Lab Report Outline: Bungee Challenge II

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Section: Th. 8:35am

Date: 11/16/2016

TITLE: **Do the k values of a free-falling bungee system at different lengths of cord remain consistent with the k values determined from treating the cord like an ideal spring?**

ABSTRACT:

In our last bungee experiment, where we hung a mass from a bungee,we determined that the k value of a bungee cord that behaves like a spring varies by length of bungee cord used. We also found an equation that gave us the k value in terms of length. In order to confirm that this equation will work, so that we can accurately find cord measurements that will exert the correct amount of force on the egg for the most "optimal" bungee jump, we set up a smaller-scale full bungee jump using jumpers of varying weights and varying lengths of cord. We were able to use the CWE theory equation to set up a formula that calculates the k value based on the jumper's potential energy at the bottom of the jump. We then used this data to find a model that predicts k as a function of elastic band length, but it turned out to be a different equation than what we found in the last lab. Going into the bungee jump, we will need to address the reasons for these differences in order to find a model that will lead us to establishing the best parameters for the jump.

INTRODUCTION:.

We know that the k value of an elastic cord that behaves like a spring varies according to its length. Now we are trying to find out how closely to a spring the bungee system behaves when the weight is dropped from the top of the system and when the energy of the system at the point where the weight has fallen as far as it will go is accounted for. We want to see if the k function we find in this experiment is consistent with what we found previously, since the same cord and weights are being used. We found this k value by plotting a graph of the potential energy at the top of the jump against the potential energy at the bottom, since that gave us a slope value of k

Relevant equation(s) specific to this experimental purpose or setup, identifying variables:

$$(PE+KE)_{Top} = (PE+KE)_{Bottom}$$

$PE_{Top} = mgh$, where m is the mass, h is the height of the jump, and x is the length the cord stretches

$$PE_{Bottom} = \frac{1}{2}kx^2$$

Because we are concerned with the point at which the weight has fallen as far as it can go from rest ($KE_{Top} = 0$), we can say that the only energy in the system at the bottom of the jump (where it is instantaneously at rest) is potential energy of a Hooke's Law spring…

$$PE_{Top} = PE_{Bottom}$$

$$mgh = \frac{1}{2}kx^2$$

-mgh represents y and ½ x^2 represents x in the y = kx equations that we graphed

Hypothesis (or expectations):

We still expect the k value to act the same as we found previously, which we found as getting smaller as the length increased. We are predicting that when we set up a mini bungee jump situation, the k function of length we get will be similar to what we got before because the system will still behave like an ideal spring.

METHODS:

We will be dropping three different weights at three different lengths of cord, so that we can graph a function based on the equation above that gives us a k value for the length.

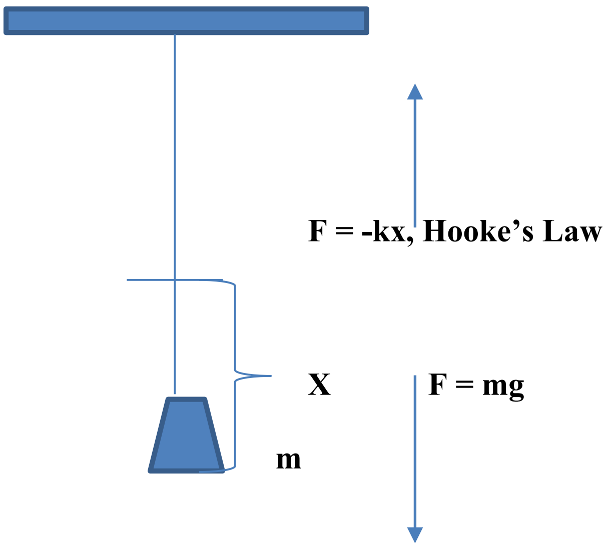


Figure 1, Experimental Design – The mass starts at rest from the top of the system and falls from there until x length past equilibrium length.

We measured the length of our elastic bungee cord and tied it, maintaining as close to the same length as possible, to the overhead rod. Then, we attached the weight and measured the difference between the new equilibrium length and the unstretched length. We made sure to use weights that wouldn't stretch the cord more than three times its length in order to preserve the physical integrity of the cord.

