Chris Osier
11/28/16

# Relationship of Stretch and Cord Length

Abstract:

The purpose of our experiment is to find the relationship between the slack length of a bungee cord and the length it stretches to for a given mass of ~ 120 grams (±.01 grams). This length of stretch would be calculated by subtracting the static length from the max length that the cord stretched when dropped from its connection point to the table mount with the 120 gram mass. These measurements are labelled $X_L$ and $X_{Max}$ respectively. We measured $X_{Max}$ by using a slow-motion camera phone application which gave us a slight standard error of about (±.005m) for the $X_{Max}$ variable, due to varying angles between the camera and the knot of the cord as it reached its apex. These results were calculated and the respective values were placed in a table in Excel. A graph was then derived from the table and an equation was extracted using a linear trendline function. Our uncertainty for this value was around ~14% which we did not deem as being statistically significant enough to disprove our hypothesis. We attribute the slightly larger value with variations in data due to an increase of residual stretch in the cord over multiple uses. In conclusion, we believe that this equation is the last mathematic value we will need to solve for the perfect bungee experience. We have no statistically significant values that disprove our hypothesis that this equation relates stretch and initial length.

Introduction:

The purpose of this experiment is to calculate the correlation between the length of a bungee cord and the amount of stretch that is documented when a mass is attached to one end and dropped from the height of the stationary end of the cord that is attached to a mount. The equation we used to calculate stretch was such that Stretch = $X_{Max} – X_L$, where $X_{Max}$ was the maximum length the cord was pulled down by a mass after it was dropped from the connection point and $X_L$ was the massless, hanging length of the cord from the knot in one end to the knot in the other with no mass attached. The equation we derived for our Stretch vs. Length correlation can be found in Figure 3, and is pictured as y = 2.4133x + .0192, where “y” is stretch and “x” is length. The idea behind this is that once we find the correlation we will be able to use the mathematic equation, derived from the trendline, to help derive the length of cord we will need to achieve the perfect bungee experience.

Methods:

To depict the correlation of stretch versus length we measured out random lengths of bungee cord and attached a 120-gram mass to one end and hung it from the other. We then dropped the mass and observed the depth of the apex of the drop using a slow-motion video app. This would allow us to determine the correlation between length and stretch so we that we can create a perfect bungee experience.

