Rachel Steffen, Joe Zoeller **Phys 113-06** **November 28, 2016**

What number of bungee strands produces the best bungee situation?

ABSTRACT:

In this experiment we tested the effects of adding multiple bungee strands to support varying masses. By measuring the static displacement, we could determine the k value for each bungee situation. By maintaining a constant initial length of bungee and varying the mass hung from it we could see the overall trend of k with an increase in bungee strands based on it's displacement. Knowing the behavior of multiple bungee strands will allow us to better predict the best bungee situation for a higher drop that does not decelerate too quickly. The trend found was that k increased with the number of bungee strands confirming our hypothesis. We inferred that the ideal bungee drop would consist of only one bungee strand due to one strand producing the greatest deceleration time.

INTRODUCTION:

Start with a statement that introduces the overall experiment. Orient the reader to the particular problem, purpose or question, and why you want to know. Give enough context that the reader understands the environment or situation from which it arose:

Previously we found the value of k resulting in an equation for bungee length given the height, but, in order to predict the ideal bungee situation, we wanted to test the effect of multiple strands of bungee supporting a mass. The ideal bungee situation is defined as one with the greatest deceleration yet comes closest to the ground without hitting it. By testing the static displacement of different masses with a varying number of bungee strands we could derive the k value for each number of strands using Hooke's law:

$F=kX$, where F is the force of tension on the mass and X is its static displacement.

The force acting on the bungee is equal to the mass of the hanging weight multiplied by acceleration due to gravity ($F=ma$).

Hooke's law can be used because the bungee can be looked at as a series of springs.

We predicted that k would increase with the number of bungee strands because, although the force of tension would stay the same, we believed that the static displacement would become smaller.

METHODS:

By varying the mass hung from each number of bungee strands at a constant length of .553 m the k values could then be determined from the slope of the dataset for each number of strands.

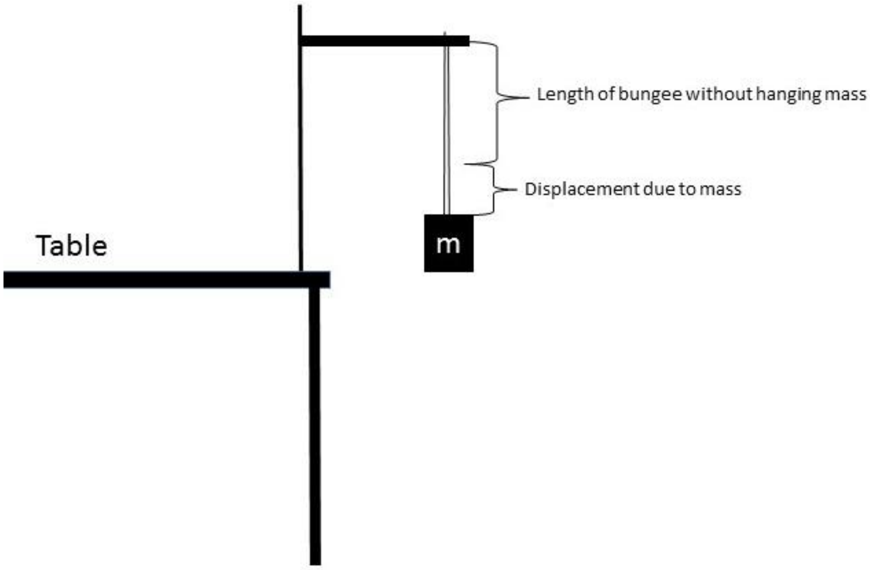


Figure 1: Setup of the bungee and hanging mass

The bungee hung from a secured apparatus off the end of a table. The bungee was tied to the apparatus at the top and to the hanging mass at the bottom. The length of the bungee (.553 m) was maintained throughout the experiment.

