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How Far Will It Stretch?

ABSTRACT:

The goal of our experiment was to find the relationship between the static equilibrium (X_0) of a bungee with some hanging mass attached to it and the max stretch for the bungee (X_{max}) when the bungee is in free fall. The idea behind this was experiment was that since we already calculated the relationship between the X_0 and the mass of the hanging mass, we can then use the predicted X_0 distance to predict the X_{max} distance using our results from this experiment. To do this we dropped different masses each attached to varied lengths of the bungee and used a slow motion camera to record the Xmax of the bungee. The mass was varied solely to ensure the bungee's resistive threshold would not be exceeded with the possible masses for our egg. A Xmax vs. X0 graph was plotted for each mass to find an equation that characterizes the relationship between the two measurements. We were able to find a relationship that we believe accurately predict the max stretch of the bungee based on the X_0 position. This relationship is defined by the equation $X_{max} = 1.93(X_0) + 0.039m$.

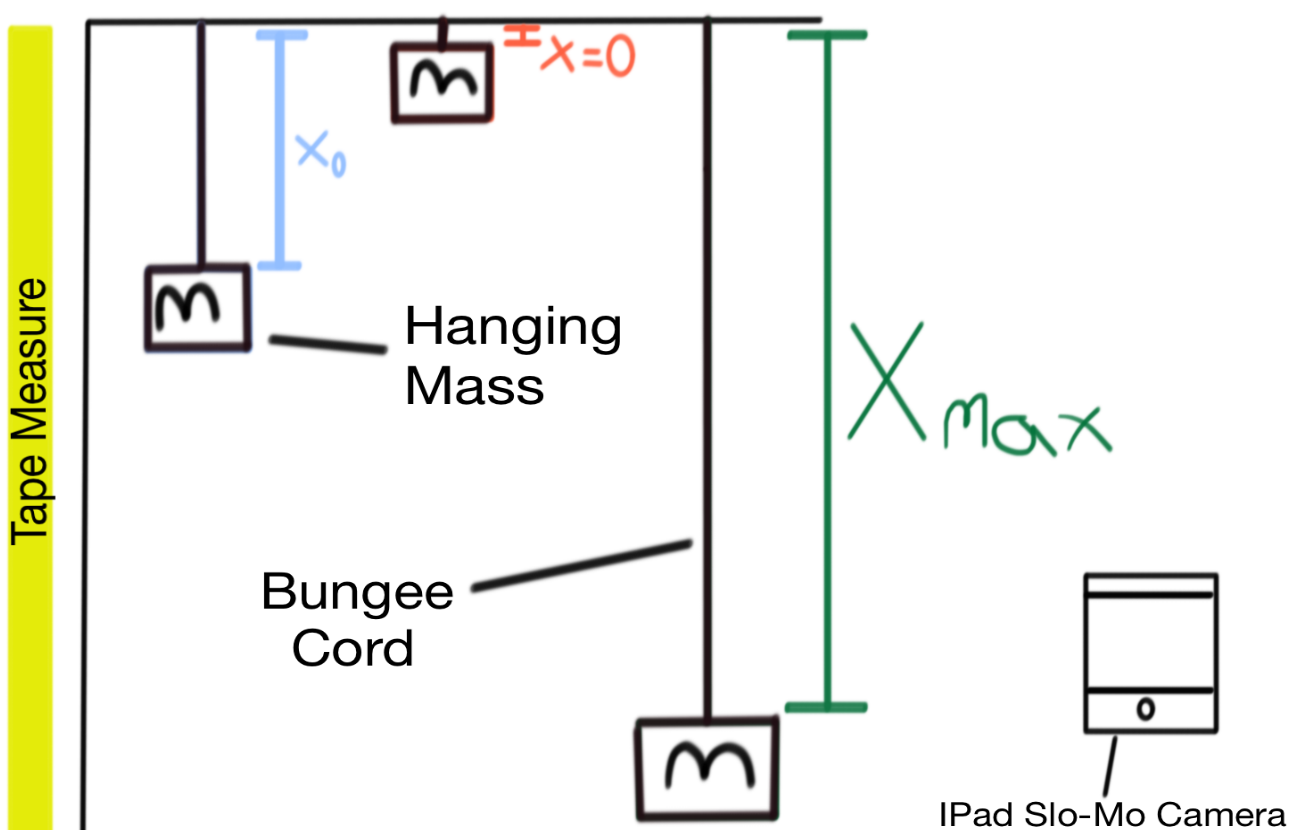
INTRODUCTION:

Our experiment was designed to predict the max stretch of the bungee using X_0. To do this we decided to drop a hanging mass with different X_0 positions and record the max stretch to find an accurate relationship between the two. There are no equations or background information behind this particular experiment. The objective was plainly to see if there was a relationship that existed between X_{max} and X_0 for our particular bungee. Are hypothesis was simply: "There is a mathematical relationship between X_0 and X_{max}."

