Jay Roberts, Katie Volk 01 **10-24-16**

TITLE:

Finding K of a .29m Bungee Cord

ABSTRACT:

The goal of the experiment is to find as many properties of the bungee as possible. However, each property should pertain to the overall goal of the Bungee experiments and that is to be able find the K of the bungee at any point on the cord so that we will be able to choose a length, know the K, and have the egg survive the drop. The challenge is that the equation must be less than or equal to three times the weight, otherwise the egg will be cracked in the experiment. Newton's second law equation can be written as (F_B-mg=ma)≤3mg. The methods used in the experiment of week one are quite simple. The bungee cord is to be attached at some distance above the ground, which we chose to be 2m. Then, a knot is put in the cord so that the mass could hang freely. In week one of the experimentation, we chose to find the K for .29m. This was found by knowing the unstretched position (X_I), which is .29m and adding weight to the bungee causing the cord to stretch to its equilibrium position (X_E). This is the position where the force of the weighted object is equivalent to the force of the bungee cord. That is to say that mg=Kx. Each weight was recorded while X_E was also. This gave us a graph of Weight vs. $X_{E.}$ The equation yielded was W=2.5543X_E-0.2447, indicating that the K is approximately 2.6 N/m. The low value of K supports the fact that bungee cords usually stretch long distances. Since the graph was already linear, there was no need to linearize the data. The regression analysis gave us an uncertainty of .03N/m, which translates to a percent uncertainty of 1.0%.

INTRODUCTION:

Purpose or question: Finding the K of a .29 m cord. This is the start of finding different K's for different lengths in our next experiment so that a relationship of K versus length can be found and used to determine K of the length used in the final experiment with the egg.

Equation: mg-Kx=0
m-mass of the object (kg)
g-the acceleration due to gravity (m/s^2)
K- the constant of bungee cord (N/m)
x- the amount in meters the cord is stretched (m)

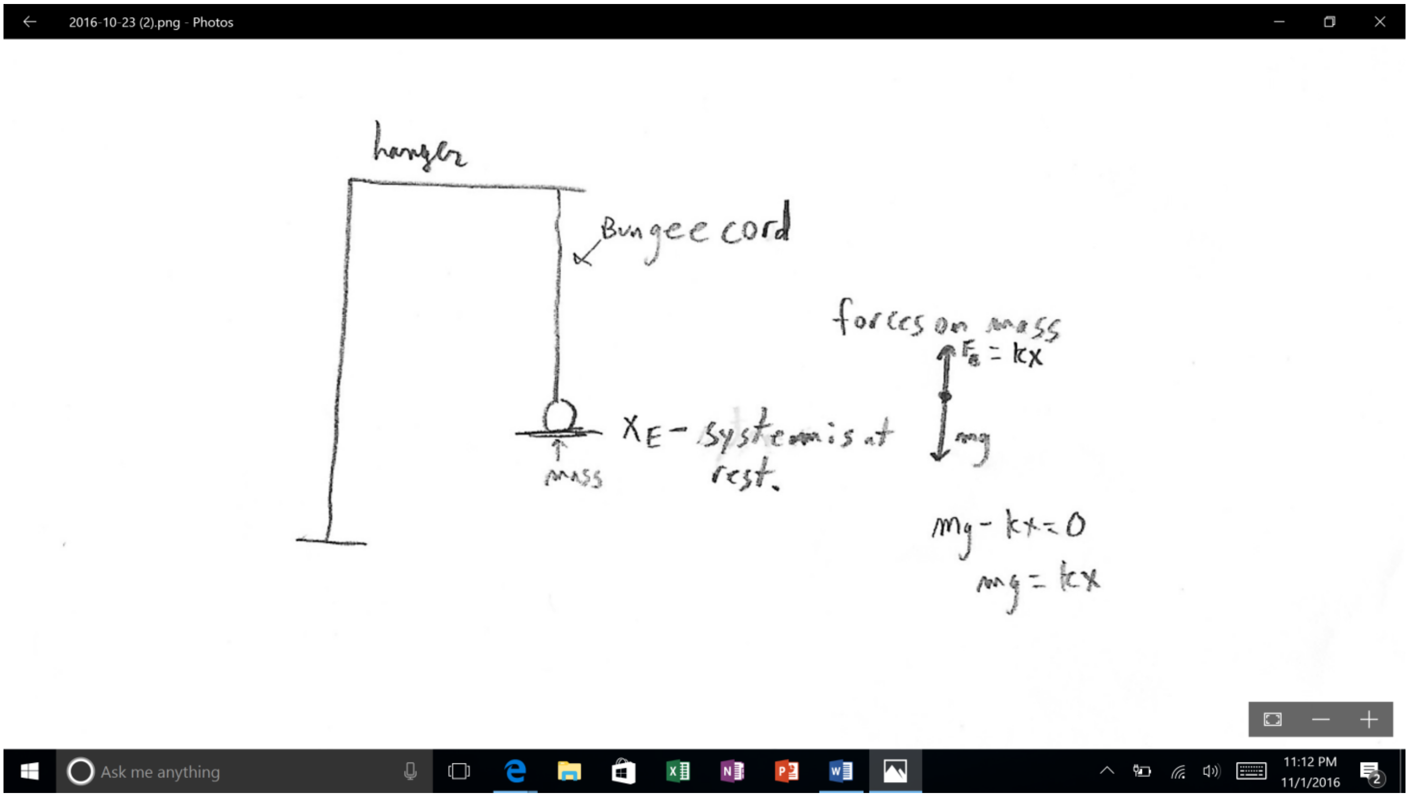
Basis or brief theoretical background: The weight of the object is equivalent to force of the bungee cord. Since mg is equal to the force of the bungee cord, the system is at rest. This enables us to measure the distance the string stretches. The amount that the cord stretches is directly related to how large the value of K is. If a low K, then the cord should stretch a big amount before breaking. If a high K , then the cord has the ability to stretch very little before breaking.

