

Open End Air Column Lab

Teacher's Guide

Topic:

Sound and Music

The following information is provided to the student:

Question:

What is the speed of sound? (open end air column)

Purpose:

To determine the speed of sound using an open end air column.

A complete lab write-up includes a Title, a Purpose, a Data section, a Conclusion and a Discussion of Results. The Data section should include collected data; data should be organized and labeled (a diagram may be more useful than a table). Calculations of speed should be organized, labeled and clearly shown. Fudge factor adjustments for end effects (both ends) should be made; work should be shown and labeled. Class data should be included in the Data section. The Conclusion should respond to the question raised in the Purpose section (as always). The Discussion of Results should include an error analysis. The reliability of the results should be evaluated based upon the theoretical value for the speed of sound. A percent error calculation should be performed; work should be shown and labeled.

Materials Required:

Tuning fork; tuning fork activator; hollow tube (at least 30 cm in length); digital function generator; speaker; meter stick; thermometer.

Description of Procedure:

A speaker is connected to the output of a digital function generator so as to create a sound source with an adjustable frequency and intensity. The frequency output is adjusted to a very low pitch. The hollow tube is held vertically above the speaker with one of its open ends an inch or so above the speaker. The intensity of the speaker is lowered so that it is just barely audible. The frequency is slowly increased and the sound is observed. The increase in frequency continues; as the frequency of the source begins to approach the natural frequency of the hollow tube, a noticeable increase in intensity is observed. This increase reaches a maximum when the frequency of the speaker matches the natural frequency of the column of air. To insure an accurate reading of the resonant frequency, the frequency output is adjusted until the loudest sound is observed. The temperature of the room is measured for the purpose of calculating a theoretical value for the speed of sound.

Alternative Materials and Procedure:

Alternative materials and procedures are not recommended.

Safety Concern:

There is always a higher than usual level of risk associated with working in a science lab. Teachers should be aware of this and take the necessary precautions to insure that the working environment is as safe as possible. Student *horseplay* and off-task behaviors should not be tolerated.

The Laboratory

Suggestions, Precautions, Notes:

1. Tuning forks should never be struck on hard surfaces. Striking it on or with soft rubber will preserve the frequency of the tuning fork. A light tap on a rubber shoe sole usually sets it into vibration.
2. It is presumed that the hollow tube is forced to resonate at its fundamental frequency.
3. Though costly, digital function generators are available from many science supply houses. For instance, [Pasco Scientific](#) offers the following model: [PI-8127 Function Generator](#).
4. End effects cause the vibrational antinode to be located just beyond the open end of the hollow tube. The effective length of the air column is longer than the measured length by an amount equal to $4/10^{\text{th}}$ s of the tube's diameter. This correction factor must be made for each open end and should be included in the calculations in order to improve the results.
5. Pooling class results for the speed of sound is a useful means of allowing lab groups to have feedback. It also can be made into a lesson on the nature of science as a cooperative venture.

Auxiliary Materials:

None

Scoring Rubric:

S5. Open End Air Column Lab	Score
____ Included, labeled and organized all parts of the lab report. ____ Data section includes a diagram with organized and labeled data; units are shown. Work for speed calculation is shown and labeled; adjustments for end effects (both ends) is shown and labeled. Class data is organized in a table. Individual results are reasonably accurate (after correcting for end effects). ____ Conclusion states the experimentally-determined speed of sound in air. ____ Discussion of Results includes a well-written error analysis; experimental value for sound speed is compared to the theoretical value. A percent error calculation is performed; work is clearly shown and labeled.	____/____

Connections to The Physics Classroom Tutorial:

The following reading is a suitable accompaniment to this lab:

<http://www.physicsclassroom.com/Class/sound/u1115c.cfm>

Connections to Minds on Physics Internet Modules:

Sublevels 8 and 9 of the Sound and Music module are suitable accompaniments to this lab:

<http://www.physicsclassroom.com/mop/module.cfm>