

Music in a Bottle Lab

Teacher's Guide

Topic:

Sound and Music

The following information is provided to the student:

Question:

How is the length of the air column in a pop bottle mathematically related to the frequency of the sound which it produces?

Purpose:

To determine the mathematical equation relating the length of the air column in a pop bottle to the frequency of the sound which it produces.

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 a diagram of the experimental set-up with the height indicated on the diagram. It should also include a table of data organized in a row-column format. A plot of frequency vs. length (frequency along the y-axis) should be constructed; linear regression analysis should be performed and statistical results should be reported. The Conclusion should state the mathematical equation relating the frequency to the length of the air column; meaning of the symbols in the equation should be defined. The Discussion of Results should utilize information from class discussions and textbook readings in order to explain the meaning of the slope of the line on the graph. The meaning should be identified and logically discussed.

Materials Required:

Computer interfaced microphone; meter stick or metric ruler; pop bottle (or other bottle); water.

Description of Procedure:

Students bring their own pop bottle or bottle to class. The bottle is filled with water to a height of a couple of cm from the top. Students blow across the top of the bottle in order to create a resonant sound. Using a computer interfaced microphone, the sound of the resonating bottle is *captured*. The waveform is analyzed in order to determine the frequency of the sound it produces. The corresponding air column length is measured with the meter stick. Some water is emptied from the bottle and a new set of air column length and frequency measurements are made. The data are analyzed in order to determine the equation which relates the air column length and the frequency.

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. Students should avoid touching their lips to the surface of any bottle other than their own.

The Laboratory

Suggestions, Precautions, Notes:

1. Caution students about the importance of avoiding the contact of their lips to the surface of any bottle other than their own bottle (or their girlfriend's bottle).
2. Most of the software which accompanies computer interfaced microphones displays the sound pressure as a function of time (usually in milliseconds). If the waveform looks relatively pure, then students can measure the period, convert to seconds and take the reciprocal in order to determine the frequency.
3. Either before of after the lab, compare and contrast two different methods of determining period - measuring the time difference between two adjacent peaks versus measuring the time elapsed for 10 cycles (i.e., from peak 1 to peak 11) and dividing by 10. Each reading would be characterized by the same amount of raw measurement error. But in the case of measuring the time for 10 periods, the raw error has one-tenth of the effect on the resulting period measurement.
4. This lab offers students a challenge at collecting quantitative data and making numerical sense of it. In their Conclusion/Discussion, students might simply state the equation which they have read in some physics textbook. Emphasize that they are to provide evidence for such equations, making specific references to their data. Like any lab, the goal is to accumulate evidence in support of a conclusion and to logically explain how the data serve as convincing evidence for the conclusion.

Auxiliary Materials:

None

Scoring Rubric:

S7. Music in a Bottle Lab	Score
____ Included, labeled and organized all parts of the lab report. ____ Data section includes a diagram of the set-up; length of air column is accurately indicated on the diagram. Frequency-length data is organized in a table with labeled column headings and units. A plot of the frequency-length plot is provided; the results of the linear regression analysis (slope, y-intercept and regression constant) are reported. Results are reasonable accurate. ____ Conclusion reports the equation relating frequency to the length; variables in the equation are defined; did not use y and x in place of f and L . ____ Discussion of Results discusses the meaning of the slope (or constant of proportionality in the equation). Relevant information from class discussions and textbook readings are used in the discussion; Logic and reasoning is evident as an effort is made to relate this constant to other physical quantities. Discussion reveals understanding of closed-end air columns.	____/____

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>