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Bungee Challenge Week 1

ABSTRACT:

This lab report presents our first experiment to determine an appropriate model formula for our final Bungee Challenge. We used Hooke's Law, F=kx, to find the relationship between the length of bungee cord and the effective spring constant. Later, we will use our understanding of this relationship to prevent damage to our egg in our Bungee Experiment. We chose five different cord lengths and dropped five different weights from each string's equilibrium position. Using a Newton's Second Law diagram, we were able to determine the equation mg=kx. By calculating mg and measuring the change in x for each of the twenty-five drops, we could solve for the effective spring constant, k. Combining the graphs for each string length, we created one graph that compared k to cord length. This graph allows us to understand how the length of the cord affects the effective spring constant k. Our graph had the equation $y = 1.6942x^{-0.982}$, which we linearized by raising each length to -1. We performed a linear regression analysis on our linearized graph and found the uncertainty of our slope to be 0.0295. As this uncertainty is fairly low, we feel confident in our model equations' ability to predict the effective spring constant from the length of the cord.

INTRODUCTION:

In this lab, we sought to better understand the relationship between the effective spring constant, k, and the length of the cord. We hope to use the information we gather from this experiment in our final Bungee Drop Challenge, where we will attempt to drop an egg as low as possible to the ground without damaging the egg. Combining Newton's Second Law, F=ma, and Hooke's Law, F= kx, we derived the formula mg=kx. We hypothesize that, by performing multiple trials at different cord lengths and weights, we will be able to derive an accurate equation that relates k to the length of the cord. We hope to then use this relationship to successfully execute our final Bungee Drop Challenge.

METHODS:

We attempted to create an experiment that would allow us to relate the effective spring constant to the length of the cord. To do so, we chose five different string lengths and dropped five different weights from each different length. We measured the displacement of the knot tied in the string on which the weights were hung from the unstretched, or equilibrium position, to the stretched position. We calculated the force, mg, of each trial, before graphing the force by the change in x in excel. The slope of the line on each of the five graphs represented the effective spring constant, k. In our analysis, we graphed the different spring constants we found by the length of the string to get a relationship between cord length and k. We then linearized this final graph by raising the cord lengths to -1, as indicated by our power equation with an exponent of -0.982. Finally, we performed a linear regression analysis on our linearized graph to find the uncertainty of the effective spring constant k.

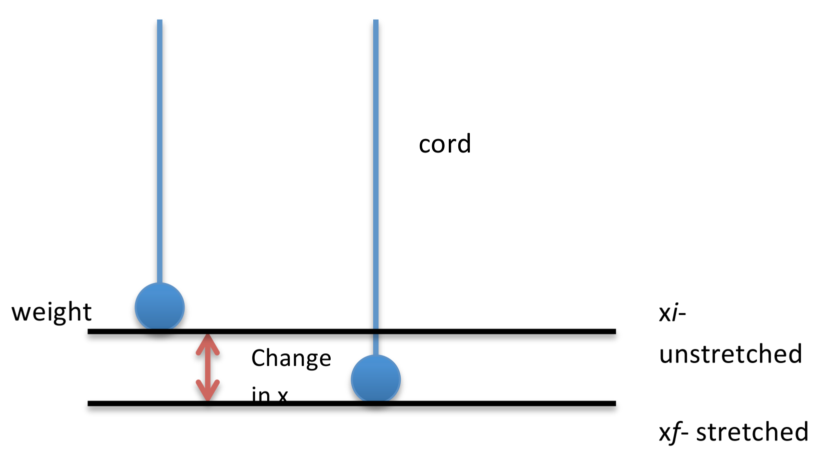


Figure 1: Experimental Set up

Figure one demonstrates how we set up our bungee cord system. The cord was hung from a vertical height that would prevent the weight from hitting the floor. Weight (.05 kg, .06 kg, .07 kg, .08 kg, .09 kg, and .1 kg) was added or removed from the cord and the change in x was measured.

RESULTS: Our results include our raw data, five graphs that show the force by the change in x with a slope of k, and a graph comparing k to length both linearized and not linearized.

