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Proving the Resonance of DO, RE, MI, FA, SOL, LA, SI, High DO Tones by Comparing Frequency of Sound Produced by Wine Glasses

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Abstract

Due to the lack of standard laboratory facilities in many schools in Indonesia, the researcher created a simple musical instrument based on the concept of sound physics. The research was to prove the phenomenon of 'resonance' with the frequency comparison of the sound from 'wine glasses'. Eight identical glasses filled with water at different heights to produce the do, re, mi, fa, sol, la, si, and do. The results showed the longer air column, the higher frequency of the sound produced. The sound produced by the glasses filled with less water was louder than the glasses filled with more water. This happened because of the resonance between the sound waves produced by the glasses and the sound waves propagating in the tube. Thus, it was in accordance with the theory. It could be used in the laboratory. Suggested, the researcher used tall and straight wine glasses to make it easier.

INTRODUCTION

Experiment is one of the important activities in science learning, especially natural science. However, due to the lack of standard laboratory facilities in many schools in Indonesia. This has an impact on the low quality and quantity of experiments conducted by students and teachers [6]. Therefore, there is a need for efforts to improve the availability, feasibility, and utilization of school laboratories in Indonesia.

When studying physics, there is one material that attracts attention, namely material about sound. Without us realizing it, sound is closely related to our lives and we always apply it directly in our daily activities. The material of sound itself can be said to be an abstract phenomenon, where we cannot see the sound directly, but we only hear it using our sense of hearing or ears [1,2]. Sound is produced by vibrating objects [11], for example when we hear the sound of a plucked guitar due to vibrations in the guitar strings. Sound is the most important thing in making musical instruments. We can note that on average classical musical instruments that are played without using electricity have an air cavity, such as guitars, violins, flutes, drums, and others which have air cavities inside. This air cavity is what makes musical instruments produce the distinctive sound of each type. In physics, this cavity is called air resonance. Making musical instruments yourself can be made using simple tools and materials, therefore the author made a musical instrument from glass by applying organ pipes physics material.

Resonance is a phenomenon that occurs when a vibrating system is subjected to a series of periodic pulses at one of the system's natural frequencies. The system oscillates with a relatively large amplitude or maximum amplitude [9]. A physical system that vibrates at a certain frequency causes another physical system to vibrate, a phenomenon known as sound resonance [7].

Organ pipes are one of the sound sources found in musical instruments which produce sound by standing wave vibrations in the pipe from the influence of the air column [12]. The open organ pipe has two bellies and one node at its fundamental frequency. Apart from that, both ends of the pipe are open and the reflected waves are stomach-shaped. Always equal to $1/2$ on the distance between two belly points. The length of the pipe, L, is equal to the distance. L= $1/2$, which is the same as 2L. We can obtain $f1 = v/2L$ by using the general wave formula. The following is a picture of the first harmonic pattern to the third harmonic pattern on an open organ pipe [5].

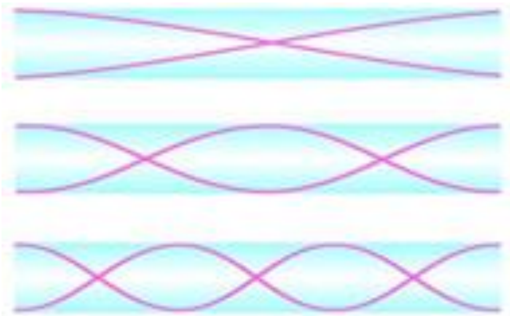

Figure 1. Open organ pipe harmonic pattern

In a closed organ pipe, all resonances are in the form of a knot because all the ends are closed. For a closed tube there is always a deviation in the form of a closed knot at the open end of the pipe because the distance between a closed and adjacent open knot is $1/4\ \lambda$ [3]. A quarter of a wavelength is the adjacent distance from the midpoint and the nodal point. The fundamental frequency f, can be obtained $f1 = v/4L$. The following is a picture of the harmonic pattern of a closed organ pipe [5].