- **We used three different masses for the hanging weight (0.05, 1.0, 0.15 kilograms)**
- **We also used three significantly different cord lengths (0.198, 0.373, 0.617 meters) and recorded the new equilibrium lengths with the varying weights attached to each length.**
- **We dropped the weight from the top, starting it at rest by holding it still, and recorded the maximum length it fell, performing three trials with each weight at each length.**
- **We used a motion camera to measure the bungee's displacement. This allowed us to pinpoint where exactly the weight fell to its maximum length**

RESULTS: *What do you get? Report your data and analysis—**Just the facts**, but give all a reader needs to know! (No need to show calculations, though.) Refer to the* **Uncertainty Guide (UG)** *for details on finding uncertainties in data and equations. Refer to the* **Excel Guide (EG)** *for technical details on tables and graphs, and on **linearizing** a graph.*

We measured the equilibrium length and subtracted it from the total height each weight dropped in order to find h. Then we multiplied that by the gravitational constant and the mass in order to get mgh, a component of the potential energy conservation equation.

Table(s), inserted from *Excel*, **formatted and labeled according to the "Formalities" document** in Resources tab, including "raw" data and averages/standard deviations where appropriate, and **with columns or uncertainties identified further** in caption or in text after the table, if needed:

H average (m) ±0.1m	Mass (kg) ±0.01kg	Mgh ± 0.1
0.306	0.05	0.150
0.408	0.1	0.401
0.611	0.15	0.899

Figure 2: Height, mass, and mgh at cord length 0.198m.

H average (m)) ±0.1m	Mass ±0.01kg	Mgh ± 0.1
0.625	0.05	0.307
0.809	0.1	0.794
1.024	0.15	1.507

Figure 3: Height, mass, and mgh at cord length 0.373m.

H average (m)) ±0.1m	Mass ±0.01kg	Mgh ± 0.1
0.994	0.05	0.488
1.290	0.1	1.266
1.632	0.15	2.402

Figure 4: Height, mass, and mgh at cord length 0.617m.

We graphed the found mgh values and graphed them against their corresponding 1/2 x^2 values, so that the resulting slope would be equal to k.

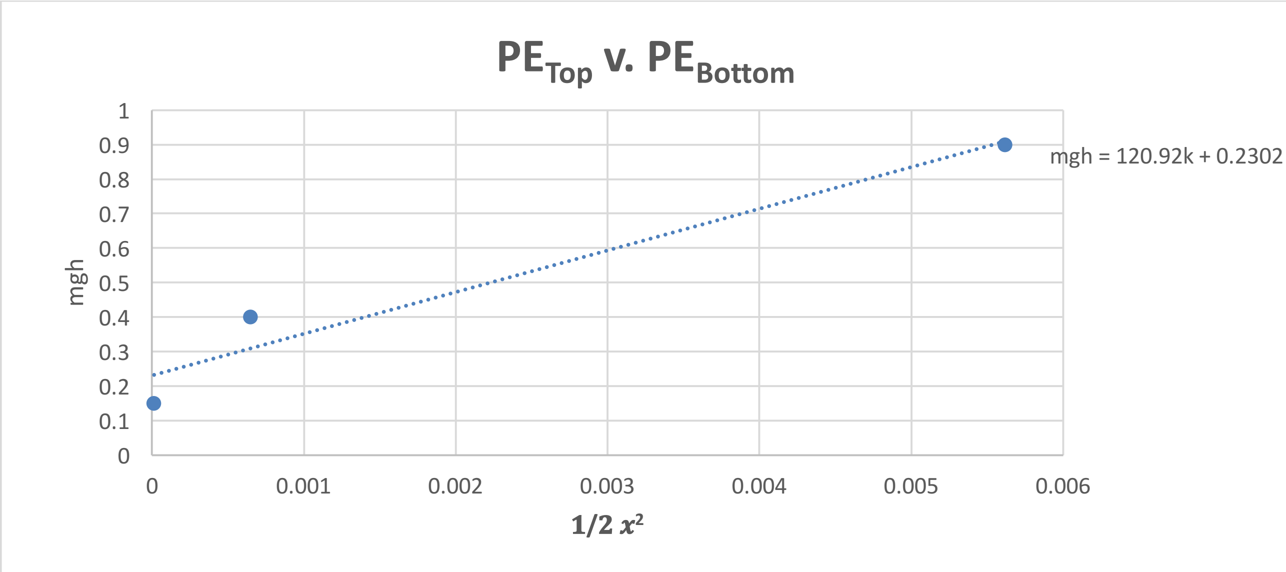


Figure 4: Potential Energy at the top versus at the bottom. The slope 120.92 represents the k value at 0.198m.

