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# DEVELOPMENT OF SIMPLE ORGAN PIPE LEARNING MEDIA WITH THE HELP OF SOUND GENERATOR SOFTWARE

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***Abstract**. This research is motivated by the process of making a simple resonant pipe tool in organa pipe practicum. The purpose of writing this research is to analyze the effect of frequency on the speed of propagation of sound using paralon and prove the experiment on the speed of propagation of sound. This research is done by experiment, where the pipe is inserted in a container in the form of a bucket filled with water, and the audio generator application is placed on the pipe until it produces the biggest sound with a certain tone which is done by raising the position of the pipe. The results of this study are organa pipe practicum using simple tools carried out by trials and obtained data on the speed of propagation generated at frequencies of 1400 Hz, 2000 Hz and 2600 Hz sequentially by 350 m/s, 360 m/s and 364 m/s. The research gives the result that f ~ v and the results show that the sound propagation speed data is close to 340 m/s. So it can be concluded that the frequency with the speed of propagation of sound is directly proportional through a simple organa pipe experiment, and the resulting propagation speed of both frequencies of 1400 Hz, 2000 Hz, and 2600 Hz around the*

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*original propagation speed of 340 m/s. Therefore, this organa pipe props can be called accurate and can be easier to use for students.*
***Keywords**: Organa pipe, Frequency, Paralon*

**Abstrak**. *Penelitian ini dilatarbelakangi oleh proses pembuatan alat pipa resonansi sederhana pada praktikum pipa organa. Tujuan dari penulisan penelitian ini adalah untuk menganalisis pengaruh frekuensi terhadap cepat rambat bunyi dengan menggunakan paralon dan membuktikan percobaan tersebut terhadap cepat rambat bunyi. Penelitian ini dilakukan dengan cara eksperimen, dimana paralon dimasukkan ke dalam wadah berupa ember yang berisi air, dan aplikasi audio generator diletakkan di atas paralon hingga menghasilkan bunyi yang paling besar dengan nada tertentu yang dilakukan dengan cara menaikkan posisi paralon. Hasil dari penelitian ini adalah praktikum pipa organa dengan menggunakan alat sederhana yang dilakukan dengan cara uji coba dan didapatkan data kecepatan rambat yang dihasilkan pada frekuensi 1400 Hz, 2000 Hz dan 2600 Hz secara berurutan sebesar 350 m/s, 360 m/s dan 364 m/s. Penelitian tersebut memberikan hasil bahwa f ~ v dan hasilnya menunjukkan bahwa data kecepatan rambat suara mendekati 340 m/s. Sehingga dapat disimpulkan bahwa frekuensi dengan cepat rambat bunyi berbanding lurus melalui percobaan pipa organa sederhana, dan kecepatan rambat yang dihasilkan dari kedua frekuensi yaitu 1400 Hz, 2000 Hz, dan 2600 Hz berada di sekitar cepat rambat aslinya yaitu 340 m/s. Oleh karena itu, alat peraga pipa organa ini dapat disebut akurat dan dapat lebih mudah digunakan untuk siswa.*
**Kata kunci**: *Pipa organa, Frekuensi,Paralon*

## BACKGROUND

Education has a crucial role in the progress and development of a nation. Education plays a crucial role in shaping an individual's character. Furthermore, via education, an individual can attain their objectives in accordance with their aspirations and capabilities. Each learning activity encompasses various subjects, such as science, social studies, mathematics, and more specifically, Physics and Chemistry. Physics is often perceived as an intimidating subject by certain students due to its integration of mathematics and physics, which contributes to the perception of its difficulty (Peranti et al., 2019). Physics offers insights into previously unexplored concepts that can be used to everyday life. An example of this is the employment of organ pipe materials in flute music (Agnes Renostini Harefa, 2019).

Media refers to the means of communication, encompassing both textual and audio-visual formats, as well as the equipment used for such communication. The term "medium" in Latin, derived from the word "intermediarius," refers to the middleman that facilitates communication between a message source and a message receiver. Physics learning media refers to a tool or medium used to convey physics concepts from the source (such as a teacher or textbook) to the intended recipients, who are the students. The concept of organ pipe material, which involves waves and sound, poses a significant challenge for pupils to comprehend. Hence, there is a want for interactive educational tools to facilitate students' comprehension of the subject matter effortlessly (I Wayan Roby Yanto M, 2019).

