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Discovering the Characteristics of Our Bungee

I. Experiment Summary

The Purpose of this experiment was to observe and identify the characteristics of our bungee cord, the same cord that will be used in the final bungee challenge. To do this we aimed to determine the k constant of our specific cord, but this k constant varies with the length of the cord. So, more specifically, we hoped to determine an equation that would predict our k value at certain lengths.

We started by acquiring k values at specific lengths of the cord. We hung the cord from an apparatus down to distances of 0.2 m, 0.6 m, and 1.2 m. At each equilibrium distance, we hung a weight from the cord. The distances that the cord stretched from equilibrium at each length were recorded. We completed this process with three different masses (0.025 kg, 0.05 kg, and 0.1 kg). To get k values from this data, we used the equation $mg=k\Delta x$, where m is the mass of the weight, g is the acceleration due to gravity, k is our k constant, and x is the stretch distance. This means that our k values will be equal to weight divided by stretch distance ($k=mg/\Delta x$). From this, we acquired three relatively accurate k values that we used for further analysis. These were graphed vs. the equilibrium length of the rope used to find them. This gave us the exponential equation $k=12.322e^{-1.693x}$. The line of this equation produced an R^2 value of 0.9981, which gave confidence to this equation. This equation will be used moving forward in the bungee challenge to calculate k values at different lengths of rope and/or to calculate lengths of rope at different k values.

We produced a relatively reliable exponential equation, but it is not perfect. The most likely explanation for this is that our measurements were a little off in calculating stretch distances. We had a measuring tape hanging down next to our cord, but it was 4 or 5 inches away from the cord, leaving the judgment of our measurement to our visual perception. We also only measured to 0.00 m, where as we could have sought a more precise measurement. Lastly, in taking so much data, we felt rushed and accepted slight deviation from our beginning equilibrium lengths. These factors of imprecision affected our “Weight vs. Change in Distance” graphs, which in turn affected our k values.

II. Diagram

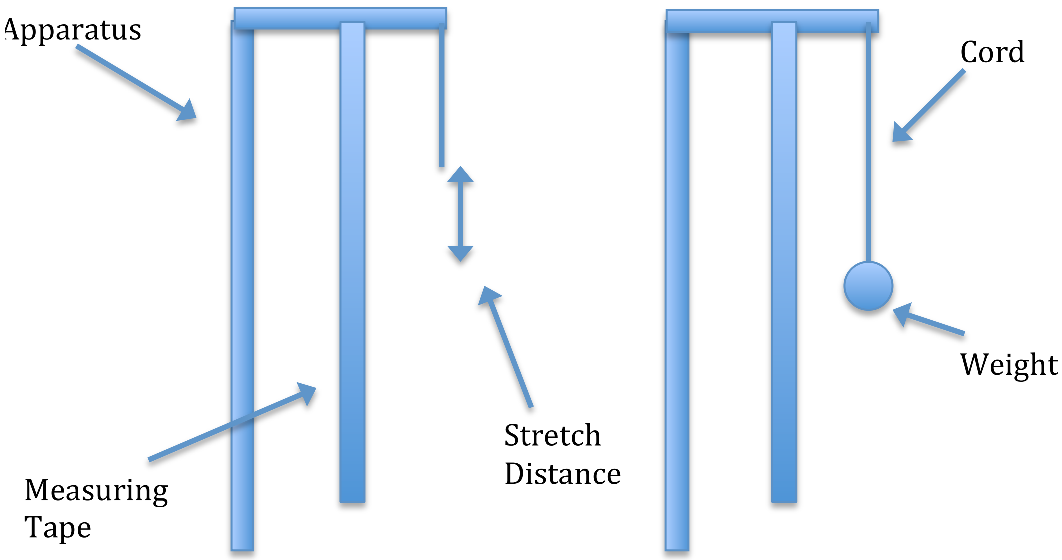

Figure 1: Diagram of Experimental Setup. We hung a cord from an apparatus at specified lengths (equilibrium lengths). Then, we hung a mass from the cord and the distance it stretched from equilibrium was recorded. This was performed on the same cord at six different lengths. This process was completed for three different masses.

