(JOUMI):Jurnal Multidisiplin Indonesia
Vol.1, No.4 Desember 2023
e-ISSN: 2986-7541; p-ISSN: 2986-7533, Hal 295-301

# ANALYSIS OF COMPARATIVE RESULTS OF STANDING WAVES BETWEEN WAVES ON GUITAR STRINGS AND WAVES ON STRINGS

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***Abstract***. *This research aims to analyze the comparison of standing wave results between waves on a guitar string and waves on a cord. The study is conducted through two separate experiments, focusing on understanding the relationship between wave velocity and tension on the string, understanding the relationship between wave propagation speed and mass per unit length on the string, and analyzing the comparison of standing wave results. The first experiment is focused on observing the changes that occur as the tension value on the string increases. Meanwhile, the second experiment is designed to observe the tight binding of the string's mass and the propagation speed of sound waves. Standing waves, also known as standing waves, emerge as a result of interference between two waves with the same frequency and amplitude but different propagation directions. The amplitude peak occurs at the node, while the antinode indicates the minimum amplitude. Essentially, waves are generated from a string attached to a vibrator.*
***Keywords***: *Standing waves, melde, frequency, amplitude.*

**Abstrak**. Penelitian ini bertujuan untuk menganalisis perbandingan hasil gelombang berdiri antar gelombang pada senar gitar dan gelombang pada tali. Penelitian dilakukan melalui dua percobaan terpisah, dengan fokus pada memahami hubungan kecepatan gelombang dengan tegangan tali, memahami hubungan antara kecepatan rambat gelombang dan massa per satuan panjang pada tali, dan menganalisisnya perbandingan hasil gelombang berdiri. Eksperimen pertama difokuskan untuk mengamati perubahan

*Received: November 29, 2023; Accepted: Desember 22, 2023; Published: Desember 31, 2023*
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yang terjadi seiring dengan bertambahnya nilai tegangan pada tali. Sedangkan percobaan kedua dirancang untuk mengamati pengikatan erat massa dawai dan kecepatan rambat gelombang suara. Gelombang berdiri, juga dikenal sebagai gelombang berdiri, timbul akibat interferensi antara dua gelombang yang frekuensinya sama dan amplitudo tetapi arah rambatnya berbeda. Puncak amplitudo terjadi pada node, sedangkan antinode menunjukkan amplitudo minimum. Pada dasarnya, gelombang dihasilkan dari tali yang diikatkan pada vibrator.
**Kata kunci**: Gelombang stasioner, melde, frekuensi, amplitudo.

## INTRODUCTION

Waves are an abstract aspect in the field of physics and the subject of study itself. Information regarding the existence of waves is generally only found in books or references, without providing a concrete description of the nature of the waves. Therefore, the interpretation of waves often remains limited to concepts without concrete evidence. Hence, experiments on strings are necessary as an effort to prove the existence of waves. According to Sri Jumini (2015), there is a significant relationship between waves, load mass, and wave velocity on a string. The larger the load mass, the greater the wave velocity on the string, resulting in an increased wave propagation. Waves are also associated with the mass of the string and the propagation speed on the string. It can be observed that as the mass of the string increases, the frequency becomes lower because frequency has an inverse relationship with the quality of the string. To facilitate the understanding of wave material and the principles of wave occurrence, we will conduct a demonstration and analysis comparing a string with a guitar string. It is hoped that this demonstration will simplify the abstract nature of wave material.

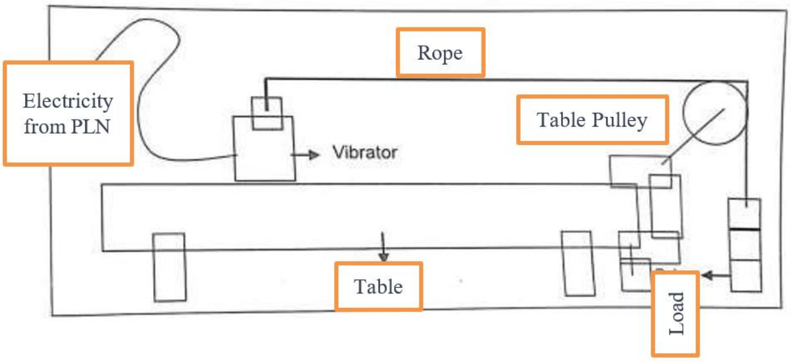
In this report, an experiment is conducted to analyze the comparison of standing wave results between waves on a guitar string and waves on a cord. The objectives of this experiment are (1) to understand the relationship between wave velocity and tension on the string, (2) to comprehend the relationship between wave propagation speed and mass per unit length on the string, and (3) to analyze the comparison of standing wave results between waves on the string and guitar strings..

