San Diego Mesa College

Physics 197 Laboratory Experiment

Title: Resonance in Columns of Air

Name:____________________________________

Date: ____________________________________

Group Members: __________________________

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Objective: To test the theoretical formula for the speed of sound through a gas by direct measurement of the wavelength associated with a source of a known frequency. Also, to determine the frequency of an unknown source of sound using these analysis techniques.

Theory: The rate of energy propagation in a stretched string is described by the propagation speed. Furthermore, the speed of any wave in any medium follows the relationship given by:

$$v_{propagation}(m/s) = \lambda(m) f(s^{-1})$$

For sound waves propagating through a gaseous medium, the speed of sound is given by:

$$v_{sound} = \sqrt{\frac{\gamma R T}{M}}$$

where M is the molecular weight, R is the ideal gas constant and T is the temperature of the gas. γ is the ratio of the specific heat at constant pressure to the specific heat at constant volume for a diatomic gas.

Equipment:

- Deionized Water
- Tuning Forks
- Resonance Column
- Rubber Strikers

Setup and Procedure:

Do not touch the vibrating tuning fork to the glass tubes as they may shatter

Part I: Determination of the resonant wavelengths

Standing waves will be created in a column of air by a tuning fork of known frequency by adjusting the height of the water column until resonance occurs. Resonance will be accompanied by a loud ‘hum’. When resonance has been achieved the water level will determine the location of a node.

To create the resonance condition, strike the tuning fork on the rubber block (and only the rubber block). Then place the fork such that the ends vibrate horizontally over the opening to the resonance column.

Record the temperature of the air inside the resonance column in your data table. Record the position of the water column for two to three resonances for each of two different tuning forks in the data table. Be as accurate as possible when recording the position of the water column.

Data:

Room Temperature (C)			
Molecular Mass (kg)			
Known Fork 1	Water Level 1 (m)	Water Level 2 (m)	Water Level 3 (m)
(Hz)			
Known Fork 2			
(Hz)			
Unknown Fork			

Analysis: Due to the fact that the antinode does not occur directly at the end of the air column but just outside the tube, the distance of the first water level does not correspond exactly to a quarter-wavelength. However, this error may be eliminated since the same error is present in each of our measurements.

Since water level 2 corresponds to three-quarters of a wavelength plus the error, and water level one corresponds to one-quarter of a wavelength plus the error, this error can be eliminated. $(L_2+\varepsilon)-(L_1+\varepsilon) = L_2-L_1= \lambda/2$

1) Calculate the wavelength of both known forks and the single unknown fork in the space provided.

2) Use the theoretical equation for the speed of sound in a gas to calculate the expected propagation speed of the sound wave in the space provided.

3) Using the relationship between propagation speed, wavelength and frequency, calculate the actual propagation speed in the air column in the space provided for each of the known tuning forks.

4) Calculate the percent error between the theoretical and experimentally determined speed of sound for each of the known tuning forks. Percent error is given by:

$$\%Error = \frac{\left|v_{theoretical} - v_{\exp erimental}\right|}{v_{theroretical}} * 100$$

5) Determine the frequency of the unknown tuning fork

Conclusion: Briefly discuss the physics involved in the experiment, summarize the data, address potential sources of error and methods to reduce or eliminate them, and state whether or not the experimental results validate the theory.