To gain comprehension of occurrences in daily life, one must engage in observation or experimentation. These experiments are typically conducted in laboratories, which are facilities equipped to do various tasks such as calibration, testing, and sampling. In general, a laboratory is a designated space where observations and experiments can be conducted, furnished with specialized instruments and equipment (Dessitasari & Sucahyo, 2020). During a separate conversation, the term "organa pipe" refers to an object capable of generating sound through the manipulation of an air column. This can result in the formation of either stationary waves or standing waves. Sound has three essential components: the medium through which it travels, the listener who perceives it, and the source that produces it (Marbun, 2017).

The Organa pipe can be classified into two types: open Organa pipe and closed Organa pipe. An open organa pipe is a pipe that has both ends unobstructed. The belly point is located at both ends of the open organa pipe. A free organ pipe has a standing wave pattern characterized by nodes at both ends and an antinode in the middle. The open organ pipe exhibits a fundamental frequency with two antinodes and one node, where the distance between each succeeding point is consistently equal to ½ (Malau, 2018).

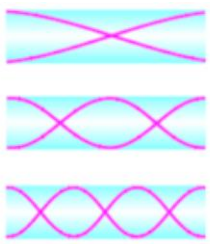

**Figure 1.** Open organa pipe

The second form of pipe is a closed organa pipe, specifically an organa pipe with one closed end. Figure 2 depicts a vertical slice of a sealed organ pipe at its bottom extremity. When air is blown into a closed organ pipe, the open end is referred to as the belly point, while the closed end is known as the knot point. The distance between the belly point and the adjacent node point is one-fourth of the wavelength.

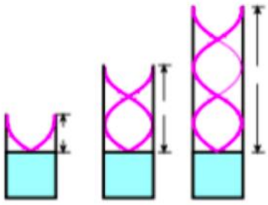

**Figure 2.** Closed organa pipe

Studying organ pipes allows for the exploration of related topics such as stationary waves and sound. Sound is a sort of vibration that travels through a material, such as gas, liquid, or solid, as an acoustic wave. The organ pipe produces both sound and a distinct tone. The tone will be characterized as an ideologized wave, namely a stationary or standing wave. In the standing wave, two distinct stages can be observed: the creation of knots and the formation of stomachs. At the node position, the sound reaches its highest amplitude, while the least amplitude occurs at the belly of the wave. The sound wave propagates through the air at a speed of 340 m/s.

The acquisition of knowledge by practical application is commonly linked to laboratories, which serve as venues for conducting practical exercises. Practicum is an educational endeavor designed to furnish students with instructional materials that facilitate comprehension of both theoretical concepts and practical applications (Nisa, 2021). In the field of organ pipe material, there exists a specific tool known as the resonant pipe tool, which is elongated like a pipe. Within this pipe, there is a lengthy aluminum hook that facilitates the propagation of waves, resulting in the formation of various tones.

This instrument is really straightforward, as it is solely connected to the audio generator using a connecting connection. However, regrettably, practitioners are limited to conducting studies exclusively inside the confines of a laboratory setting. Furthermore, according to the article "Development of a Sound Experiment Tool with an Android Smartphone-Based Data Acquisition System," it is mentioned that experimental exploration of physics learning in the organa pipe subchapter has not been conducted due to the unavailability of experimental tools. Therefore, we have developed a device that can assist students in conducting experiments on organa pipe material. This paper enables a straight forward organum pipe practical to be conducted at home, eliminating the need to visit the campus laboratory (Muhafid & Primadi, 2014). However, in the field of Physics, measurements are subject to inaccuracies due to the presence of uncertainties in the tools utilized. The error is defined as the discrepancy between the measured value and the true value. Therefore, it is crucial to carefully consider the outcomes of the practical experiment.