Franz Melder was a German physicist who first conducted experiments to measure the speed of wave propagation. His experiment is known as the Melde experiment. Repetitive motion around the equilibrium point is called vibration. Equilibrium, in this context, refers to the state in which an object is in balance and experiences no movement. Vibration can be defined as repetitive motion that starts from a displacement, returns to the equilibrium point, and continues in the same or opposite direction after a certain displacement. If an object moves from point X to Y, Z, and back to Y, it is called a vibration, with point Y as the equilibrium point. An example of this can be found in a pendulum. The farthest displacement includes points X or Z, preventing the pendulum from surpassing these points. This is known as amplitude. At points X or Z, the object will momentarily stop and then move back to point Y. Waves are a phenomenon of the spread of vibrations or disturbances, which continue as long as the source of vibration remains in motion. One characteristic of waves is their ability to exert an overall force. (Rheina Shavira, 2016).

Waves can be defined as vibrations that propagate. It can be understood that vibrations are the source of waves. The motion of waves can cover long distances, but the motion of the medium is limited. One wave is formed by three nodes or two antinodes. Waves move without material displacement, and this motion can be viewed as a transition of forces and points from X to Z. In mechanics, objects are characterized by having velocity when flowing, including propagating waves. In waves, their velocity is influenced by the nature of the medium through which they propagate. (Giancoli, D. C, 2014).

## METHODS

To ensure the success of this experiment, clear tools, materials, and procedures are required. In the first experiment, the relationship between the linear mass density of the string and the wave propagation speed of the string will be proven. In the second activity, the connection between the linear mass density of the string and the wave propagation speed of the string will be demonstrated. Prepare the tools and materials by ensuring that the equipment functions properly. Set up the strings and guitar strings, calculate the mass of each length of string, take the first string or cord, attach one end to the vibrator, connect the other end to the load M, and turn on the vibrator until it lights up. Move the vibrator until a standing wave is formed, paying attention to the appropriate length of the string, then measure the length of the string from the vibrator to the pulley. Record all observations on constant tension mass, observation sheets, and calculate the wave propagation speed of the string for each activity.




***Picture 1.*** *Experiment Sketck*

## RESULT

Activity 1. Relationship between tension force in the string and wave propagation speed.

Wave frequency = 50 Hz

Gravitational acceleration = 10 m/s²

**Table 1.** Results the tension force of the rope/string with fast wave propagation

| Object Name | Rope Length (m) | Numbers of Waves | Tension (kg.m/$s^2$) | Wavelength (m) | Wave Propagation Speed (m/s) |
|---|---|---|---|---|---|
| Rope | 0,97 | 1 | 0,01 | 0.5 | 48,5 |
| String B-2nd | 0,93 | 1 | 0,01 | 0,5 | 46,5 |
| String D-4th | 0,93 | 1 | 0,01 | 0,5 | 46,5 |
| String E-1st | 0,93 | 1 | 0,01 | 0,5 | 46,5 |
| String E-6th | 0,84 | 1 | 0,01 | 0,5 | 42 |
| String G-3rd | 0,84 | 1 | 0,01 | 0,5 | 42 |

