

PHY 157

Speed of Sound in Air (Experiment 6)

Name: _____

1 Introduction

In this lab you will determine the speed of sound in air and compare the experimental value of the speed of sound to the theoretical value.

Because the speed of sound in air is too fast to be determined from distance and time measurements, it will be determined using the standing wave method. The method consists of setting up standing waves at a *known* frequency f in an air column, finding the wavelength λ of the waves from the length of the air column, and computing the speed from the frequency/wavelength relationship $v = f\lambda$.

The apparatus for setting up standing waves in an air column is shown in Figure 1. The apparatus consists of a long horizontal plastic tube with a movable piston that is used to vary the effective length of the air column. Sound waves at a given frequency are sent into the tube by a small speaker connected to a harmonic sound generator. When the air column is adjusted to the proper length, standing waves are set up within the column with a node at the piston (fixed end) and an antinode near the open end (free end). A microphone, placed near the antinode end, picks up the resonance vibrations and the output of the microphone is displayed on an oscilloscope.

Recall that the condition for standing waves in a tube closed at one end is that an *odd number of quarter wavelengths* should fit into length L of the tube. Because the antinode at the open end does not occur *exactly* at the end of the tube, two *adjacent* resonance positions

such as x_1 and x_2 , shown in Figure 1, must be found. Note that the distance between the two positions, $(x_2 - x_1)$, is equal to one-half wavelength of the standing waves.

2 Apparatus

- PASCO resonance tube
- PASCO signal generator
- oscilloscope
- speaker and microphone
- cables
- thermometer

3 Procedure

1. Use the following table to record your data.

Frequency f (Hz)	Node posn. x_1 (cm)	Node posn. x_2 (cm)	Wavelength λ (cm)	Wave Speed (m/s)	Air Temp. ($^{\circ}\text{C}$)

2. Set up the apparatus with the speaker close to the open end of the tube as shown in Figure 1. So that this end is truly open, position the speaker about 5 mm from the end of the tube. Attach the microphone to the apparatus, turn on the microphone amplifier, and connect it to the oscilloscope. Set the frequency to 550 Hz and place a thermometer near the apparatus.
 - (a) Push the piston close to the speaker and then slowly pull it back until you detect a resonance indicating the presence of standing waves. You should be able to *hear* the resonance, as well as see the maximum occur on the oscilloscope. To see better the maximum on the scope, set the time/cm control so that many cycles, spaced closely together, are displayed on the screen. Move the piston back and forth through the resonance and determine the best measurement for its position. Record the position to the nearest 0.1 cm. Repeat for the next *adjacent* resonance position. Use your data to compute the wavelength of the

waves and compute a value for wave speed using the frequency/wavelength expression $v = f\lambda$. (Remember to convert x_1 and x_2 to from centimeters to meters first so that the speed of sound will be in m/s.) Record the temperature.

(b) Repeat the above for frequencies of 800 and 1100 Hz.

4 Analysis

1. Use the following analysis table for your analysis.

Frequency f (Hz)	Measured sound speed (m/s)	Theoretical sound speed (m/s)	% Difference

Record the frequency and speed data from your data table into the first two columns.

2. **Theory.** A theoretical value of the speed of sound in air at temperature T is given by the expression

$$v = 331.0 + 0.60T \quad \text{m/s}, \quad (1)$$

where T is the temperature of the air in degrees Celsius.

Use this expression to calculate a theoretical value of the speed of sound for each frequency and record the results in the above analysis table. Also calculate the percent difference between the measured and theoretical values and record in the last column of the table. The percent difference between the measured and theoretical values is found from

$$\% \text{ Diff.} = \frac{\text{measured speed} - \text{theoretical speed}}{\text{theoretical speed}} \times 100 \quad (2)$$

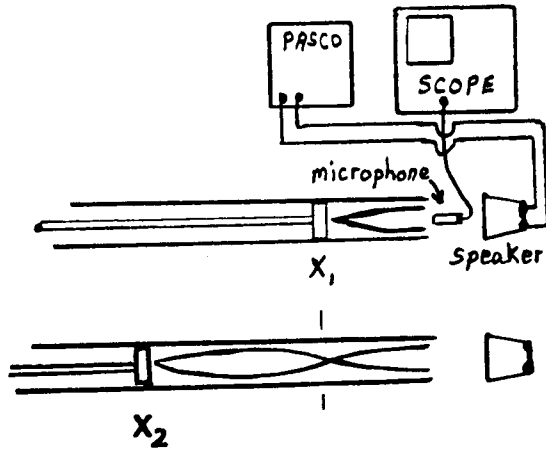


Figure 1.