State Examination Commission – Physics Higher Level, 2006

Question 3

A cylindrical column of air closed at one end and three different tuning forks were used in an experiment to measure the speed of sound in air. A tuning fork of frequency *f* was set vibrating and held over the column of air.
The length of the column of air was adjusted until it was vibrating at its first harmonic and its length *l* was then measured. This procedure was repeated for each tuning fork. Finally, the diameter of the column of air was measured.
The following data was recorded.

f/Hz	512	480	426
l/cm	16.0	17.2	19.4
Diameter of column of air = 2.05 cm			

Describe
(i) how the length of the column of air was adjusted;
(ii) how the frequency of the column of air was measured;
(iii) how the diameter of the column of air was measured. (16)
How was it known that the air column was vibrating at its **first** harmonic? (9)
Using all of the data, calculate the speed of sound in air. (15)

Describe
(i) how the length of the column of air was adjusted;

By lowering or raising an open pipe in a container of water

(ii) how the frequency of the column of air was measured;

When the column of air was resonating with the tuning fork, the frequency of the tuning fork was the same as the frequency of the air column. This frequency was read from the fork.

(iii) how the diameter of the column of air was measured. (16)

A vernier callipers measured the internal diameter of the open pipe

How was it known that the air column was vibrating at its **first** harmonic? (9)

The open pipe was immersed fully in the container of water and then raised, with tuning fork held at top, until the first position of resonance was located. This first position of resonance corresponded to the fundamental mode of vibration, the first harmonic.

Using all of the data, calculate the speed of sound in air. (15)

$\lambda/4 = (l + 0.3\,d)$
$\lambda = 4(l + 0.3\,d)$
Now, $v = f\lambda = 4f(l + 0.3\,d)$

Substituting the values of *f, l* and the diameter of the air column, *d,* from the above table gives us

$v_1 = 340$ m s^{-1}
$v_2 = 342$ m s^{-1}
$v_3 = 341$ m s^{-1}

Taking an average of these determined values for the speed of sound, yields $v_{ave} = 341$ m s^{-1}

(note; there was insufficient data to justify use of a graph in this instance of the experiment)