Hypothesis: I expect that the K of the .29m bungee cord is going to be low. The deceleration of the mass caused by the stretching of the cord is what makes the thrill of the bungee experience. So,

METHODS:

The method was simply to hang the bungee cord at two meters with a knot in the cord so that a mass could be suspended. This was the simplest experiment that can achieve our goal, which is finding the K of the bungee at a certain length. The mass that is hung will stretch the cord and the amount that the cord stretches will recorded each time.

Diagram:



Setup and procedure:

- A knot must be tied in the string so that it can be hung two meters above the ground.
- Then another knot must be tied so that a hanging mass can be attached.
- The hanging mass is 50 grams and after each trial 10 grams will be added.
- From each trial the mass and the position of equilibrium will be recorded.
- After ten trials multiply the masses by the acceleration due to gravity so that the weight (N) of the object can be plotted versus the position of equilibrium. This will cause the slope to be the K of the cord.

RESULTS:

The data collected was the mass suspended by the cord and the position of the mass when the system was at equilibrium. Then, before graphing, the mass was multiplied by the acceleration due to gravity so the weight of the object could be found. The weight was then plotted against the equilibrium position. This graph was already linear, so there was no need to linearize the graph. The regression analysis was done to the graph giving us a 1.0% uncertainty of the slope of the graph. The slope is of interest, because the slope is the K value of the cord at this length: 0.29m, which is the goal of the experiment.

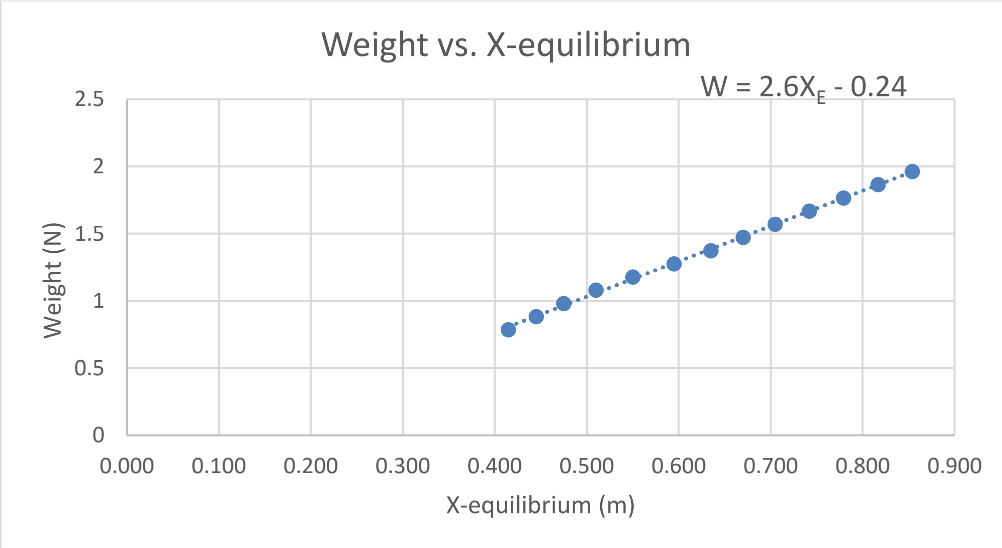
Table(s)

Fig.1- The equilibrium position of the hanging mass for bungee cord .29m. Each trial 10 grams was added to the mass.

X-equilibrium (m) ±.002m	Weight (N) ±.001N
0.415	0.7848
0.445	0.8829
0.475	0.981
0.51	1.0791
0.55	1.1772
0.595	1.2753

0.635		1.3734	
0.67		1.4715	
0.705		1.5696	
0.742		1.6677	
0.779		1.7658	
0.817		1.8639	
0.854		1.962	

Fig.2- The weight of the hanging mass vs. equilibrium position of the hanging mass. The slope, 2.5543 (±.03) N/m, is the K of the cord at the length of 0.29m.