Describe procedure

We used data from the bungee I experiment to obtain the k value for a single strand, so we began by doubling over the bungee and tying it to the 0.05 kg hanging mass. Bungee strands were added by folding the remaining bungee extending from the original strand and tying it to the screw the original strand was tied to or to the bottom of the original strand. The strands overlapped eachother.

1.) We measured the static displacement of the bungee with a measuring tape by subtracting the initial length (.553 m) from the final length of the bungee.
2.) We then added weights and measured the static displacements for hanging masses of 0.06 kg, 0.07 kg, 0.08kg, 0.1 kg, 0.11 kg, 0.12 kg, 0.13 kg, 0.15 kg, 0.2 kg.
3.) The bungee was tripled over and the displacement of the different weights was again measured.
4.) A fourth strand was then tied to the hanging mass and the static displacement of each hanging mass was again measured.
5.) The displacements were then graphed according to the number of strands from which the masses hung.

RESULTS:

The displacement due to the hanging mass was compared to the force of the hanging mass on the bungee. The graph of this comparison results in a slope equal to the k value for each number of bungee strands.

Table 1: The displacement of one bungee strand when acted on by different forces

Displacement (m) ± 0.002m	Force (N)
0.115	0.491
0.149	0.589
0.185	0.687
0.222	0.785
0.313	0.981
0.373	1.079
0.43	1.177
0.494	1.275
0.622	1.472
0.962	1.962

Table 2: The displacement of two bungee strands when acted on by different forces

Displacement (m) ± 0.002m	Force (N)
0.044	0.491
0.056	0.589
0.068	0.687
0.08	0.785
0.109	0.981
0.123	1.079
0.139	1.177
0.157	1.275
0.192	1.472
0.3	1.962

Table 3: The displacement of three bungee strands when acted on by different forces

Displacement (m) ± 0.002m	Force (N)
0.032	0.491
0.04	0.589
0.046	0.687
0.053	0.785
0.068	0.981
0.077	1.079
0.086	1.177
0.095	1.275
0.112	1.472
0.166	1.962

Table 4: The displacement of four bungee strands when acted on by different forces

Displacement (m) ± 0.002m	Force (N)
0.021	0.491
0.027	0.589
0.033	0.687
0.038	0.785
0.056	0.981
0.061	1.079
0.067	1.177
0.071	1.275
0.085	1.472
0.136	1.962

The force is the weight of the hanging mass (mg). The displacement is a measurement of how far the added mass causes the bungee to stretch. The standard error of displacement was 0.002 based on the difficulty in gauging the initial and displaced position of the bungee to the hundredths place.

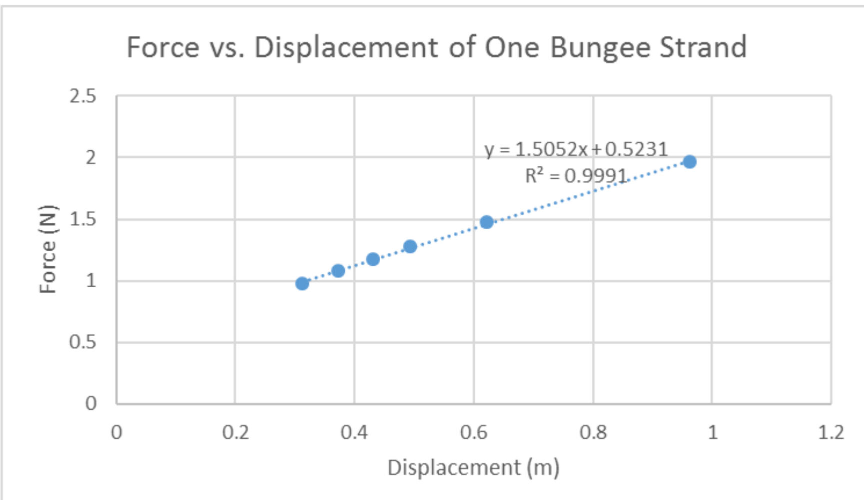
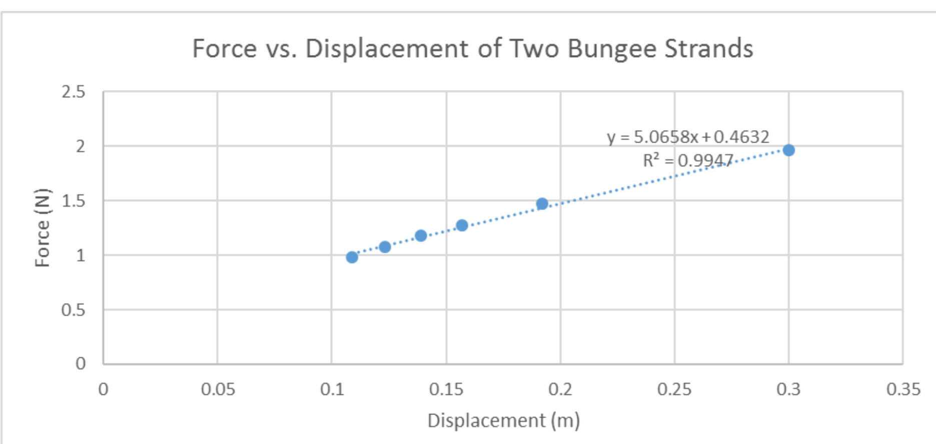


