

Standing waves on strings and in pipes

Physics grades 11-12 (A Level · IB · Class 11-12) · Lab

Name: _____ Date: _____ Class: _____

How can resonance in an air column measure the speed of sound? Use tuning forks of known frequency and a tube dipped in water, find the first loud position for each fork and use a graph of length against $1/f$ to find the speed and the end correction.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB C.4

Aim

To find the speed of sound in air and the end correction using resonance in a tube closed at one end.

Equipment

- Open glass tube about 60 cm long and 2 cm radius (inner diameter 4 cm)
- Tall measuring cylinder or pipe filled with water
- Set of tuning forks (256, 320, 384 and 512 Hz) and a rubber pad
- Metre rule, thermometer

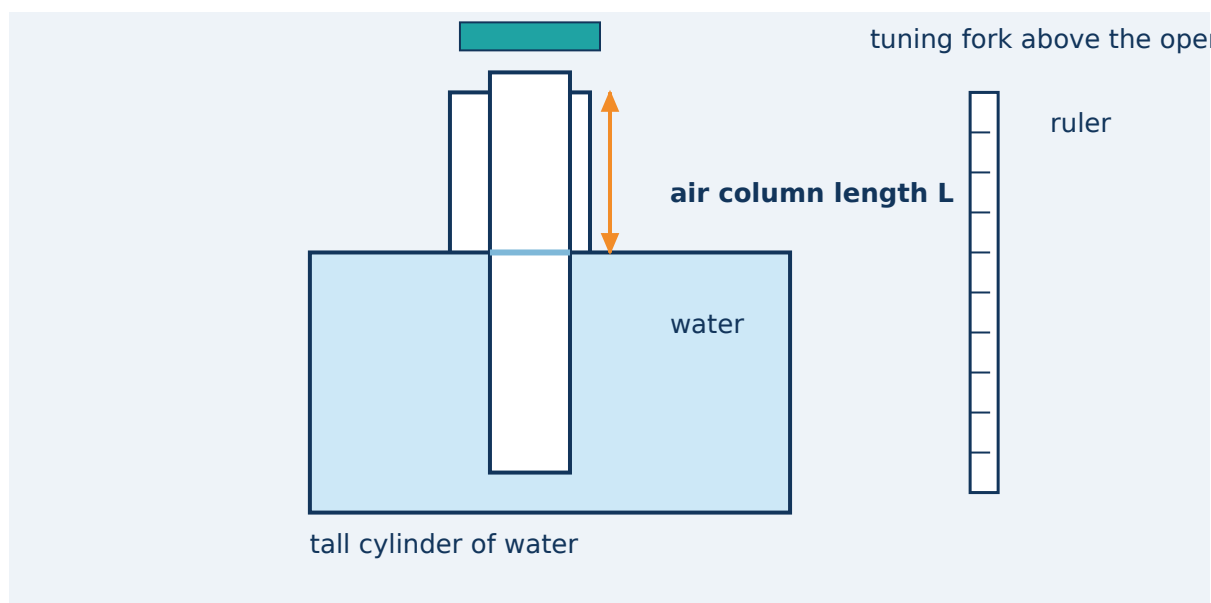
Safety

Safety

Handle glass tubing carefully and stand the cylinder on a tray so spills are contained. Strike tuning forks on a rubber pad, never on the bench or on glass, and keep the forks away from your face.

Method

1. Stand the tube in the water so the air column is short and hold a vibrating fork just above the open end.
2. Raise the tube slowly until the sound becomes loudest. Measure the length L of the air column above the water to the nearest millimetre.
3. Repeat three times and take the mean.
4. Repeat for the other forks, recording the room temperature.
5. Calculate $1/f$ for each fork and plot L against $1/f$.



A tuning fork held over a tube dipped in water. The first loud sound happens at the first resonance length L .

Results

Sample first-resonance lengths (mean of three), room temperature 20 °C:

f / Hz	$1/f / 10^{-3} \text{ s}$	L / m
256	3.906	0.326
320	3.125	0.259
384	2.604	0.214
512	1.953	0.158

Analysis questions

Question 1 Resonance condition

Explain why the first resonance occurs when $L + e = \lambda/4$, where e is the end correction.

Question 2 Line equation

Use $v = f\lambda$ to show that $L = v/(4f) - e$. State what to plot.

Question 3 Slope of the line

Find the slope of the line of L against $1/f$ from the 256 Hz and 512 Hz readings.

Question 4 Speed of sound

Calculate the speed of sound from the gradient.

Question 5 End correction

Calculate the intercept and state the end correction.

Question 6 Percentage difference

The accepted value of v at 20 °C is 343 m/s. Calculate the percentage difference.

Question 7 Second resonance

For the 512 Hz fork the second resonance is found at $L_2 = 0.493$ m. Use L_1 and L_2 to find v without needing e .

Question 8 Uncertainty and improvement

Estimate the percentage uncertainty in L for the 512 Hz fork if the loudest position is uncertain by ± 3 mm, and suggest one improvement.