## RESEARCH METHODS

The objective of this project is to facilitate students in demonstrating physics concepts, specifically related to organa pipes, by utilizing basic tools. The purpose is to enable students to do experiments without the need for a physical laboratory setting. The experiment seeks to examine the impact of frequency on the velocity of sound propagation, as well as investigate the correlation between frequency and wavelength. The instruments and supplies utilized comprise a measuring meter, which serves the purpose of quantifying the height of the column in the atmosphere, paralon/pipe, water, bucket as a receptacle for water, and a cellphone equipped with sound generating software.

In the construction of this organa pipe trainer, it needed multiple experiments to discover the proper data and results. Initially, errors arose due to the relatively high resulting propagation speed at the start of the experiment. Consequently, we conducted multiple tests with varying frequencies until achieving the desired propagation speed of 340 m/s. Organa pipe props can be constructed by measuring a 40 cm length of pipe or paralon yaamajang, and then connecting a meter meter to the pipe to simplify the measurement of the air column's length. This meter is used to determine the length of the air column, serving as an alternative to organ pipe props. Subsequently, the receptacle, taking the shape of a bucket, is filled with water until it reaches near maximum capacity. Next, the pipe that has been appropriately trimmed is fitted into the container, reaching all the way to the bottom. Subsequently, measurements of tone can be conducted.

The props development scheme is shown in Figure 3.

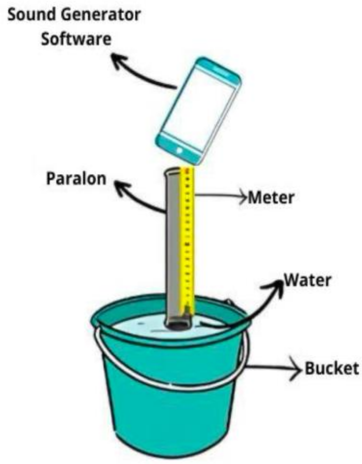


**Figure 3.** Schematic of organa pipe props development

Subsequently, the practitioner initiated the frequency generator on the cellphone, employing a frequency of 1400 Hz for the initial experiment. The mobile phone with the accessible application is moved closer to the top of the pipe above the water surface. Gradually elevate or lower the pipe until the fundamental frequency is perceived, followed by the second harmonic and subsequent harmonics, until reaching the point where the sound produced by the tone is maximized. Subsequently, once the practitioner has achieved the highest level of sound, they proceed to determine the length of the pipe column responsible for producing this maximum sound. This measurement is then recorded on the worksheet, serving as an indicator of the intensity of the tones generated by the pipe. Subsequently, the identical procedures were executed using distinct frequencies. Specifically, the second trial employed a frequency of 2000 Hz, whereas the third trial utilized a frequency of 2600 Hz. These experiments utilize the ear as a means of detecting and measuring the highest sound output produced by the sound generator application.

## RESULTS AND DISCUSSION

**The relationship between air column length and frequency**

**Table 1.** Observation results of simple organa pipe props test to determine the length of the air column

| No | Freque-ncy (Hz) | Air Column Length at Harmonic Tone | | Air Column Length at Harmonic Tone (cm) |
|---|---|---|---|---|
| | | First $I_1$(cm) | Second $I_2$(cm) | |
| 1. | 1400 | $17{,}5 \pm 0{,}05$ | $30 \pm 0{,}05$ | $12{,}5 \pm 0{,}05$ |
| 2. | 2000 | $20{,}5 \pm 0{,}05$ | $29{,}5 \pm 0{,}05$ | $9 \pm 0{,}05$ |
| 3. | 2600 | $22 \pm 0{,}05$ | $29 \pm 0{,}05$ | $7 \pm 0{,}05$ |

Based on the results of the studies, specifically determining the speed of sound propagation for the kind of open organa pipe. In this experiment, there are three independent variables with distinct frequencies, namely 1400 Hz, 2000 Hz, and 2600 Hz. Experiments with water medium generated two tones, the first and second tones when the pipe was lifted. The length of the air column for the first harmonic tone at 1400 Hz is 17.5 cm, and 30 cm for the second harmonic tone. The length of the air column for the first tone at a frequency of 2000 Hz is 20.5 cm, while the length of the air column for the second tone is 29.5 cm. At a frequency of 2600 Hz, the first tone's air column length is 22 cm while the second tone's air column length is 29 cm.