Equation: $W=2.6X_E-0.24$

Used *Excel* regression analysis

uncertainty for slope= .03 % uncert=1.0%

uncertainty for y-intercept= .02 % uncert=8.0%

This uncertainty is most likely from the visual estimation of the measurement. That is to say that we had look at the meter stick with various space in between the mass and the meter stick, so the measurement could be off by a mm or so. Also, the masses can be dented just from years of use, and so the mass may not be exact.

Identify experimental value(s) of interest:

value obtained = K=2.6

uncertainty of experimental value(s) =.03 % uncert=1.0%

Technique of Propogation:

The excel function of regression analysis was used to obtain this uncertainty. Since the uncertainty was 1.0%, we can assume the variables that contribute to uncertainty are very minute. Such as, as previously stated, the uncertainty may have come from the visual estimation of the measurement. Also, the condition of the masses could cause some mass to be lost. Therefore, causing the mass to not be exact yielding uncertainty.

Pertinent info:

The acceleration due to gravity must be multiplied by mass so that force of gravity, the weight, can be plotted against the position of equilibrium. Because it is the weight of the object that is equivalent to the force of the bungee, not just the mass. So multiplying by 9.81 m/s^2 was necessary for the correct value of K.

Summarize Results:

Given that the weight and the force of the bungee are equivalent in this static situation. That is to say mg=Kx. Any mass plugged into the equation with the correct equilibrium system should yield the constant, K, of the system as long as the length of the unstretched cord is 0.29m. This related to the entire bungee experiment, because in a few weeks we are going to have to be able to choose a length and calculate the K so that the egg will not crack. The egg will crack if the overall equation, mentioned in the abstract, (F_B-mg=ma) is greater than 3mg. Finding the K for one length is a start for finding the others. In the next lab a graph of K vs length will be found and that slope will tell us what length the egg should be put at so the egg will not crack.

DISCUSSION:

Error analysis:

Uncertainty vs. error, or % uncertainty vs. % error, for each value of interest from Results section: Percent error is based off of two values being compared. We must find another value of slope (other than the slope of the entire graph) in order to make the comparison. So I chose the points (.415,.7848) and (.445, .8829) and calculated the slope between those two points. The slope was 3.27 between the two points. The percent error is 25% The uncertainty is the slope is 1.0%.

Sources of uncertainty:

As stated before, the uncertainty can be found by the mass not being exact. Also the visual estimation of the measurements can be added into the cause of uncertainty. Also, another source of uncertainty could be the consistency of going back to the same length of the cord. This is why we were told to stretch the cord out before using. If the cord never returns back to its original position, the measurements of the equilibrium position will be skewed. The conditions of the masses most likely are not the greatest source of uncertainty, while the consistency of the cord and the visual estimation of the measurements very well could skew the data more so than the masses.

Any further observations:

The fact that the standard error is so much higher than the percent uncertainty concerns me. This is most likely due to the fact that I only checked for one point on the graph. The slope of the entire graph is the average of all the slopes at each point. So, an outlier in the graph is not surprising.

My hypothesis was correct in saying that K should be low, because bungee cords are meant to stretch. Indeed, the K was rather low, only 2.6 N/m. The results were also consistent because the K stayed constant for the bungee at this given length. The only time the K calculated is unsupported is in the standard error, and that is because it is the K for just one point as opposed to the entire graph.

CONCLUSION:

The experimental outcome was to find the K for a certain length of the bungee cord. In our case, the length was 0.29m and the K that was found is 2.6 N/m.

Implications of these conclusions:

This is helpful in our next step of this experiment, because we are going to graph length vs. K values next lab. This should let us know the K value of any length given. By knowing the K value of a given length, we will be able to choose the best position at which to put the egg, so egg will not crack.

REVISIT ABSTRACT:

The goal of the experiment is to find as many properties of the bungee as possible. However, each property should pertain to the overall goal of the Bungee experiments and that is to be able find the K of the bungee at any point on the cord so that we will be able to choose a length, know the K, and have the egg survive the drop. The challenge is that the equation must be less than or equal to three times the weight, otherwise the egg will be cracked in the experiment. Newton's second law equation can be written as (F_B-mg=ma)≤3mg. The methods used in the experiment of week one are quite simple. The bungee cord is to be attached at some distance above the ground, which we chose to be 2m. Then, a knot is put in the cord so that the mass could hang freely. In week one of the experimentation, we chose to find the K for .29m. This was found by knowing the unstretched position (X_I), which is .29m and adding weight to the bungee causing the cord to stretch to its equilibrium position (X_E). This is the position where the force of the weighted object is equivalent to the force of the bungee cord. That is to say that mg=Kx. Each weight was recorded while X_E was also. This gave us a graph of Weight vs. X_E. The equation yielded was $W=2.5543X_E-0.2447$, indicating that the K is approximately 2.6 N/m. The low value of K supports the fact that bungee cords usually stretch long distances. Since the graph was already linear, there was no need to linearize the data. The regression analysis gave us an uncertainty of .03N/m, which translates to a percent uncertainty of 1.0%.

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

Pledged: Jay Roberts