Analysis of Factors Affecting Period on GHS Using PhET Simulation

Noval Mulya Dava, Syahri Ramadhanti, Yunita Ayudhia Anzani
[1] Physics Education Study Program, Sunan Gunung Djati State Islamic University, Bandung, Indonesia
* Corresponding Author

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ABSTRACT

Physics is one of the sciences that is studied based on facts, natural phenomena, ideas, and results of experiments/experiments. Physics is a science that is closely related to everyday life, one of which is found in Simple Harmonic Motion which discusses pendulums on clocks and strings on guitars. Simple vibrations (GHS) are an example of periodic motion when the amplitude of vibrations in the system is relatively small and the displacement is less than 15°. GHS is a regular alternating motion through the equilibrium point and the number of vibrations in one second is always constant. If the movement occurs repeatedly within a certain time interval, it is called periodic motion. One of the experiments that can be done with simple vibrations is to make a mathematical pendulum or a simple pendulum. The method used in this research to determine the factors that affect the period of pendulum vibrations is a literature review and experiments using PhET simulations. The results of this study are data generated from experiments and calculations which state that the factors that affect the period of pendulum vibrations in simple harmonic motion are the length of the rope and the acceleration due to gravity. While the mass has no effect on the period of the pendulum vibration. The effect of the length of the string is directly proportional to the period of the pendulum's vibration, and the effect of gravity is inversely proportional to the period of the pendulum's vibration.

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1. INTRODUCTION

Science is explored using facts, natural events, theories, and experimental findings. Physics is a branch of science. Inanimate objects, natural phenomena, fictional events or happenings, and energy are all topics discussed in physics education. Basic Harmonic Motion which explains the pendulum in a clock and the strings in a guitar is an example of how Physics is linked directly to everyday life [1]. When the vibration of the system has a small amplitude and a displacement of less than 15°, simple vibration (GHS) is an example of periodic motion [2]. Making a mathematical pendulum or basic pendulum is an experiment that can be carried out with simple vibrations [3]. The improved basic pendulum model consists of a point mass maintained by a rigid thread with massless mass (zero mass) [4]. Once released, the pendulum bends from its equilibrium position, swings, and oscillates back and forth in its equilibrium state. During vibration, the pendulum has a period, frequency, and angular frequency [5].

Objects will oscillate and move away from the equilibrium point when a force or torque is applied to the object [6]. GHS is a regular back and forth movement through an equilibrium point and the number of vibrations per second is always fixed or constant. If the movement occurs repeatedly within a certain unit of time, it is called periodic movement. To determine the value of the period of vibration of a pendulum mathematically and physically, formulas can be used respectively, namely $T=2\pi \sqrt{L/g}$ and $T=2\pi \sqrt{2L/3g}$ and also through the formula $T=t/n$ [7]–[11].

The motion of the pendulum is said to be close to GHS if the amplitude of the motion is small. A simple pendulum has a string length (L) and mass (m), and the forces on the weight are the weight (mg) and string tension (T). When determining the solution for the pendulum motion, it is assumed that the pendulum can oscillate when the pendulum moves because the weight of the pendulum is very large. The vibrational motion of a pendulum can be determined with the help of nonlinear differential equations. The general concept of a pendulum uses Newton's second law, namely $\vec{F} = m \vec{.a}$ [12]–[15].

Frequency, or the number of oscillations that occur in one second, is one of the key characteristics of oscillatory motion. The SI unit for frequency is hertz (Hz), and its sign is f where 1 H_z=1 oscillation per second=1 S^{-1} [16]–[19].

The period of motion T, or how long it takes for the oscillation to complete, is a concept related to frequency (cycle), namely: $T= 1/f$ [20]–[23].

Meanwhile, in simple pendulum motion, if the deviation angle is small, the period of vibration of the mathematical pendulum is along L in a place where the gravitational acceleration is g, then the equation is $T=2\pi \sqrt{L/g}$ [24]–[30].

If the angle is not too large, the pendulum will move in easy harmonic motion. When the displacement is too large, the relationship between the force exerted on the object and the displacement is no longer linear. After being deflected, the pendulum will move continuously without stopping past the equilibrium point, so it is called simple harmonic motion. The equation for small angles in simple harmonic motion is $F=(-mg)/l$ [2], [12], [21].

In GHS, if the length of the rope increases, a period will be produced that is consistent with the practical experiment. Period does not depend on time. This phenomenon occurs because the restoring force is directly proportional to mass. Meanwhile, gravitational acceleration can be measured using the pendulum equation, which is as follows.

$$g=(4\pi^2 L)/T^2 \tag{1}$$

Apart from that, there are several external factors that can influence the period value of the pendulum, namely environmental factors such as air or wind blows.

