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Determining the Formula of Elasticity of the Bungee Cord based upon Hooke's Force Law Formula.

Abstract:

In this lab, we determined the formula of elasticity of the Bungee cord based upon Hooke's Force Law formula. Guaranteed by the CWE theorem, we were able to determine the cord potential energy was equal to the gravitational potential energy of the object. Keeping the length of the cord constant, we dropped five different weights from the same height, three attempts per weight. Recorded with an IPad, we were able to determine and recorded the lowest point of the drop and calculated our changing displacement. Using Excel, we were able to determine the formula for the bungee cord comparing to the actual Hooke's Law formula. We determined our formula to be $y = 1.3576 \times \Delta x^{1.5635}$. After determining the formula, we tested our formula by dropping the same weight and comparing the actual changing in length with the calculated change in length. We found out our formula has a percentage error of 10%.

Introduction:

The ultimate purpose of this experiment was to determine the formula of elasticity of the bungee cord based upon the Hooke's Law formula. We wanted to know this formula because we want to use this formula to calculate the length of the cord that is needed to perform the bungee jump. The CWE theorem and the Hooke's Force law theorem was widely used in this experiment. The CWE theorem states that in a "conservative" system – one that neither loses nor gains energy from outside the system. The total-energy sum of the potential and the kinetic energies is constant. The equation for the CWE theorem is $(PE + KE)_{top} = (PE + KE)_{bottom}$. Since there was no kinetic energy on top for the masses and there was no potential energy on the bottom for the masses, we could re-write the equation based on the formula for gravitational potential energy ($PE = mgh$) and Hooke's Fore Law ($PE = \frac{1}{2}k\Delta x^2$). The simplified equation is $mgh = \frac{1}{2}k\Delta x^2$ where:

m is the mass of the object

g is the acceleration due to gravitational force

h is the total height (x + Δx)

k is the spring constant

Δ*x* is the change in displacement.

By making the length, hence k, constant, and change the mass (*m*), we were able to determine the whether or not the formula of the elasticity of the cord is the same as the formula of Hooke's Force law.

Method:

We set up our lab as shown in Figure 1. From the previous lab, we determined the relationship between the k value for our cord with the length of the cord. Since the k value of the cord is changing over length, we kept the same cord length throughout our experiment. We tied a small knot on our cord in order for us to hang the different masses from it, and made sure the knot is as small as possible because of the elasticity of the knot itself. After finishing preparing for the lab, we chose five different masses ranging from 0.05 kg to 0.07 kg and drop them from the same height and recorded the length of the fall. By using excel, we were able to determine the average height fell, the change in distance, and the gravitational potential energy. After calculating those different values, we plotted our data into a graph in order for us to determine the formula of the elasticity of our bungee cord.