Length= 1.59

XL (Unstretched) (m)	Xo (m)	mass (kg)	Delta X (m)	F (N)
1.59	1.864	0.05	0.274	0.4905
1.59	1.932	0.06	0.342	0.5886
1.59	2.097	0.07	0.507	0.6867
1.59	2.116	0.08	0.526	0.7848
1.59	2.209	0.09	0.619	0.8829
1.59	2.256	0.1	0.666	0.981

L= 1.061 m

XL (Unstretched) (m)	Xo (m)	mass (kg)	Delta X (m)	F (N)
1.06	1.261	0.05	0.201	0.4905
1.06	1.319	0.06	0.259	0.5886
1.06	1.376	0.07	0.316	0.6867
1.06	1.44	0.08	0.38	0.7848
1.06	1.518	0.09	0.458	0.8829
1.06	1.586	0.1	0.526	0.981

L= .76 m

XL (Unstretched) (m)	Xo (m)	mass (kg)	Delta X (m)	F (N)
0.76	0.898	0.05	0.138	0.4905
0.76	0.939	0.06	0.179	0.5886
0.76	0.982	0.07	0.222	0.6867
0.76	1.028	0.08	0.268	0.7848
0.76	1.079	0.09	0.319	0.8829
0.76	1.133	0.1	0.373	0.981

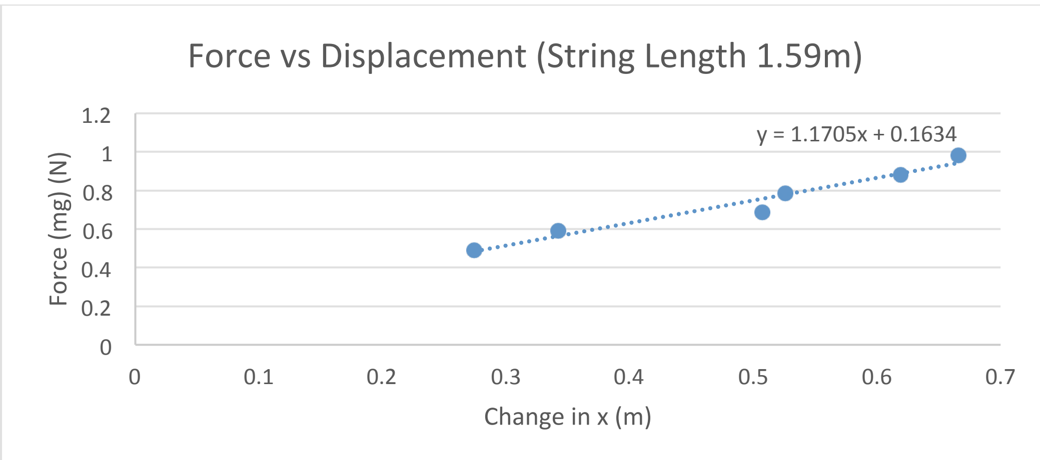
L= .399 m

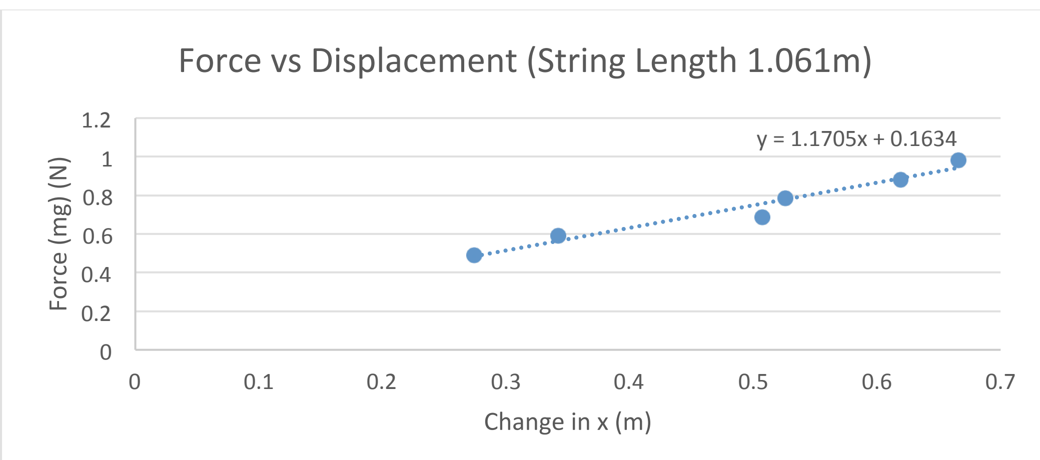
XL (Unstretched) (m)	Xo (m)	mass (kg)	Delta X (m)	F (N)
0.399	0.459	0.05	0.06	0.4905
0.399	0.476	0.06	0.077	0.5886
0.399	0.496	0.07	0.097	0.6867
0.399	0.519	0.08	0.12	0.7848

