Lab Report Outline—the Bones of the Story

In this course, you are asked to write only the outline of a lab report. A good lab report provides a complete record of your experiment, and even in outline form should convey a coherent and comprehensible story. This is an outline, not a summary. Give the relevant details *throughout—the details that answer the questions a scientifically educated reader might ask while following your story line. The emphasis is on clarity, thoroughness, and relevance, and of course conciseness (being an outline).* ***Report Outlines are individual assignments. Cite any work not your own, acknowledge any aid, and pledge the report.***

Fill in this form for reporting on experiments when required. (Did we say to give the relevant details throughout?) When finished, feel free to delete instructional verbiage or unused parts, for proofreading ease, and reading "flow."

Your name and your lab partner(s): Thomas Caldwell and Jenn Biegel **Section:** Monday **Date: 11/1/16**

TITLE: Change in Elasticity of Bungee Cords as a Result of Progressive Drops

ABSTRACT: *The purpose of this experiment was to explore how attached mass, segment length, and frequent use changed the elastic properties of a bungee cord. To implement the experiment, a single bungee cord was cut into varying lengths and each length was then attached to a specific mass. The mass was allowed to drop from a constant height and not allowed to bounce. The length of the cord was then measured to produce data regarding the change in the cord after each consecutive drop. Each segment of cord endured ten drops or snapped before ten drops could be attained. It was shown that after the original extension of the cord attached to mass was measured, the first drop caused the most significant change in the length of the cord, having changed roughly 6-7% over one drop for a smaller mass and a 20% change when a larger mass was attached. The data revealed that at the approximate mass of the egg drop, the length of the cord is marginally impacted after the first full drop. This experiment provided valuable information for future experiments that rely upon accurate prediction of the extended length of bungee cords when attached to a specific, predetermined mass.*

INTRODUCTION:

This experiment was focused on determining the change in elasticity of a bungee cord as attached mass, cord length, and use varied. Future experiments will rely on the data collected throughout this process as success will depend on the accurate prediction of the extended length of a bungee cord when attached to a specific mass. The recorded changes will provide insight into how to stretch the cord before testing so that the most desirable outcome is achieved.

Relevant equation:

Percent Change = $|length_2 - length_1| \,/\, length_1$

The percent change equation provided an equalizer in the data to allow for direct comparison across cord lengths and variations in mass. $Length_2$ represents the length of the cord post drop, while $Length_1$ represents the length of the cord before the drop.

