Development of an ICT-Based Air Column Resonance Learning Media

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Abstract. Commonly, the sound source used in the air column resonance experiment is the tuning fork having disadvantage of unoptimal resonance results due to the sound produced which is getting weaker. In this study we made tones with varying frequency using the Audacity software which were, then, stored in a mobile phone as a source of sound. One advantage of this sound source is the stability of the resulting sound enabling it to produce the same powerful sound. The movement of water in a glass tube mounted on the tool resonance and the tone sound that comes out from the mobile phone were recorded by using a video camera. Sound resonances recorded were first, second, and third resonance, for each tone frequency mentioned. The resulting sound stays longer, so it can be used for the first, second, third and next resonance experiments. This study aimed to (1) explain how to create tones that can substitute tuning forks sound used in air column resonance experiments, (2) illustrate the sound wave that occurred in the first, second, and third resonance in the experiment, and (3) determine the speed of sound in the air. This study used an experimental method. It was concluded that; (1) substitute tones of a tuning fork sound can be made by using the Audacity software; (2) the form of sound waves that occured in the first, second, and third resonance in the air column resonance can be drawn based on the results of video recording of the air column resonance; and (3) based on the experiment result, the speed of sound in the air is 346.5 m/s, while based on the chart analysis with logger pro software, the speed of sound in the air is 343.9 ± 0.3171 m/s.
Keywords: Resonance, Air Column, Learning Media, ICT.

1. Introduction

In the 21st century learning, ICT-based learning media is an innovative modern media which has a very important role in learning [1, 2, 3]. ICT strongly supports lifelong learning that can create a fun learning and enable to enhance the understanding and learning outcomes of students so that they can determine educational success [4, 5, 6, 7, 8]. The use of ICT in learning can also overcome the difficulties of students' learning, improve teacher competence, and form a creative and innovative teacher [9, 10, 11]. ICT can also support the success of contextual learning and problem-based learning [12, 13]. In addition to its use in the classroom, ICT can be used for assessment, research [14, 15], and distance learning [16, 17].

Generally, mobile phone is used for communication media. However, the mobile phone can also be used as a learning media, and assessment [18, 19, 20].

Commonly, the tools used in resonance experiments in the air column resonance is a tube made of glass which is equipped with a plastic funnel. Air column resonance experiment is carried out to determine the speed of sound in air. Sound sources used in this experiment are generally a vibrated tuning fork. The sound produced by the tuning fork occurs so quick, so it can not be used to perform experiments of the second resonance, third resonance, and so on. Another limitation is that a tuning fork produces weak sounds, consequently the sound produced by a air column in the glass tube also will also be weak. The experiment of air column resonance can also use an audio frequency oscillator [21]. This tool generates more steady sound, but it requires some components of the electrical circuit, so it is not practice.

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Based on the above background, the idea of making tones with specific frequencies using Audacity software was realized. The tones that have been made were stored in the laptop and their initial WAV files were, then, converted by using the Prism Video File Converter Software into MP3 files in order to make them be able to be stored in the mobile phone. The tones stored in the mobile phone were, then, used as a source of sound in the air column resonance experiments to replace tuning fork [22]. This sound source has many advantages, e.g the produced sound stayed relatively longer and has the same quality. Its resulting sound can be used for the series of resonance experiments. Form of sound waves occured in the glass tube can be seen by playing the recorded resonance experiments using the Audacity software. Based on the results of audio recording, form of sound wave during a first resonance (¼ λ), the second resonance (3/4 λ), and third resonance (5/4 λ) can be known. Thus, by using the software, the relationship among the first, second, third resonance of the sound and the wave forms generated.

2. Method

The experiments of a sound resonance in an air column were conducted by employing the sound source of the tone produced by a mobile phone. The experiments were performed 10 times with various tone frequencies: 600 Hz, 650 Hz, 700 Hz, 750 Hz, 800 Hz, 850 Hz, 900 Hz, 950 Hz, 1000 Hz, and 1050 Hz.

The movement of water in a glass tube mounted on the tool resonance and the tone sound that comes out from the mobile phone were recorded by using a video camera. Sound resonances recorded were first, second, and third resonance, for each tone frequency mentioned above.

Video recordings were transferred into the laptop. The MPEG file format was then changed into MP3 one. This aimed to make it able to be played using the Prism Video File Converter sofware. The MPEG format of video recording did not removed prior to next uses.

At the time of recording the movement of water, scale of the first, second, and third resonances characterized by louder sounds coming out from the mouth of the glass tube were observed. Scale where these resonances occured were, then, recorded in the observations table.

Next stage was playing video recordings that have been converted into an audio format using Audacity software to see form of sound waves at first, second, and third resonance. The data of wave form of an audio recording were analyzed, to determine the number of formed waves and sound resonance that occured.