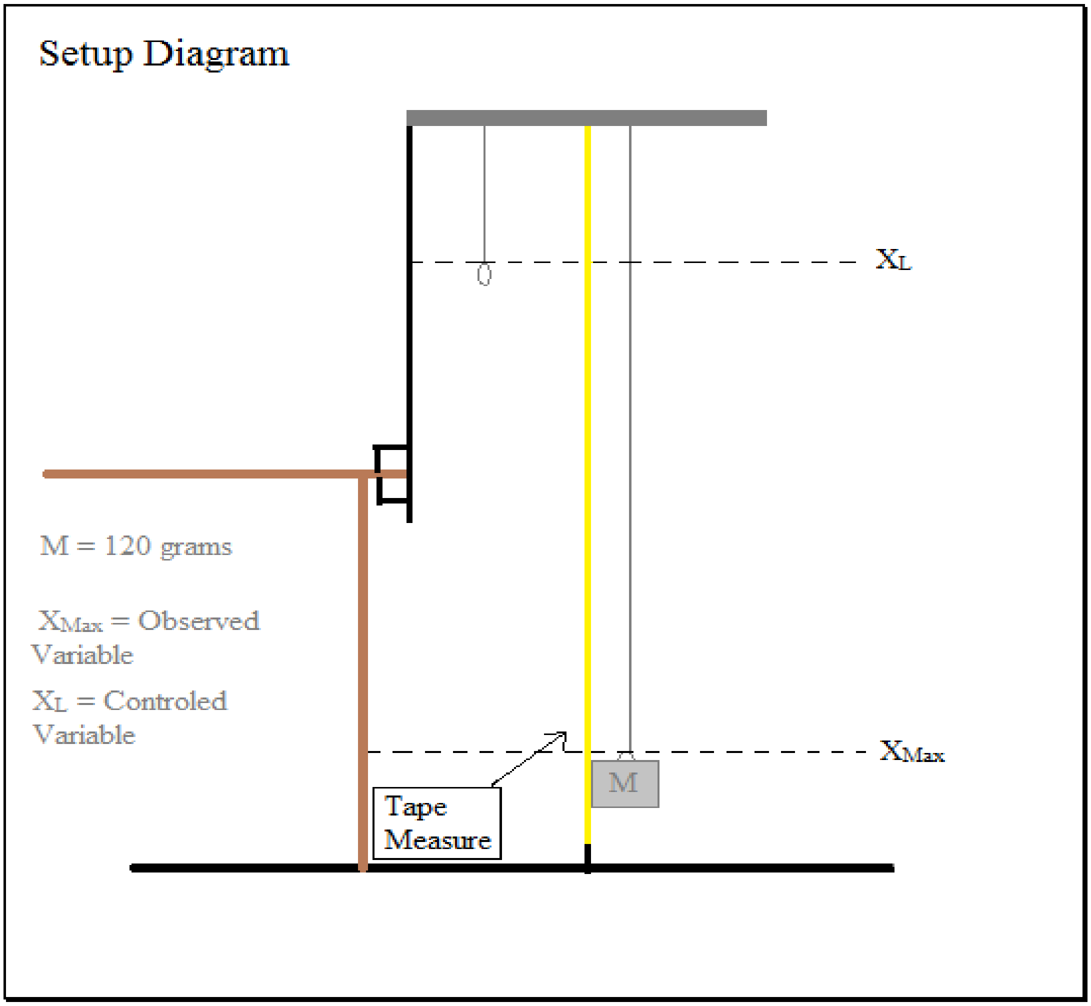


Figure #1: *Setup Diagram:* Diagram detailing the setup and its inherent variables.

For our setup, we used a stationary mounting point in the form of a table clamp mounted to a vertical pole with a horizontal beam attached to it that was positioned over the table edge. We attached our cord to a bolt in this beam and taped one end of our tape measure adjacent to our cord and the other end to the floor directly beneath the beam. First we measured out the greatest length we wanted to begin with and then attached a 120-gram mass to the hanging end. We then dropped the mass from the height of the connection point and captured the apex of its drop using a slow-motion video app and the hanging tape measure. We repeated this for eight different lengths of bungee cord and recorded the results.

Results:

The results we collected were the varying $X_{Max}$ lengths of our different cord lengths. We then plotted our $X_{Max-}$ $X_L$ values with their respective $X_L$ cord lengths on a graph and then plotted a linear trendline through the data and extracted our equation through excel. Our graph was formatted using the data from the table in Figure 2. The graph derived from Figure 2 is depicted in Figure 3 and it portrays the semi-linear relationship between stretch and cord length.

| Length (m) (±.001m) | Stretch (m) (±.005m) |
|---|---|
| 0.166 | 0.426 |
| 0.268 | 0.613 |
| 0.307 | 0.858 |
| 0.363 | 0.88 |
| 0.441 | 1.034 |
| 0.511 | 1.219 |
| 0.554 | 1.354 |
| 0.585 | 1.48 |