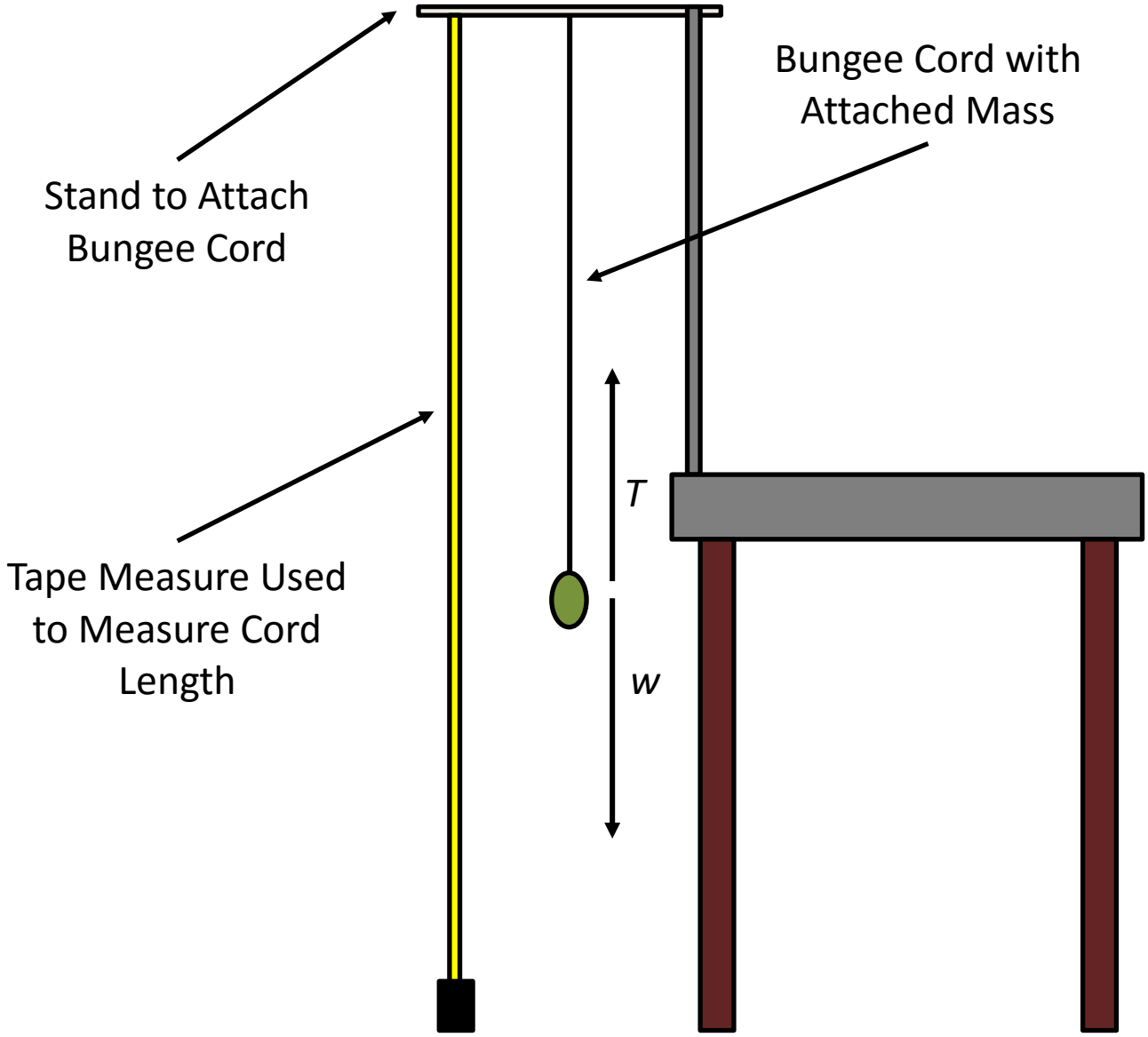
The basis of this experiment relies upon the idea of hysteresis. Hysteresis refers to the change in elasticity of an imperfect elastic band as force is applied and then removed. This is applicable to the experiment at hand because weight will be applied to the bungee cord, removed, and then applied again over multiple trials.

It is predicted that the change in the length of the bungee cord will be greater than ten percent over ten trials, and that the mass attached will be related to the total percent change observed. As there was no prior knowledge regarding the elasticity of the segment of bungee cord used in the experiment, a ten percent change in length seemed like an appropriate arbitrary level that the bungee would exceed over ten trials.

METHODS

One bungee cord was cut into varied lengths and masses were attached to each length. Each segment was measured with the mass attached without dropping, to provide a baseline for extension. The mass was then dropped and cord length measured for ten trials, or until the cord failed.

Figure 1: Diagram depicting the set-up from which the masses were dropped and cord length measured.



Attached to a table was a stand to which the bungee cord was tied. Attached to the same stand was a tape measure used to measure the length of cord after each drop. The mass was released from a point level with the stand.

Describe procedure, *including relevant or significant details* (may be bullets):

1. **The same bungee cord was cut and then two loops were tied at either end so that the straight portion of the cord was equal 0.15m or 0.30m depending on the segment.**
2. **The mass was then inserted through one of the loops and the other loop was attached to the overhanging portion of the stand.**
3. **The mass was then carefully lowered until the cord was fully extended.**
4. **The length was then measured from the bottom of the hanging mass.**

5. **The mass was then raised so that the bottom of the mass was level with the bottom of the overhanging portion of the stand.**
6. **The mass was then dropped and caught directly after the drop and resulting vertical movement.**
7. **The mass was then carefully lowered until the bungee cord was fully extended.**
8. **Length of the cord was then measured.**
9. **Steps 5-8 were repeated for ten trials, or until the bungee cord failed and snapped.**

RESULTS

It was discovered that the length of the bungee did change significantly after the first drop, regardless of mass attached or length of the cord. In addition, the change in length of the cord did not change noticeably after the first drop.

