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ANALYSIS OF ORGANA PIPE RESONANCE FREQUENCY UTILIZING PHYPHOX APPLICATION AND AUDITORY PERCEPTION IN KUNDT'S TUBE

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Abstract. *The use of the Phyphox application proves to be highly beneficial in attaining precise experimental data by leveraging existing technology. This application is freely downloadable for both Android and iOS platforms. The research aims to compare resonance frequency values using human auditory perception and the Phyphox application. The study utilizes a transparent glass organ pipe with a length of 100 cm, conducting three repetitions for each obtained pitch. The selected menu on the Phyphox application is 'audio amplitude,' which displays the maximum sound intensity through numerical dB readings and a graphical representation. Phyphox serves as an auxiliary tool for determining the maximum noise value in open-closed organ pipes to identify the resonance frequency. It is crucial to use the Phyphox application in a noise-free environment, as even the slightest noise can influence the displayed maximum noise values on the application. The results indicate that the relative error value in the Phyphox*

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application is smaller compared to human auditory perception, with 0.25% < 0.27%. Therefore, it can be concluded that the values obtained through the Phyphox application are more accurate with a minimal margin of error.
***Keywords**: Phyphox application, resonant frequency, the sense of hearing*

Abstrak. Penggunaan aplikasi phyphox sangat membantu untuk mendapatkan ketepatan data percobaan dengan memanfaatkan teknologi yang ada, karena aplikasi ini dapat diunduh secara bebas baik untuk android dan ios. Penelitian ini dilakukan bertujuan untuk membandingkan nilai frekuensi resonansi menggunakan indra pendengaran dan aplikasi phyphox. Penelitian ini dilakukan dengan menggunakan pipa organa berbahan kaca bening dengan panjang pipa 100 cm dan dilakukan sebanyak 3 kali pengulangan untuk masing-masing nada yang didapatkan. Menu pada aplikasi phyphox yang digunakan adalah audio amplitude, dimana pada aplikasi tersebut dapat ditampilkan hasil perolehan bunyi yang terdengar maksimum melalui tampilan angka db dan grafik. Phyphox digunakan sebagai media pembantu untuk menentukan nilai bising maksimum pada pipa organa terbuka-tertutup dalam menentukan nilai frekuensi resonansi. Penggunaan aplikasi phyphox harus dalam ruang tanpa gangguan suara, karena noise sekecil apapun akan mempengaruhi hasil bunyi bising maksimum yang ditampilkan pada aplikasi. Hasil yang didapatkan yaitu nilai kesalahan relatif pada aplikasi phyphox lebih kecil dibandingkan dengan indra pendengaran sebesar 0,25% < 0,27%. Sehingga dapat disimpulkan bahwa hasil perolehan nilai pada aplikasi phyphox lebih tepat dengan rentang kesalahan yang minimum.
Kata kunci: Aplikasi phyphox, frekuensi resonansi, indera pendengaran

BACKGROUND

With the advancement of time, scientific knowledge has also progressed, including the technology used in learning activities, especially in physics education, which increasingly involves experimental activities (Muhafid & Primadi, 2014). Therefore, to keep up with technological advancements, the learning process requires instructional media. In order to address issues that arise during learning activities, the utilization of instructional media is crucial in the learning process. Using media in learning activities can help develop thinking patterns. Various media, such as ebooks, instructional videos, websites, and research tools, can facilitate the learning process (Manda & Saehana, 2021).

One example commonly used in physics education is research activities. Research is highly beneficial in the learning process as it aids individuals in better understanding the material after engaging in practical activities. Difficulties in comprehending certain physics concepts often arise in the learning process, and conducting experiments can facilitate a better understanding of the material (Riskawati, Ali, & Kamaluddin, 2021).

The research we conducted refers to a previous study by Lucky Dessitasari and Imam Sucahyo (2021) on the Development of Organ Pipes Using the Physics Toolbox Suite Application to Determine the Speed of Sound in Air as a Learning Medium for Sound Wave Material. The results of the study by Lucky Dessitasari and Imam Sucahyo (2021) on open organ pipes obtained a speed of sound in air value of (322,6$\pm$5,376) m/s with a precision of 98,4% and an accuracy of 94,89%. Meanwhile, in closed organ pipes, the speed of sound in air obtained was (335,4$\pm$8,133) m/s with a precision of 97,6% and an accuracy of 98,65%. Based on these results, the developed experimental tool is deemed suitable for use as a learning medium (Dessitasari & Sucahyo, 2021). Our research differs from previous studies as we used a different application, namely the Phyphox Application. The use of the application also differs from previous research because the Phypox application is used to determine resonance frequency. The resonance frequency values obtained are then used to compare with resonance frequency values using auditory perception and the Phyphox Application.