III. Quantitative Data and Analysis

To analyze our data, we used the data for the three masses at our three chosen lengths (0.2 m, 0.6 m, and 1.2 m). The masses (0.025 kg, 0.05, and 0.1 kg) were multiplied by the acceleration due to gravity and graphed against the distance the cord stretched from equilibrium. Consequently the slope of these graphs gives us our k values at these lengths.

Weight (N) (+/- 0.001)	Δx (m) (+/- 0.005)
0.25	0.03
0.49	0.05
0.98	0.11

Table 1: Weights with their Corresponding Stretch Distances. The changes in distance are shown for three different weights. Each of these was taken at an equilibrium length of 0.2 m.

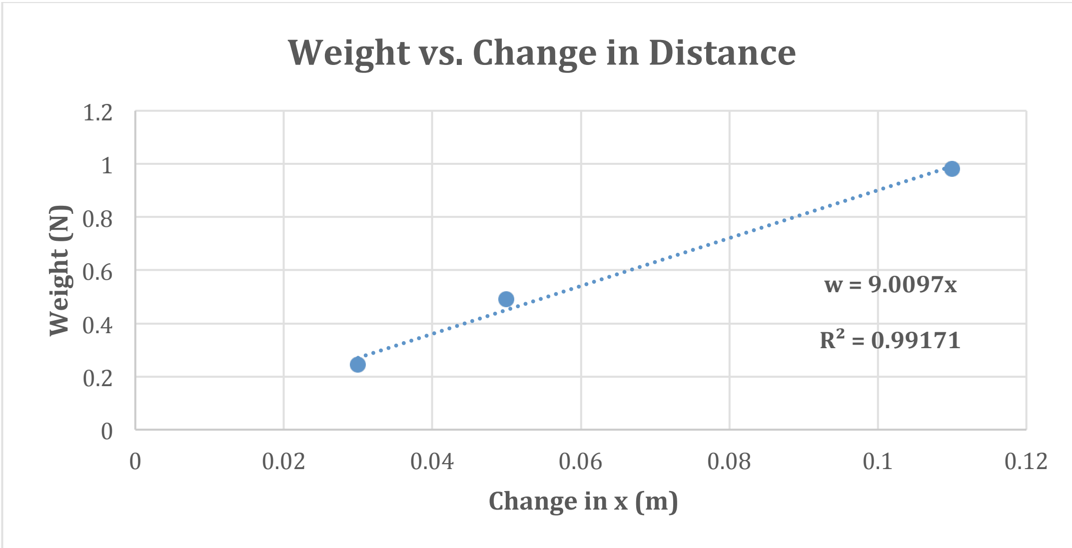

Figure 2: Graph of Weight vs. Stretch Distance. The weights are graphed against the change in distance for each. These distances were obtained at an equilibrium length of 0.2 m. Our slope gives us an experimental k value at this length. We have a good R^2 value giving confidence to our linear equation.

Weight (N) (+/- 0.001)	Δx (m) (+/- 0.005)
0.25	0.05
0.49	0.09
0.98	0.24

Table 2: Weights with their Corresponding Stretch Distances. The changes in distance are shown for three different weights. Each of these was taken at an equilibrium length of 0.6 m.

