The Influence of Inclined Plane Angle to the Oscillation Period of Spring and Block Systems

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***Abstract*—The topic of oscillation in spring and block systems in the inclined plane is fairly complex and rarely to be discussed in the oscillation research topic. Not only theoretical calculations, physical quantities in this topic can also be calculated through experiments. This research determines one of the physical quantities present in this system, namely the oscillation period experimentally with the help of a light sensor on a smartphone. Experiments were carried out with variations in angular position on the inclined plane with spring-mass block launched from the top of the plane. The spring used has a constant (2.68313 ± 0.002152) N/m while the block has a mass of 0.0892 Kg. Through weighted linear regression analysis, this study shows a linear relationship between the angular position of the inclined plane and the oscillation period with a linear equation y = -0.005x + 1.3661 and R^2 = 0.98358. The greater the angle of the incline, the smaller the value of the oscillation period. These results can provide further development of the use of light sensors on smartphones for physics experiments, especially in spring systems and block on inclined planes.**

Keywords*—oscillation period, inclined plane, smartphone light sensor

I. Introduction

Oscillating motion is one of the important studies of physics to understand. In understanding physics studies, an understanding of theory and evidence is needed through experiments [1]. One of the research topics about oscillation can be found in spring systems and block in inclined planes. This system can be found in everyday life, for example in the phenomenon of landslides on hillsides or mountains [2]. The material of oscillation motion in this system is fairly complex and rarely to be discussed in the oscillation research topic. Not only in theory, to understand this material, it is also necessary to understand experimentally to investigate and prove the value of magnitude found in the oscillating motion of spring systems and block in inclined planes.

The physical magnitude in oscillation that can be measured includes the period of oscillation and its damping time. These measurements can be done using sensor technology found on a smartphone. Some smartphones are equipped with various sensors that can retrieve data in real-time, such as an accelerometer sensor, gyroscope, magnetometer, light, and pressure. Because all sensors can be read by the required application, many quantitative studies can be done with smartphones [3]. Also, smartphones have provided opportunities for new learning perspectives, including relationships between teachers, students, and learning material [4]. Hence, smartphones can be used as experimental tools in the world of education, including physics.

Several experimental studies related to oscillation and oblique biding have been carried out using light sensors on smartphones. For example, the determination of spring coaster with a good level of accuracy [5] as well as determining the acceleration and speed of objects in the inclined plane with a good level of accuracy [6]. Based on these studies, researchers tried to develop it into new research to determine the oscillation period of spring systems and block on the inclined plane using a light sensor on a smartphone. This research is only an experimental study, conceptual calculation and comparison with experimental results can be done in further research.

A. Damped Oscillation

Periodic motion is the movement of an object continuously so that the object returns to a certain position after a certain interval [7]. An example of a simple form of periodic motion is an object that oscillates at the end of spring because it is called simple harmonic motion [8]. The force produced by a spring on an object is directly proportional to its position, as=stated− by Hooke's law [7]

$$F_s = -kx \tag{1}$$

When a spring system is styled, the response that occurs depends on the external force applied to the system and the attenuation experienced by the system. The total force acting on the mass of m is [9]

$$\sum F = -kx - bv = ma \tag{2}$$

or,

$$m\frac{d^2x}{dt^2} + kx + b\frac{dx}{dt} = 0 \tag{3}$$

When the drag force is small compared to its maximum recovery force, the solution to equation (2) is

$$x(t) = Ae^{-\frac{b}{2m}t}\cos(\omega t + \phi) \tag{4}$$

where A is the deviation, ϕ is the initial phase angle, ω is the vibration angle frequency which is directly related to the period of T oscillation and the spring constant k in the equation: [7]

$$\omega = \frac{2\pi}{T} = \sqrt{\frac{k}{m} - \left(\frac{b}{2m}\right)^2} \tag{5}$$

B. Smartphone Light Sensor

The smartphone is very suitable as an experimental tool because it has many sensors [10]. The sensor that can be used for physics experiments is a light sensor. The light sensor on the smartphone is used as a lighting control on the LCD screen which can adjust the screen brightness automatically. Brightness describes how strong the light source is felt by the human eye. This brightness is measured in units called lux. This unit measures light-emitting power and calculates light flux per unit area [11]. The light sensor on this smartphone can be accessed with several applications, one of which is the phyphox application. This application was developed by RWTH (Rheinisch-Westfälische Technische Hochschule) Aachen University and is available on Android and iOS devices [12]. Phyphox application is able to record light intensity in real-time by generating data and graph the relationship between time t and light intensity 1.

II. Method of Research

This research method uses the experimental method. Data retrieval is carried out in a laboratory with a span of time from September 2018 to January 2019. This experiment follows the research procedure as follows:

1. The phyphox application on the smartphone is activated. After that, select the light menu.
2. The LED circuit on the block is turned on.
3. Tools such as figure 1 are arranged in a certain angle position, then press the play button on the phyphox application on the smartphone.

