Lab Report Outline—the Bones of the Story

Your name: Evan Kramer **Section:** 04 **Date:** 10-19-2016

TITLE: Does the bungee cord follow Hooke's Law (F= -kx) and if so, what is its Hooke's constant?

ABSTRACT:

We developed a model to test whether or not our bungee cord follows Hooke's Law, and to find its Hooke's constant. We preformed our experiment by tying a section of the bungee to a stand and hanging different masses off the end in order to measure its stretch. Since we measured at static equilibrium the weight acting on the bungee was equal to the force of the bungee. We derived an equation trying to model Hooke's Law using the force of the bungee and the distance the bungee cord stretched. Our equation modeled Hooke's Law in this form, $x= F_b/k$, so our slope value was the inverse of Hooke's constant. Our slope value was 0.29 m/N, so our value for Hooke's constant was 3.45 N/m. We tested this value by plugging values into Hooke's law equation using our calculated Hooke's constant. By comparing these theoretical values to our experimental values, we got a very high percent error compared to our percent uncertainty. So, we concluded that our value for Hooke's constant was not acceptable.

INTRODUCTION:

Purpose or question:
Does the bungee cord follow Hooke's Law?

Relevant equation(s), identifying variables:

$F= -kx$, $F_b= -kx$	**F= force of a spring (or in this model a bungee),**
$F_b - mg= ma$	**F_b= force of the bungee**
$x_o - x_L= x$= total bungee stretch	**m= mass, a= acceleration, g= gravity**
	x_o= equilibrium length of the bungee with weight (just hanging)
At Static Equilibrium:	**x_L= length of the un-stretched bungee**
$F_b= mg= W$	**k= Hooke's constant**
	x= distance the bungee is stretched
	W= Weight

Basis or brief theoretical background:

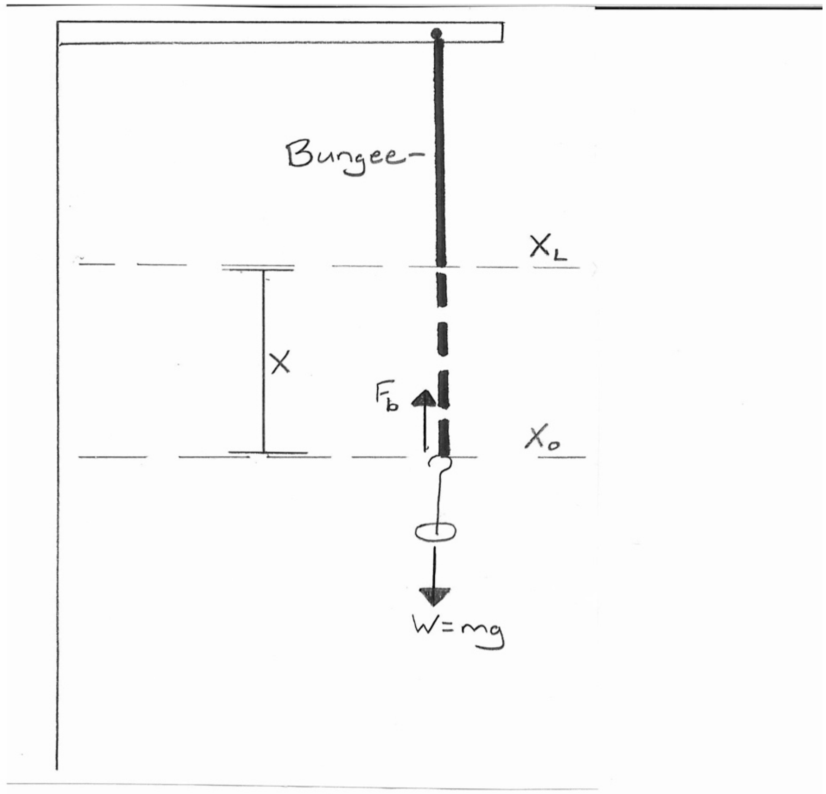
> **We are attempting to create the best bungee jump (most exciting while still being safe) for an egg we are going to drop, so in figuring out how to create our bungee jump we first needed to figure out if the bungee cord follows Hooke's Law and what its Hooke's constant is. Similar to a spring, our bungee cord has elastic movement and can oscillate, which is why we believe it will follow Hooke's Law.**

Hypothesis (or expectations):

> **I predict that the bungee cord will follow Hooke's Law and have a Hooke's constant value.**

METHODS:

> **We tied a section of the bungee cord over a tall rod and hung it down 0.25 m. We added weight to the end of the bungee and measure the total distance stretched, so we could use the data to calculate Hooke's constant.**



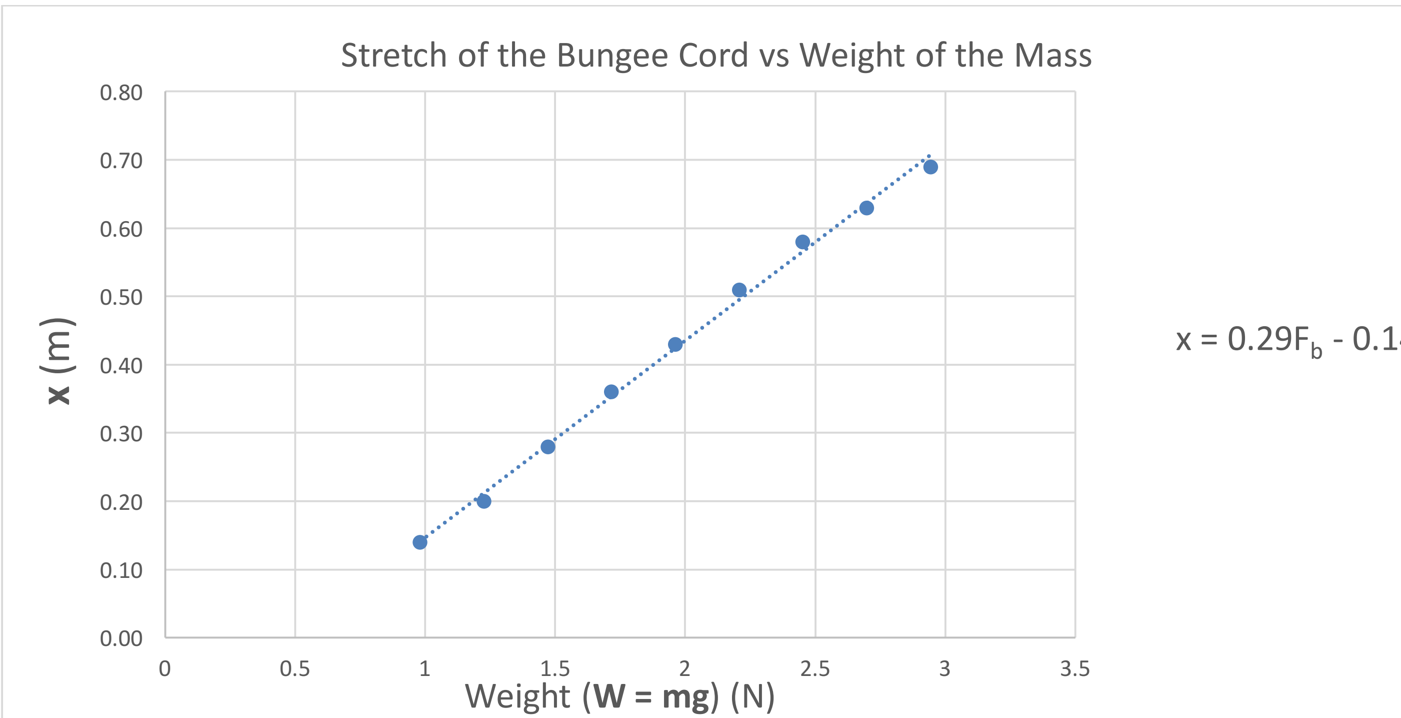
Setup and procedure:

1. **We stretched the entire length of our bungee cord 3 times to make sure it would remain at about the same length when returning to x_L after having weight added to it**
2. **We tied a "balloon" knot in our bungee cord at one end and other knot further up the bungee so that when it hangs it reaches 0.25 m (x_L).**
3. **We put the loop in the middle of the bungee around a rod a couple meters up in the air**
4. **We attached a tape measure next to the bungee to make measuring x_o easier**
5. **We added weight to the bungee, starting with 0.100 kg because we discovered in previous experiments that anything less than that did not move the bungee a significant amount needed for accurate calculations.**
6. **After the bungee had reached x_o and stopped moving we recorded x_o then calculated x**
7. **We repeated numbers 5 and 6, each time re-measuring x_L incase the bungee had stretched and increasing the weight added by 0.025 kg.**
8. **We stopped the experiment once the weight reached 0.300 kg**
9. **We analyzed our data, imputed it into excel and created a graph of stretch vs weight.**

RESULTS:

We recorded the distance the bungee stretched as we added each separate mass to it along with the individual uncertainties of each distance stretched. We then graphed the distance the bungee stretched vs weight of the hanging mass, which gave us the inverse of Hooke's constant (the slope).