METHODS:

We hung 4 different masses from the bungee and dropped each of these masses from rest. Each mass was dropped with 4 different lengths of bungee attached. The masses were dropped from each height five times and the average Xmax was recorded to ensure precision.

Figure 1: Methods Diagram (Depiction of one trial of the experiment)



The setup included a tape measure, the bungee, hanging masses and an IPad. The first bungee on the left represents how X_0 was measured. The middle bungee represents the position in which X was dropped from and the third bungee represents the max stretch of the bungee (X_{max})

Procedure:

- Start with a known mass
- Measure the length of the string without the mass attached
- Attach the mass and measure the new static equilibrium length (X0)
- Bring mass to the top of the stand and let it fall from rest
- Record the distance it reaches using the IPad
- Repeat at least 5 times
- Perform same test with 3 other lengths
- Change the mass and perform the test using the same 4 lengths

RESULTS:

In this experiment we measure the unstretched static of the bungee, the static equilibrium with the mass attached (X0), and the max stretch of the bungee once set in motion. A table and graph was made for each of the 4 different masses and then compared to see if the relationship remained consistent.

Figure 2: Table for a mass of 0.100kg

Unstretched static equilibrium (m)	Static equilibrium with mass (m) +/- 0.01 m	Max stretch (m) +/- 0.1m
0.19	0.29	0.59
0.29	0.45	0.87
0.32	0.56	1.13
0.42	0.67	1.33
0.19	0.29	0.59

Figure #3: Table for a mass of 0.125kg

unstretched static equilibrium (m)	static equilibrium with mass (m) +/- 0.01 m	Max stretch (m) +/- 0.1m
0.19	0.4	0.83
0.29	0.56	1.16
0.32	0.64	1.31
0.42	0.83	1.66
0.19	0.4	0.83

Figure #4: Table for a mass of 0.150kg

unstretched static equilibrium (m)	static equilibrium with mass (m) +/- 0.01 m	Max stretch (m) +/- 0.1m
0.19	0.46	0.94
0.29	0.68	1.31
0.32	0.78	1.52
0.42	0.96	1.90
0.19	0.46	0.94

Figure #5: Table for a mass of 0.170kg

unstretched static equilibrium (m)	static equilibrium with mass (m) +/- 0.01 m	Max stretch (m) +/- 0.1m
0.19	0.51	0.97
0.29	0.69	1.41
0.32	0.86	1.67
0.42	1.07	2.05
0.19	0.51	0.97

Graphs:
The graphs all plot Xmax vs X0 and have a best fit line and corresponding equation that describe the relationship between the two variables

