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Section 1

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Bungee 1: Analyzing the Bungee Cord

B. Diagram

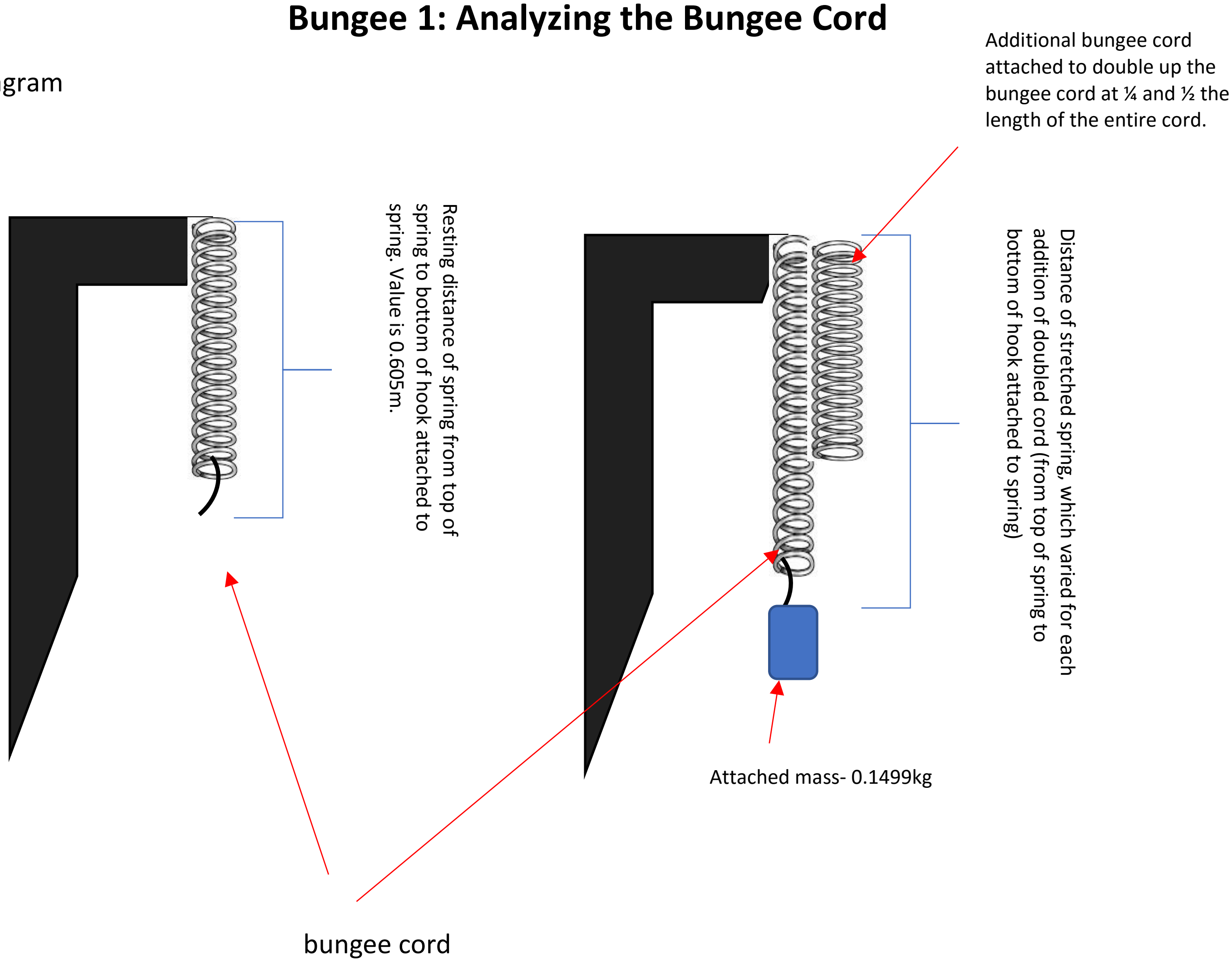


Figure 1: Diagram of experiment. We measured the equilibrium length of the bungee with no mass attached, which was 0.605m. With each trial, a different fraction of the bungee had its cord doubled up. We doubled up 0%, 25% and 50% of our bungee cord in three different trials. Equilibrium length was kept constant at 0.605m and a mass of 0.1499kg was attached to the end of the bungee in all trials and the displacement was measured in meters.

D. *Experiment Summary*

In this experiment, we sought to analyze the spring constant of the bungee cord we will be using for the egg bungee at the end of the term. However, we believe that the bungee cord will need to be altered somehow before the final egg drop, meaning that some or all of the cord will need to be doubled up. In this experiment, we sought to analyze how doubling up different amounts of the bungee cord affects the spring constant, k, value.

