An experimental study on the speed of sound

Aim

The aims of this experiment are to verify the law of standing waves and to measure the speed of sound via repeated measurements.

Background information

Waves are propagations of disturbances from place to place in a regular and organised way. In the simplest waves, the disturbance oscillates periodically with a fixed frequency and wavelength. In the case of mechanical waves, such as sound, a medium through which to travel is required, differently from electromagnetic waves which can also propagate through a vacuum. More in deep, standing waves form due to the combination of two waves moving in opposite directions, each having the same amplitude and frequency. The formula for the wavelength of standing waves with one end fixed and the other end free, is $\lambda_n = \frac{4L}{n}$, while the formula for frequency is $f = \frac{v}{\lambda}$.

Instruments and materials

Instruments:

- Vernier Calliper —> sensitivity ± 0.02 mm ; range 200.00 mm
- Microphone with spectrum analyser —> sensitivity ± 1 Hz ; range 20 - 20000 Hz

Materials:

- Water
- Cylindrical beaker

Safety issues

- Keep the cylindrical beaker distant from the computer to avoid risking of spilling the water in it onto the computer.
- In addition, due to COVID-19, it is preferable to have only one person blowing inside the Vernier calliper, in the way to reduce the risk of infection.

Procedure

- Firstly, set up the microphone and the computer to then test if the sounds are registered in the correct manner. A very simple and free software to use, which suites very well to register sounds and see the frequencies of them, is Audacity.
- Using the Vernier Calliper, measure as precisely as possible the length of the cylindrical baker from the top to the bottom of the cavity for the 1° measurement, and to the water for the 2° measurement onwards.

- When all is set up and working, start registering the audio from the microphone, and then blow inside the cylindrical beaker trying to make a sound. It should be similar to a whistle, and it still works even if it is not completely neat.
- Stop registering, and analyse the audio's frequencies, to then select the peak frequency of when the whistle was made. It is simpler to understand which peak is the correct one by being very silent while registering and by making the audio as short as possible by including only the wanted sound.
- Add 10 mm of water more or less inside the cylindrical beaker and retake the 2°, 3° and 4° steps of the procedure.
- Repeat the 5° step for at least 5 times, in order to obtain a discrete amount of data

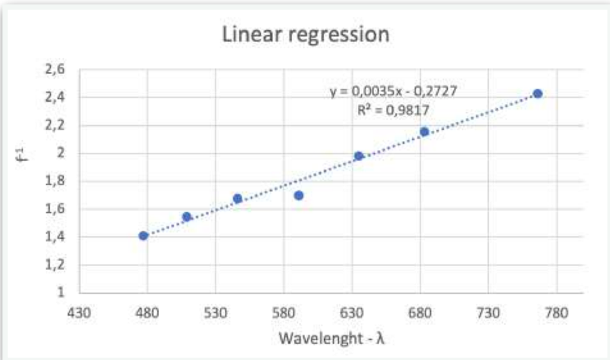
Results

Measurement n°	L —> length	$\mathscr{F}$ —> Frequency
	(cm ; ± 0.02)	(Hz ; ± 1)
1	17,76	477
2	16,17	509
3	14,91	546
4	14,72	591
5	12,61	635
6	11,60	683
7	10,31	766

Pressure	Temperature
(KPa ; ± 1)	(°C ; ± 0.1)
101.11	21.7

Analysis

λ ; m	Speed of sound (m s^{-1})
(L ∗ 4) / 1	λ ∗ $\mathscr{F}$
0,71	339
0,65	329
0,60	326
0,59	348
0,50	320
0,46	317
0,41	316



Graph 1 —> Relationship between $\mathscr{F}^{-1}$ and λ

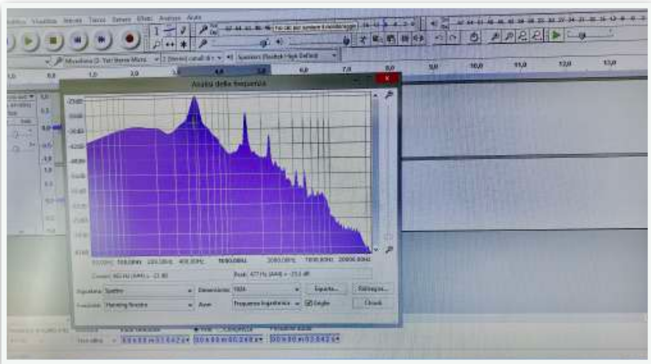
- The value given for the speed of sound according to the calculations is on average (328 ± 34) ms^{-1}
- The R^2 value of the relationship between $\mathscr{F}^{-1}$ and λ is of 0,9817 , which means that the two values are strongly related with an almost exactly directly proportionality.

Conclusion

In conclusion, the value calculated for the speed of sound is (328 ± 34) ms^{-1} and the value of 343 ms^{-1} for the speed of sound is within the range of the uncertainty. Also the R^2 value reported gives support to the result of the experiment as 0,9817 represent a very strong relationship between the two values, which means that their relationship is practically linear. Even though, the experiment has some limitations such as the length of λ , as when measuring the distance between the bottom and the top of the cylindrical beaker, the degree of accuracy wasn't only determined by the sensitivity of the Vernier Calliper, but even by the degree of human error involved.

Bibliography

- Physics for the IB diploma, sixth edition
- https://www.britannica.com/science/wave-physics



Picture 1 —> Audacity software representing the frequencies