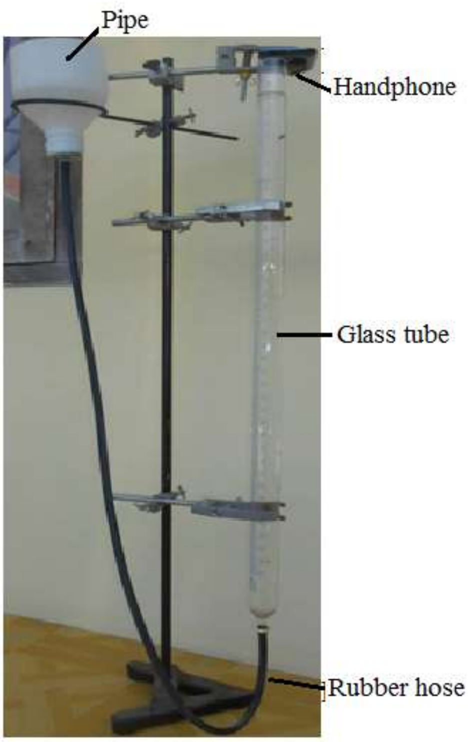


Figure 1: The series of experiments of air column resonance

3. Results and Discussion

Table 1 : Data of Experiment Results of Air Column Resonance

No.	Sound Frequency (f) (Hz)	Length of an Air Column on		L_3-L_1 5/4 λ- 1/4λ = λ (m)	Speed of Sound v = λ x f (m/s)
		Resonance I L_1 (x 10^{-2} m)	Resonance III L_3 (x 10^{-2} m)		
1	600	13.2	71.2	0.58	348.0

Journal of Physics: Conference Series **739** (2016) 012032 doi:10.1088/1742-6596/739/1/012032

No.	Sound Frequency (f) (Hz)	Length of an Air Column on Resonance I L_1 (x 10^{-2} m)	Length of an Air Column on Resonance III L_3 (x 10^{-2} m)	L_3-L_1 5/4 λ- 1/4λ = λ (m)	Speed of Sound v = λ x f (m/s)
2	650	13.0	65.6	0.53	341.9
3	700	11.0	60.8	0.50	348.6
4	750	10.2	56.6	0.46	348.0
5	800	9.6	52.8	0.43	345.6
6	850	8.8	49.6	0.41	346.8
7	900	8.4	46.8	0.38	345.6
8	950	7.8	44.4	0.37	347.7
9	1000	7.4	42.0	0.35	346.0
10	1050	7.0	40.0	0.33	346.5
	Average speed of sound				**346.5**

Based on the experiments' data it can be seen that the average speed of sound in air is 346.5 m/s.

Based on Fig. 2

L_3 - L_1 = 5/4 λ - ¼ λ =4/4λ = λ

The speed of the sound waves can be calculated using the formula: v = λ . f. where L_3 is length of the air column in the tube during the third resonance, and L_1 is length of the air column in the tube at the time of the first resonance.

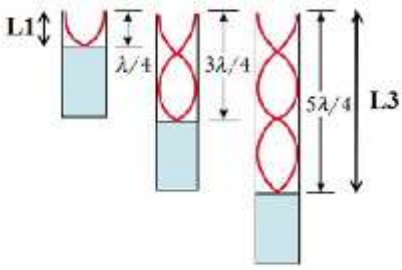
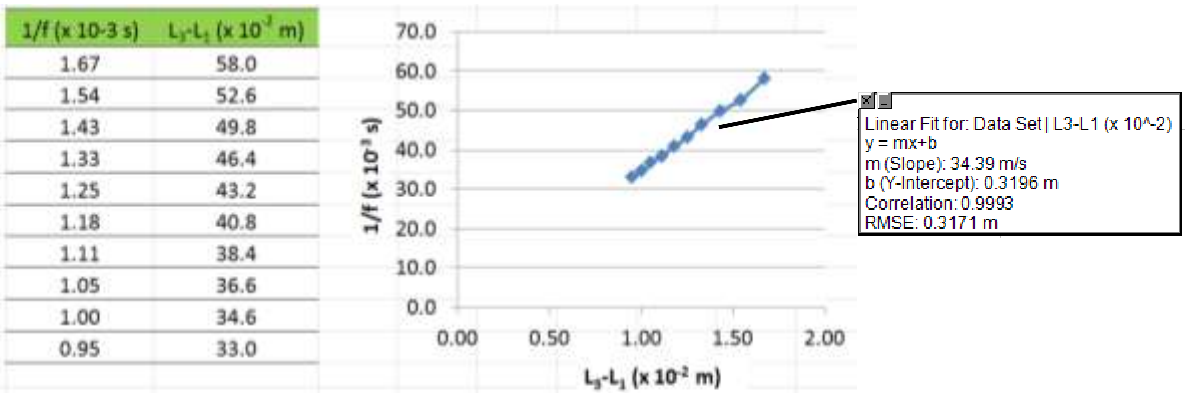


Figure 2: Schematic sound on the 1st, 2nd and 3th resonance

Graph of the relationship between L_3 - L_1 and 1/f



1/f (x 10-3 s)	L_3-L_1 (x 10^{-2} m)
1.67	58.0
1.54	52.6
1.43	49.8
1.33	46.4
1.25	43.2
1.18	40.8
1.11	38.4
1.05	36.6
1.00	34.6
0.95	33.0

Figure 3 : Graph of the relationship between the frequency of the sound with the sound wave length

