Report on Exercise to Demonstrate Methods of Measuring the Velocity of Sound.

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OBJECTIVE

To demonstrate three methods of measuring the velocity of sound in free air and to assess the accuracies of each method against the recognised standard calculation for the velocity of sound.

Standard Calculation for Velocity of Sound in Free Air

The recognised standard calculation for the velocity of sound in free air uses the formula for $V_{sound} = (331.4\ ms^{-1} + 0.6\,T_c)$ where T_c is the ambient temperature in degrees Celsius. With the temperature at the time of the experiment being 10^{o}C this gives rise to the calculated V_{sound} for the day, and environment, as being $336.8\,ms^{-1}$.

Method 1

In this method a volunteer was asked to walk a fixed distance from a group of people. The volunteer was then to clap his hands together while the group of people used the stopwatch facility on their mobile phones to measure the time between them seeing the handclap happen and actually hearing the handclap.

The volunteer was asked to walk to a position 100m (approx.) from the measuring group.
The group then carried out individual timing actions. The average time recorded between seeing the clap and hearing it was 0.35seconds. The figures of 100m and 0.35s can be used in the formula

$V = \frac{d}{t}$, where;

V = The velocity of sound expressed in ms^{-1} ; *d*= the distance in meters and *t* = time in seconds

To give this calculation: $V = \frac{100}{0.35}$ which gives the result *V* = 285.71 ms^{-1}

Method 2

For the second method, the measurement group joined the volunteer at a distance of 100m (approx.) from the College building. In this experiment the time was measured for the sound of a handclap being reflected from the college building. Thus the distance was now doubled.
This gave the following values: *d* = 200m, *t*= 0.65s.

Using these values in the formula gives:
$V = \frac{200}{0.65}$ which gives the result *V* = 307.69 ms^{-1}

Method 3

This is a more technical method as it involved using a system comprising of a PC , a sound card generating pink noise, a PA system to transmit the pink noise, and a remote microphone coupled back to the system using a digital radio transceiver. Accurate distance measurements for the microphone to PA distance were recorded using a laser measure. This system is illustrated in the block diagram of Figure 1.

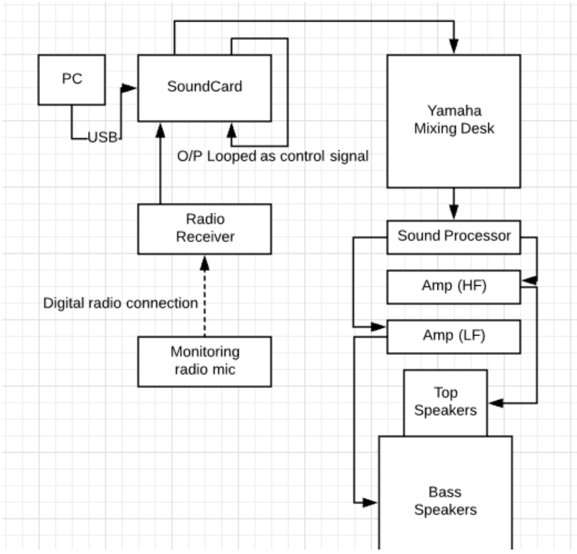
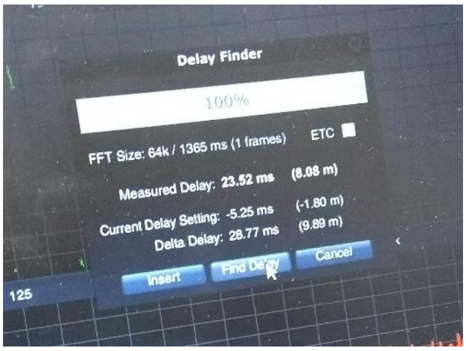


Figure 1. System for measurement of Velocity of Sound

The laser measured distance was found to be 6.3m This is an important figure to note as the results from the software on the PC varied from this measurement.

The results from the System are shown in the screenshot from the PC below.



The system has calculated the distance from the remote mic to the PA as being 8.08m, yet the laser measured it as being 6.2m.

Using these figures in the formula $V = \frac{d}{t}$ gives the result V= 343.53 ms^{-1} . This is closer than either Method 1 or Method 2, yet despite the technology used is still not 100% accurate.

Conclusions

How can we explain the difference between the calculated figure and those calculated from the three different experimental methods? To recap, the results were:

Calculated V_{sound}	Method 1 V_{sound}	Method 2 V_{sound}	Method 3 V_{sound}
336.8 ms^{-1}	285.71 ms^{-1}	307.69 ms^{-1}	343.53 ms^{-1}

There are obviously potential areas for error in the first two methods which required human reaction time to be as accurate as possible. The ability to accurately control a stop-watch application on a mobile phone is the most likely source of variance and error in the measurements. A further area for error is in the distance between the measuring group and the volunteer clapping. This may not have been precisely 100m. Method 2, although having the same possible sources of error as Method 1 yielded a more accurate result. This may have been because the time was effectively doubled allowing for more accurate human response time when using the stop-watch functions on the phones. Again, in Method 2, the distance was approximate so it is possible that this time the assumed distance of 200 meters was more accurate.
For Method 3, the most likely reason for the error and variance from the calculated figure is due to the radio system being used being digital. There will have been some latency introduced by the Digital to Analogue conversions used in the system. If the laser measured distance is used with the results of Method 3 then the time T can be calculated as being 18ms. Thus, the latency in the D to A processing is is approx. 5ms. This seems a plausible source for the error inherent in Method 3.