Figure #6: Graph for a mass of 0.100kg

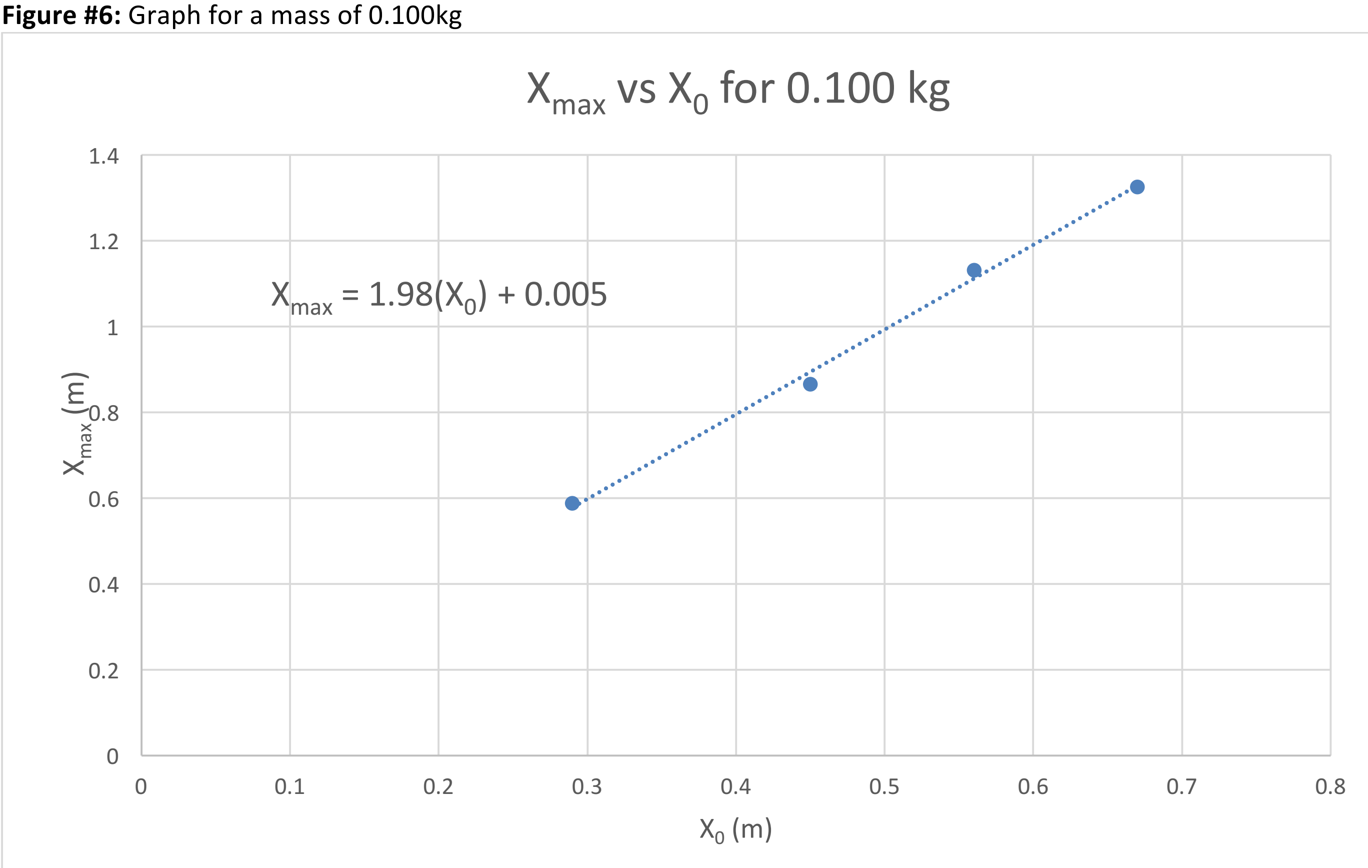