The advancement of technology, exemplified by the presence of smartphones, facilitates quick access to targeted sources for individuals. Smartphones play a crucial role in educational activities, including physics learning. They can be utilized for various learning tasks, such as calculations, measurements, and many other activities that enhance the learning experience (Nurfadilah, Ishafit, Herawati, & Nurulia, 2019). Smartphones are modern communication devices that are popular, easily portable, and flexible. Within smartphones, numerous applications are available to aid in physics experiments. Smartphones are well-suited for conducting physics experiments due to their integration of sensors and document storage capabilities (Ewar, Bahagia, Jeluna, Astro, & Nasar, 2021).

In conducting a learning session, it is essential to have easily accessible media that can make the learning experience engaging, impressive, and interactive, influencing students' understanding, especially in studying physics, specifically the topic of organ pipes. One of the media that can be employed for conducting organ pipe experiments to determine resonance frequency is the Phyphox audio amplitude media (Oktavia & Syamsu, 2022).

Phyphox is a physics experiment application available on smartphones. The Phyphox application can be obtained for free on Google Play Store and Apple's App Store since September 2016. This application is compatible with both Android devices and tablets. Phyphox is user-friendly as it is directly accessible through the application, connecting to various sensors (Sahlan, Widodo, & Ishafit, 2021). Within this application, there are numerous options available for conducting physics experiments. In our research, we utilized the Audio Amplitude menu option provided within the Phyphox application to determine the wavelength.

The value of the speed of sound in air refers to previous research conducted by Sintya Rina Lestariana, Teguh Darsono, Sugianto, and Sugiyanto (2022) on the Development of Acoustic Resonance Laboratory Equipment with Kundt Tube Assisted by Visual Analyzer (VA) Software, which examines the speed of sound in the air. The obtained value was 347.1 m/s, and it is applied in this research based on the similarity between the two studies, both conducted at room temperature with a range of 22ºC in the Java Island, Indonesia (Rina Lestariana, Darsono, Sugianto, & Sugiyanto, 2022).

One intriguing aspect of conducting this mini-research is when a piston in the open-closed type of organ pipe apparatus is moved, at some point, the sound heard is the maximum or loudest sound. As the piston is moved back, the sound returns to its original state and repeats according to the length of the pipe. This phenomenon occurs due to the presence of sound waves, specifically longitudinal waves that result from compression and rarefaction in the air medium. Waves can be generated when an object, such as a tuning fork, is vibrated, causing disturbances in the density of the medium (Agustina Dwi Astuti, 2016).

By conducting this research, we can gain a better understanding of how musical instruments such as the flute, trumpet, and clarinet work through organ pipe experiments. Additionally, if a school lacks adequate facilities to determine the resonance frequency of organ pipes, the Phyphox application can be utilized as it is available in the application stores and is free. However, when conducting measurements with the Phyphox application, it must be done in a very quiet environment to prevent data collection errors. Even minor ambient noise can affect the accuracy of the obtained data, as the application is somewhat sensitive to surrounding sounds.

When air is introduced into the mouth of an organ pipe, the air will vibrate, causing a displacement in the mouth of the organ pipe, and the air inside the organ pipe can move freely. As the air moves freely, the air volume expands, leading to the occurrence of air pressure nodes. There are two types of organ pipes: open organ pipes and closed organ pipes. In this study, we used a closed organ pipe, where one end is closed and the other end is open (Yuliana Kua et al., 2021).

This research is necessary to ascertain the more accurate method between using the Phyphox application or auditory perception in determining the resonance frequency in the organ pipe experiment. Typically, in organ pipe experiments to determine the noise level in the organ pipe apparatus, auditory perception is employed, and differences in opinions among fellow practitioners often arise. By conducting this research with three repetitions, utilizing both the Phyphox application and auditory perception, the data allows for a comparison of accuracy and precision through the calculation of relative measurement errors.

Therefore, this research is conducted to demonstrate that the Phyphox application can determine resonance frequency more precisely and accurately compared to using auditory perception. It aims to identify the fundamental tone, first harmonic, and second harmonic through the Phyphox application and analyze the feasibility of organ pipe learning media using the Phyphox application.

RESEARCH METHODS

The type of research conducted is quantitative research, where the data generated is the result of experimental activities. This study was carried out in the Physics Laboratory of UIN Syarif Hidayatullah Jakarta from December 6th to December 13th, 2022. In this research, two activities were conducted to determine the resonance frequency value in open-closed organ pipes. The first activity involved determining the maximum noise level using auditory perception, and the second activity involved using the Phyphox application.

