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The Relationship Between Constant and Spring Stretch in Hooke's Law Material Using Virtual Lab (PhET)

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Abstract. This study aims to analyze the relationship between spring constant and spring stretch using Virtual Lab (PhET). The method used in this study is an experimental method that allows testing hypotheses or theories through the control of certain variables to understand the cause-and-effect relationship between independent and dependent variables. The independent variable in this study is the mass that is changed to affect the spring, while the dependent variable is the change in the position of the spring and the force produced. The simulation was carried out using PheT learning media. The first thing to do is to vary the mass. Then you will get the result of increasing the length for each mass. After that, the data that has been obtained is analyzed to determine the spring coefficient. Based on these simulations, it can be concluded that a spring's elasticity level influences the stretching level that occurs after a spring is treated in the form of varying masses.

Keywords: Elasticity, Hooke's Law, Spring, Virtual Lab

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INTRODUCTION

Since the emergence of the COVID-19 pandemic, various transformations have occurred in the implementation of various activities, including in education. Education, which was previously conducted face-to-face or offline, now has to switch to an online format. Nevertheless, the learning process continues to be carried out to develop the affective, cognitive, and skills aspects of students (Amnirullah et al., 2020). The positive impact that can be identified so far from the emergence of the COVID-19 pandemic is the ability to leverage various technologies. This situation has accelerated society's adaptation to technological developments, opening up opportunities for exploration and implementation of digital solutions in various aspects of daily life, one of which is in the field of Education.

In the world of science and technology, experiments and research are the main pillars in understanding the fundamental principles of physics. This has led to the creation of virtual laboratories. In physics, direct experiments are often limited by financial constraints, safety, and the availability of appropriate equipment. This is where the role of simulations using Virtual Lab technology becomes very significant.

A virtual laboratory is a digital representation of facilities and processes that are typically found in a laboratory, which can be simulated through a computer or other devices (Malik et al., 2020). Virtual Lab is a simulation environment that allows users to conduct experiments and virtual measurements using accurate mathematical models (Salame & Makki, 2021). Virtual Lab can be defined as a collection of programs that allow for the visualization of abstract phenomena or complex experiments conducted in a real laboratory (Santi et al., 2020). The purpose of the Virtual Lab is to enhance learning activities and develop the skills needed for problem-solving (Puspita, 2021; Yuliati et al., 2018).

The Virtual Lab used in this experiment utilizes PhET simulations (Physics Education and Technology), which were developed by a team led by Katherin Perkins and her colleagues from the University of Colorado in the United States (Jania et al., 2022a; Ramadhany et al., 2022). They have created this simulation in Java or Flash format, which allows the simulation to be accessed and run directly through the website using standard web browsers. PhET simulations can be accessed at https://phet.colorado.edu/ (Rizaldi et al., 2020; Sinulingga et al., 2020)

Physics, as one of the scientific disciplines that emphasizes scientific research activities in the laboratory, requires the use of equipment in the implementation of physics experiments in the laboratory (Wardani et al., 2023). One of the physics concepts that can be explored using a virtual lab is Hooke's law (Jania et al., 2022b)

Hooke's law is a concept introduced by the English physicist named Robert Hooke in the 17th century (Rychlewski, 1984) . This concept discusses the relationship between the forces applied to an elastic material, such as a spring, and the changes in shape produced by that spring (Jhoni et al., 2022; Toe et al., 2020).

Robert Hooke discovered this law in 1660 when he conducted a series of experiments on springs (Narang et al., 2022) . He realized that the change in shape or stretching of a spring is proportional to the force applied, as long as the material does not exceed its elastic limit. The results of his experiments were then formulated into a mathematical law known as Hooke's Law, which is as follows (Abdullah, 2016; Halliday et al., 2005)

$$F = k\ x\ \Delta x \qquad [1]$$

Where F is the force produced, k is the spring constant, and Δx is the change in the length of the spring. From equation 1, it can be said that the relationship between the spring constant is proportional to the extension of the spring (Budiman et al., 2023)

Therefore, the aim of this research is to analyze the relationship between the spring constant and the stretching of the spring using Virtual Lab. By utilizing Virtual Lab technology, we can easily model, simulate, and analyze this experiment in various scenarios without the need for physical components. Thus, the author has designed a study titled "The Relationship between Spring Constant and Stretching of Springs in Hooke's Law Material using Virtual Lab (PhET)."