Figure #7: Graph for a mass of 0.125kg

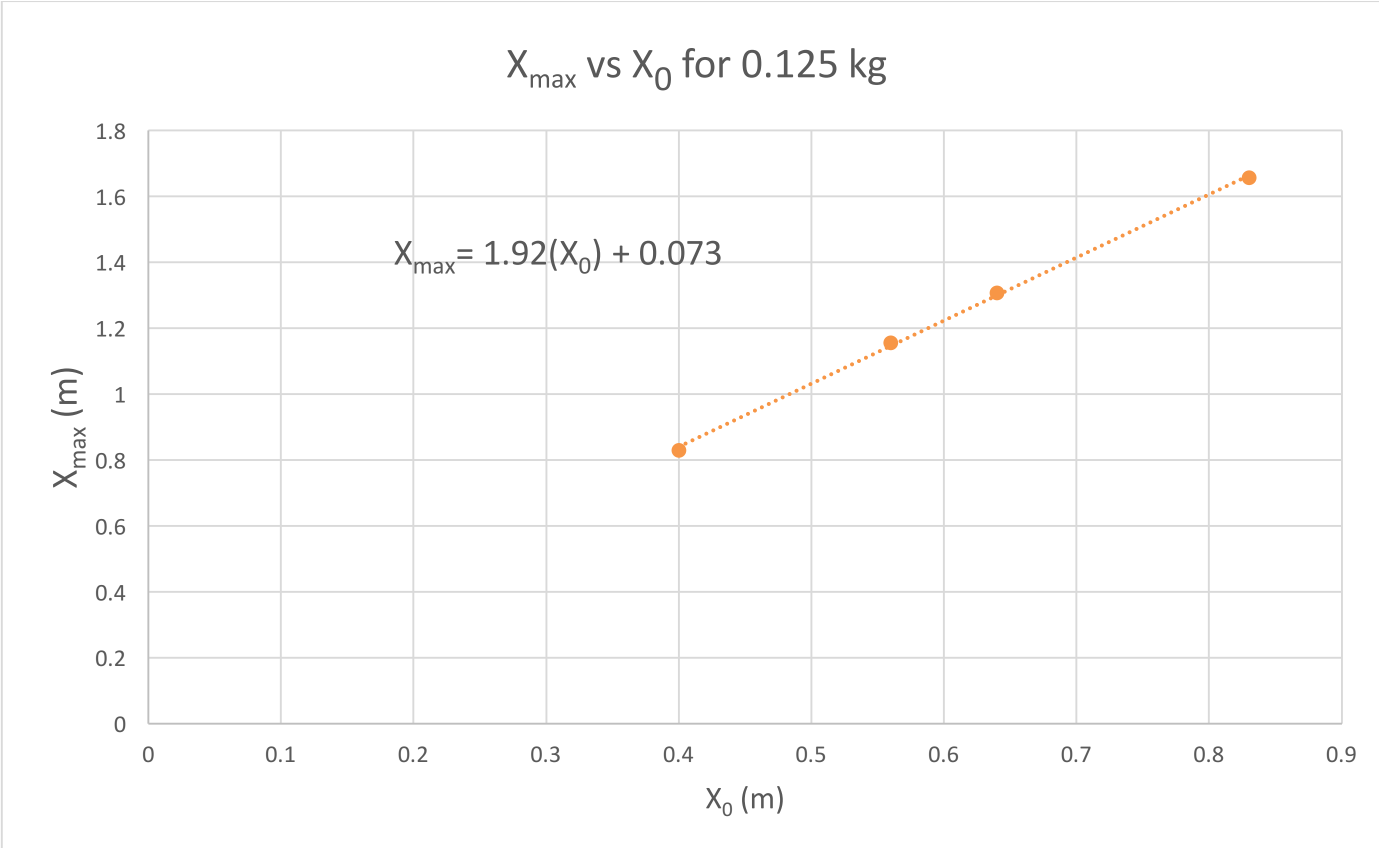


Figure #8: Graph for a mass of 0.150kg

