MEASUREMENT OF THE SPEED OF SOUND IN AIR

Apparatus

1000 ml graduated cylinder, resonance tube, set of tuning forks in the frequency range 256 Hz to 512 Hz, vernier callipers, metre stick, stand (longest upright type), clamp and wooden block.

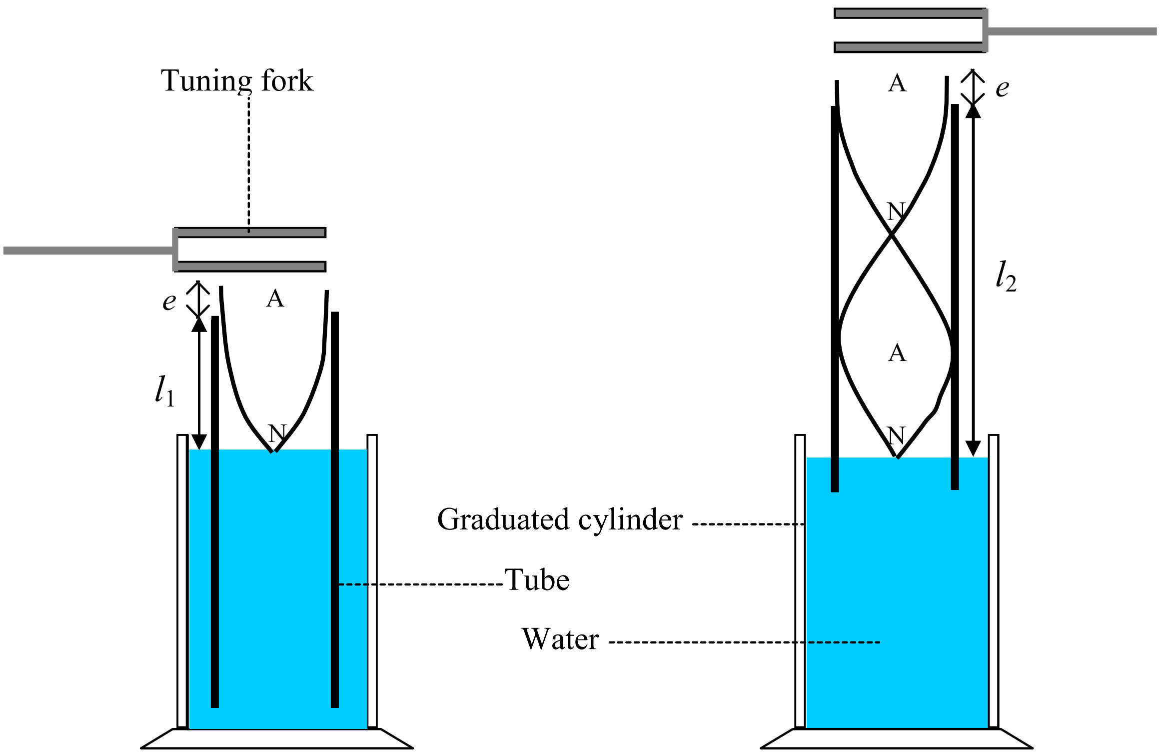


Fig.1 **Fig. 2**

Procedure

1. Clamp the tube so that the water in the graduated cylinder closes its lower end. The tube should be free to slide vertically through the clamp jaws. Take an approximate value of 300 m s^{-1} for the speed of sound to obtain a rough estimate of the quarter wavelength resonance position.
2. Strike the highest frequency (512 Hz) tuning fork on the wooden block, and hold it in a horizontal position just above the mouth of the tube (Fig. 1).
3. Slide the tube slowly up/down until the note heard from the tube is at its loudest; resonance is now occurring.
4. Tighten the clamp in this position and measure the length of the air column (from the water level to the top of the tube) l_1 with a metre stick.
5. Clamp the tube (or its extension) so that the air column is 2 or 3 cm less than $3l_1$ (Fig. 2).
6. Obtain a second weaker resonance with the same tuning fork by again sliding the tube until the note heard is at its loudest, at the three-quarters wavelength resonance position.
7. Clamp the tube in this position and measure with a metre stick, the air column length l_2 at this resonance.