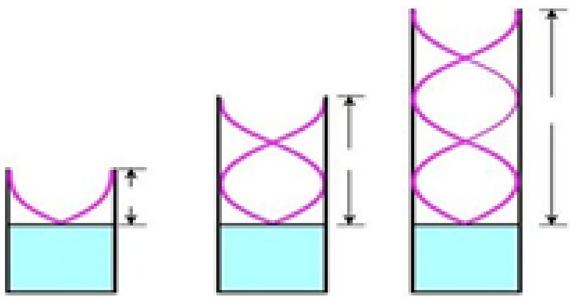

Figure 2. Close organ pipe harmonic pattern

Western music is based on a series of notes written in "alphabets" or numbers "1-8" in the diatonic scale. Each tone has a regular interval of regular distance where the regular interval is compared based on the frequency of one tone with the frequency of a lower tone [4]. Based on this description, numbers greater than 1 are included in the regular interval distance. The standard frequency of notes is defined as “A” or “A4”. Anaximandros, who was an ancient Greek philosopher, the following are the ratios of a note:

Table 1. The rations of note

Line of Notes	1	2	3	4	5	6	7	8
Tuning	Do	Re	Mi	Fa	Sol	La	Si	Do’
Tone Series	C	D	E	F	G	A	B	C’

Line of Notes	1	2	3	4	5	6	7	8
Frequency	262	294	330	349	392	440	494	524
Comparison	24	27	30	32	36	40	45	58
Pitch Distance	1	1	1/2	1	1	1	1	1/2
Interval	Prime	Sekonde	Ters	Kwart	Kwin	Sext	Septine	Oktaf

METHOD

The experiment using glass filled with water was conducted to analyze the variables that affect the sound frequency. The experiment was carried out by taking data on the wine glass height, the water level in the wine glass, and the air column height in the wine glass, each of which was measured using a ruler. Water was added to the wine glass at a certain height to produce different tones. For the tones Do, Re, Mi, Fa, Sol, La, Si, high D that are produced, the water level in the wine glass is adjusted to produce tones with a certain frequency. This is done so that the air in the air column can resonate. The measurement was done eight times using different glasses. The data analysis technique used was analysis using graphs and mathematical calculations. The technical design of the experiment is shown in Figure 3 below.

Figure 3. Experimental design

In Figure 4, it is a method for determining the length of the air column which is calculated from subtracting the height of the wine glass from the height of the water. The data obtained will be calculated using Equation (1) to calculate the frequency value of the open organ pipe and Equation (2) for the closed organ pipe.

$$f = \frac{(n)v}{2L} \quad (1)$$

$$f = \frac{(n)v}{4L} \quad (2)$$

The sound produced in a wine glass with less water will be louder, this is influenced by the greater height of the air column and vice versa [8]. This frequency is influenced by the size of the air column [10].

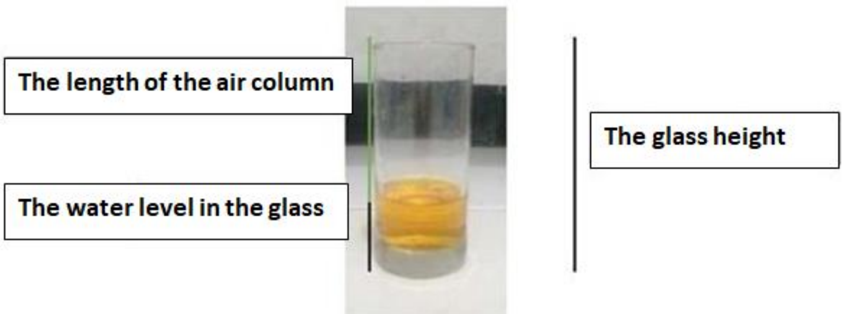

Figure 4. Determination in determining the length of the air column

RESULT AND DISCUSSION

Based on experiments that have been carried out, the following are the data results and discussion. In Figure 5 below is the result of the open organ pipe practicum that has been carried out.