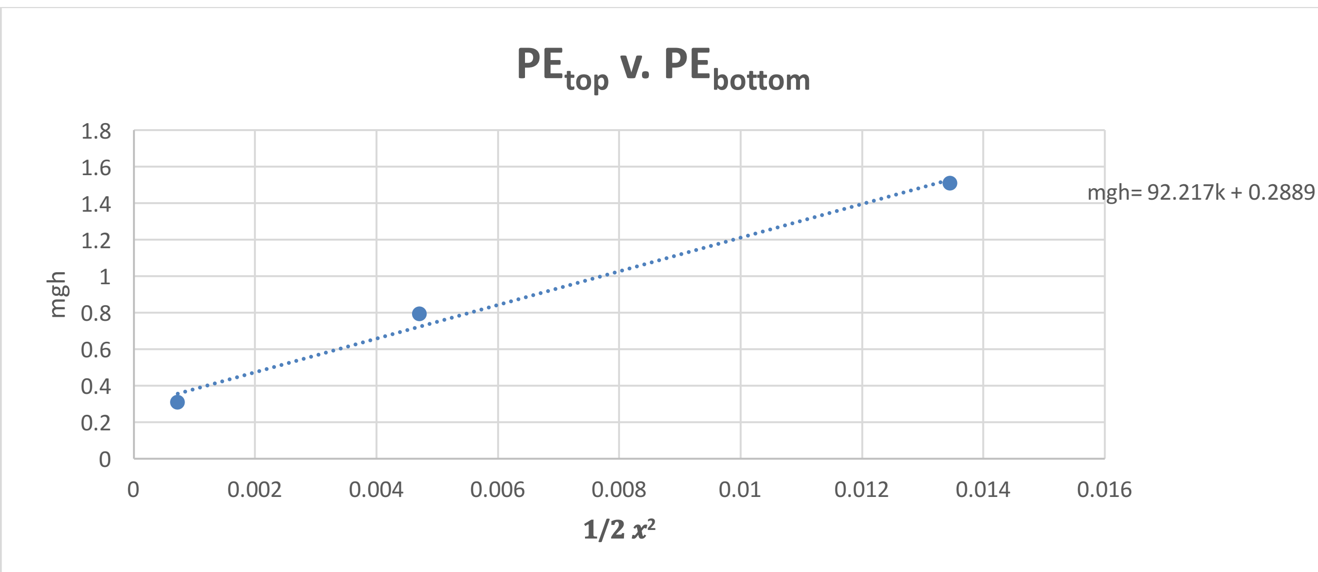


Figure 5: Potential Energy at the top versus at the bottom. The slope 92.217 represents the k value at 0.373m.

