This paper describes a simple experiment that students can do at home to determine the speed of sound in air. A set of audio files with selected frequencies is first created and stored on the student’s computer. Resonances are obtained in a straight pipe partially inserted into a bucket of water. The length of the air-filled part of the pipe is changed by raising and lowering the pipe. Resonances are detected by ear. We present some typical results obtained by students at home. All are in good agreement with the expected value.

Of all the experimental setups to determine the speed of sound in different materials, including air, perhaps the most commonly cited involves resonances in a tube partially filled with water. Warden has recently described an improved method that requires no plumbing. Here we describe a similar experiment that students who have a computer can perform at home.

During recent years, personal computers have become popular and several experimental setups for the determination of the speed of sound in different materials using this tool have been proposed. Besides personal computers, such setups include electronic circuits with speaker, software for data acquisition and detectors for resonance, or even oscilloscopes (see, for example, Refs. 4 and 5).

The intention of this paper is to join one of the classical methods for the determination of the speed of sound in air, namely the detection of resonance in a pipe, with the execution of .wav files for fixed frequencies in a computer. This combination enables the execution of the experiment without tuning forks, electronic circuitry, or detectors (other than the student’s ear). Consequently, the experiment can be carried out by students at home, thus extending the learning process beyond the walls of the classroom.

**Experiment**

The experimental setup, shown in Fig. 1, consists of a bucket filled with water in which a PVC pipe is inserted. In this way, the length of the air column can be easily varied and the points of resonance can be detected using the experimenter’s own ear as a sound detector. The sound source is the speaker in the student’s computer. A set of eight audio files with extension .wav may be generated by the software TTG. The created files produce pure tones of frequencies 1.20, 1.60,
..., and 4.00 kHz, available from Ref. 7.

The basic idea is to execute the .wav files as an infinite loop on the personal computer beginning with a frequency of 1.20 kHz. One end of the pipe is then slowly inserted into the water of the bucket in order to diminish the length of the air column inside the pipe. Simultaneously, the ear is placed near the other end of the pipe, as shown in Fig. 1. When resonance occurs due to the reflection of the waves at the water surface inside the pipe, one gets the impression that the sound is emitted directly from inside the pipe. This sensation is caused by the increase in loudness of the sound due to the reinforcement of the sound wave energy at resonance. The location of the resonance point can be obtained by a fine adjustment of the vertical position of the pipe, similar to the procedure of tuning a radio to a broadcasting station. This position is measured and recorded. Then the pipe is slowly lowered into the water until the next resonance occurs. The difference between the positions of the two resonances is \( \Delta L = \frac{\lambda}{2} \) at the frequency used. Of course, since only the differences between consecutive resonances are considered, systematic errors due to end effects at the open end of the pipe cancel out. The procedure may be repeated to try to locate a third resonance point and then take the mean value of both measurements.

**Measurements and Results**

The necessary material for the execution of the experiment is generally available at home (or easily and inexpensively purchased): a ruler, a computer containing a set of audio .wav files for the generation of the pure tones, a straight pipe of about 60 cm length and 32 mm diameter, and a bucket roughly 50 cm high.

It’s a good idea to run through the experiment twice, the first time quickly to get familiarized with the measurement procedure, and the second time slowly and carefully. The results obtained at 23°C, using the frequencies available at Ref. 7, are given in Table I.

Since \( \lambda = 2 \Delta L = \frac{\nu f}{2} \), a plot of graph of \( \Delta L \) versus \( \frac{1}{f} \) (see Fig. 2) should give a straight line of slope \( \nu/2 \). Using curve-fitting software (LAB Fit, for example), we obtain \( \nu = (344 \pm 3) \text{ m/s} \). This is in good agreement with the expected value \( \nu = 345 \text{ m/s} \) for \( T = 296 \text{ K} \).

**Comments**

This experiment was carried out by several students at home. The values obtained differed from each other by less than 5% and were very close to the expected value given above. We conclude that the experiment is a simple, practical, and accurate method of determining the speed of sound in air.

**References**

2. Jim Warden, “Measuring the speed of sound without
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8. LAB Fit curve fitting software, online at http://www.angelfire.com/mb/labfit.


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