8. Repeat this procedure to obtain the corresponding values of l_1 and l_2 for all the tuning forks in order of decreasing frequency.
9. Record the measurements in a table.
10. Calculate the wavelength using $\lambda = 2(l_2 - l_1)$ in each case.
11. Calculate the speed of sound from $c = f\lambda$, for each of the tuning forks.
12. Find the average value for the speed of sound.

Results

f/Hz	l_1/m	l_2/m	λ /m	c/m s^{-1}

The average value of the speed of sound in air =

Notes

The experiment can be done using just one tube. Proceed to obtain resonance as before. Measure the length l_1. The antinode forms above the top of the tube and so an end correction factor has to be added to the length. From theory, it is found that the correction factor $e = 0.3d$, where d is the average internal diameter of the tube (measured using a vernier callipers).

Hence $\lambda = 4(l_1 + 0.3d)$

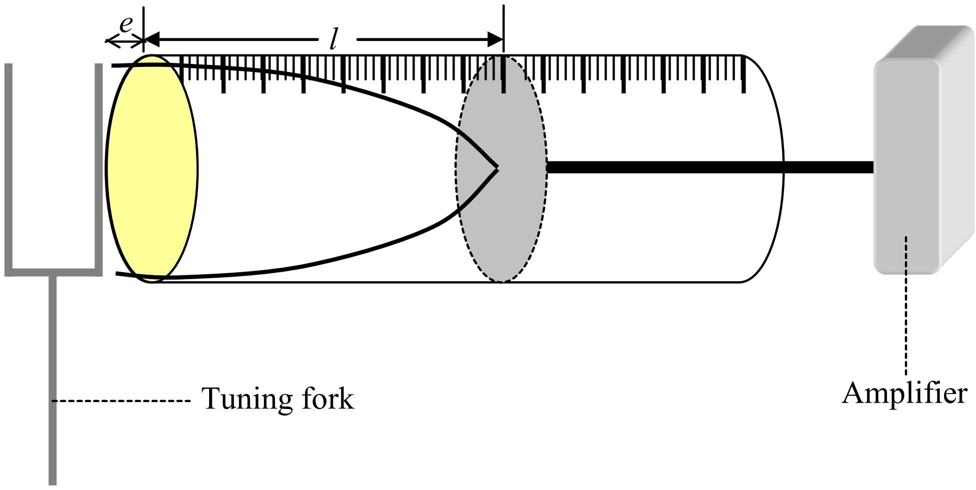
$c = f\lambda$

$c = 4f(l_1 + 0.3d)$.

Calculate a value of c for each tuning fork and find an average value for the speed of sound.

If a resonance tube is not available, use 50 cm lengths of 40 mm and 30 mm plastic pipes.

A specially designed apparatus called a resonometer can also be used to obtain the data.



Beginning with the highest frequency tuning fork and a very short column of air, adjust the piston until the sound from the vibrating air column is loudest; this is the first resonance point. Measure the length *l* of the air column at resonance. Proceed to use the set of tuning forks to complete the data table as in the previous method (it is difficult to distinguish resonance for frequencies below 340 Hz).

$\lambda = 4(l + e)$ where *e* is the end correction factor
$\lambda = 4(l + 0.3d)$ where d is the internal diameter of the tube
$c = f\lambda$
$c = 4f(l + 0.3d)$.

It is also possible to cause resonance in the air column using a signal generator and a loudspeaker; the 8 Ω, 5 cm diameter model of loudspeaker is ideal. Clamp the loudspeaker in a horizontal position just above the mouth of the tube. Connect the loudspeaker to the low impedance output of the signal generator. Gradually increase the signal generator frequency from zero until the air column resonates. Calculate the speed of sound using the same procedures as before. Repeat the experiment for different lengths of the air column.