Determination of Springs Constant by Hooke’s Law and Simple Harmonic Motion Experiment

S Wulandari1, B H Iswanto and I Sugihartono
Physics Education Master Program, Universitas Negeri Jakarta
Jl. Rawamangun Muka, Jakarta 13220, Indonesia
Email: algieba892@gmail.com, bhi@unj.ac.id, iwan-sugihartono@unj.ac.id

Abstract. This study aims to calculate the spring constants of two types of stainless using Hooke's Law principle and simple harmonic motion methods. Two types of springs (spring I and II) with different sizes in diameter have spring constant k values of 24 N/m and 5.4 N/m, respectively. Based on the experiment and calculation, the spring constant of spring I calculated by Hooke's Law and the simple harmonic motion experiment has an average value of 23.22 N/m with an error of 3.24% and 23.06 N/m with an error of 3.90%. On the other hand, the spring constant of spring 2 calculated by Hooke's Law and the simple harmonic motion experiment has an average value of 5.47 N/m with an error of 1.44% and 5.32 N/m with an error of 1.48%. Hence, we concluded that the determination of spring constant using Hooke's Law has better accuracy.

1. Introduction
Spring is a component used for experiment in physics lessons both in junior high school and senior high school. In learning at school, springs are commonly used in experiment to calculate the value of the spring constant. The spring includes an elastic material, which if stretched will return to its original state, due to the presence of an elastic reaction force over the stretching tension force [1]. The spring restorers force is opposite to the deviation so that it can return to the equilibrium position. The restorer force evoked by a spring is determined by Hooke's law [2]. In addition, the spring can also dampen vibrations so that in the selection of the spring needs to be adjusted to the working force [3].

Each spring has a constant value usually called a spring constant. The value of each spring constant differs depending on the given force and the length of the spring [4]. Some factors that affect the length of the spring that can affect the value of spring constants include the type of spring, the diameter of the spring material, the diameter of the spring, and also the coil of the number of spring coils [5]. The greater the value of the spring constant, the greater the force required to stretch the spring. So the stiffer the spring, the larger the spring constant [6].

In line with the progress of technology now, the development of smartphones is very fast. Generally smartphones are used as a means of communication. Smartphones are mini computers that are easy to carry and contain applications that make it easy for users [7]. Smartphones are usually equipped with several sensors, including accelerometers, magnetometers, gyroscopes, light sensors, and GPS [8] [9]. The use of smartphones can be used in physics learning by utilizing built-in sensors and downloading existing open-source applications. Then the load will be used in the form of smartphones and case holders.

The value of spring constants can be determined in both static and dynamic ways [2]. The method of determining spring constants using Hooke’s Law can be done by measuring the length of the initial spring then hanging the smartphone as a load on the spring and measuring the length of the spring after...
the smartphone is hung. From here we can obtain the increase in the length of the spring. The method of determining spring constants with simple harmonic motion can be done by giving deviation to the suspended smartphone so that the spring will produce vibrations with a certain period. Therefore, it can be done by comparing the value of the spring constant of the two methods. Based on the description above will be conducted experiments using both methods so that we will see which method has good accuracy in determining the value of spring constants.

2. Experiment Setup
This experiment aims to calculate spring constants of two types of stainless steel spring sizes using hooke’s law principle and simple harmonic motion method. First, calculate the value k of the literature using the help of Spring Calculator with the following data.

| Table 1. Specifications of the spring used |
|------------------------------------------|
| **Pegas 1 (Extended Hooks)**   | **Pegas 2 (Machine Hooks)**   |
| **(mm)**                       | **(mm)**                       |
| Hook Length 1 : 30             | Hook Length 2 : 22             |
| Outer diameter 1               | Outer diameter 2               |
| Length inside hooks 105        | Length inside hooks 170        |
| Wire diameter 0.77             | Outer diameter 15              |

From the results obtained the value of k literature for spring 1 is 24 N/m and for spring 2 is 5.4 N/m. The experiment set used consists of a statue pole made of iron, two springs, ruler, and a smartphone and case holder. At first, the load in the form of a smartphone and case holder was weighed, so that a mass of 0.218 kg was obtained. From here, it is known which F value will work.

If based on the theory of the value of k obtained using both methods should be the same. In this case, we’ll compare the two methods and we can see which method is more accurately used to determine the value of spring constants based on the experiments performed.

3. Hooke’s Law
Experiment is done by measuring the length of the initial spring, the spring is hung on the statue then hangs the smartphone and case holder on the spring and measures the length of the spring after the smartphone is hung so that the length of the spring is obtained. Using the Hooke’s Law method is combined with Newton’s Law II. Where we obtain the increase in the length of the spring by using the following hooke’s law.

\[ F = -k \cdot y \]  

Where is Newton’s II Law,
\[ F = m \cdot g \] 

(2)

So that it can be substituted:

\[ m \cdot g = -k \cdot y \] 

(3)

\[-k = \frac{m \cdot g}{y} \] 

(4)

From the results of experiments for spring 1 calculated using the Hooke’s Law method obtained an average length increase of 0.092 m. As for spring 2 calculated using the Hooke’s Law method obtained an average length increase of 0.39 m.

| Table 2. Comparison of Hooke’s Law method with k value |
|-----------------|-------------|-------------|-------|
| Springs | Methods 1 (N/m) | k Value (N/m) | Diff%  |
| 1     | 23.22        | 24          | 3.24% |
| 2     | 5.47         | 5.4         | 1.44% |

4. Simple Harmonic Motion

For methods with simple harmonic motion periods, the load is given a deviation of 2-3 cm and turn on the application to display the period by utilizing sensors from the smartphone. Here, make sure the spring moves harmoniously. So that the value of the spring constant uses the equation of harmonious motion as follows.

\[ F = m \cdot a_y \] 

(5)

Where \( a_y \) the acceleration of harmonic motion,

\[ a_y = -\omega^2 y \] 

(6)

So obtained,

\[-k \cdot y = m \cdot -\omega^2 y \] 

(7)

\[ k = m \cdot \omega^2 \] 

(8)

\[ \omega^2 = \frac{k}{m} \] 

(9)

\[ \omega = \sqrt{\frac{k}{m}} \] 

(10)

With angular velocity \( \omega = \frac{2\pi}{T} \), so that

\[ \frac{2\pi}{T} = \sqrt{\frac{k}{m}} \] 

(11)

\[ \frac{2\pi^2}{T^2} = \frac{k}{m} \] 

(12)

Then obtained the value of k,

\[ k = \frac{4\pi^2 \cdot m}{T^2} \] 

(13)
From the results of experiments for spring 1 average period using the simple harmonic motion method of 0.611. For spring 2 average period using the simple harmonic motion method of 0.272.

Table 3. Comparison of Simple Harmonic Motion method with k value

| Springs | Methods 2 (N/m) | k Value (N/m) | Diff% |
|---------|----------------|--------------|-------|
| 1       | 23.06          | 24           | 3.90% |
| 2       | 5.32           | 5.4          | 1.48% |

5. Conclusion

Based on the results of this experiment it can be concluded that the method of calculating spring constants by measuring the increase in the length of the spring when weighed, using the concept of Hooke’s Law has better accuracy. This can be seen from the percented different for the method. For spring 2 has a smaller k value than spring 1. When using the simple harmonic motion method, it is necessary to ensure that the spring oscillates properly. The magnitude of the spring constant greatly affects the given force. For future research it is recommended to varies the type of spring.

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