We hung the bungee cord from a post and it had an unstretched equilibrium length of 0.605m. We attached a mass of 0.1499kg onto the end of the cord and measured the distance that the cord stretched. We combined Newton's Second Law, F_{net} = mass*acceleration and $F_{spring} = k\Delta x$ into $ma = k\Delta x$ because we are assuming that the only force acting on the mass is the bungee. We used $a = 9.81\ m/s^2$ because we assumed only the acceleration of gravity was acting on the mass in the y direction. We found k to increase linearly with increasing fraction of doubled cord with a slope of 1.7423 and standard error of the slope 0.183. The final equation is k = 1.7423*(fraction of doubled cord) + 2.1983. The y-intercept represents the k value of the bungee itself with no doubling up, which is 2.1983 N/m and has a standard error of 0.0589. We measured k to be 2.224 N/m with no doubled cord, which is within one standard error of our y-intercept. There is no accepted value of k for this bungee cord, but we deemed the y-intercept to be the accepted value. The percent error of our measured to accepted value is 1.17%. Our results make sense because we would assume that as we add more length of doubled cord to the bungee that the force of the spring would increase since there is more cord to exert a force, which would then increase k because force and k are directly related. We did try to see if k has a better linear relationship with fraction of doubled cord^2 or fraction of doubled cord^3. However, we found that these graphs had lower R^2 values and thus we conclude that fraction of doubled cord vs k is the best linear fit for the data. Since our measured k value is within one standard error of our accepted k value from the y-intercept of the equation of interest, we can assume that our k measurements were accurate.

One source of error is that we have too few data points to be able to conclude with absolute confidence that the relationship between the fraction of cord doubled and k is linear. We found so much data for lots of different variables, that when it came time to choose one variable to discuss we found that we only had three data points. We should fix this in the future by testing less different variables and gathering more data for the one experiment that we will focus on. Another source of error is that the measurements for Δx were a little difficult to discern because the bungee would bounce up and down a little when we were trying to measure. This can be eliminated by having a steadier hand and being more careful when measuring the Δx distance.

This experiment was undoubtedly important in order to determine how increasing the amount of doubled cord will affect the bungee experience of the egg. In real life, this is critical for actual bungee jumping to ensure that the jumper will have the maximum thrill while being completely safe from hitting the ground. Thus, the design of the cord must be carefully thought through. A next step for this experiment is likely to be tackled in Bungee 2 and will need to consist of analyzing the effect of an object extending the bungee with an initial velocity and acceleration. Undoubtedly, this will be important in determining the ultimate length that the bungee will extend upon release of the egg and will need to be solved with energy-related equations. However, our results from today will be able to be used on the day of the bungee experiment because we can use k to analyze the force of the spring in terms of potential energy.