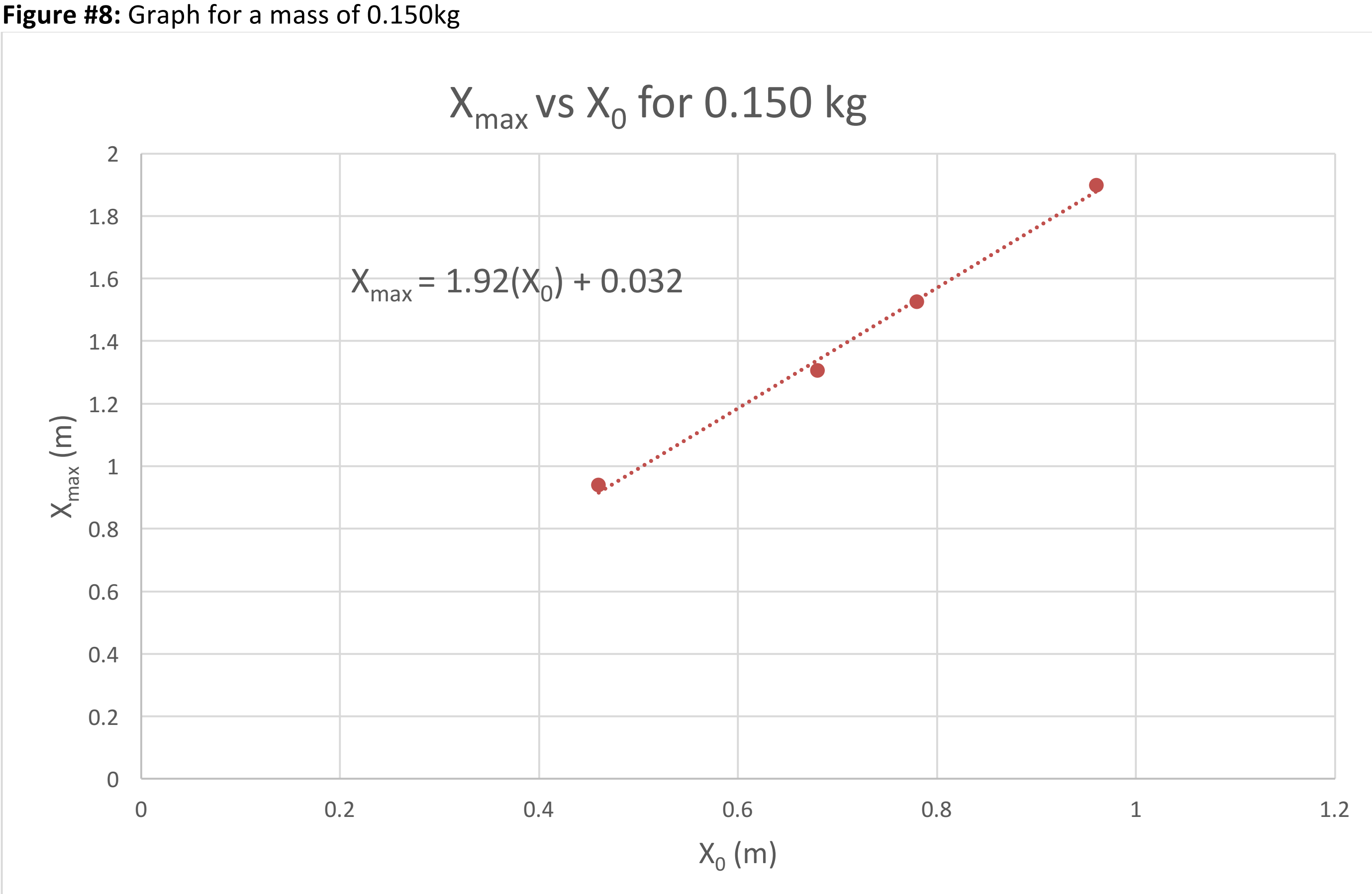
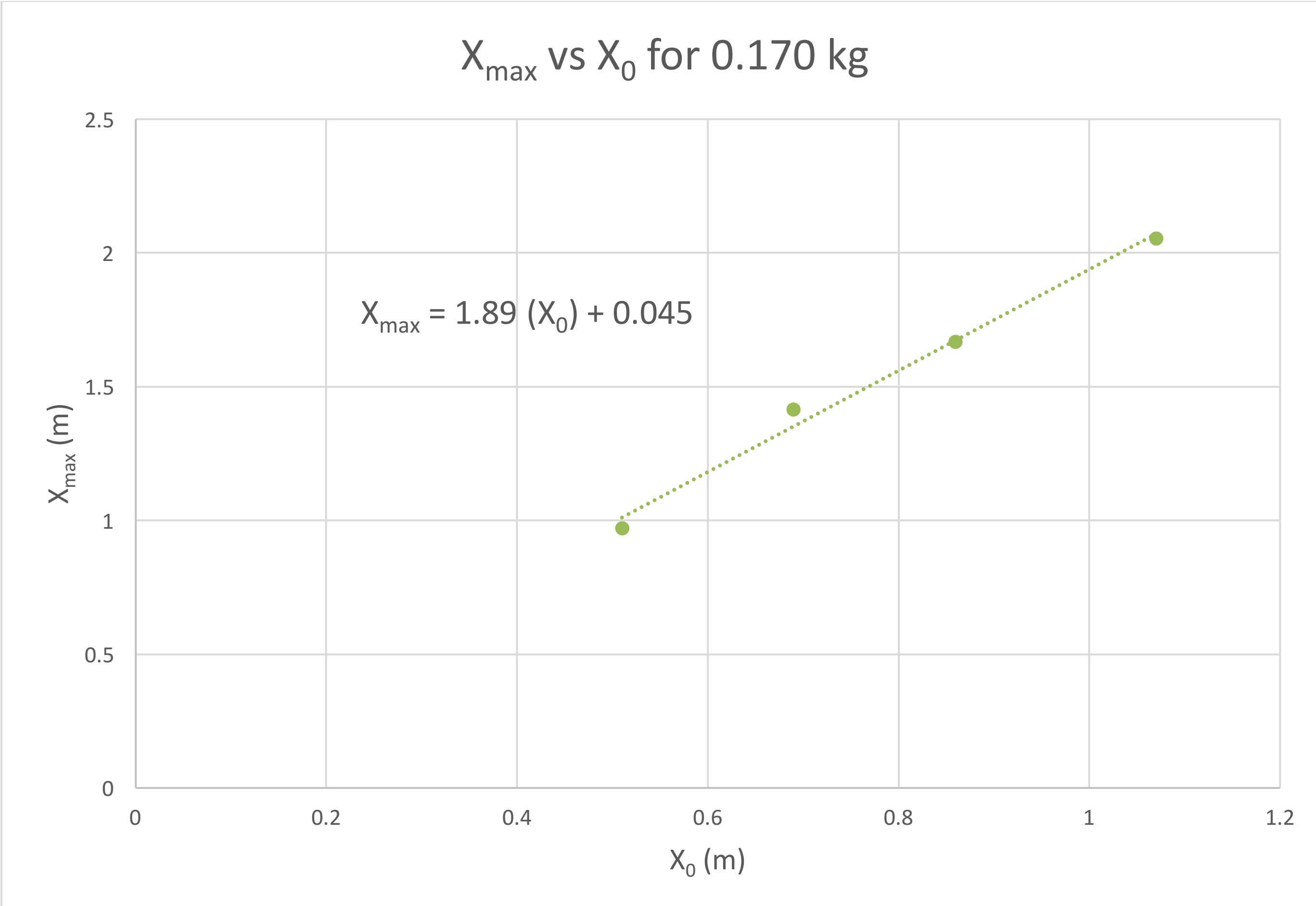