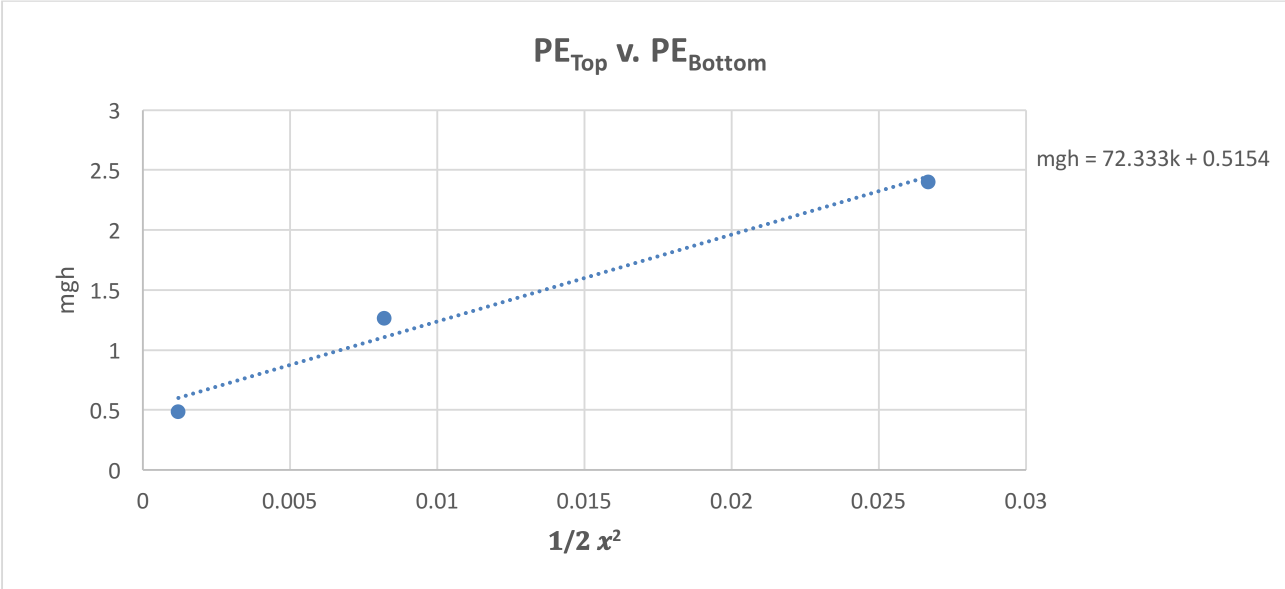
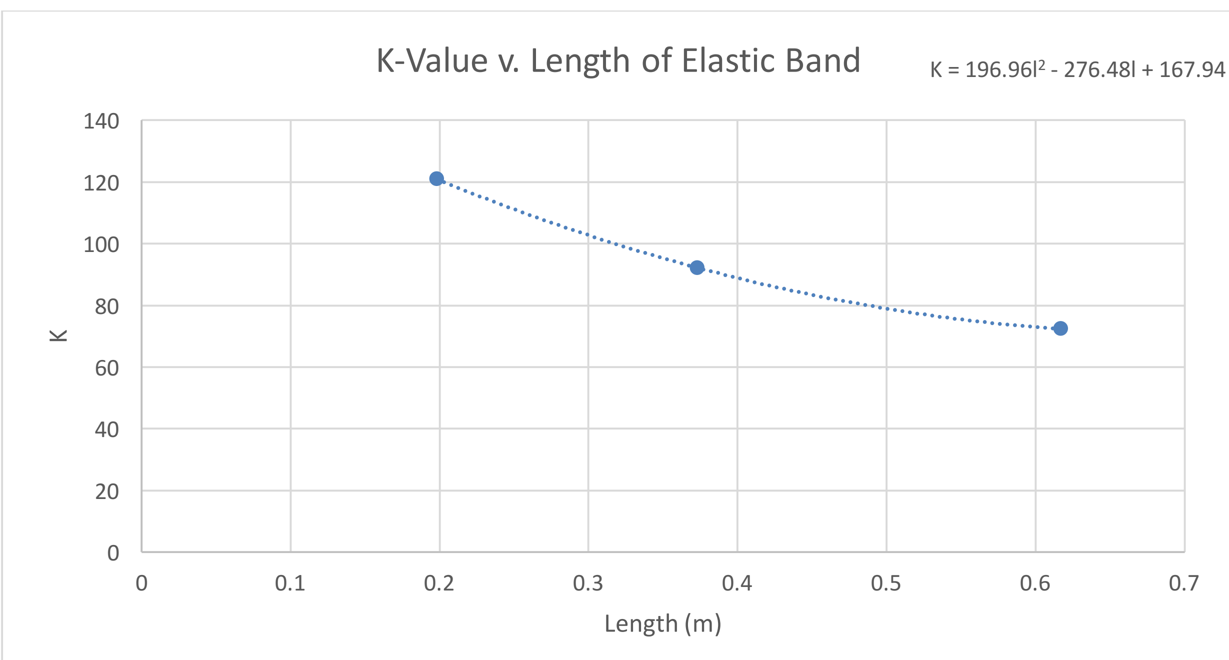


Figure 6: Potential Energy at the top versus at the bottom. The slope 72.333 represents the k value at 0.617m.