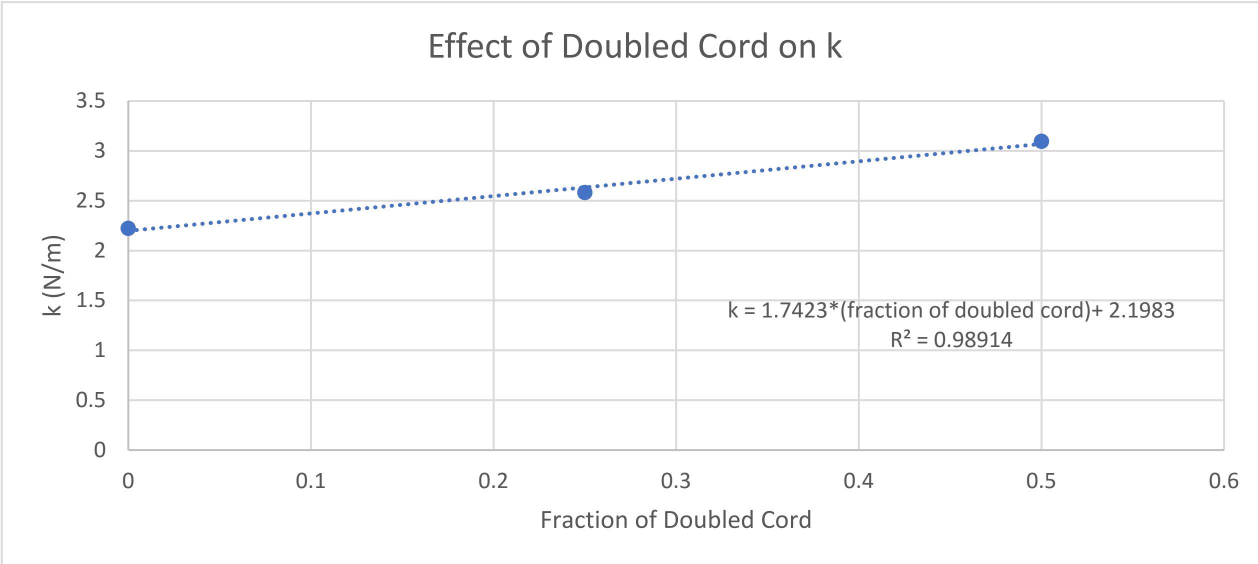
C. Data

Fraction of Doubled Cord	Displacement (m)	k (N/m)
0	0.661	2.225
0.25	0.5697	2.581
0.5	0.475	3.096

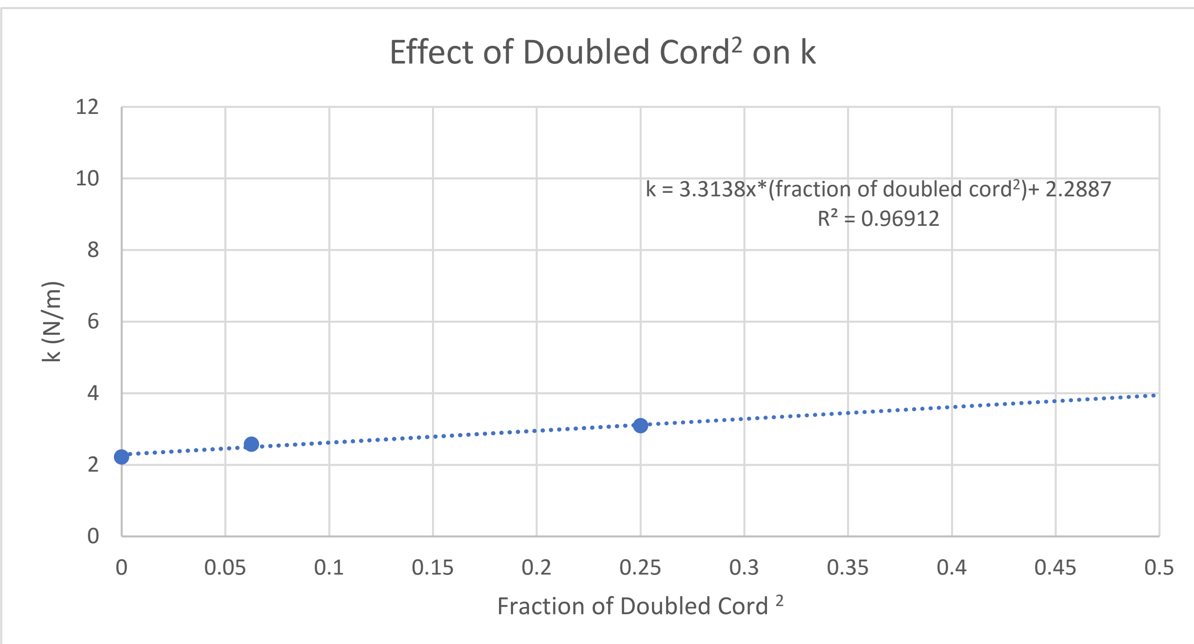
Table 1: Raw data. The displacement of the bungee at an equilibrium length of 0.605 from attaching a 0.1499kg mass was measured and used to solve for k using $ma = k\Delta x$.

Measurements of Error		
	Slope	Y-Intercept (k with no doubled cord in N/m)
Value	1.742	2.198
Standard Error	0.183	0.059
Percent Standard Error	10.477	2.680