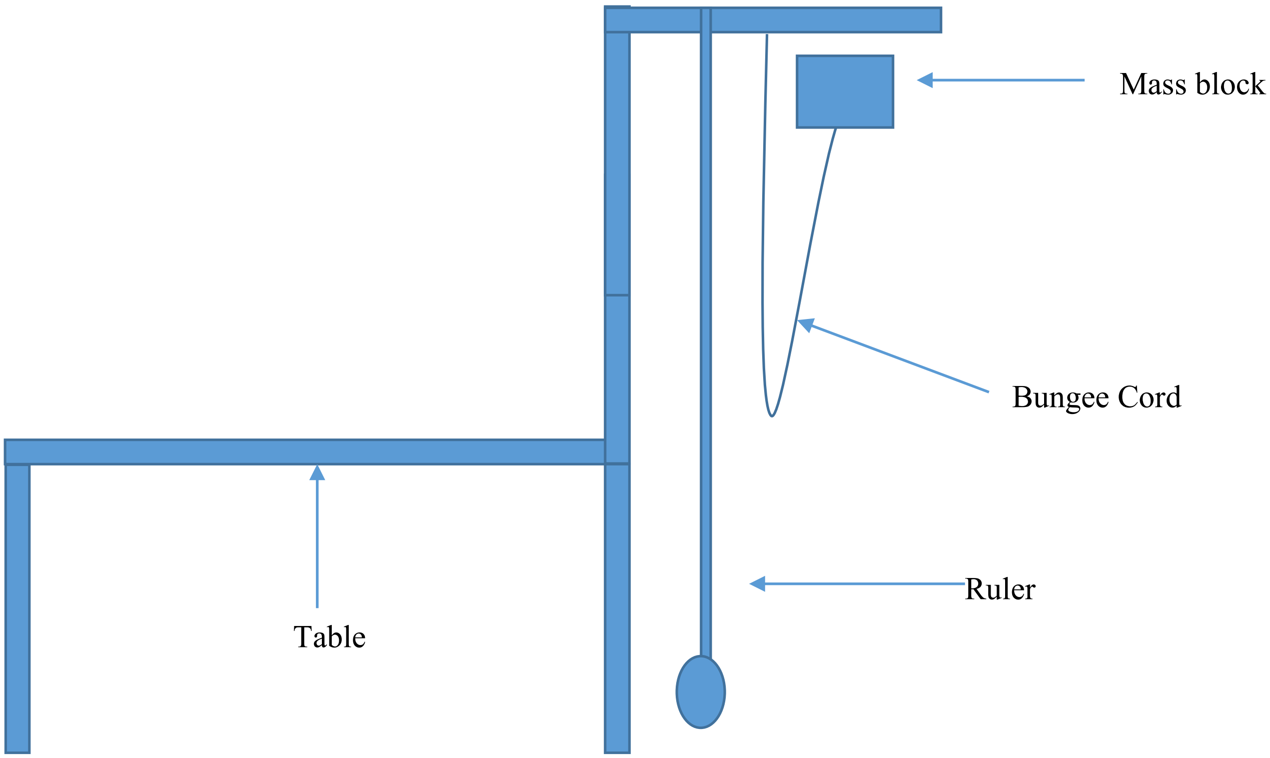

Figure 1 the setup of the lab. The length of the cord was remained and restricted to 0.60 ± 0.002m. The ruler is used to measure the total fall distance in order for us to calculate the changing displacement. We varied the weight of the mass block.

Upon obtaining our formula of elasticity for our bungee cord, we did a test run on how accurate our formula is. We changed the mass of our block and the height of our object. We then calculated the Δx, and according to Δx, we calculated the distance (x) we need for our bungee jump. We dropped the object and measured the actual height of the drop of the object to compare it with our experimentally derived height.

Results:

We determined the formula by finding the relationship between the potential energy of the object and the kinetic energy for the spring. According to table 1, we calculated the gravitational potential energy according to the mass, and height. From Figure 2 we can see is the graph between the gravitational potential energy and the change in displacement Δx.

Table 1: This is the raw data we collected from the experiment, we changed the weight of the hanger but kept the length unchanged.

Mass (kg)	h=height (m)	Average height (m)	mgh	Δx=h-L (m)
0.05	1.17	1.174666667	0.5756	0.5746667
	1.174			
	1.18			
0.055	1.235	1.237666667	0.6671	0.6376667
	1.24			
	1.238			
0.06	1.29	1.293666667	0.7607	0.6936667
	1.295			
	1.296			
0.065	1.346	1.345333333	0.857	0.7453333
	1.348			
	1.342			
0.07	1.398	1.396666667	0.9581	0.7966667
	1.39			
	1.402			