Length of Cord	K Value
0.198	120.92
0.373	92.217
0.617	72.333

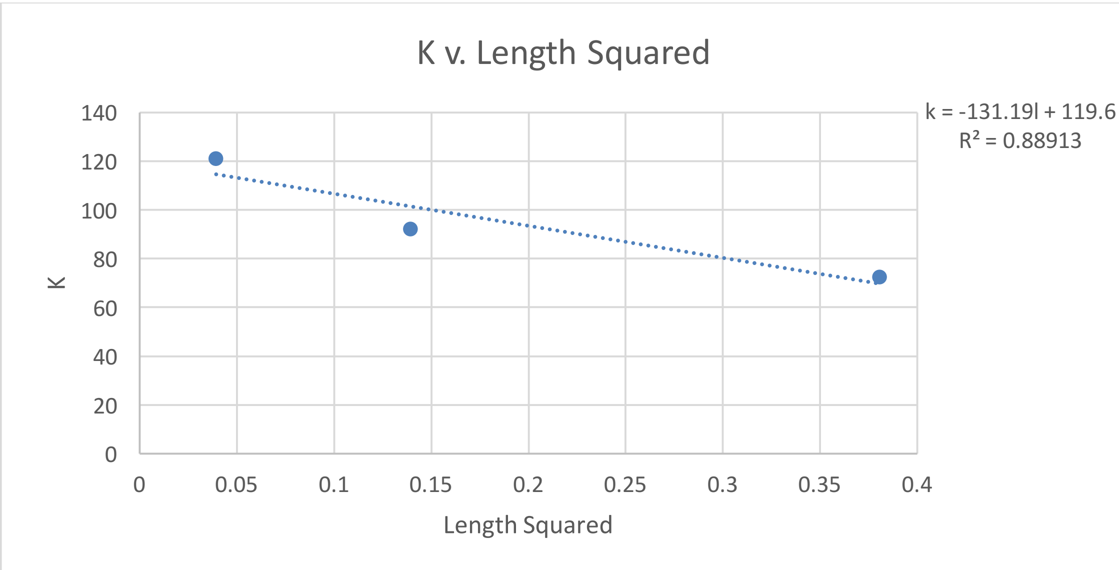
We see from the table above that the k value trends in the same way we found in our last experiment- it decreases when length is increased. Now we must plot a graph of k v. length in order to determine if this experiment will yield the same equation and therefore give us a way to find an accurate k value for our bungee project.



r^2=0.96

Figure 7: Graph of K against Length. This graph gives us an equation for k in terms of the length of the elastic cord.

***Linearized* graph**



Use *Excel* regression analysis on any graph that has a **linear** fit only (see EG), to obtain:

uncertainty for slope= 46.33 % uncert= 26%
uncertainty for y-intercept= 10.89 % uncert= 17%

Now you are ready *to interpret (not evaluate) your results in light of your purposes and conceptual background/theory. Here, identify, extract and calculate those experimental value(s) of interest from your graph(s) and equation(s)—usually embedded in the coefficients— that you can* later *(in Discussion) compare to accepted or expected value(s) for precision, accuracy, significance, etc. Report them…*

Identify experimental value(s) of interest, why it is of interest, and how/from where obtained, briefly:

value obtained = The function of k: **k = -131.2l + 119.6**

uncertainty of experimental value(s) = **±46.33**slope, **±10.89**intercept
% uncert= **26%**slope, **17%**intercept
Used Excel Regression Analysis

We found a model to evaluate k in terms of length, but it is much different than what we had found when we found k differently in the previous lab.

DISCUSSION:

There is no technically accepted k value, as the k value can vary on an elastic bungee system depending on the type of cord used, the number of cords used, and, what was primarily examined in this experiment, the length of the cord. Since we can't evaluate our results based on an accepted

theoretical number, we would have to evaluate it by testing our equation. We would do this by setting a random measured cord length, predicting k, and carrying out the experiment the same way we did in this procedure to see if our value matches the predicted one. However, the high percent error does make our result not seem reliable.

Sources of uncertainty and their relative significance:

Only having three points of data on our graph could have given us skewed results. The equations for PE_{Top} v. PE_{Bottom} seemed to start out linear, but then become less linear at around .15kg. More data could have given us a more accurate graph. The knots we tied could also have been a source of uncertainty; we had to re-tie the knots between experiments and they could not have all been the same, and therefore affected the overall movement of the bungee system differently. One more source of error could have come from the fact that we measured the maximum length the weight fell by using a slow-motion camera. The camera was set a few feet away, so it was difficult to approximate the distance by anything closer than a centimeter.

In a couple sentences**, describe whether your main results support your hypothesis.** How well were the results in agreement with theory, expectations, or otherwise deemed “acceptable”? Why/how so, or not?

The results support our hypothesis in that we confirmed that k does shift the same way depending on how length is varied, but it did not support our prediction that our formula would be approximately the same as the one we got in part I (which was k = -12.8x+13.6). At this point, further experimentation and correcting of possible errors would have to happen before we could determine which formula is the “acceptable one.”

CONCLUSION:

We found that k behaves the same in a spring and bungee setting, but in this experiment we found a completely different equation for k than in the first lab. This could suggest significant errors in the experiment or in calculations, or that this bungee system does not behave as similarly to an ideal spring as we had originally thought. The former, however, seems more plausible, so in order to be able to determine the optimal measurements for an effective bungee jump, we will have to work to find a more agreeable equation for the k value of this system.

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