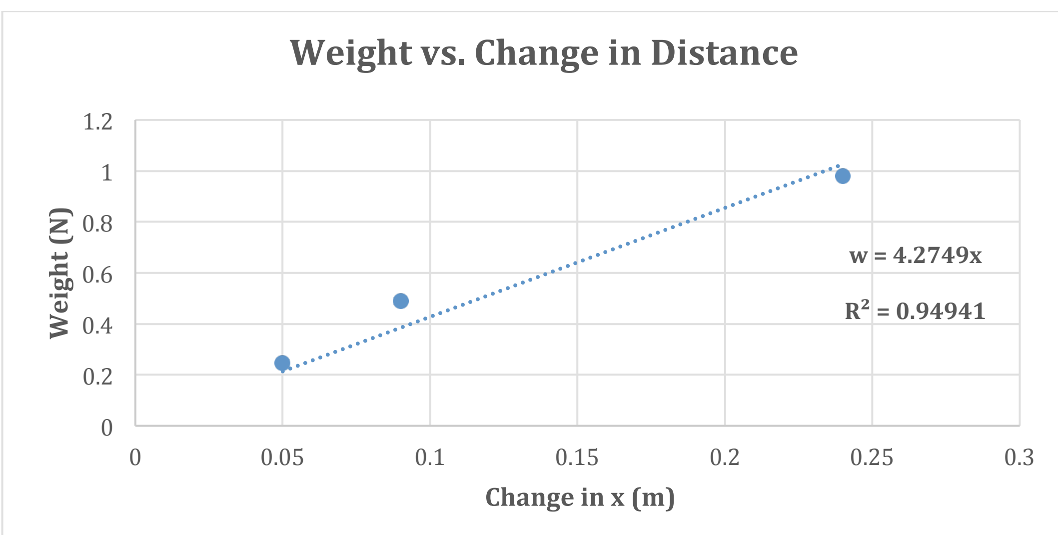

Figure 3: Graph of Weight vs. Stretch Distance. The weights are graphed against the change in distance for each. These distances were obtained at an equilibrium length of 0.6 m. Our slope gives us an experimental k value at this length. We have an acceptable R^2 value giving confidence to our linear equation.

Weight (N) (+/- 0.001)	Δx (m) (+/- 0.005)
0.25	0.10
0.49	0.25
0.98	0.63

Table 3: Weights with their Corresponding Stretch Distances. The changes in distance are shown for three different weights. Each of these was taken at an equilibrium length of 1.2 m.

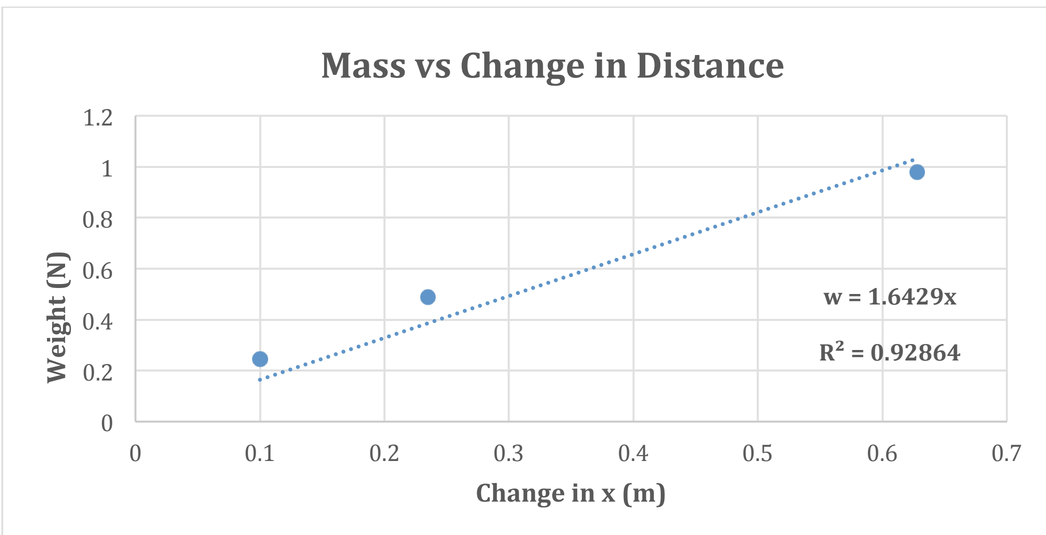

Figure 4: Graph of Weight vs. Stretch Distance. The weights are graphed against the change in distance for each. These distances were obtained at an equilibrium length of 1.2 m. Our slope gives us an experimental k value at this length. We have an acceptable R^2 value giving confidence to our linear equation.