Based on the results of the study, namely regarding the air column length data obtained at the first harmonic tone and the second harmonic tone. The results of the wavelength and sound propagation speed of the various frequencies used are different. The data obtained is in accordance with the principle of the relationship found in organa pipes. Where the greater the frequency, the smaller the column length, the smaller the wavelength, and the greater the speed of propagation.

Based on results, it proves that the relationship between frequency and wavelength is inversely proportional. Where the greater frequency produces a wavelength on a decreasing graph. Conversely, the relationship between frequency and sound propagation speed is directly proportional. Where the greater the frequency, the faster the propagation of sound on the graph increases.

In the development of organa pipe props that have been tested, we make observations on the length of the air column from the results of the basic tone, the first upper tone, and the next upper tone. After obtaining data on the length of the air column for the first tone and second tone, then for the length of the entire air column it is the difference from the length of the second tone air column minus the length of the first tone air column. From the air column length data (L) we can determine the wavelength and speed of propagation of sound using the formula that applies to organa pipes.

Based on the trials that have been carried out, namely determining the speed of propagation of sound for the type of open organa pipe. In this experiment, there are 3 data with different frequencies as independent variables, namely with frequencies of 1400 Hz, 2000 Hz, and 2600 Hz. Experiments conducted with water medium produced 2 tones, namely the first tone and the second tone when the pipe is raised. The length of the air column for the first harmonic tone with a frequency of 1400 Hz is 17.5 cm and the second harmonic tone is 30 cm. At a frequency of 2000 Hz, the length of the air column for the first tone is 20.5 cm and the second tone is 29.5 cm. While at a frequency of 2600 Hz, the length of the air column for the first tone is 22 cm and the second tone is 29 cm.

This research is a study of a simple experiment made for organa pipe material. Organa pipe is a tool that can produce sound, where the sound produces different tones. The organa pipe used in this experiment is an open organa pipe type, where both ends of the pipe are open. So that the formula used is in accordance with the type of pipe. In this organa pipe, the basic tone of the open organa pipe will form 1 knot and 2 stomachs and 1/2 wave occurs. Thus the length of the pipe is equal to half a wave or $l = 1/2\ \lambda$. While on the second base tone, 2 knots and 3 bellies will be formed and one wave is formed or can be written $l = \lambda$.

A knot in the wave can occur due to the meeting of two stationary waves, namely the incident wave and the reflected wave or commonly called superposition. In this paralon pipe, the knot is the maximum sound produced by the paralon when the paralon is lifted and the maximum sound is formed on the paralon. While the stomach is formed when the sound produced is small or minimum. In this discussion, there is a connection between organa pipes and stationary waves regarding the sound waves formed are standing waves or stationary waves.

From the data on the length of the air column in the first tone and the second tone, the length of the entire air column is obtained, namely with a frequency of 1400 Hz an air column length of 12.5 cm is produced, with a frequency of 2000 Hz an air column length of 9 cm is produced, and with a frequency of 2600 Hz an air column length of 7 cm is produced. Based on the frequency data and the length of the air column produced, it is proven and in accordance with the theory. Where the relationship between frequency and air column length is inversely proportional. The greater the frequency used, the smaller the air column length is obtained.

**Relationship between frequency, wavelength, and sound propagation speed**

**Table 2.** Relationship between frequency, wavelength, and sound propagation speed

| **No.** | **Frequency $f$ (Hz)** | **Wavelength $\lambda$ (cm)** | **Speed of Sound Creation $v$ (m/s)** |
|---|---|---|---|
| 1. | 1400 | $25 \pm 0{,}05$ | 350 |
| 2. | 2000 | $18 \pm 0{,}05$ | 360 |
| 3. | 2600 | $14 \pm 0{,}05$ | 364 |

Based on the second table, the air column length results are used to determine the wavelength. Where this wavelength is equal to twice the length of the resulting air column. Based on the data obtained, the wavelength for frequency 1400 Hz is 25 cm, for frequency 2000 Hz is 18 Hz, and for frequency 2600 Hz is 14 cm. The relationship between frequency and wavelength in this experiment is proven and in accordance with the theory that frequency is inversely proportional to wavelength. The greater the frequency used, the smaller the wavelength obtained.