Figure #9: Graph for a mass of 0.170kg



Average Slope and Y-Intercept: $1.93(X_0) + 0.039$ m
Equation for X_{max} (equation 1): $X_{max} = 1.93(X_0) + 0.039$m

The value of interest is equation 1 because this equation can be used to find the max stretch of the bungee cord when the position is dropped from rest. This equation, along with other equations calculated in a past experiment will allow us to find how much a bungee will stretch based on the mass attached to it.

The uncertainty for this experiment was 0.1m because the reading of the Xmax position using the IPad slow motion camera had an uncertainty of 0.1m and all other uncertainties were neglected because of the weakest link shortcut. There was no need to linearize the graphs because all had linear trendlines.

DISCUSSION:

Are results were fairly precise. All of our slopes were within the uncertainty of 0.1 m and therefore is precise for our range of masses. The accuracy of the results is unknown because we have yet to test our equation and calculate a max stretch position and test the accuracy of our calculation. The accuracy of this measurement will eventually be measured when we perform the test egg drop. The sources of uncertainty could be the bungee itself. The bungee is not an ideal sting or spring system and therefore has undefined and indefinite characteristics. Because of this it is unknown whether the bungee's restoring force acted consistently throughout the test since we have no way to ensure the accuracy of our experiment yet. Another source of uncertainty are the masses. The masses were measured based on the value that was imprinted on each mass. These masses may have been inaccurate and therefore could have made our range of masses vary. Another source of uncertainty are the values for Xmax. The slow motion camera did not always have the best resolution and it was hard to record what the exact position of the end of the bungee was at the Xmax position. This also caused our uncertainty value to be larger and allowed for all of our slopes to be within the uncertainty range. This uncertainty could have caused us to falsely assume that all 4 masses resulted in the same relationship. Our results agreed with our hypothesis. There is a relationship between the max stretch of the bungee and its static equilibrium position with a mass attached to it and it is defined by equation 1. This equation is acceptable because all of the slopes fell within the uncertainty of the slopes so we can assume that the mass does not affect the relationship found between X_0 and X_{max}.

CONCLUSION:

This experiment will be used to find the max stretch of our bungee during our egg jump. Since we know how height the egg will be dropped from, we can pick an appropriate length of bungee and string to use to ensure the "thrill factor" is as great as possible without damaging our egg. The relationship between the X_0 position and the max stretch is defined by equation 1. Our next step will be to put our results together to find how much bungee cord we need. In addition we will have to figure out the force that will be exerted on the egg and this will be done using a combination of other experiments by our peers and our own experiments. Once we are confident in all of our values we will test our values in the egg jump.

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

Pledged: Matthew Dodson