Speed of sound in air

Technician and teacher sheet

Apparatus

- A Motion sensor with the range set to Time.
- A Temperature sensor or a thermometer.
- Rule or measuring tape.
- Flat reflective surface e.g. glass window pane, plastic sheet, metal sheet, wood.
- Calculator.

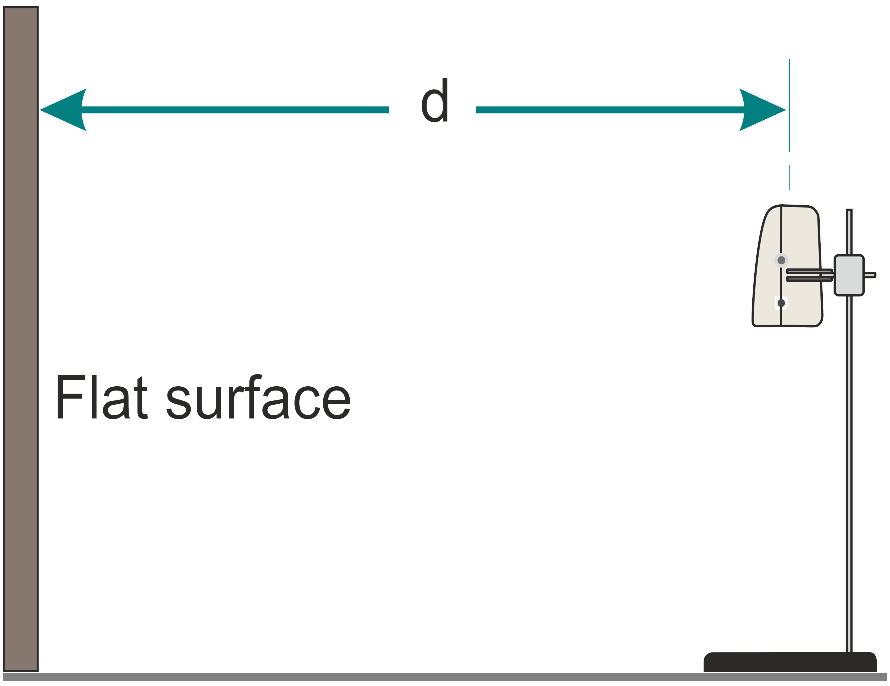
Data recording setup.

Use setup to set the intersample time to 20 ms (to match the response time of the Motion sensor)

Leave all other settings to default.

The motion sensor has a rang, often overlooked, that simply measures how long it takes for the sonar “chirrup” to go from the sensor to the reflective surface and back.

Remembering that the “chirrup” has to cover the distance twice, we can use distance and time of flight to calculate the speed of the sound.



Practical notes

1. The reflecting surface needs to have good ultrasound reflectivity. It would be worth the time to check before the practical. It is surprising how many surfaces do not reflect ultrasound (for example unpainted pin-board, suspended ceiling tiles, display posters etc).
2. Use a retort stand to elevate the sensor above any work surfaces.
3. You could use a fan heater to heat the airspace between the sensor and reflecting surface to show the effect of heat - this would be uncontrolled as the temperature of the heater would be localised.
4. The simplicity of the practical is it’s strength. This is about using the speed calculation. As you have known value to find it it can be useful to see if the mathematics is being used correctly. One of the errors to look out for is the correction for microseconds to seconds.

Use the equation:

Find the velocity of sound in metres per second

Velocity = Distance divided by Time

The pulse has travelled to the flat surface and back = distance (d) x 2

The value for the time measurement is in microseconds (µs). micro (µ) means divide by 1,000,000 i.e. 10^{-6}.

Correct the time to plug into the formula as seconds.

$$v = \frac{2d}{t \times 10^{-6}}$$

e.g. Velocity = $\frac{\text{Distance}}{\text{Time}} = \frac{2 \times 1\ \text{m}}{5{,}800\ \mu\text{s} / 1{,}000{,}000} = \frac{2}{0.0058\ \text{seconds}}$ = 344.8 metres per second.

Extension:

How has the temperature of the room affected the speed of sound?

The motion sensor has a temperature sensor inside the case. If this is selected as another range to record the ambient temperature can be found without the need for additional temperature sensors.

An additional temperature sensor can, of course, be used.

The value of velocity of sound increases with temperature. At 0°C the velocity of sound = 331.3 metres per second.

The velocity of sound increases at 0.607 metres per second per degree Celsius. (Ref Kaye and Laby)

At 24°C speed/velocity of sound = 331.3 + 24 x 0.607 = 345.9 metres per second.

Compare your results with the standard. There should be a close agreement.

Software knowledge required.

1. How to link the sensor to the software.
2. How to change / select ranges in the software.
3. How to set up intersample time.
4. Use tools to find values.