METHOD

This research uses an experimental method. The experimental method allows for the testing of hypotheses or theories through the control of certain variables to understand the cause-and-effect relationship between independent and dependent variables. The independent variable in this study is the mass that is altered to affect the spring, while the dependent variable is the change in the position of the spring and the force produced. The PhET simulation is used to measure and monitor these changes by varying the mass and stiffness settings on the spring to understand the extent to which the behavior of the spring in the simulation aligns with Hooke's Law and the principles of elasticity. This research method begins by accessing simulations related to Hooke's Law or springs on the PhET website. The first step involves suspending masses of different sizes (50 g, 100 g, and 250 g) on Spring #3, which has a default stiffness. Each experiment records the mass used, the initial position of the accelerator before the suspension of the mass, and the change in the position of accelerators when recorded as a shift. The next step involves repeating the experiment by changing the softness of the Accelerator to soft and hard. The collected data will be used to calculate the style applied to the accelerator using Hooke's Law and to build a style versus shift chart. This data analysis aims to evaluate the extent to which acute behavior in a PhET simulation is consistent with Hooke's Law, while identifying factors that may affect the accuracy of the experimental results.

As for the flowchart in this study as follows.

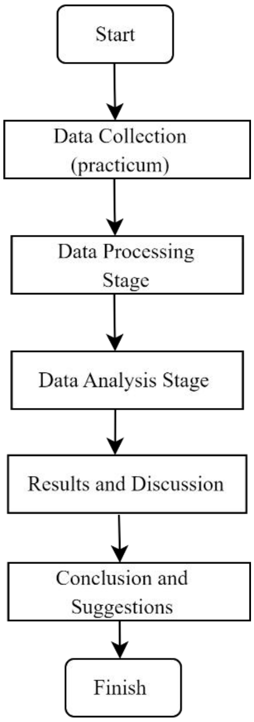

Figure 1. Research Flowchart

RESULT AND DISCUSSION

The $ma = - kx$ equation describes the relationship between the force that works on an object, the mass of the object, acceleration, and the constant of agitation in the context of Newton's and Hooke's laws. This equation shows that the force (F) which works on the object is comparable to the change in the length of the agitation (x) through the constant (k), and comparable also to the speed (a) of the thing through the mass (m) of that object.

In the context of Newton's law, this equation is a representation of the second Newton law,

$$F = ma \qquad [2]$$

where the style (F) that works on an object is equal to the mass (m) of the object is multiplied by its speed (a). While in the context of Hooke's law, this equation describes the restoration style which works on the pegasus, in which the style is comparable to the change in the length of the picasus (x) through the constant of the Pegas (k).

Thus, the question

$$ma = - kx \qquad [3]$$

It reflects the principles of physics underlying the relationship between force, mass, acceleration, and accelerating constants in the context of Newton's and Hooke's laws.

Data collection in this experiment using a virtual laboratory (PhET). In this experiment, repeated data collection with different mass variations, namely, 50g, 100g, and 250g as much as 40 times data collection by 3 aces with different levels of elasticity. (semi-soft, average, and hard). Then we get the mean value of each mass, style, and length addition of the accelerated as a result of the style change presented in the table below.

Table 1. Results of the calculation on the accelerator with the semi-soft elasticity level

Experiment	Mass (gram)	Force (N)	Stretch (cm)	Spring Constant (N/m)
1	50	0,49	17	2,882
2	100	0,98	33	2,969
3	250	2,45	81	3,024

Table 1 shows that there is a relatively straight relationship between the style variable and the stretch, in which the greater the style given to a speaker will result in an increase in the amount of stretch produced by the speaker. This is in line with the hooke law that says "if the pull given to an speaker does not exceed its elasticity limit, then the increase in length of the object occurs is proportional to that pull given".