From the equations of these graphs we obtained three experimental k values that varied with length as expected. At the 0.2 m equilibrium length, we found a k value of 9.0097. At 0.6 m, we found a k value of 4.2749. And at 1.2 m, we found a k value of 1.6429. The k value at 0.2 m resulted from a linear equation with an R^2 value of 0.99171, making this k a reliable experimental value. The k values at 0.6 m and 1.2 m had slightly lower R^2 values, but were still acceptable for further analysis.

The next step of our analysis aimed to find an equation from our data that could be used to predict k values at certain lengths. To do this, we graphed our experimentally determined k values against their specific equilibrium lengths.

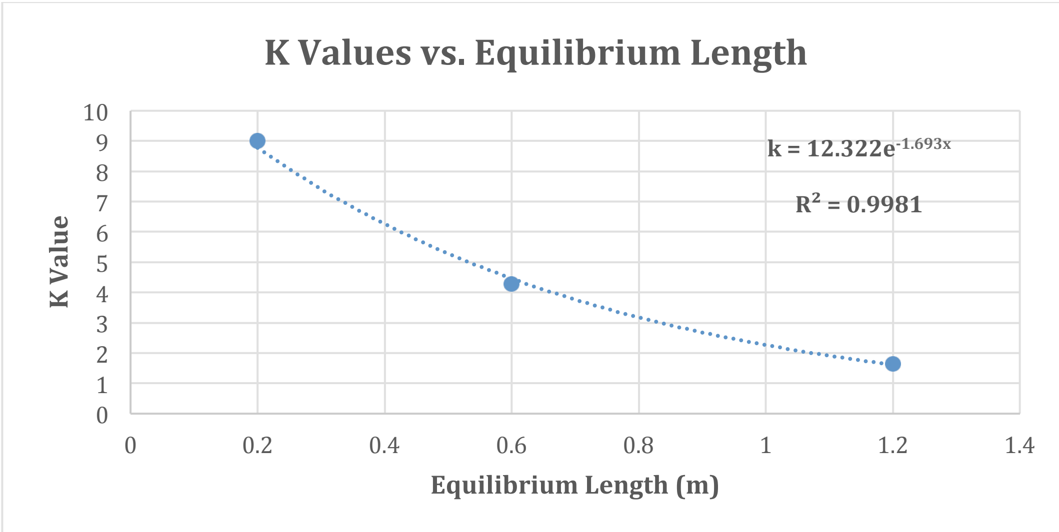

Figure 8: Our experimental k values are graphed against their equilibrium lengths. This gives us an exponential line and equation. It has a near perfect R^2 value giving confidence to this equation.

As evident from the graph, our k values decrease with increasing equilibrium length. We expected to see decreasing k values with increasing equilibrium length, and as equilibrium lengths get much larger moving forward k values will never be zero because this would make the spring force nonexistent. As is expected in the physical realm, our k values will continue to decrease but never reach a value of zero. Therefore our value of interest from this experiment is the equation $k=12.322e^{-1.693x}$. Our R^2 value is 0.9981, which is almost a perfect value. This means that we can be confident in our selected exponential trend line, and we can use our chosen exponential equation with confidence in the next stage of the bungee challenge.

Our chosen equation will be the mathematical basis for our selection of cord length moving forward. In selecting a trend line and equation, we initially chose a parabolic line and quadratic equation because of the perfect R^2 value of 1 that it gave us. However, if a parabola decreases at first then it always must increase after. So, had we chosen this equation, we would have gotten increasing k values as x increased towards larger values. This is inconsistent with physical reality. A logarithmic equation was then considered as it had an excellent R^2 value, but it gave negative k values as x got larger and larger. Our k values cannot be negative, so this equation was also discarded. Finally, the exponential line and equation were chosen because of its good R^2 value and its fit within the realm of physical expectation, constantly decreasing but never reaching zero.