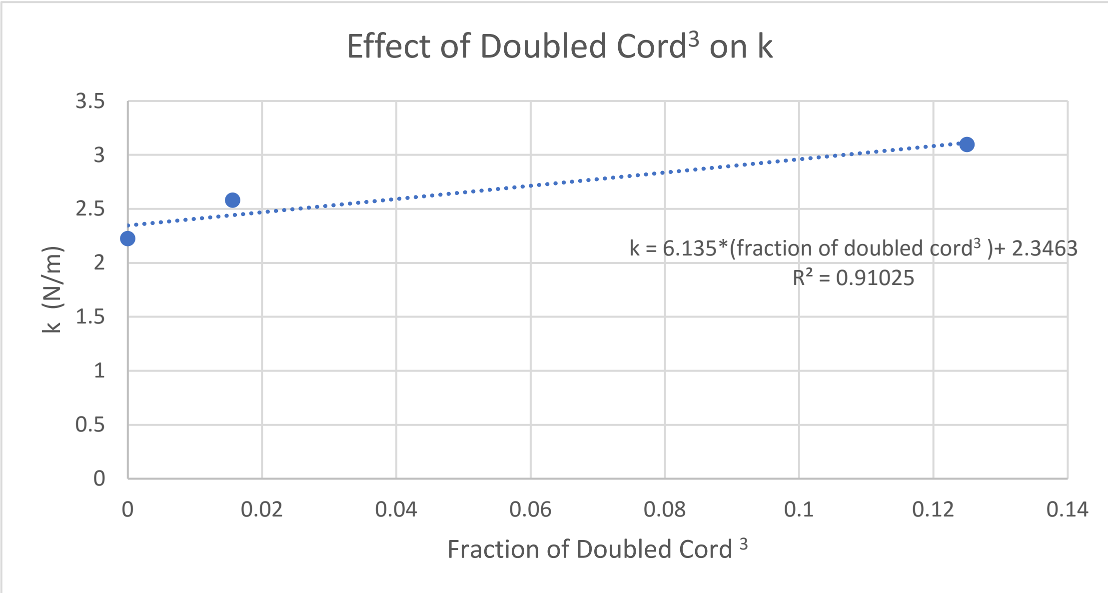
Table 2: Measurement of error. Our equation of interest, k = 1.7423*(fraction of doubled cord) + 2.1983 was found from graphing fraction of doubled cord vs k. The standard error of the slope was found using the excel linear regression tool. The y-intercept represents the value of k for the bungee cord alone with no fraction of it doubled and the linear regression tool was used to find the standard error of this measurement. Our measured value of k for the bungee itself with no fraction of doubled cord is 2.224 N/m, which is within one standard error of our y-intercept value.



Effect of Doubled Cord on k
k (N/m)
3.5
3
2.5
2
1.5
1
0.5
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Fraction of Doubled Cord
k = 1.7423*(fraction of doubled cord)+ 2.1983
R² = 0.98914



Effect of Doubled Cord² on k
k (N/m)
12
10
8
6
4
2
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Fraction of Doubled Cord ²
k = 3.3138x*(fraction of doubled cord²)+ 2.2887
R² = 0.96912



Figures 2, 3 and 4: We found that a linear fit between the fraction of doubled cord and k is the best fit for the data from Table 1. However, we attempted plotting fraction of doubled cord^2 vs k in Figure 3 and fraction of doubled cord^3 vs k in Figure 4 to see if one of those would have a better fit. However, they did not and we got our equation of interest, k = 1.7423*(fraction of doubled cord) + 2.1983, from the linear analysis in Figure 2.

Experimental Value of Interest

Our experimental equation of interest was the equation obtained from the graph of fraction of doubled cord vs k because it yields the information about how k changes with changing the fraction of the bungee with double cord. Thus, we can determine the relationship between doubling the cord and k. We found our equation to be k = 1.7423*(fraction of doubled cord) + 2.1983 with the standard error of the slope being 0.1825 N/m and percent standard error of 10.48% (Figure 2 and Tables 1 and 2). The y-intercept of 2.1983 has a standard error of 0.0589 N/m with a percent standard error of 2.20% (Table 2). Standard errors were found using the excel linear regression analysis tool. The y-intercept of our equation is the k value of the bungee with no doubled cord, and this will be deemed as our accepted value of k since there is no accepted value given to us. Our measured k value for the bungee with no doubled cord is 2.224 N/m (Table 1). Since our measured value is within one standard deviation of our accepted value, we can conclude that we found the true value of k in our experiment. The percent error is 1.17%, which is very low. However, our experiment could be made even more precise by finding a better way to measure displacement without moving the bungee and causing it to oscillate. We also could make this experiment better by doing more trials. We tested other variables than the effect of doubling the cord on k, so we had a lot of data to work with, but only a few data points for the focus of this lab report.

We did try to see if k has a better linear relationship with fraction of doubled cord^2 or fraction of doubled cord^3 (Figures 3 and 4). However, we found that these graphs had lower R^2 values and thus we conclude that fraction of doubled cord vs k is the best linear fit for the data. We could do more trials to increase the confidence in this conclusion.

The next test of this experiment will be on the day that we drop our egg from the Great Hall. We will need to know how k changes with doubling different amounts of the cord and the effect that this will have on the fall. We will need our results from this lab when we analyze the problem in terms of energy because k will go into the spring force calculation, which is a conservative force. We will thus need this data to determine the amount of cord we want to double on the day of the egg drop and the best equilibrium length to use. Additionally, another step for our experiment would be to see how k alters with attaching different masses to the cord to see how k changes with being stretched more due to a larger force of weight increasing the displacement.