To achieve the maximum noise level, the piston inside the organ pipe is slowly shifted. When the application displays the highest dB value, a certain pipe length will form one wave, known as the fundamental tone. This process is repeated until the range of tones is obtained with a pipe length of 100 cm. The Phyphox application should be accurately positioned next to the speaker connected to the audio generator. The arrangement of the circuit can be seen in Figure 1.

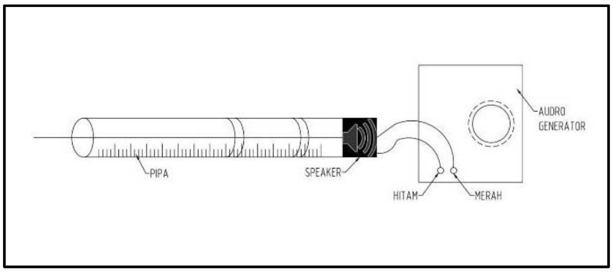


Figure 1. Arrangement of equipment in the research activity

To validate the data results, three repetitions were conducted for each generated tone, whether using auditory perception or the Phyphox application. In addition, referring to the equation $f = (2n + 1)\ \frac{v}{4L}$ (1), as the wavelength formed becomes longer, the resonance frequency value will decrease.

Explanation:

f = Resonance frequency (Hz)

v = Speed of sound in air (m/s)

L = Pipe length (m).

RESULT AND DISCUSSION

The research results compare the accuracy of resonance frequency values using auditory perception and the Phyphox application. In the circuit, an audio generator serves as the frequency generator with a set value of 5 Hz, connected to the organ pipe via a connecting cable. In the installed Phyphox application, there is an audio amplitude menu that displays the maximum dB value when maximum noise occurs in the closed organ pipe.

The data presented in **Table 1** represents the average results of resonance frequencies obtained through the use of auditory sensors. Table 2 displays the average values of resonance frequencies achieved using the phyphox application.

Tabel 1. The resonance frequency utilizes the sense of hearing.

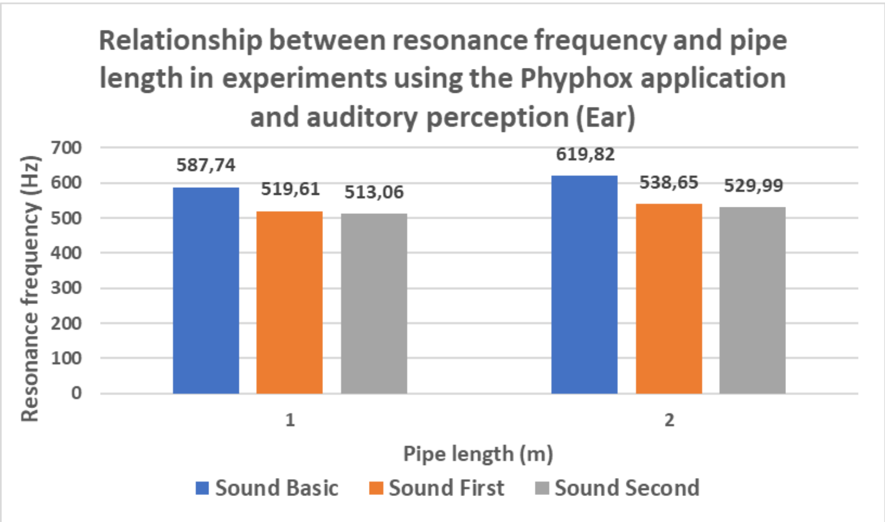
Sound	Resonance frequency (Hz)	Pipe length (m)
Basic	587,74	0,148 ± 0,001

First	519,61	0,501 ± 0,001
Second	513,06	0,846 ± 0,001

Tabel 2. The resonance frequency using the phyphox application.

