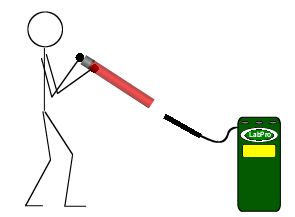
Boom Whackers & The Speed of Sound

**Purpose:** To determine the speed of sound in air by using a set of Boom Whackers.

**Materials:** Boom Whackers with the black lids on, Logger Pro and LabPro with a microphone-sensor, thermometer, and measuring tape

**Theory:** Boom Whackers are 8 bright colored plastic tubes in different lengths and together they cover the tones of an octave in the diatonic scale.

The black lids can be used to close one end of the tube, so we will expect the tube to behave as a quarter-wave resonator, with a node in the closed end and an antinode in the open end. So the first harmonic, f1, has a wavelength a little more than 4 times the length of the tube.

We will measure the resonant frequency for each tube. This is the frequency at which a standing wave forms in the tube. From this information, the wave equation can be used to find the speed of the wave.

\*\*Extension

In practice it is a little more, since we take the end-correction into account.

The end-correction is approximately (π/8)∙D, where D is the diameter of the tube. This means, that the effective length of the tube can be calculated using the equation

**Procedure:**

You will be recording the frequency of the 1st harmonic for tubes of varying lengths. From this relationship of frequency & wavelength you will be able to experimentally determine the speed of sound in air. In order to compare your experimental value with the theoretical value, you will need to record the temperature. \*\*Extension – You will need to measure the inner-diameter of the tube to take the end-correction into account.

Remember to record the precision of the equipment you use. If you repeat measurements, you should keep track of this so that you can get a measure of the random uncertainty.

Connect a microphone to a Lab Pro. In Logger Pro make a time-based measurement for one second with 10000 measurements per second. There will already be a graph of pressure against time. Choose insert/additional graph/FFT, to make a new frequency spectrum; you should then double click on the graph, and set a tick by “Legend” and Peak Frequency. The FFT graph should show frequencies up to 1500 Hz rather than 5000 Hz. You should be able to see both graphs.

Hold the bottom just past the end cap of the tube, and hit the end cap with a flattened hand about ½ second after the Collect-button has been pressed. Try a few times with the first tube - it should be the 1st harmonic (the peak furthest to the left) which has the greatest intensity on the FFT-graph. If it’s not, then repeat the experiment and try tapping the tube a little more softly. Save one of the FFT graphs to include in your report.

Continue with the rest of the tubes, recording the length and frequency of the fundamental harmonic.

**Data analysis:**

*How can you see on the FFT graph, that we are dealing with a quarter wave resonator?*

Use your measurements to explain your answer.

Create a graph of frequency against wavelength.

*What relationship does the graph show? How can you adjust the values plotted on the axes to produce a linear graph?*

Once you have adjust the axes to create a linear graph, use the slope to determine how to get a measurement of the speed of sound.

The theoretical value for the speed of sound in air at any given temperature can be calculated by this equation where T is the temperature.

Compare your value of the speed of sound to the theoretical value.

Remember to end the report with a conclusion and evaluation, where you discuss the sources of error in the report.

**Report:**

You will write a full report for this practical. Things to keep in mind for the report:

* Include a nicely formatted table with uncertainties
* Include a sample calculation for one value of the independent variable
* Include a copy of the FFT graph, and explain what it shows
* Include a graph of frequency against wavelength
* Include your final graph