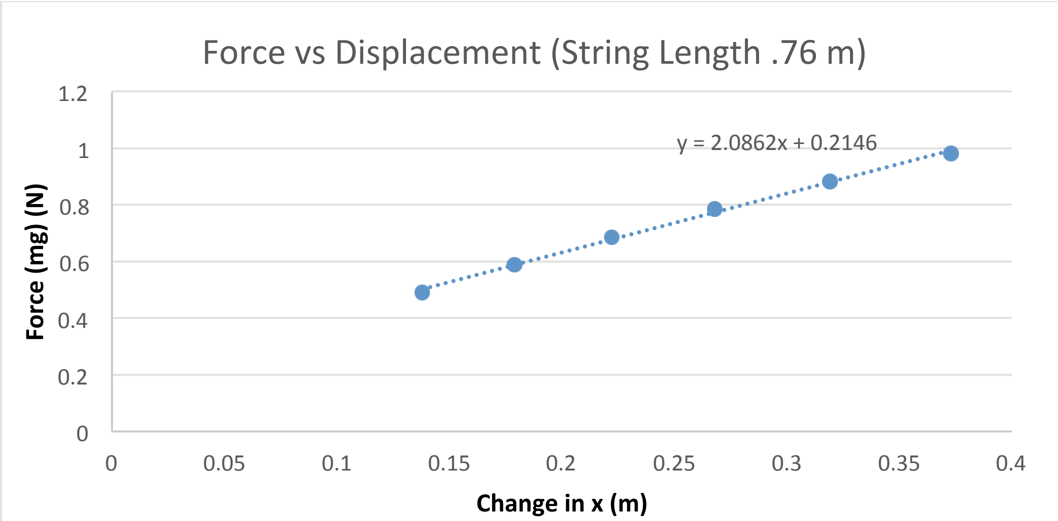
0.399	0.544	0.09	0.145	0.8829
0.399	0.573	0.1	0.174	0.981