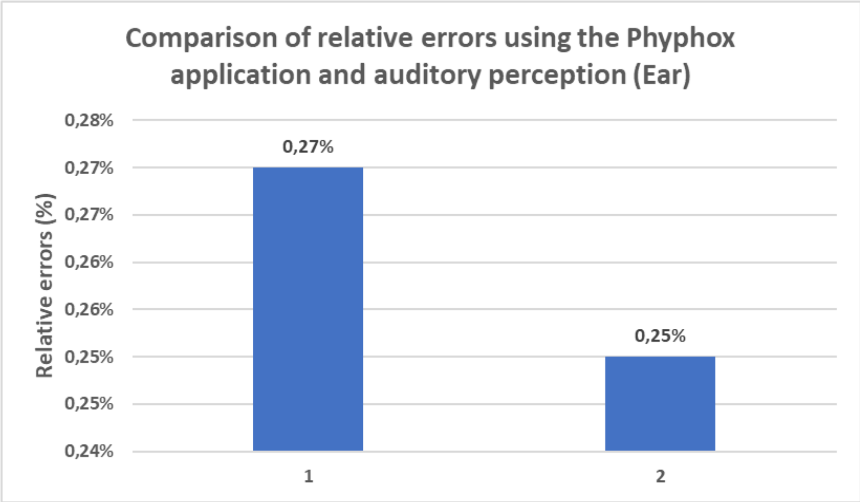
Sound	Resonance frequency (Hz)	Pipe length (m)
Basic	619,82	0,14 ± 0,001
First	538,65	0,48 ± 0,001
Second	529,99	0,82 ± 0,001

Based on the presented data, it shows the relationship between wavelength and resonance frequency. The relationship between them is inversely proportional, where the longer the wavelength formed, the lower the resonance frequency value. From the table above, a graph depicting the relationship between wavelength and resonance frequency can be constructed.



Graph 1. Relationship between resonance frequency and pipe length in experiments using the Phyphox application and auditory perception (Ear)

The graph illustrates an inverse relationship between wavelength and resonance frequency. This aligns with the theory applicable to organ pipes.



Graph 2. Comparison of relative errors using the Phyphox application and auditory perception (Ear)

Based on the above graph, the relative error when using auditory perception is 0.27%, while with the phyphox application, the relative error is 0.25%. From these relative error values, it can be observed that the results obtained are more accurate and precise when using the phyphox application. This is because the relative error value when using the phyphox application is smaller compared to using auditory perception.

From the obtained data, it can be concluded that the acquisition of resonance frequency values using the phyphox application has fewer errors. The magnitude of the relative error difference between auditory perception and the phyphox application is 0.2%. Thus, the data results obtained using the phyphox application are more accurate compared to auditory perception.

The display of the phyphox application during maximum noise can be observed in **Fig.2**.

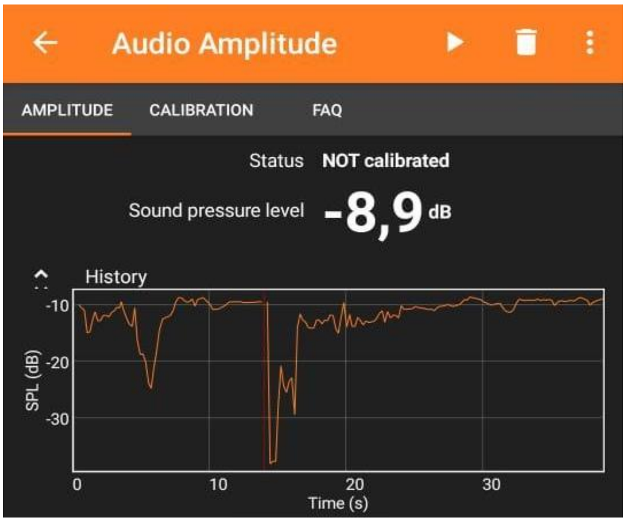


Figure 2. The values displayed on the phyphox application during maximum noise.

Previous research conducted by Lucky Dessitasari and Imam Sucahyo (2021) aimed to determine the speed of sound in the air using open-closed organ pipes. The research conducted with the organ pipe apparatus was highly valid, with a validation rate of 87.5%. This study utilized the Toolbox application as a supportive medium. In a prior investigation on the use of the phyphox application by Nurfadilah (2019) focused on collisions, the distinction lies in the selected menu. However, no research has been conducted on the magnitude of resonance frequency values produced in open-closed organ pipes using the phyphox application. Typically, determining pitches in open-closed organ pipes relies solely on auditory perception. Therefore, this research offers a solution to anticipate inaccuracies in the resulting values by leveraging evolving technology based on an 'easy-to-use' approach, namely the phyphox application.

The research conducted serves as a means to compare the accuracy of determining resonance frequency using auditory perception and the Phyphox application. The use of the Phyphox application is easily accessible for both iOS and Android users. Moreover, the application offers a variety of menu options that facilitate users in the learning process. As part of the millennial generation, the utilization of the Phyphox application exemplifies effective use of technology in the digital era. In this study, average calculations were performed, where data collection for each generated tone was repeated three times, both using auditory perception and the Phyphox application. This was done to ensure the accuracy and precision of the obtained data. To assess the accuracy and precision values using auditory perception or the Phyphox application, the calculation of relative error values from the obtained data is employed.