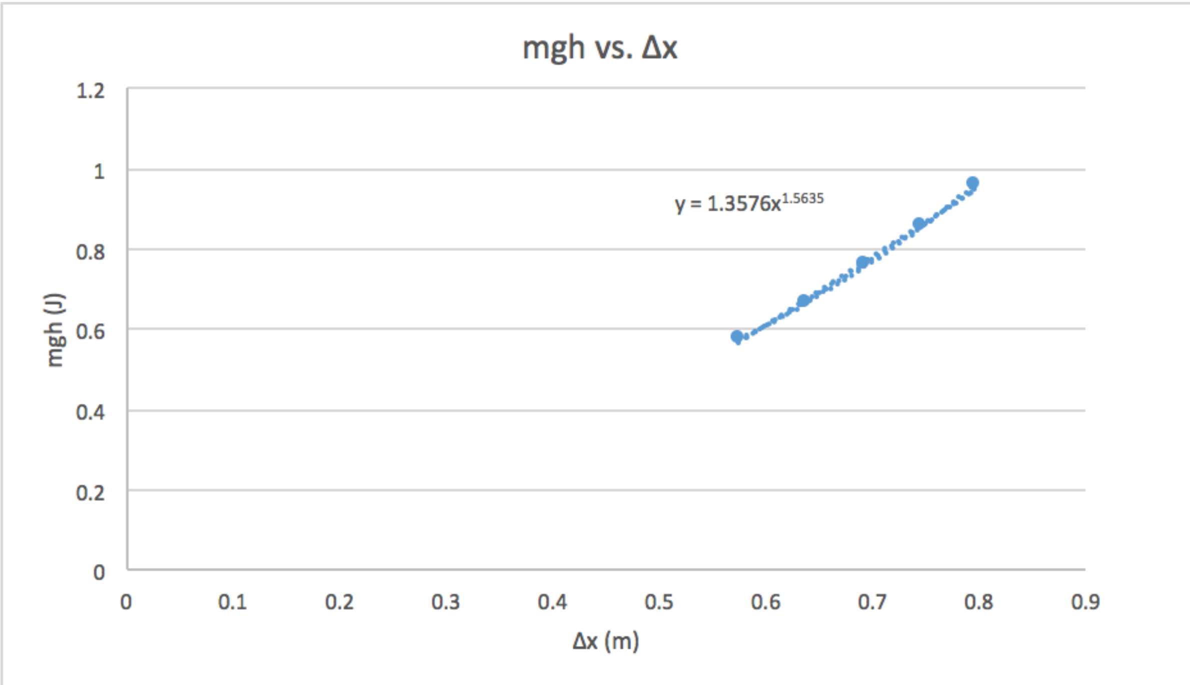

Figure 2: The relationship between the gravitational potential energy (mgh) with the changing displacement difference Δx.

From Figure 2 we can obtain the formula for the elasticity of the cord to be $y = 1.3576x^{1.5635}$ where x doesn't represent the original length, it represents the Δx. According to Hooke's Force Law,($\frac{1}{2}k\Delta x^2$). We determined that our coefficient 1.3576 is the value of $\frac{1}{2}k$ and instead of Δx^2, we determined the equation should be $\Delta x^{1.5635}$.

Discussion:

Our uncertainties were around 0.1 during our labs as it is a little bit difficult for us to obtain the most accurate data value from an IPad. We determined the reason why our group's equation for elasticity was not the same as Hooke's Force Law states is because our bungee cord is not a perfect spring that Hooke's law was created for. After determining the formula for the Bungee Cord's elasticity, we decided to test how well our formula fits into an actual experiment. We varied the mass(*kg*) and the height(*h*), and calculated the Δx for this particular mass and height. By using the height formula (h = x + Δx), we calculated the appropriate length for it.

After a couple test runs, we measured the difference between our experimentally calculated height with the actual height. We determined our percentage error to be 10% in our test run. As a group, we decided that the reason we have a 10% percentage error is because our uncertainty in our lab was high.

Conclusion:

This lab made it possible for us to calculated the length we needed for the bungee cord as were given the length and the change in displacement (Δx). In this lab, we determined that the formula for the elasticity of the Bungee cord is different from the formula of Hooke's Force law. We determined our formula to be $y = 1.3576x^{1.5635}$ with a percentage error of 10%.

Honor Pledge:

On my honor, I have neither given nor received any unacknowledged aid on this lab report.