With the increasingly rapid development of the world of technology and information, several educational institutions, including schools, produce and use various interactive media. The same can be said for conducting experiments, which can be done with interactive simulation media. This allows educators and students to use various learning tools, one of which is Physics Education and Technology (PhET) which helps students understand abstract physics concepts, especially in practical activities. PhET's dynamic visual simulation media, which can explicitly bring to life the conceptual and visual models used by physicists, is intended to help students visualize physics topics. PhET simulations outperform traditional techniques for student learning outcomes.

The aim of this research is to examine the elements that influence the period of pendulum vibration in Simple Harmonic Motion using PhET simulations. PhET simulations are more effective to use, because PhET simulations are very easy to use on a computer, the data produced is also more accurate/precise than data produced from manual practicums. Apart from that, this media can also minimize obstacles during practical activities.

2. METHODS

The method used in this research is literature review and experimentation. Literature studies come from journals, articles or other publications that contain the same topic as the one raised by the researcher, in order to produce a new article relating to a particular topic. Meanwhile, the experimental method is used by collecting data repeatedly to find out what influences the period of a simple pendulum. This simple pendulum measurement is carried out by varying several variables, namely the length of the string, mass and gravity, while the fixed variables are the number of oscillations 10 times and the angular deviation of 15º. All data collection for each variable was carried out 10 times using PhET simulation.

So the data obtained in the practical experiment is the length of the pendulum string, the mass of the pendulum, gravity, and the time needed to oscillate 10 times. Then the data is processed, calculated, and observed what influences can influence the value of the pendulum period as evidenced by observation tables and graphs.

3. RESULTS AND DISCUSSION

This research was carried out 3 times, namely observing the influence of the length of the string on the period of the pendulum, the influence of the mass of the object on the period of the pendulum, and the influence of gravity on the period of the pendulum. Based on data collection, data processing, and data calculations according to the equation T=2π L/g, the data analysis listed in the following table is produced.

Table 1. Data on the influence of string length on the pendulum vibration period

Trial to-	Rope Length (m)	Experimental Results (s)	Calculation Results (s)
1	0,50	1,42	1,42
2	0,80	1,80	1,80
3	1,00	2,01	2,01

Table 2. Data on the influence of load mass on the pendulum vibration period

Trial to-	Rope Length (m)	Experimental Results (s)	Calculation Results (s)
1	0,50	2,01	2,01
2	1,00	2,01	2,01
3	1,50	2,01	2,01

Table 3. Data on the influence of gravitational speed on the pendulum vibration period

Trial to-	Rope Length (m)	Experimental Results (s)	Calculation Results (s)
1	1,62	4,96	4,94
2	9,81	2,01	2,01
3	24,79	1,27	1,26

From the results of the observations and calculations above, it can be seen that the factors that influence the period of vibration of the pendulum are the length of the string (L) and the acceleration of gravity (g), while mass has no effect on the period of vibration of the pendulum. This is in accordance with the equation T=2π L/g, this equation states that the relationship between the length of the string is directly proportional to the period of vibration of the pendulum, that is, the greater the length of the pendulum string, the greater the period of vibration of the pendulum, and vice versa. This can be seen in table 1, which shows that a string length of 1 meter has a greater period than a string length of 0.5 meters or 0.8 meters. This can be proven by the graph below.

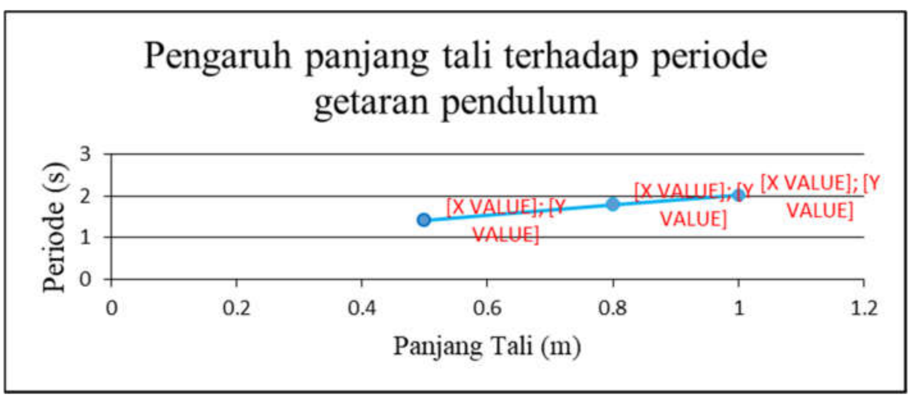

Figure 1. Effect of string length on the pendulum vibration period

Meanwhile, in table 2 it can be seen that whatever mass is given to the pendulum, the experimental results and calculations do not change at all. Therefore, it can be concluded that mass has no effect on the period of pendulum vibration. This is in accordance with a quote from Tipler's 1991 book, which states that periods do not depend on time. The restoring force is precisely proportional to the mass, so this is true. The graph below shows this:

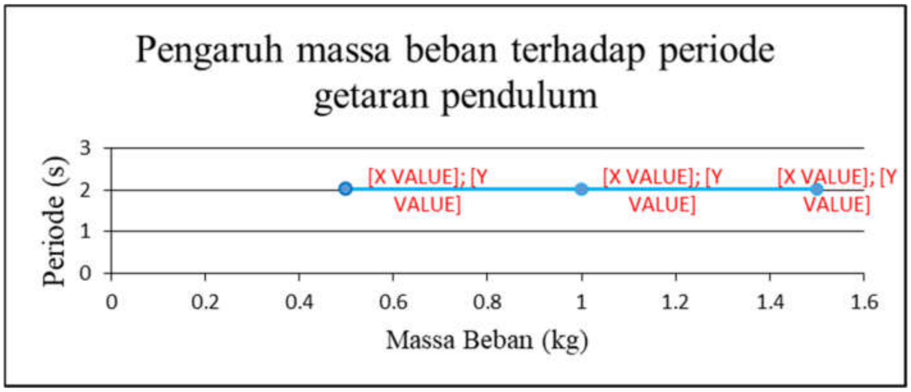

Figure 2. Effect of load mass on the pendulum vibration period

Lastly, the effect of gravitational acceleration is inversely proportional to the period of vibration of the pendulum. So the greater the gravitational acceleration, the smaller the period of vibration of the pendulum, conversely, if the acceleration of gravity is smaller, the greater the period of vibration of the pendulum. This can be seen in table 3, which shows that the gravitational acceleration on the Moon (1.62 m/s2) has a greater period than the gravitational acceleration on Earth (9.81 m/s2) and Jupiter (24.79 m/s2). This can be proven in the graph below.

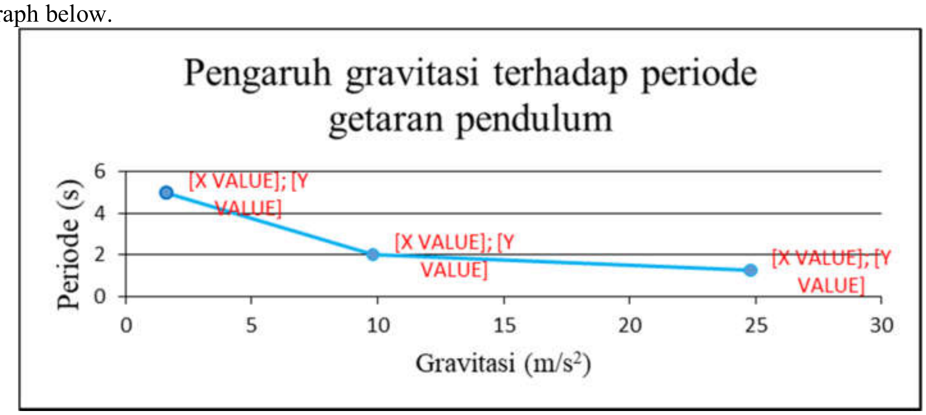

Figure 3. Effect of gravitational speed on the period of pendulum vibration

4. CONCLUSION

From the results of observations and calculations regarding the factors that influence the period of pendulum vibration, it can be concluded that the factors that influence the period of vibration of the pendulum are the length of the string and the acceleration of gravity. This is in accordance with the general equation for the period of a simple pendulum. The relationship between the length of the string and the period of the pendulum is directly proportional. This means that the greater the length of the string given to the pendulum, the greater its period. On the other hand, if the length of the string is smaller, the period of vibration of the pendulum will be smaller. The effect of gravitational acceleration is inversely proportional to the period of pendulum vibration. This means that the greater the gravitational acceleration, the greater the value of the pendulum period. Conversely, if the smaller the gravitational perception, the greater the period of vibration of the pendulum. Meanwhile, mass has no effect on the period of vibration of the pendulum, whatever mass value is given, the period of vibration of a pendulum will be the same.

DECLARATION

Author Contribution

The method used in this research is literature review and experimentation.

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Conflict of Interest
Declare conflicts of interest or state “The authors declare no conflict of interest.”

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