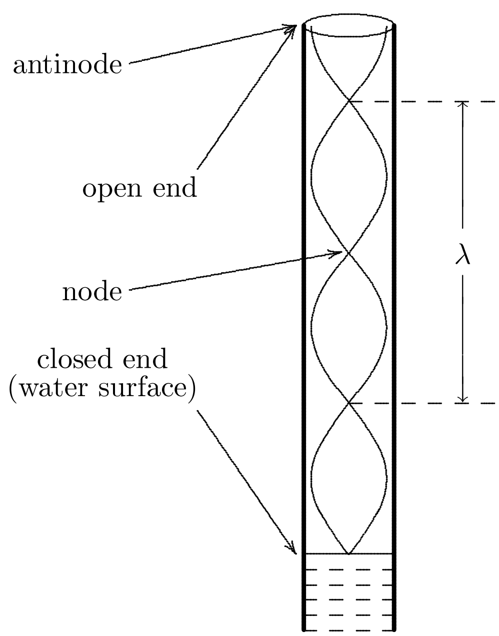
Speed of Sound*

Object

To measure the speed of sound in air.

Theory

Standing sound waves can be created in a hollow tube with one end closed and the other open. An antinode (point of maximum displacement) is created at the open end and a node (point of minimum displacement) is created at the closed end. With this condition one may see that an odd integer number $(1, 3, 5, \cdots)$ of quarter waves can be fitted along the length of the tube (see figure).



If a source of sound of a known frequency f is brought near the open end, it will produce waves of wavelength λ such that the speed of the wave is

$$v = \lambda f. \tag{1}$$

As v is independent of f and λ, one has to adjust the length of the tube to make an odd integer number of quarter waves fit in it. When such a fit occurs, the air in the tube vibrates at the same frequency as the source (resonance) making it sound louder. In the experiment one searches for this resonance. Two successive lengths of tube that produce resonance can be seen to be half a wavelength apart. This allows one to measure the wavelength directly. As the frequency is already known, equation 1 now enables the computation of the speed of sound.

The measurement method

To produce a variable length tube, we use a vertical transparent tube connected at the bottom to a flexible hose leading upto a water reservoir. As the level of the water reservoir is changed the level of water in the tube changes. The surface of water in the tube provides the closed end and it can be moved up or down. The top end of the tube is open.

A tuning fork is hit with a rubber mallet to produce sound of a known frequency (stamped on the tuning fork). It is then brought near the open end of the tube while the water level is slowly lowered from its highest point. One listens for resonance while this is done. Any two successive water levels for which resonance is heard are marked. If the distance between these marks is L, then

$$\lambda = 2L. \tag{2}$$

Then, using equation 1, we compute the speed of sound.

Some trials

Measure the speed of sound as described above. Compare it to the speed of sound in dry air at STP (331 m/s). What factors are responsible for the difference? Compare your results to that of the rest of the class. What factors are responsible for this difference?

Measure the distance of the top of the tube from the first node. Is it a quarter wave as compared to your wavelength measurement? If not, what do you think is responsible for the discrepancy?