Based on the graph shown in Fig. 3 the speed of sound in air can be determined as follows

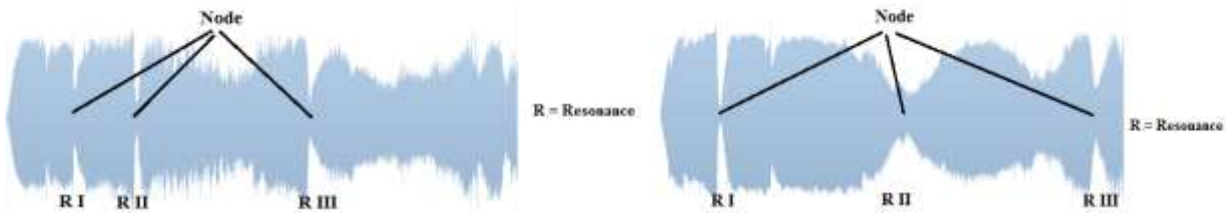
$$v = \tan \alpha \quad = 34.39 \text{ x } \frac{10^{-2}\text{m}}{10^{-3}\text{s}} \quad = 34.39 \text{ x } 10^{1} \text{ m/s} \quad = 343.9 \text{ m/s}$$

The speed of sound in air based on the graph is: 343.9 ± 0.3171 m/s.

Error persentage is: $\frac{0.3171}{343.9}x100\% = 0.0009$ %, while the correction factor is: 2 cm = 0.02 m

Analysis of Video Recording Image of Air Column Resonance with Audacity sofware:

Frequency of sound sources: 600 Hz, and 650 Hz



(a) (b)

Figure 4: The shape of the sound wave on the 1st, 2nd and 3th resonance using the frequency (a) 600 Hz , and (b) 650 Hz

The shape of a sound wave anti-nodes on the 1st, 2nd and 3th resonance by using a frequency of 600 Hz and 650 Hz (Figure 4a and 4b) are unstable. This is due to the source of the sound which is influenced by sounds from outside the system.

Frequency of sound sources: 700 Hz, and 750 Hz

(a) (b)

Figure 5: The shape of the sound wave on the 1st, 2nd and 3th resonance using the frequency (a) 700 Hz , and (b) 750 Hz

The shape of a sound wave anti-nodes on the 1st, 2nd and 3th resonance by using a frequency of 700 Hz and 750 Hz (Figure 5a and 5b) are unstable. This is due to the source of the sound which is influenced by sounds from outside the system.

Frequency of sound sources: 800 Hz, and 850 Hz

(a) (b)

Figure 6: The shape of the sound wave on the 1st, 2nd and 3th resonance using the frequency (a) 800 Hz, and (b) 850 Hz.

The shape of a sound wave anti-node at resonance by using a frequency of 800 Hz and 850 Hz (Figure 6a and 6b) is more stable than using a frequency of 700 Hz and 750 Hz. Sound source of tone used in the experiment is still slightly influenced by sounds from outside the system.

Frequency of sound sources: 900 Hz, and 950 Hz

(a) (b)

Figure 7: The shape of the sound wave on the 1st, 2nd and 3th resonance using the frequency (a) 900 Hz, and (b) 950 Hz.

The shape of a sound wave anti-node at resonance by using a frequency of 900 Hz and 950 Hz (Figure 7a and 7b) is more stable than using a frequency of 800 Hz and 850 Hz. Sound source of tone used in the experiment is not influenced by sounds from outside the system.

Frequency of sound sources: 1000 Hz, and 1050 Hz

(a) (b)

Figure 8 : The shape of the sound wave on the 1st, 2nd and 3th resonance use the frequency (a) 1000 Hz, and (b) 1050 Hz.

The shape of a sound wave anti-nodes on the 1st, 2nd and 3th resonance by using a frequency of 1000 Hz and 1050 Hz (Figure 8a and 8b) stable. This is due to the source of the sound is not influenced by sounds from outside the system.

Based on theory, resonance occurs when sound waves reinforce each other to form an anti-node wave, which affects louder sound. While based on the results of the experiment shown in **Fig. 4, 5**, **6, 7,** and **8**, the 1st, 2nd and 3th, resonance occur when the node waves are formed. This is probably caused by a sound source phase delay when converting sound of the experiment results using the Prism Video File Converter software.

4. Conclusion

Based on the data analysis of the experiment, it can be concluded that (1) substitute tones of a tuning fork sound can be made by using the Audacity software; (2) the forms of sound waves that occur in the 1st, 2nd and 3th resonance in the air column resonance can be described based on the video recordings of the air column resonance, and (3) based on calculations, the average speed of sound in air is 346.5 m/s, and based on a graph the relationship between (L_3-L_1) and 1/f, the speed of sound in air is 343.9 ± 0.3171 m/s.

Acknowledgments

We express our gratitude to Mr. Setyobudi, Head of SMP Negeri 2 Demak, Central Java, Indonesia, which has provided the facility to use the physics laboratory for running this research. We also would like to thank Mr. Eko Sudinuryanto who has guided the use of Audacity software, so that this research can run well and smoothly.

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