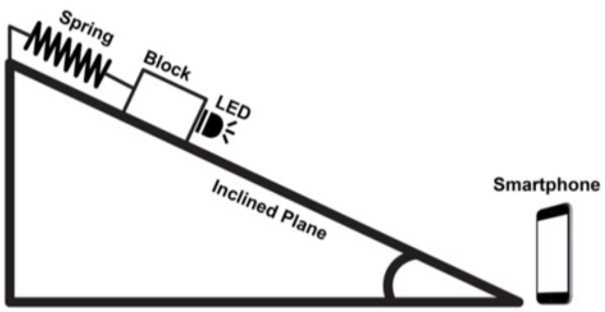

Fig. 1. Design series of experimental devices

4. The block will oscillate for a period of time. When the block is idle, press the stop button on the phyphox application on the smartphone.
5. Select the export data menu to get data from the light sensor.
6. Steps (1) to (5) are repeated over different angles.

Data analysis is done to get the period of oscillation that occurs by calculating the difference in time between peak to peak in the graph of the relationship of time to light intensity. This analysis is carried out by weighted linear regression techniques with variations in the position of the angle of the inclined plane. At the end of the analysis, we will get a graph where the angle of the inclined plane is the x-axis and the oscillation period as the y-axis. Hence, the linear regression can be expressed as

$$y = ax + b \tag{6}$$

III. Results and Discussion

Before the experiment, the light sensor recorder application on the smartphone by recording the light intensity coming out of the flashlight. The researcher uses the Xiaomi redmi note 3 pro smartphone with the location of the light sensor above the front screen. Several applications are tried such as sensor kinetics pro, data sensors, phyphox, and sensors. Of the various applications, the phyphox application has many advantages over other applications. Besides being able to download free, this application has a remote access feature, export data in excel form, and is able to record light intensity data every 0.05 seconds.

After finding the right application for conducting the experiment, then testing the sensitivity of the light sensor on the smartphone was conducted. This is needed so that researchers can find out how far the inclined plane will be made. This trial is done by recording the light intensity coming out of the small-size flashlight at close and long distances and in the conditions of dark and bright rooms. The results show that in bright conditions, the light sensor can record a minimum distance of 6 cm with an intensity of 10000 lx. When the researcher try to get closer again, the sensor stopped thinking. The minimum distance of 6 cm depends on the intensity of the light source. If done with a light source that has a high intensity, the minimum distance is above 6 cm. While the maximum distance obtained by researchers with a small flashlight source is 51 cm with an intensity of 225 lx. In dark conditions, the minimum and maximum distance obtained is the same. Thus, this experiment can be carried out by the length of the inclined plane 50 cm in the condition of the dark and bright room.

Another trial conducted before conducting an experiment was comparing the results of the light sensor measurements on a smartphone with a light sensor in the LoggerPro vernier. The results obtained are shown in figure 2.

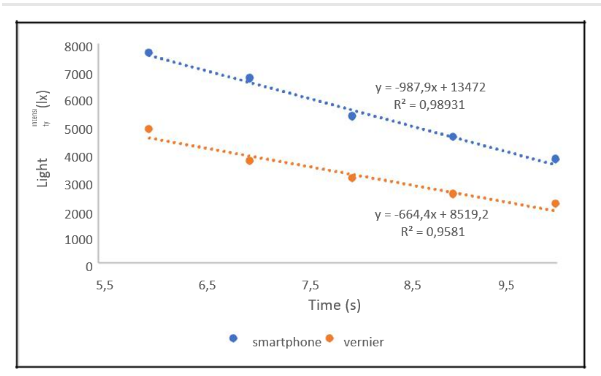

Fig. 2. Graph of the measurement results of light sensors on the loggerpro smartphone and vernier.

Figure 2 shows that the light sensor on the smartphone has a linear relationship with the light sensor on the vernier. After conducting various tests, then a spring constant measurement was carried out with a video analysis software based on Tracker software as shown in Figure 3. There are 2 springs that are measured by the measurement results namely (2.68313 0.002152) N/m and (5.51626 0.067927) N/m. The researcher chose springs with the smallest constants in this experiment because they were more flexible and made more oscillation periods in the inclined plane.

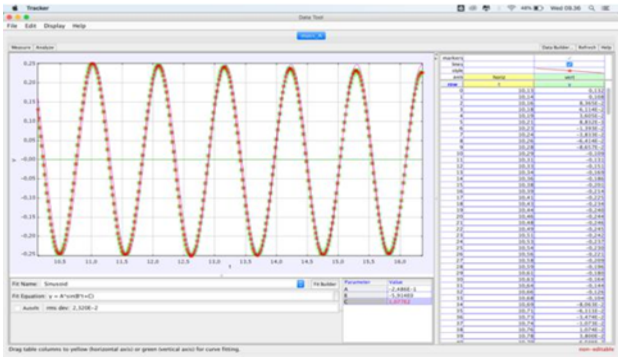

Fig. 3. Measure the spring constant using the tracker software.