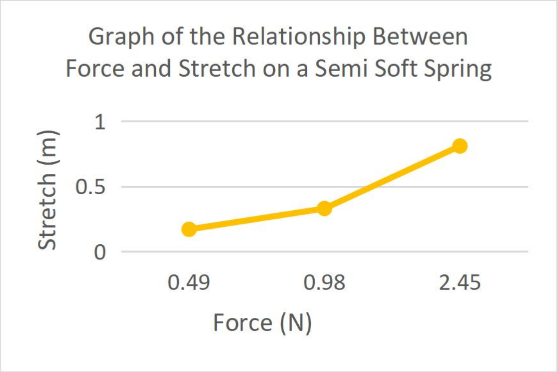

Figure 2. Graphic of the relationship between the style and the stretch on the semi-soft accelerator

The graph above shows a linear relationship between the style variable and the stretch on the semi-soft accelerator. Of the 3 styling variations applied, the semi-soft clamp can hold up to a maximum of 0.81 and a minimum of 0.17. The semi soft clamp has a large enough elasticity that it can easily hold up if given a little clamp.

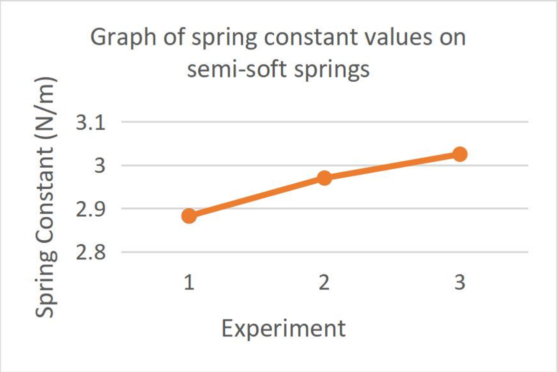

Figure 3. Graph of spring constant values on semi-soft springs

The graph above shows the constant values generated by a semi-soft accelerator after given 3 different styles variations. The resulting constants values are 2,882, 2,969, and 3,024, where the three values have relatively small differences that can be attributable to the uncertainty values of the style (F) and the stretch (Δx).

Table 2. The result of the calculation on the speaker with the average level of elasticity

Experiment	Mass (kg)	Force (N)	Stretch (m)	Spring Constant (N/m)
1	0.05	0,49	0,07	7
2	0.1	0,98	0,13	7,538
3	0.25	2,45	0,31	7,903

Table 2 shows that there is a relatively straight relationship between the style variable and the stretch, in which the greater the style given to a speaker will result in an increase in the amount of stretch produced by the speaker. This is in line with the hooke law that says "if the pull given to an speaker does not exceed its elasticity limit, then the increase in length of the object occurs is proportional to that pull given".

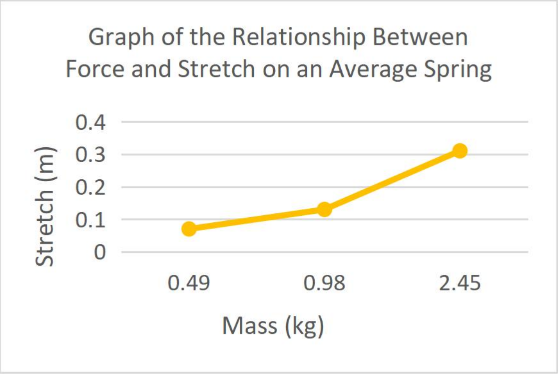

Figure 4. Graphic of the relationship between the style versus the stretch on the average accelerator

The chart above shows a linear relationship between the style variable and the stretch on the accelerator with the average elasticity. Of the 3 style variations applied, the average clamp can hold up to a maximum of 0.31 and a minimum of 0.07. Average clamp has a moderate elasticity so it can hold if given enough clamp.

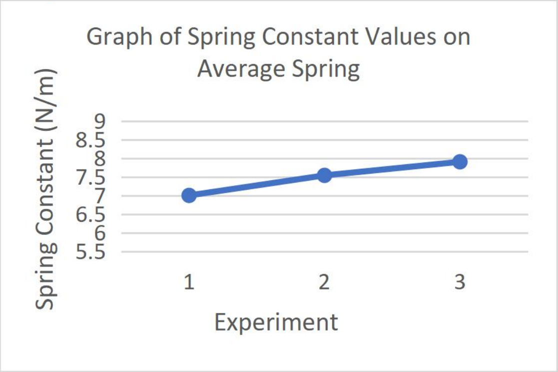

Figure 5. Graphic of constant values on average instantaneous values

The chart above shows the constant values of the fastener generated by the average fastener after given 3 different variations of style. The resulting constant (average) values are 7, 7,538, and 7,903 where the three values have relatively small differences that can be due to the uncertainty values in the style (F) and the stretch (Δx).