Figure 2: Measured Length after Each Drop. *This table presents the change in length of the bungee after each drop of the mass, categorized by size of the mass and length of the cord. "v2" denotes the second attempt with a specific length/mass combination.*

Length and Mass	**.149kg (.150m)**	**.149kg (.150m) v2**	**.149kg (.300m)**	**.400kg (.150m)**	**.400kg (.150m) v2**
Trial Number	Length (m) (+/- 0.001m)	Length (m) (+/- 0.001m)	Length (m) (+/- 0.001m)	Length (m) (+/- 0.001m)	Length (m) (+/- 0.001m)
0	0.54	0.564	0.833	0.868	1.046
1	0.568	0.596	0.89	1.045	1.25
2	0.568	0.604	0.901	1.053	Snapped
3	0.568	0.606	0.904	1.081	
4	0.57	0.609	0.908	1.097	
5	0.571	0.61	0.911	1.111	
6	0.571	0.611	0.916	1.122	
7	0.572	0.613	0.916	1.176	
8	0.572	0.614	0.919	Snapped	
9	0.573	0.614	0.922		
10	0.574	0.614	0.923		

Uncertainty was found using the raw uncertainty of the tape measure used in the experiment. Due to constrictions in the length of bungee cord available, a second trial could not be performed with the .300m length. Uncertainty in all mass values is +/- 0.0001kg.

***Figure 3: Extended Cord Length vs. Drop Number**. The chart presents the change in length of the cord after each successive drop.*

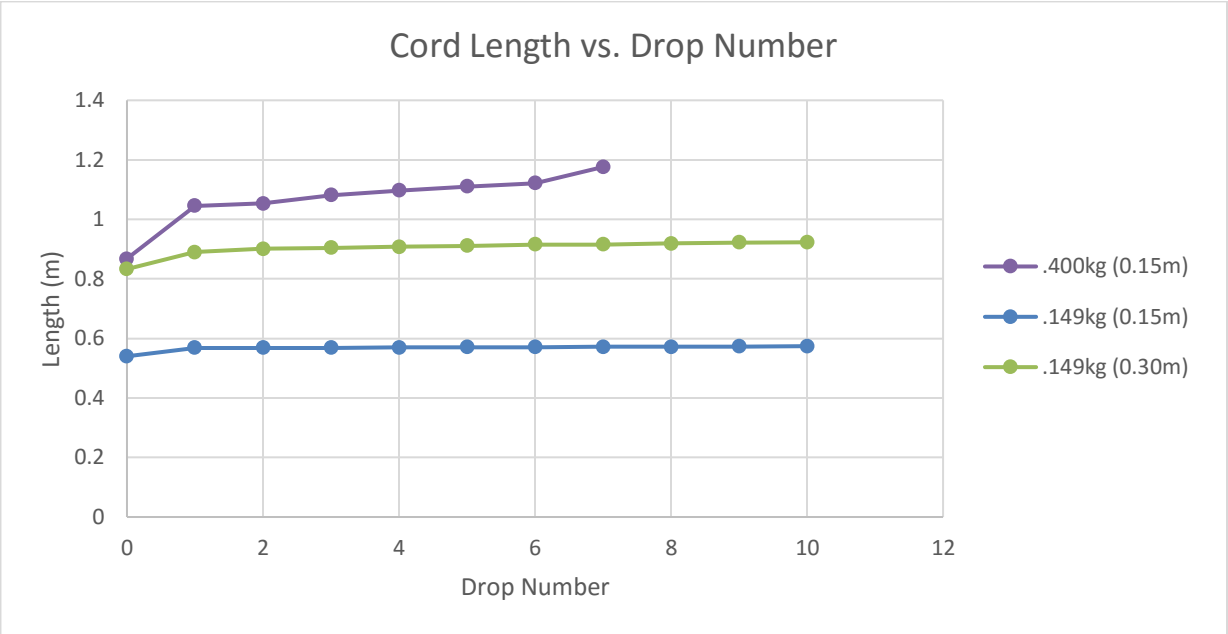
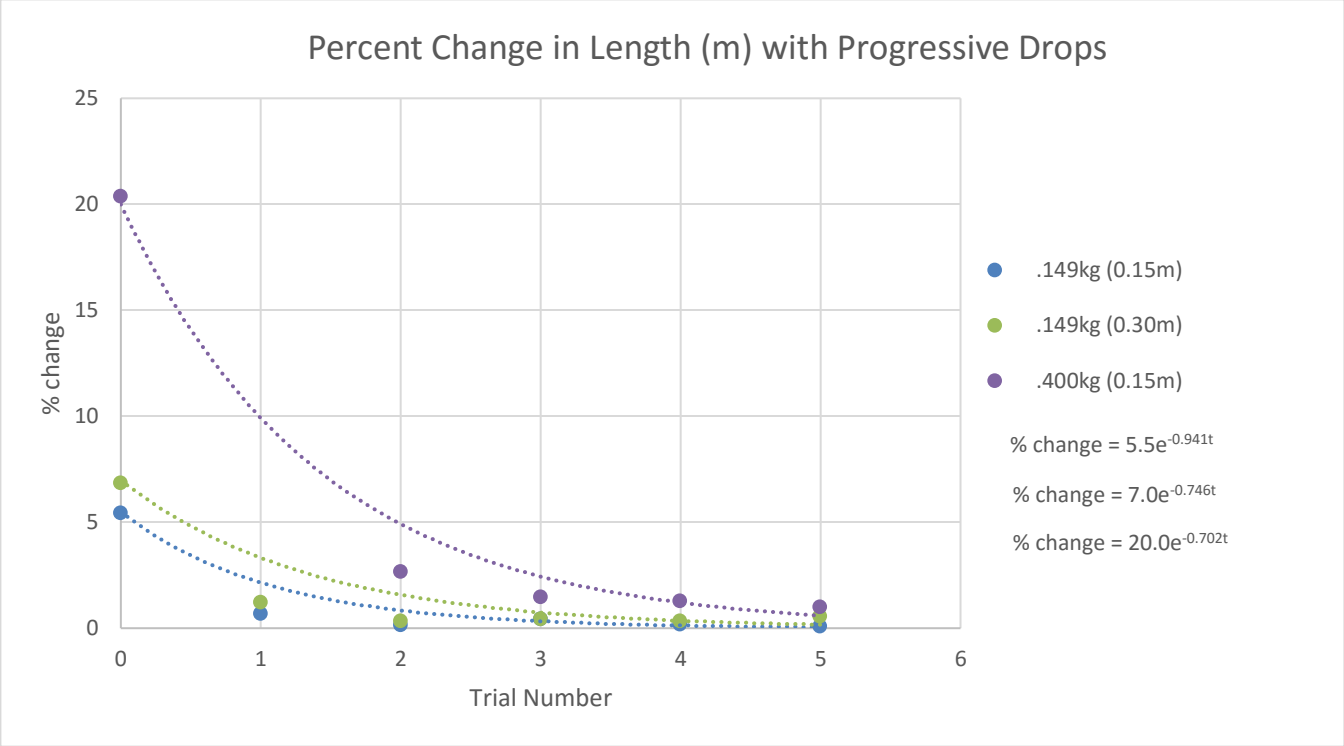