The experimental results conducted with a comparison of using the Phyphox application to determine the resonance frequency in organ pipes involved a comparison with auditory perception, namely the ear. From the experiments conducted with auditory perception (ear) and the Phyphox application, three trials were carried out for the fundamental tone, first harmonic, and second harmonic. These were performed directly, with data collection involving the determination of the lengths of the organ pipe and the speed of sound, both predetermined according to the set standards for the speed of sound in the laboratory electronics room with air conditioning at a temperature of 22 degrees Celsius. The obtained value for the speed of sound in air was 347.1 ± 3.83 m/s, which was consistent with the previous research conducted by Sintya Rina Lestariana, Teguh Darsono, Sugianto, and Sugiyanto (2022) on the Development of Acoustic Resonance Laboratory Equipment with Kundt Tube Assisted by Visual Analyzer (VA) Software, which investigated the speed of sound in the air. In the experiment using auditory perception, the average lengths of the organ pipe from three repetitions for the fundamental tone were 0.14 ± 0.001 m, for the first harmonic 0.48 ± 0.001 m, and for the second harmonic 0.82 ± 0.001 m. Meanwhile, in the data obtained using the Phyphox application, the lengths for the fundamental tone were 0.148 ± 0.001 m, for the first harmonic 0.501 ± 0.001 m, and for the second harmonic 0.846 ± 0.001 m. The experimental results using auditory perception and the Phyphox application showed relatively similar data for the fundamental tone, first harmonic, and second harmonic, with minimal differences in the obtained results.

If we take the average of the experimental data obtained using auditory perception (ear), the resulting relative error is KR=0.27%, while the relative error from the data obtained using the Phyphox application is KR=0.25%. When comparing the relative error values (KR) between using the Phyphox application and auditory perception, it is more appropriate to use the Phyphox application for organ pipe experiments to determine the fundamental tone to the second harmonic because it has a smaller relative error compared to using auditory perception. The relative error value from the Phyphox application is only 0.25%, whereas when using auditory perception, the relative error value is 0.27%. Therefore, it is more accurate and precise to use the Phyphox application. Although auditory perception can also be used, it should be noted that during experiments, there is often a difference of opinion among different experimenters in hearing the loudest sound. Hence, it is recommended to use the Phyphox application as it visually displays the highest noise level, reducing the potential for differences in determining the values from the fundamental tone to the second harmonic.

The acquisition of this data can demonstrate the relationship between wavelength and frequency, where the correlation between the two is inversely proportional. Examining the results of one experiment reveals resonance frequency values for the fundamental, first harmonic, and second harmonic as 619.82 Hz, 542.34 Hz, and 529.12 Hz, respectively. Similarly, one experimental result indicates the wavelength values for the fundamental, first harmonic, and second harmonic as 0.14 m, 0.48 m, and 0.82 m. By analyzing the experimental data, it is evident that the relationship between wavelength and resonance frequency holds true. As the number of harmonics increases, the wavelength values also increase, while the resonance frequency values decrease. For instance, when the fundamental frequency is formed, the number of wavelengths is 1; for the first harmonic, the number of wavelengths is 2, and so on. This confirms that as the wavelength values increase, the resonance frequency values decrease.

By examining the acquired data, it is evident that using the phyphox application allows for more precise and accurate determination of resonance frequency values compared to relying on auditory perception (ear). This conclusion is drawn from the results of relative error calculations, where the relative error value using the phyphox application is only 0.25%, while the relative error value using auditory perception is 0.27%. From these findings, we can infer that the use of the phyphox application yields more accurate and precise results. To determine the fundamental, first harmonic, and second harmonic frequencies through the phyphox application, audio amplitude can be utilized within the application. If the organ pipe produces maximum noise, it will be visually represented in the phyphox application with the highest dB magnitude, indicating the fundamental frequency of the organ pipe. This holds true for both the first and second harmonics. In cases where school facilities are inadequate, the phyphox application can be employed for organ pipe experiments, as it is easily accessible and available for free on Google Play Store and Apple App Store through a simple download of the phyphox application.

CONCLUSIONS

Based on the experimental results comparing data obtained using the phyphox application and auditory perception (ear), utilizing the phyphox application to determine resonance frequency values is more accurate than relying on auditory perception (ear). This is evident from the calculated relative error, where the relative error value using the phyphox application is only 0.25%, while the relative error value using auditory perception is 0.27%. Additionally, the data obtained confirms the relationship between wavelength and resonance frequency, showing an inverse correlation – the larger the wavelength formed, the smaller the resonance frequency value. It is expected that the use of applications in physics education in the current technological era will facilitate the wider community in learning activities.

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