**Activity 2.** Relationship between wave propagation speed and linear mass density of the rope/string

Linear mass density of the rope : 0,010309 kg/m

Linear mass density of the string A-5th : 0,010752 kg/m

Linear mass density of the string E-6th : 0,011904 kg/m

**Table 2**. Results Fast bond wave propagation with mass unity rope/string

| Object Name | Load Mass (kg) | Rope/String Length (m) | Numbers of Waves | Wavelength (m) | Wave Propagation Speed (m/s) |
|---|---|---|---|---|---|
| Rope | 0,05 | 0,97 ± 5 | 1 | 0.97 | 48,5 |
| String A-5th | 0,05 | 0,93 ± 5 | 1 | 0,93 | 46,5 |
| String E-6th | 0,05 | 0,84 ± 5 | 1 | 0,84 | 42 |

**DISCUSSION**

The aim of this standing wave observation is to understand the principles of the wave experiment (rope/string), tension relationship (rope/string), and wave propagation velocity, mass density (rope/string) or mass per unit length (rope/string), and wave velocity. Factors related to wave propagation speed include tension in the rope, mass density of the rope, load mass, rope mass, rope length, wavelength, and vibrator frequency.

This standing wave observation consists of two activities, namely studying tension (rope/string) and wave propagation speed, as well as wave propagation speed and mass per unit length (rope/string), followed by comparing the rope with a guitar string for the obtained results. The tools and materials used include a vibrator, digital scale, ruler, rope, guitar string, pulley rail, and load lifter.

After analyzing the data in the first activity, it was concluded that the wave velocity is directly proportional to the square root of the rope tension; the greater the rope tension, the greater the wave propagation speed. Conversely, the smaller the rope tension, the smaller the wave propagation speed. Based on this relationship, it can be concluded that the greater the rope tension, the greater or faster the wave propagation speed. At the same time, if the mass per unit length of the rope is larger, the wave propagation speed is smaller or slower. Meanwhile, according to the second activity, it can be concluded that the mass density of the rope is inversely proportional to the wave propagation speed.

Based on the results obtained in this experiment using a load mass of 0.05 kg with a tension force of 0.01 kg.m/s², the load mass will affect the magnitude of the tension force in the rope, so the generated data can express the relationship between wave speed and rope tension force. Out of 7 experiments, one wave was formed with the rope length in experiment 1 (0.97 ± 5) m, and the string length in experiments 2,3,4, and 5 (0.93 ± 5) m, while the string length in experiments 6 and 7 was (0.84 ± 5) m. After data processing, the wave propagation speed results for experiment 1 were (48.8 m/s), experiments 2,3,4, and 5 were (46.5 m/s), and the reults for experiments 6 and 7 were (42 m/s).

This standing wave experiment allows for the analysis of variables influencing each other. In the first activity, we analyze the relationship between rope tension and wave propagation speed. The control variables in the first activity are frequency and the type of rope used.

The independent or manipulated variable in the first activity is the load mass. The dependent variable in the first activity is the rope length and the number of waves. In the second activity, we analyze the relationship between rope mass density or mass per unit length and wave propagation speed. The control variables in the second activity are rope mass density (1, 2, and 3), load mass, and vibrator frequency. The independent or manipulated variable in the second activity is the rope length. The dependent variables in the second activity are the number of waves, wavelength, rope length, and wave propagation speed.

## CONCLUSION

After analyzing the data from the first experiment, it can be concluded that the wave velocity is directly proportional to the square root of the tension in the string. The larger the tension in the string, the greater the wave propagation speed. Conversely, the smaller the tension in the string, the smaller the wave propagation speed. Based on this relationship, it can be concluded that the greater the tension in the string, the greater or faster the wave propagation speed. At the same time, if the mass per unit length of the string is larger, the wave propagation speed becomes smaller or slower. From the second activity, it can be concluded that the mass density of the string is inversely proportional to the wave propagation speed; the larger the mass density of the string, the smaller the wave propagation speed. Additionally, it is known that the results are greater in the string compared to the guitar string, due to the differences in mass density and string length.

## KNOWLEDGEMENT OF THANKS

We would like to thank the lecturer of the Optics and Wave Practicum course, Mr. Ahmad Suryadi, M.Pd., the lecturer of the English course, Mrs. Fuji Hernawati Kusumah, M.Si., and the supervising laboratory assistant, Ms. Hasanah S.Pd, who has directed and guided us well so that we can complete this mini research on time.

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