The minimum friction force is required for the sliding phenomenon. Block and inclined planes are made with a glass surface to reduce friction. Even so, the oscillation period that occurs is not so much. On the surface of the inclined plane, crystal powder is sprinkled as a lubricant so that the researcher gets more oscillation period of the block that has been given a mirror on the surface, then given a series of LEDs on the front. This is made so that the smartphone's light sensor can capture the period of oscillation that occurs from the LED's light source. The series of tools in this experiment can be seen in Figure 4.

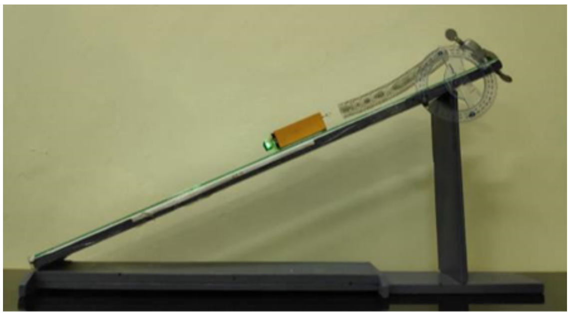

Fig. 4. Experimental apparatus.

Data retrieval is done by determining the angle of the incline. After the LED on the block is turned on, the phyphox application on the smartphone will record the light intensity coming out. Block is swung with maximum deviation so that oscillations can occur. Light sensor data in the phyphox application are observed as shown in Figure 5.

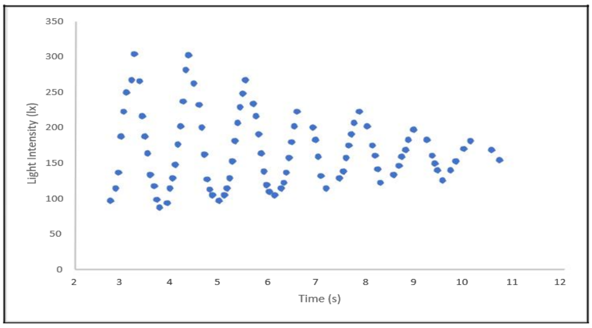

Fig. 5. Graphical images of the relationship of time to the light intensity recorded on a smartphone's light sensor.

In figure 5, the oscillating block is damped for approximately 10 seconds. At the end of the graph, the smartphone also doesn't record the final process of damped oscillation. In calculating the period of oscillation, the researcher determines the time interval between one peak to another in the graph.

After doing 5 variations in the angle of the inclined plane, the graph shows the relationship of the angle of the sloping plane to the oscillation period as shown in Figure 6.

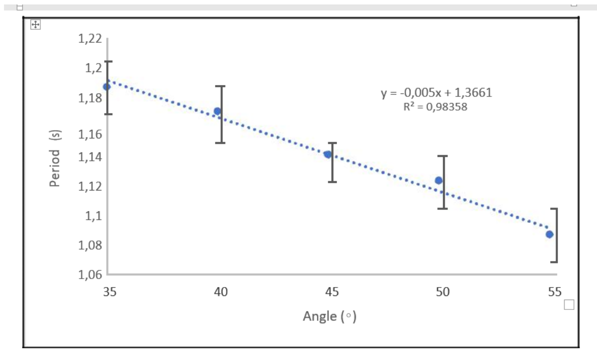

Fig. 6. The graph shows the relationship of the angle of the inclined 3lanet o the oscillation period.

The graph above shows a linear relationship between the angular position of the inclined plane and the oscillation period with a linear equation y=-0.005x+1.3661 and R^2=0.98358. The greater the angle of the incline, the smaller the value of the oscillation period.

Apart from obtaining a linear relationship between the position of the angle of the incline and the period of oscillation, this study still needs further development. Such development can be carried out on a series of experimental devices to reduce friction between the block and the inclined plane. The data recorded by the light sensor on the smartphone is also not too much so that the damped oscillation graph produced is pointed. Besides, analytical theories can also be proven to continue this research..

IV. Conclusion

Research has been carried out to determine the period of oscillation of spring systems that have constants (2.68313 ± 0.002152) N/m and a block with a mass of 0.0892 kg on an inclined plane using a smart sensor light sensor. This study also shows that there is a linear relationship between the angular position of the inclined plane and the oscillation period with the linear equation y=-0.005x+1.3661 and R^2=0.98358. The greater the angle of the incline, the smaller the value of the oscillation period. These results can provide further development of the use of light sensors on smartphones for physics experiments, especially in spring systems and block on inclined planes. Further development in this research can be done by analyzing theory analytically.

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