**Figure #2:** ***Length and Stretch.*** The length of bungee cords and their respective $X_{Max}$-$X_L$ measurements.

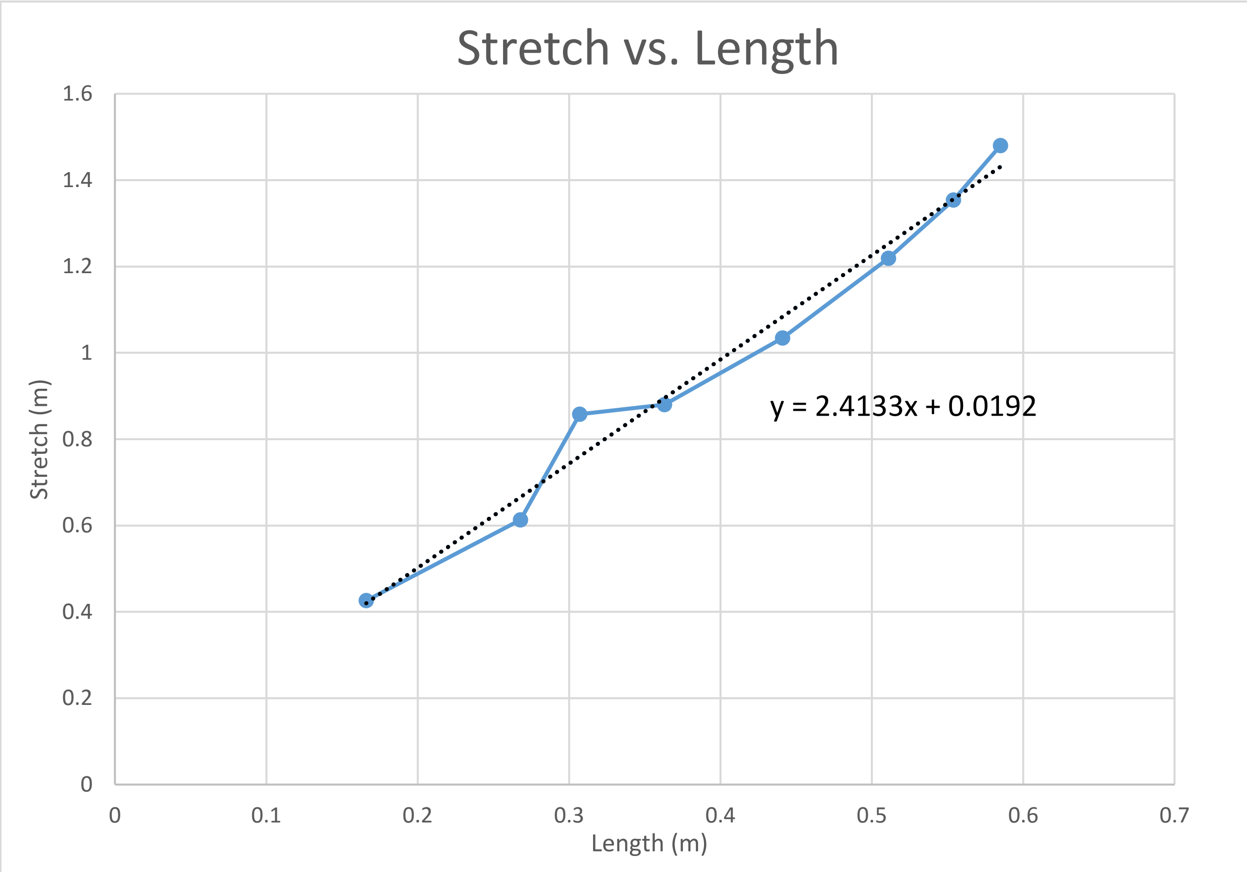


***Figure #3: Length vs. Stretch.*** Graph depicting the semi linear correlation between the actual length and the net stretch it experiences when a mass is attached and dropped from the height of the connection point of the cord.

Our equation for our trendline depicts the correlation of stretch and length as:

Stretch = 2.41(length) + .019

The uncertainty of the slope of our graph was about .142 or about 14% and the uncertainty of our y-intercept was .06 or about 6%.

The experimental value of interest for this experiment was the equation we derived from our graph in that it will help us calculate the relationship between the length of a static bungee cord and the maximum distance that cord will stretch when a mass is attached and dropped. The relationship we found was that our stretch was equal to our length multiplied by 2.41 with .019 added to the total value. Our experiment therefore revealed the relationship between the length of a cord and the inherent stretch it experiences when it is pulled down by a mass of 120 grams.

This is the last mathematical relationship we need to help us create our perfect bungee experience in that we already have the relationship between weight and stretch and now we have the relationship between length and stretch. Therefore. we should be able to calculate the correct length of cord for a certain mass and total distance that we would like the mass to travel.

Discussion:

Our experimental value for the relationship between stretch and length had an uncertainty of 14% for the coefficient of the length variable and an uncertainty of 6% for the y-intercept of the equation. There also may have been a slight uncertainty of about ± .005 (m) in the measuring of the $X_{max}$ due to the angle between the camera of the video recording device and the knot of the cord above the hanging mass. The correlation we found between length and stretch was similar to the expected linear relationship. We interpret the subtle differentiations from linearity as being caused by the gradual increasing of residual stretch in the cord from multiple uses. With a percent uncertainty of only 14% we assume that our experimental values are accurate and therefore the equation may be used with statistical certainty.

Conclusion:

To conclude, our experimental value of Stretch = 2.41(length) + .019

(±.005m) satisfies the second to last step in the search for our perfect bungee experience. Now that we have this relationship and that of weight and stretch we can calculate what length of cord we will need to use to keep our egg from hitting the ground or breaking due to a G-force higher than three in the perfect bungee experience.