***Figure 4: Percent Change vs. Length of Cord and Mass.** This table shows the percent change in the length of the cord representing the difference in length between drops relative to the previous length.*

Trial Number	.149kg (.150m) (% change) (+/- 0.4)	.149kg (.150m) v2 (% change) (+/-0.3)	.149kg (.300m) (% change) (+/-0.2)	.400kg (.150m) (% change) (+/-0.2)
1	5.2	5.7	6.8	20.4
2	0.0	1.3	1.2	0.0
3	0.0	0.3	0.3	2.7
4	0.4	0.5	0.4	1.5
5	0.2	0.2	0.3	1.3
6	0.0	0.2	0.5	1.0
7	0.2	0.3	0.0	4.8
8	0.0	0.2	0.3	N/A
9	0.2	0.0	0.3	N/A
10	0.2	0.0	0.1	N/A

Uncertainty in percent change was found using standard propagation of uncertainty for a quotient.

Figure 5: Percent Change in Cord Length vs. Drop Number. *The graph shows the exponential relationship between the percent change in length and the first five drops endured by the bungee cord.*



Equation of the curve-fit from the graph, if applicable (*substitute* your variables for *Excel's* y and x, and round coefficients and powers appropriately—also within graph):

1. % change = $5.5e^{-0.941t}$
2. % change = $7e^{-0.746t}$
3. % change = $20e^{-0.702t}$

Where *t* = trial number

OR use appropriate propagation-of-uncertainty analysis on any **non-linear** equation *(see UG)* to obtain:

uncertainty in coefficient of .149kg (0.15m) = 0.3 % uncert= 5%

uncertainty in coefficient of .149kg (0.30m) = 0.2 % uncert= 3%

uncertainty in coefficient of .400kg (0.15m) = 0.2 % uncert= 1%

State where/how you got this uncertainty:

The uncertainty in each coefficient was found using the standard propagation of uncertainty for a quotient. For the coefficient of the attempts using .149kg and a 0.15m cord, the coefficient was found using the average % change of each trial between each drop.