The wavelength results are also used to determine the speed of sound propagation. Where the speed of propagation of sound is equal to the wavelength times the frequency used. At a frequency of 1400 Hz, the sound propagation speed produced is 350 m/s, at a frequency of 2000 Hz, the sound propagation speed produced is 360 m/s, and for a frequency of 2600 Hz, the sound propagation speed produced is 360 m/s. Based on these results, it can be observed that the relationship between frequency and sound propagation speed is directly proportional. Where the greater the frequency used, the greater the sound propagation speed is obtained. The resulting sound propagation speed is also close to the actual sound propagation speed of 340 m/s.

**Data processing in finding air column length (L), wavelength (λ), and sound propagation speed (v)**

**Table 3.** Calculation of air column length ($L$), wavelength ($\lambda$), and sound propagation speed ($v$)

| No. | Air Column Length (m) | Wavelength (m) | Speed of Sound Creation (m/s) |
|---|---|---|---|
| 1. | $0{,}125 \pm 0{,}0005$ | $0{,}25 \pm 0{,}0005$ | 350 |
| 2. | $0{,}09 \pm 0{,}0005$ | $0{,}18 \pm 0{,}0005$ | 360 |
| 3. | $0{,}07 \pm 0{,}0005$ | $0{,}14 \pm 0{,}0005$ | 364 |

The third table shows the results of the air column length, wavelength, and sound velocity. A significant difference can be seen in the sound velocity test results, where the fastest sound velocity is 364 m/s.

**Table 4.** Calculating measurement uncertainty values, measurement results, and relative measurement errors

| No. | Frequency |
|---|---|
| 1. | **Frequency: 1400 Hz**<br>Measurement Uncertainty:<br>0,5 m/s<br>Measurement Result:<br>$\lvert 350 \pm 0{,}5 \rvert$ m/s<br>Relative error of measurement:<br>0,14 % |
| 2. | **Frequency : 2000 Hz**<br>Measurement Uncertainty:<br>0,6 m/s |

| | |
|---|---|
| | Measurement Result: |
| | $\|360 \pm 0{,}6\|$ m/s |
| | Relative error of measurement: |
| | 0,17 % |
| 3. | **Frequency : 2600 Hz** |
| | Measurement Uncertainty: |
| | Measurement Result: |
| | $\|364 \pm 0{,}7\|$ m/s |
| | 0,19 % |

Based on the fourth table, it can be seen that the relative measurement error in each experiment with a certain frequency is relatively small, where sequentially the relative measurement error values at frequencies of 1400 Hz, 2000 Hz, and 2600 Hz are 0.14%; 0.17%; and 0.19%.

The trials that have been carried out are very easy to apply to students, namely being able to carry out this organa pipe experiment at home without having to go to the laboratory. Where this development includes Worksheets (LK) to be practiced also on students. After testing that this props can be called accurate and can be applied to students. Because it has been proven that this experiment is in accordance with the provisions of the organa pipe principle. This teaching aid also has a relatively low measurement uncertainty and a small relative measurement error, this was proven during the trial of a simple organa pipe trainer.

This research .was conducted continuing from previous research by Alya Orkins Fitriyani & Febby Andryani (Fitriyani & Andryani, 2023) with the title "Accuracy Analysis of the Application of Audacity Software in Determining Frequency Values in Organa Pipe Practicum" which has the main objective of knowing the resonance resonance produced from each tone, which is continued in our research and developed with simple props to analyze the relationship between frequency and sound propagation speed and analyze the relationship between frequency and wavelength.

## CONCLUSIONS

Based on the results of the study, it can be concluded that the development of organa pipe props is accurate and has been tested to prove the principle that exists in organa pipes, organa pipe experiments with this simple tool can be easily applied to students without having to prove it in the laboratory, this experiment can prove the relationship between frequency, wavelength, and sound propagation speed. The disadvantage of this props is that to measure each maximum tone still uses ear hearing.

Based on the quality of the products that have been produced, further research is expected that simple organa pipe props can be used as an alternative to fun learning. It is better if this simple organa pipe props is expected to be more able to detect sound by using any tool. We recommend making more interesting variables for this organa pipe props.

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