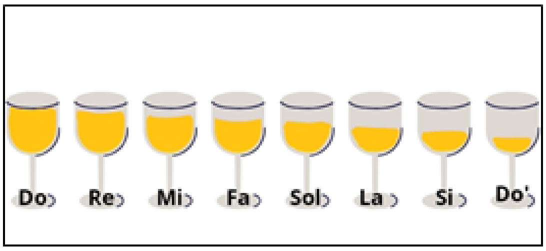

Figure 5. Wine glass open organ pipe experiment

From Table 2 open organ pipe data, it is evident that as the air column length inside the wine glass increases, the resulting sound frequency also increases. The highest frequency is 19428 Hz, and the lower frequency is 4857 Hz. The difference in frequency data obtained between the Do tone and the high Do tone is 14571 Hz.

Table 2. Open organ pipe data

No.	Musical scale	Water height (m)	Air column height (m)	Frequency (Hz)
1.	Do	0,075	0,035	4857
2.	Re	0,07	0,04	8500
3.	Mi	0,065	0,045	11333
4.	Fa	0,06	0,05	13600
5.	Sol	0,055	0,055	15454
6.	La	0,05	0,06	17000
7.	Si	0,045	0,065	18307
8.	Do'	0,04	0,07	19428

There is a relationship between sound frequency and the length of the air column in the open organ pipe glass principle. We also can see that the longer the air column, the greater the frequency. Therefore, the average rate frequency change is approximately 2081,57 Hz per data point. This indicates that the relationship between frequency and air column can be proven directly in theory and experiment.

In Figure 6 below is the result of the open organ pipe practicum that has been carried out.

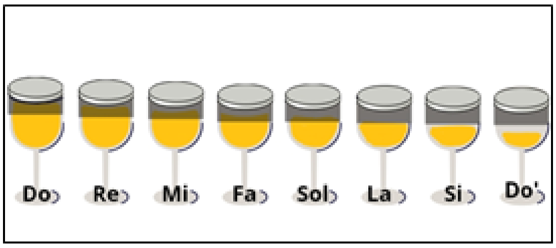

Figure 6. Wine glass close organ pipe experiment

From Table 3 close organ pipe data, it shows that the longer the air column in the wine glass, the higher the sound frequency produced. The highest frequency is 18214 Hz, and the lower frequency is 2428 Hz. The difference in frequency data obtained between the Do tone and the high Do tone is 15786 Hz.

Table 3. Close organ pipe data

No.	Musical scale	Water height (m)	Air column height (m)	Frequency (Hz)
1.	Do	0,075	0,035	2428
2.	Re	0,07	0,04	6375
3.	Mi	0,065	0,045	9444
4.	Fa	0,06	0,05	11900
5.	Sol	0,055	0,055	13909
6.	La	0,05	0,06	15583

No.	Musical scale	Water height (m)	Air column height (m)	Frequency (Hz)
7.	Si	0,045	0,065	17000
8.	Do'	0,04	0,07	18214

There is a relationship between sound frequency and air column length in a wine glass based on the principle of a closed organ pipe. From Table 3, we can see that the longer the air column, the higher the frequency. Therefore, the average rate frequency change is approximately 2631 Hz per data point. This means that the theoretical relationship between frequency and air column can be directly verified.

Based on the result, it was seen that the more volume of water given into the glass, the lower the sound produced, which made the frequency also lower. This could be explained by using the concept of sound wavelength, which was the distance between two points that vibrated in harmony. The more volume of water given into the glass, the shorter the length of the air column that vibrated in the glass. The length of the air column was inversely proportional to the length of the sound wave, which was the shorter the length of the air column, the longer the length of the sound wave, and vice versa. The length of the sound wave was inversely proportional to the frequency of the sound, which was the longer the length of the sound wave, the smaller the frequency of the sound, and vice versa.

The sound produced by giving less water to the glass was louder than the glass filled with more water. This could be explained by the occurrence of resonance between the sound waves produced by the wine glass and the sound waves propagating in the resonance tube. The resonance tube was a tube containing water and could be used to measure the frequency of the sound source by lowering or raising the water level in the tube until the loudest sound was heard. The loudest sound indicated that there was resonance between the sound waves produced by the wine glass and the sound waves propagating in the resonance tube. This resonance caused the sound produced to be stronger and louder.