Experimental Values of Interest:

value obtained = % change between drops of .149kg (0.15m) trial = 5.5

uncertainty of experimental value(s) = 0.3 % uncert= 5%

value obtained = % change between drops of .149kg (0.30m) trial = 7.0

uncertainty of experimental value(s) = 0.2 % uncert= 3%

value obtained = % change between drops of .400kg (0.15m) trial = 20.0

uncertainty of experimental value(s) = 0.2 % uncert= 1%

These values were of interest because the conversion to percent change allowed for the direct comparison of the trials with different masses and lengths. The coefficients also allow for the prediction of future changes in the length of the bungee cord after a certain number of trials.

The uncertainty in each value was found using the standard propagation of uncertainty for a quotient. For the coefficient of the attempts using .149kg and a 0.15m cord, the value was found using the average % change of each trial between each drop.

Recording and analyzing the percent change was more effective than observing the alteration in strictly the length of the bungee cord. This provided an equalizer that enabled the direct comparison between different lengths and masses used.

The first dropped produced the greatest change in length of the bungee and then changes in length were noticeably smaller as the number of drops increased. The results show that greater length with constant mass produced a slightly larger initial percent change relative to a shorter length and the same mass. The larger mass produced a much higher percent change consistently throughout the drops. The percent change measured after the first five drops followed an exponential decay pattern.

DISCUSSION

The changes in elasticity did not have a predicted value based on theory for comparison, but the percent uncertainty being less than or equal to 5% for each coefficient of percent change is satisfactory. One way in which the results could be tested is to determine whether or not the slight uptick in change with the extension of length is consistent when using a larger mass. The mass of .400kg could be attached to a 0.30m bungee cord segment and the experiment could be repeated. The data above showed a 26% increase in the percent change found after the first drop, so this could be explored to see if data matches the observed trend regardless of mass.

Although the segments were cut from the same long piece of bungee cord, there is the possibility that each segment was not uniform in production or elastic property. In addition, it is entirely possible that the use of .400kg created too much weight for this bungee cord. After seven drops with the .400kg mass attached, the cord snapped. Directly before this point, the cord showed a much larger percent change than the previous drops, which suggested that the cord was frayed and about to break and added a data point that did not fall in line with the previous data points.

The experimental design relied upon the researchers' ability to catch the weight after the first drop. At some instances, the weight was not caught and was allowed to bounce. This added extra strain to the bungee outside of the intended ten trials. In the future, a wider catching device, such as a net, could be used to provide a greater area and reduce the chance of the mass being allowed a second bounce.

In addition, it is important to address the trends in the data. The data showed to follow an exponential decay function after only the first five values for percent change after each drop were included in the model, which displayed that the change experienced by the cord after each drop decreased as the number of drops increased.

The results supported aspects of the hypothesis. They supported the prediction that increased mass would cause greater percent change in the length of the cord relative to a smaller mass. In addition, the prediction that percent change in length would be greater than ten percent was supported by the trial with mass of .400kg, but not with any trials that used the smaller mass of .149kg. The results were deemed acceptable based on their low percentage error, but more testing is required to produce a model that correctly explains the relationship between cord length, attached mass, and percent change in length.

CONCLUSION

It was observed that the first drop in all trials caused the greatest change in the elastic properties of the bungee cord segment. This suggests that the change in elasticity of the cord follows an exponential decay trend. It was also observed that as mass increases, the percent change after each drop is greater than the percent change recorded when a smaller mass was attached. Lastly, it was observed that a longer cord length causes a greater percent change in length when compared to a cord with a shorter length.

The findings presented information regarding the change in cord characteristics after each drop. Although the cord does change slightly after every drop, the most important change occurs after the first drop. In addition, the experiment provided useful data regarding the influence of mass and cord length on what change in the cord should be expected after each drop. That being said, as experimentation moves forward regarding the prediction of how the eggs will fall in upcoming weeks, it is imperative that the cord must first be run through a trial drop and then measured to attain an accurate portrayal of how the cord will act in successive trials.

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

Pledged: Thomas Caldwell