

## Closed 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? (closed end air column)

**Purpose:**

To determine the speed of sound using a closed 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 effect 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; labeled work should be shown.

**Materials Required:**

Tuning fork; tuning fork activator; hollow tube (at least 30 cm in length); long cylinder or deep container of water; meter stick; thermometer.

**Description of Procedure:**

The hollow tube is immersed in a cylinder of water. A tuning fork (of known frequency) is struck so as to vibrate. The tines of the vibrating fork are held above the opening to the hollow tube. The tube (and the tuning fork) are slowly raised above the water level in the cylinder, creating a closed end column of air inside the hollow tube. The hollow tube is raised to a position where the vibrating tines force the air column to resonate at the same frequency as the tuning fork. Once this position is determined, the length of the air column is measured. The frequency of the tuning fork is recorded. The temperature of the room is measured for the purpose of calculating a theoretical value for the speed of sound.

**Alternative Materials and Procedure:**

One means of adjusting the length of the air column in the hollow tube involves the use of a one-hole stopper, a hollow glass tube, some rubber hosing and a milk jug of water. A one-hole stopper is inserted into the end of the hollow tube. The glass tube is inserted through the hole of the stopper. (This must be done with great care so as to avoid piercing one's hand with broken glass if the glass tube breaks. Students should not be allowed to do this step; it should be done for them by the teacher prior to class.) The same stopper/glass tube arrangement is added to the milk jug. The jug is filled with water. The glass tubes of the hollow tube and the milk jug are connected with rubber hosing. The milk jug is inverted so that its water flows into the hollow glass tube. As the milk jug is raised and lowered, the water level in the hollow tube is raised and lowered. A diagram of this apparatus can be found in The Physics Classroom Tutorial: <http://www.physicsclassroom.com/Class/sound/u1114b4.gif>.

## The Laboratory

### 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.

### 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. End effects cause the vibrational antinode to be located just above 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 should be included in the calculations in order to improve the results.
3. 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:

| <b>S4. Closed End Air Column Lab</b>   | <b>Score</b> |
|--|--------------|
| ____ Included, labeled and organized all parts of the lab report.<br>____ Data section includes a diagram with organized and labeled data; units are shown. Work for speed calculation is shown and labeled; adjustments for end effect is shown and labeled. Class data is organized in a table. Individual results are reasonably accurate (after correcting for the end effect).<br>____ Conclusion states the experimentally-determined speed of sound in air.<br>____ 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/u1115d.cfm>

### Connections to Minds on Physics Internet Modules:

Sublevels 10 and 11 of the Sound and Music module are suitable accompaniments to this lab:

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