these waves is determined solely by this vibrating source. There must also be a medium (solid, liquid, or gas) in order for the sound wave to be propagated. These waves do not travel through the medium instantaneously. There is a finite wave speed which is determined by the characteristics of the medium. The wave speed is not dependent on the source. If the medium is changed, then the speed of sound also changes. For example, the pressure of a gas, the temperature of a gas, and the gas composition are all factors which affect the speed of sound in the gas.

Sound waves can experience interference just like waves on a string, especially when the waves are inside a tube, like an organ pipe. Traveling waves can reach the end of the tube, then they can be reflected back in the direction in which they came. There are now two sets of waves which can interfere, that is the two sets of amplitudes are added together. At certain frequencies this interference gives rise to a special wave called a standing wave. This is a resonance effect. Standing waves can occur in tubes which have only one end open, or in tubes that have both ends open. The derivation of the equation for these special resonant frequencies will be slightly different for these open or closed tubes. See your text book for the needed pictures and equations.

4.1 Pre-Lab Work

Show a set of pictures and equations for the first five harmonics, for both an open and for a closed tube. Show and explain what nodes and antinodes are. Show and explain what a standing wave is.

4.2 Experimental Procedure

Initial set-up:

- The source of the waves will be a stereo type speaker, powered by a frequency oscillator. The waves will move through the normal room air inside of a cardboard tube. The speaker will be placed at one end of the pipe.
- A microphone (Pasco) will be placed to receive the waves at the same end of the pipe.
- The Pasco Interface and the software Data Studio in the oscilloscope mode will be used to determine which frequencies give the maximum sound intensity for resonance.
- Measure the length of the tube.

- Calculate the resonant frequency for the n=3 harmonic, using an approximate value for the speed of sound.
- Set the generator frequency near this calculated value.

Doing the experiment:

- Adjust the sound intensity amplitude on the generator (not too loud).
- Adjust the frequency (on the generator) until the amplitude (on the scope) is actually at the maximum. This is called the resonance condition. Record the small range of frequencies which keep the amplitude at a maximum.
- Repeat this procedure to determine 4 additional resonance frequency points.
- Repeat this for both an open tube and for the closed end tube. (Five points for each type of tube.)
- Make a graph of the resonant frequency versus the harmonic number, for each tube type.
- Determine the speed of sound from each graph.
- Calculate a speed of sound value at 20°C.
- Determine the precision and accuracy for this experiment.

4.3 Questions

1. Does the speed of the wave depend on the frequency of the oscillator?

2. How does the speed of sound in air vary with the air temperature? By how much would the results of your experiment change if you conducted the experiment outside today?

3. What is meant by resonant condition?

4. In interference, at least 2 sets of waves are added together. What 2 sets of waves are added together in this experiment?

5. Why does the closed tube only show resonance for the odd harmonics?

6. Demonstrate how sound waves can be reflected by the open end of a tube.

7. What random errors might be in this experiment? And show any evidence of them.

8. What systematic errors might be in this experiment? And show any evidence of them.

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