The length of the sound wave in the open organ pipe was shorter than the length of the sound wave in the closed organ pipe for the same note. This was caused by the difference in the condition of the end of the organ pipe. In the open organ pipe, both ends formed the antinode of the wave, while in the closed organ pipe, one end formed the node of the wave. The antinode of the wave was the point that had the maximum displacement, while the node of the wave was the point that had the minimum displacement. The difference in the condition of the end of the organ pipe affected the length of the sound wave produced, which then affected the frequency of the sound produced.

CONCLUSION

This research aims to prove the resonance of the Do, Re, Mi, Fa, Sol, La, Si, high Do tones by comparing the frequency values of the sound sources in the glass. From the results and discussion, this experiment reveals that higher air column lengths lead to greater sound frequencies. Conversely, lower frequency values are produced when the air column in the glass is shorter. It can be asserted that sound produced with less water in the glass is louder compared to a glass filled with more water.

It is advisable to conduct experiments using glasses with sufficient height, avoiding the use of excessively tall glasses, as this facilitates the ease of measuring the air column height for practitioners.

REFERENCES

[1] Dessitasari, L., & Sucahyo, I., "Pengembangan Pipa Organa Menggunakan Aplikasi *Physics Toolbox Suite* untuk Menentukan Cepat Rambat Bunyi di Udara sebagai Media Pembelajaran pada Materi Gelombang Bunyi," IPF: Inovasi Pendidikan Fisika, 10(1), 8–13, 2020.

[2] Fitriyani, A. O., & Andryani, F., "Analisis Akurasi Penerapan Software Audacity dalam Menentukan Nilai Frekuensi Pada Praktikum Pipa Organa," JIPPF, 4 (1), 24-25, 2023, doi: http://dx.doi.org/10.26418/jippf.v4i1.60581

[3] Giancoli,D. C., "Fisika" 5 ed., Vol. 1, (H. H. Wibi, Penyunt., & Y. Hanum, Penerj.), Jakarta: Erlangga, 2001.

[4] Hamdani, H., "Penerapan aplikasi tone generator pada eksperimen resonansi bunyi," Jurnal Pendidikan Informatika dan Sains, 9(1), 86-89, 2020.

[5] Nya Daniaty Malau, M. S. P., "Modul Fisika Gelombang," 463, 2018, doi: http://repository.uki.ac.id/2645/1/Mo dulFisgel.pdf

[6] Rahmah, N., Iswadi, I., Asiah, A., Hasanuddin, H., & Syafrianti, D., "Analisis Kendala Praktikum Biologi di Sekolah Menengah Atas: (Analisis Kendala Praktek Laboratorium Biologi SMA)," BIODIK, 7(2), 169-178, 2021, doi: https://doi.org/10.22437/bio.v7i2777

[7] Sugiyanto, A., dan Sustini, E., "Kajian Fenomena Resonansi Gelombang pada Beberapa Alat Musik dan Animasinya dalam Ponsel Menggunakan Flashlite," Vol. 1(1): 1-8, 2011.

[8] Sulanjari, S., & Wicaksana, A., "Pengaruh Panjang Dan Diameter Kolom Udara Terhadap Performa Tabung Impedansi Sebagai Alat Penentu Cepat Rambat Bunyi Di Udara," Jurnal Teknik Mesin Cakram, 4(1), 34-38, 2021.

[9] Tipler, Paul A., "Fisika Untuk Sains dan Teknik," Jilid 1, Jakarta: Erlangga, 1998.

[10] Wahyuningsih, D., Rampai, B., & Maret, U. S., "Fisika di sekitar kita," 2020.

[11] Wana, W., Sulanjari, S., & Indriawati, A., "Analisis Performa Tabung Impedansi dalam Pengukuran Cepat Rambat Bunyi," *In Proceedings Of National Colloquium Research And Community Service,* Vol. 4, 2020.

[12] Young, H. D., A, F. R., & L, F. A., "Universitas Physics with Modern Physics" 13 ed., Pearson Education, 2012.