Table 3. The result of the calculation on a speaker with a hard level of elasticity

Experiment	Mass (kg)	Force (N)	Stretch (m)	Spring Constant (N/m)
1	0.05	0,49	0,05	9,8
2	0.1	0,98	0,09	10,88
3	0.25	2,45	0,21	11,66

Table 3 shows that there is a relatively straight relationship between the style variable and the stretch, in which the greater the style given to a speaker will result in an increase in the amount of stretch produced by the speaker. This is in line with the hooke law that reads "if the pull given to an speaker does not exceed its elasticity limit, then the length increase of the object occurs is proportional to that pull given".

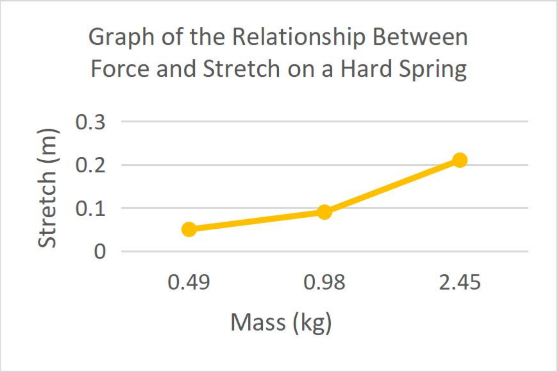

Figure 6. Graphic of the relationship between the style versus the stretch on the hard speaker

The graph above shows a linear relationship between the style variable and the stretch on a hard elastic pile. Of the 3 styling variations applied, the hard clamp can hold up to a maximum of 0.21 and a minimum of 0.05. Hard clamp has a small elasticity so it can hold if given a sufficient amount of clamp.

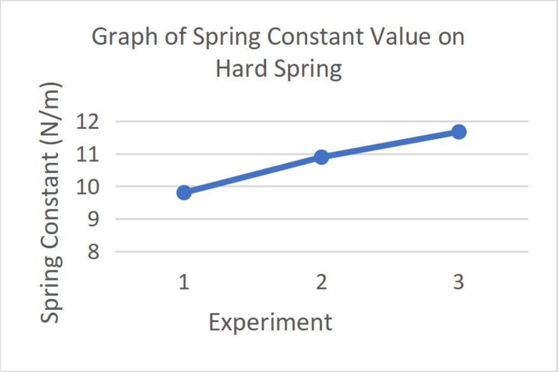

Figure 7. Chart of constant values of fastest on fastest

The chart above shows the constant values of the fastener produced by the hardener after given 3 different styles. The constant value of the hardener (hardener) is 9.8, 10.88, and 11.66, where the three values have relatively small differences which can be due to the uncertainty values in the style (F) and the stretch (Δx).

CONCLUSIONS

Based on the above explanation, it can be concluded that the data collection using the PhET virtual lab is repeatedly carried out with different mass variations, i.e., 50g, 100g, and 250g as much as 40 times data collection with 3 speakers that have different levels of elasticity. (semi-soft, medium, and hard). Calculations of the Semi-soft elasticity grades showed that the semi-softer can hold up to a maximum of 0.81 and a minimum of 0.17.

The results of the calculation on a spear with an average level of elasticity show that the average spear can hold up to a maximum of 0.31 and a minimum of 0.07. Average pins have a moderate elasticity so they can hold if given enough strength.

The calculation of a hard-elasticized clamp indicates that a hard clamp can hold up to a maximum of 0.21 and a minimum of 0.05. The hard bearer has a small elasticity so it can hold if given a sufficient amount of style.

It can then be concluded that the degree of elasticity of an accelerator affects the level of stretching that occurs after an acelerator is treated with a variable mass.

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