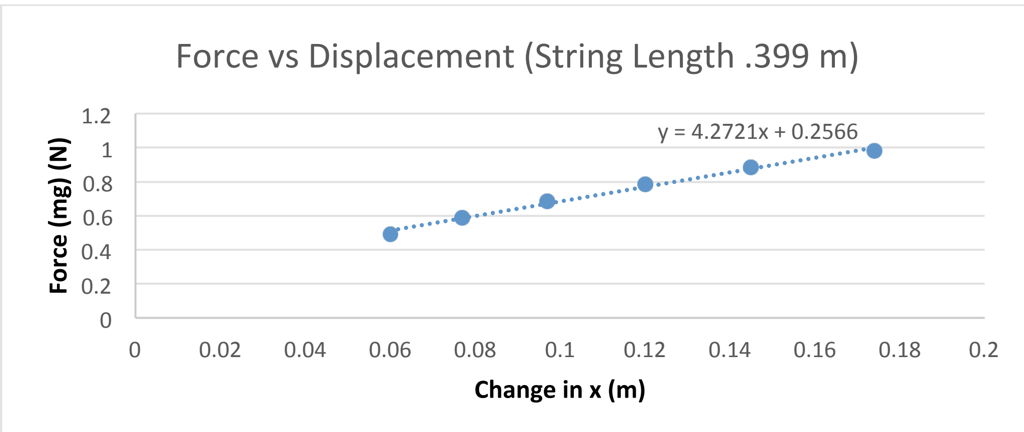
L= .185 m

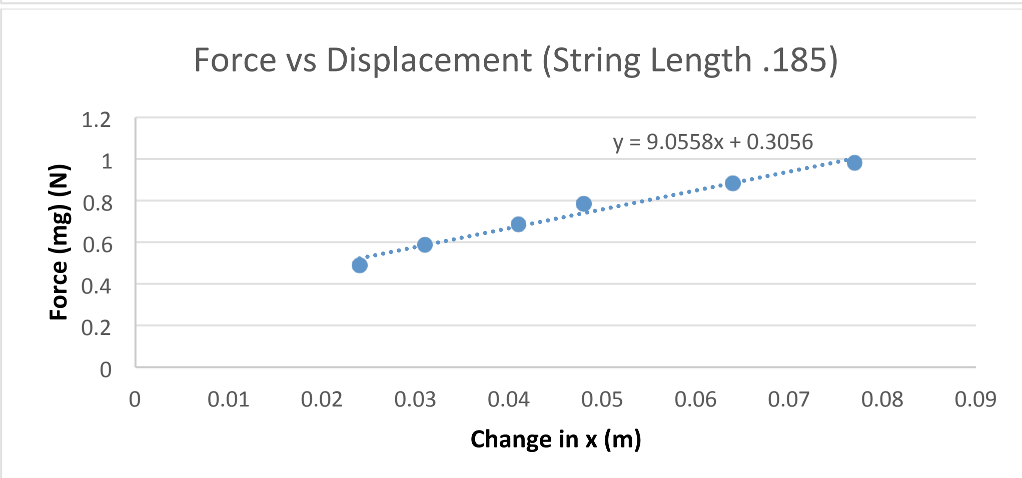
XL (Unstretched) (m)	Xo (m)	mass (kg)	Delta X (m)	F (N)
0.185	0.209	0.05	0.024	0.4905
0.185	0.216	0.06	0.031	0.5886
0.185	0.226	0.07	0.041	0.6867
0.185	0.233	0.08	0.048	0.7848
0.185	0.249	0.09	0.064	0.8829
0.185	0.262	0.1	0.077	0.981



