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RESEARCH ARTICLE

A METHOD FOR MEASURING SOUND VELOCITY BASED ON SMART PHONE APPLICATION

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Abstract

This paper introduces a method to measure the sound velocity by using the standing wave in the common milk tea tube that Opened at both ends. Just two smart phones and a tube are used in the experiment. For these instruments are readily available, we needn't to go to the school laboratory. This inspires the students' learning interest and enhances their practical ability.

Introduction:-

There are various methods for measuring sound velocity in university physics experiments, and their commonality is that they all require specialized experimental instruments to conduct the experiments. If sound velocity can be measured using some readily available tools, it undoubtedly has great benefits in stimulating students' interest in learning and enhancing their hands-on ability. The popularity of smartphones and advances in mobile application development have made this idea a reality [1-5]. This work presents a method for measuring sound velocity using the standing wave phenomenon of a common milk tea tube with two open ends, which only requires two smartphones and one milk tea tube with two open ends to conduct experiments.

Experimental principle

In the mechanics textbook[6-7], it is pointed out that the conditions for sound waves to generate standing waves in a tube with one end closed are:

$$l = \frac{2n-1}{4}\lambda \ (1)$$

Where l is the length of the tube and λ is the wavelength of the sound wave.
When both ends of the tube are open, the conditions for forming standing waves in the tube are[8]:

$$l' = \frac{n\lambda}{2} (2)$$

Where l' is the length of the open tube, λ is the corresponding wavelength of the sound wave, n=1,2,3……, as shown in Figure 1,

When the two ends of the tube are opened, the air column is connected to the outside atmosphere, and its pressure is always equal to atmospheric pressure, so there will be no compression or expansion deformation. According to the knowledge of standing waves[9], only the volume element at the belly of the wave will not be deformed, so the beginning of the air column must form a displacement belly.

By $l' = \frac{n\lambda}{2}$ and $\upsilon = \lambda f$,we kown that

$$f = \frac{n}{2l'}\nu \ (3)$$

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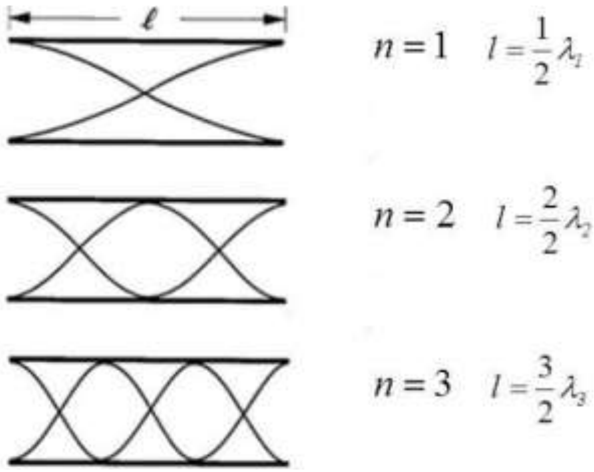

Figure 1:- Intrinsic vibrations of the fundamental and harmonic frequencies of the air column inside the tube with both ends opened.

Therefore, in a certain length of open tube, the difference between two adjacent frequencies that generate standing waves is:

$$\Delta f = f_{n+1} - f_n = \frac{1}{2l'} v \quad (4)$$

If Δf isknown, v can be found.

Experimental Materials and Procedures

Experimental materials:

Two smartphones, one earphone, audio generator software, noise detector software, milk tea tube.

Experimental Procedures:

1. Install the tone generator software to one smartphone and the noise detector to another;
2. Place the milk tea tube flat on the table, open the audio generator software, and use the headphones to send the sound from the mobile phone to one end of the tube;
3. Open the noise detector software in another mobile phone and place the mobile phone at the other port of the open tube;
4. When the frequency of the tone generator is changed continuously, the decibel value captured by the noise detector changes accordingly, and multiple peaks appear;
5. Analyze the data to calculate the speed of sound value.

Experimental data analysis

The speed of sound in air is related to air temperature, and the formula is$v = v_0\sqrt{1+\frac{t}{273.15}}$,Where v_0 is the sound velocity in the air at 0 ℃, with a value of v_0=331.45m/s,During this experiment, the thermometer displayed a laboratory temperature of 17.5 ℃, and the calculated theoretical value of sound velocity was v=341.903m/s.

When using a milk tea tube with a length of 17cm and a diameter of 8mm, the measured speed is v=334.6m/s, with a relative error of 2.11%;When using a milk tea tube with a length of 17cm and a diameter of 12mm, the measured velocity is v=329.6m/s, with a relative error of 3.598%. The relative error of the sound velocity obtained directly from the data is relatively large.we conducted the same experiment using another milk tea tube, which has a length of 22cm and a diameter of 8mm. The experimental data obtained are shown in Table 1.

Table 1:- Data obtained from a milk tea tube with a length of 22cm and a diameter of 8mm (room temperature: 17.5 ℃).

	f（Hz）						Δf （Hz）	v (m/s)
	f_1	f_2	f_3	f_4	f_5	f_6		
1	1500	2250	3000	3828.1	4500	5343.8	769.1	338.4

2	1500	2265.6	2984.4	3828.1	4484.4	5375	770.8	339.2
3	1500	2250	3000	3843.8	4546.9	5312.5	772.6	339.9
v =339.2m/s Relative Error =0.791%								

As shown in Table 1, we found that the relative error of the measurement was 0.791%, which was significantly better than the previous two results. For such an ordinary smartphone application and common milk tea tubes, it is quite good to be able to obtain such experimental data. Comparing the data of the three experiments, we found that the experimental results with the largest ratio of tube length to tube diameter were the most accurate among the three groups.

Conclusion:-

In summary,for common milk tea tubes, selecting a certain length and diameter can accurately measure the sound velocity in the air, indicating that our experimental plan is feasible.The experimental result with the highest ratio of milk tea tube length to tube diameter used in the experiment is the most accurate, but this quantitative relationship still needs further research.Our experimental method only estimates the speed of sound in the air.Compared with the traditional method of measuring sound velocity in university physics experiments,this experimental method greatly reduces the threshold, makes the experimental operation relatively easy, and the experimental equipment used is also readily available. Students only need two ordinary smartphones with free software installed and a milk tea tube to measure sound velocity. This is of great benefit to stimulate students' interest in learning and enhance students' hands-on ability.

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