Figure 2: Force of a Hanging Mass vs. Displacement of One Bungee Strand



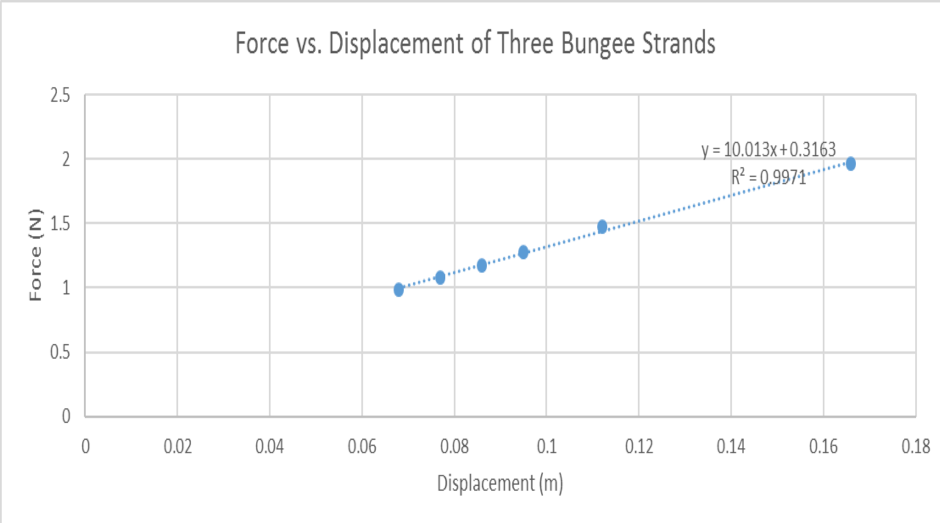


Figure 3: Force of hanging mass vs. displacement of three bungee strands

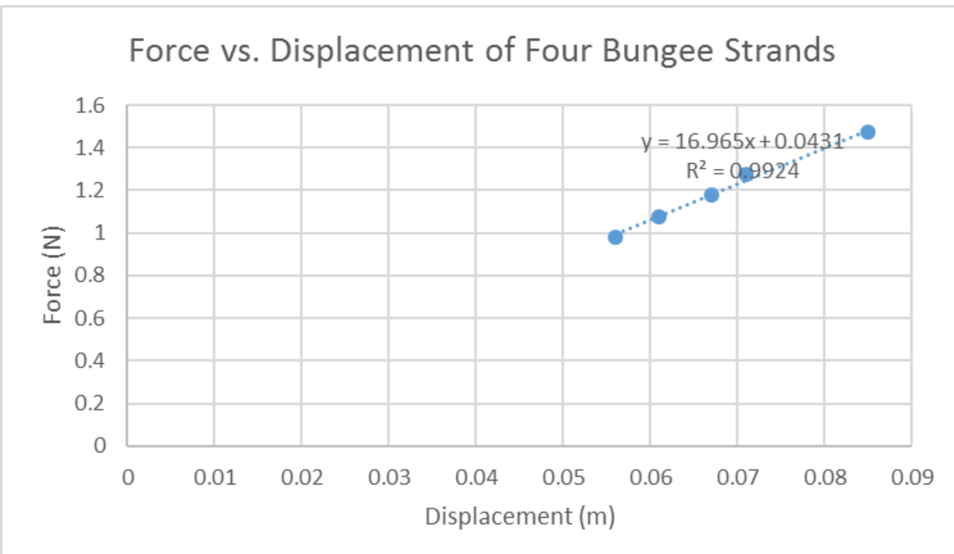


Figure 4: Force of hanging mass vs. displacement of four bungee strands

The weights chosen to be graphed for each of the bungee situations were those of weights closer to that of the final bungee drop. These provided a better linearized graph while also portraying a situation closer to the one we want to predict.

Linear equations

1 Bungee:
$F=1.505X+0.5231$

2 Bungees:
$F=5.066X+0.4632$

3 Bungees:
$F=10.013X+0.3163$

4 Bungees:
$F=16.965X+0.0431$

Bungee Strands	Uncertainty of slope	% Uncert.
1	0.02	1.49
2	0.2	3.65
3	0.3	2.70
4	0.9	5.04

Bungee Strands	Uncertainty of Y intercept	% Uncert.
1	0.01	2.47
2	0.03	7.25
3	0.03	9.03
4	0.06	136.00

Excel linear regression analysis was used to produce the uncertainty values

Values of interest:

Number of Strands	k value
1	1.505
2	5.065
3	10.011
4	16.948

Figure 5: Force of a hanging mass vs. displacement of two bungee strands

The k values were obtained via Hooke's Law F=kX, k being the slope of the graph for the displacement vs. force of each bungee situation (k=F/X). A graph of these k values does not produce a functional trend line of any type.

The k value for one bungee strand was found to be 1.505. The k value for two bungee strands was found to be 5.065. The k value for three bungee strands was found to be 10.011. The k value for four bungee strands was found to be 16.948. This demonstrates that the displacement decreases and the k value increases as the number of strands increases.

DISCUSSION:

The percent uncertainty for the Y intercept of four bungee strands (136%) may be due to the range of data graphed. We chose to only analyze the data for the higher weights because their trend line fit better and would more closely represent the results of a higher drop of a weight closer to those analyzed than that of the lighter weights tested. The trend of greater uncertainty in both the slope and Y intercept with an increase in bungee strands tells us that more bungee strands introduces more variability. This could be due to slightly varying lengths of the bungee strands tied to the weight. This could cause one strand to support more force than the other strands skewing the data. It is also difficult to gauge the length of the bungee to the hundredths place, so that introduces another possible source of error. Any pulling on the bungee while measuring or slight oscillations while measuring would introduce error. The found linear equations could be tested by choosing a new hanging mass, calculating the supposed displacement via the linear equations, and testing the actual result.

The results confirmed our hypothesis that the k value would increase with an increase in number of bungee strands. This is in agreement with Hooke's law and our assumption that there would be a decrease in displacement with an increase in strands.

CONCLUSION:

The k value increases with the addition of bungee strands.

A larger k value means less displacement and thus a shorter deceleration time because it is within the time that the bungee stretches that it decelerates. A dropped weight would retract faster if its displacement was smaller. If the ideal bungee situation is that with longer deceleration time and a less abrupt retraction, one bungee strand would provide the best situation.

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

Rachel Steffen