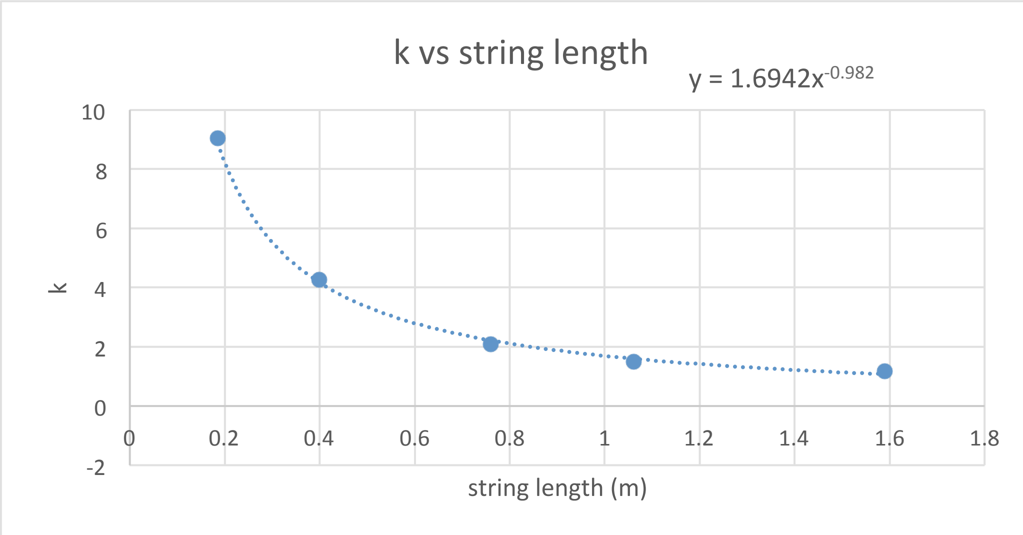


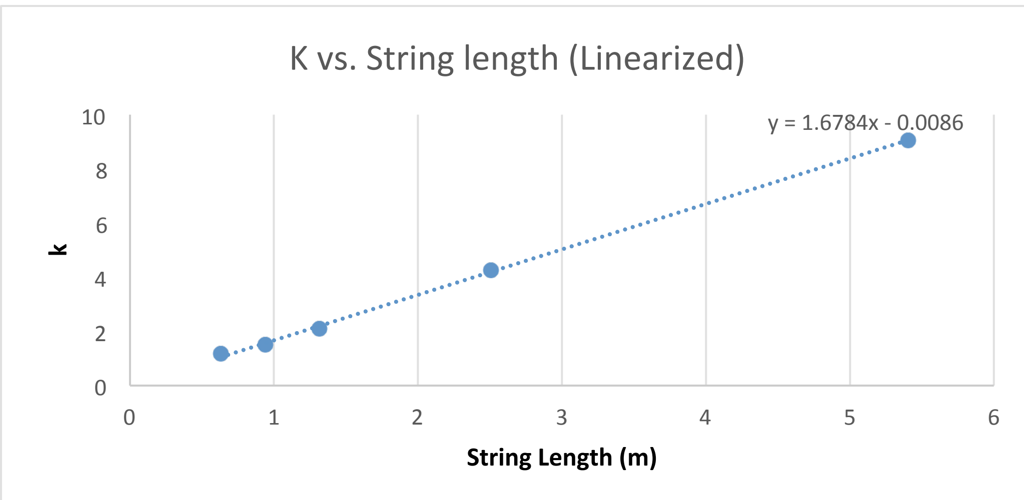






length	k	length^-1	k
1.59	1.1705	0.628930818	1.1705
1.061	1.4968	0.942507069	1.4968
0.76	2.0862	1.315789474	2.0862
0.399	4.2721	2.506265664	4.2721
0.185	9.0558	5.405405405	9.0558





uncertainty for slope=	0.02947075	% uncert= 1.76%
uncertainty for y-intercept=	0.08179389	% uncert= 9.51%

DISCUSSION:

By calculating our percent uncertainties through the linear regression analysis, we were able to more confidently support our hypothesis. With a percent uncertainty for the slope of our linearized graph of K vs String Length of 1.76% and a percent uncertainty for the y-intercept of 9.51%, we feel that we can prove our hypothesis that our experiment would reveal an equation that could accurately predict the relationship between the effective spring constant k and the string length. There were several potential sources of error in our experiment. First, I may have measured the change in x, or displacement, incorrectly or imprecisely. Additionally, I may have incorrectly dropped the weight from the equilibrium position. If I did so, the displacement would not be accurate for that trial. Finally, I may have tied the knot on the string slightly differently for each string length. Each of the five trials for that length would be correct relative to one another, but between different lengths, the difference in knot tying may affect the effective spring constant, k, of the string. If we could eliminate these errors, I believe our percent uncertainty may be even lower, further supporting our hypothesis.

CONCLUSION:

Due to our low percent uncertainty for both the slope and y-intercept, we feel confident that our hypothesis that we could create an accurate model representing the relationship between spring constant and string length was correct. The proper understanding of this relationship is important as it pertains to our final Bungee Jump Challenge. With our model equation, we could plug in the effective spring constant of our bungee, and by accounting for the length of the string, solve for the displacement from equilibrium. This information would allow us to prevent the egg from hitting the ground if we create a system where the displacement from equilibrium does not equal the distance between equilibrium and the ground. Next week, we hope to perform an experiment that would help us add motion into our system and allow us to predict the force on the egg when it is pulled upward by the bungee cord. We hope to avoid cracking the egg with this force. We will be dropping the egg from a height, not from equilibrium, so by testing a model system in the lab where we drop weights from different heights, we will be able to analyze the relationship between the height of the drop, the effective spring constant, and the displacement of the weight.

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

Pledged: Kristen Phlegar