Mass of hanging mass **m** (kg) (±0.001 kg)	Un-stretched length x_L (m) (±0.01 m)	Weight of Mass (N) (±0.001 kg)	Static Equilibrium x_o (m) (±0.01 m)	Stretch **x** (m) (±0.01 m)
0.100	0.25	0.981	0.39	0.14
0.125	0.25	1.226	0.45	0.20
0.150	0.25	1.472	0.53	0.28
0.175	0.25	1.717	0.61	0.36
0.200	0.25	1.962	0.68	0.43
0.225	0.25	2.207	0.76	0.51
0.250	0.25	2.453	0.83	0.58
0.275	0.25	2.698	0.88	0.63
0.300	0.25	2.943	0.94	0.69



Linear equation:

$x = 0.29F_b - 0.14$

uncertainty for slope= ±0.006 m/N   % uncert= 2%

uncertainty for y-intercept= ±0.01 m   % uncert= 7%

Experimental value(s) of interest:

Our experimental value obtained was our slope, 0.29 m/N, which is the inverse of our Hooke's constant value. So our calculated Hooke's constant (k) is 3.45 N/m.

value obtained = 0.29 m/N
Experimental Value = 3.45 N/m
uncertainty of experimental value(s) = ±0.01 N/m   % uncert= 4%

technique used for propagation of uncertainty: **a simple sum or difference**

Since we were measuring the distance of the stretch of the bungee at static equilibrium, the force of the bungee (F_b) and the weight (W=mg) are equal to each other. So since we took our data measuring the weight, we inputted that into the graph, but it was equal to F_b which is what we inputted into the equation. Also, our equation was only calculated using an un-stretched length of 0.25m, so, based on this experiment, we aren't sure what would happen if x_L was longer.

Summarize Results

- **As we added more weight to the bungee cord the force acting on bungee increase, therefore increasing the distance the bungee was stretched. Our equation for predicting the distance stretched is $x= 0.29F_b - 0.14$. While our obtained value is the slope, 0.29 m/N, our calculated experimental value is Hooke's constant at 3.45 N/m with 4% uncertainty.**

DISCUSSION:

We were able to find a linear relationship between the force of the bungee and the stretch, so we can relate our equation to the equation of Hooke's Law. In order to compare our calculated Hooke's constant to something, we calculated what the force at each stretch should have been based on our Hooke's constant. In comparing these theoretical values to our experimental values, we got around 25% error on average. This is probably because of our y-intercept value which causes our equation to not exactly model Hooke's Law. Since our percent uncertainty in the slope value was only 2%, while our percent error is upwards of 25%, our calculated Hooke's constant, 3.45 N/m or the inverse of 0.29 m/N, is not acceptable. Although when using our complete equation to calculate theoretical stretches, we got less than 3% error. Based on this our full equation is acceptable since our percent uncertainty was 4%.

Sources of uncertainty

- **We included the lengths of the tied loops in our stretch, and since they were double the bungee cord they had a different Hooke's constant.**
- **The fact that our y-intercept in our equation was not (0,0) added a large amount of uncertainty to our value for Hooke's constant while we tested it.**
- **Even though the bungee went back to the same x_L value each time, the repeated stretching of the bungee could have weakened it causing it to give more to the weight each time.**

Our main result does not support our hypothesis. We hypothesized that our bungee cord would follow Hooke's Law and have a Hooke's constant. Since our graph was linear it looked like our equation would be able to follow Hooke's Law but when test our value we obtained for Hooke's constant we got very high error compared to our uncertainty meaning that our value was not acceptable within our uncertainty. Our full equation was able to be used to calculate distances of stretch the bungee should experience with minimal error (less than 3%), which could be helpful in some cases, but is not what we were testing to find.

CONCLUSION:

In conclusion, we were not able to find an acceptable Hooke's constant for our bungee cord. I do not believe that it is safe to say that our bungee cord does not follow Hooke's law without further testing with less uncertainty, just that our value for Hooke's constant is not acceptable. This means that if we want to model our bungee cord after Hooke's Law we need to experiment more with our bungee and possibly see how it reacts to longer x_L values, or being subjected to a more abrupt force similar to in a bungee jump. Our next step will be to test the bungee at different x_L values, then finding what weight, if any, the bungee begins to lose its ability to return back to its normal length.

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

***Pledged: Evan Kramer* 10-26-16**