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Phys 113-01

Bungee Test Part 1 Lab Report Outline

Abstract

Can we use Hooke's law as a basis for modeling a bungee jump? Does a bungee cord have a sole spring constant value or does the value depend on the cord's length? These are the questions we sought out to answer in the first part of the bungee challenge. Armed with a bungee cord, tape measure, some weights and stand we formulated an experiment with 30 test trials meant to determine the bungee's elasticity.

Introduction

In the bungee jump experiment, my two lab partners and I will be designing a bungee jump which will be tested with a fragile egg. Before I dive into the scientific details, here is a quick background on bungee jumps and the kinematics that make them possible.

When a person or mass initiates the jump, the first part is solely acceleration in free fall which is driven by gravity. When the cord begins to stretch, it applies an upward force which decelerates the free falling mass. Eventually, the force negates the free fall and the mass is brought to rest. The goal of the jump is to attain the maximum speed and free fall distance possible without impacting the ground or decelerating too rapidly. The mass can decelerate at a rate no larger than three times the weight of the jumper.

Hooke's Law states that the force needed to stretch a spring is directly proportional to the displacement of the stretched spring. The formula for calculating Hooke's Law is

$$F=kx$$

Where F is force measured in Newtons (N), k is the spring constant measured in Newtons per meter (N/m) and x is the "amount of elongation that the elastic undergoes" or in simpler terms, how much the elastic expands, measured in meters.

In order to determine the optimal height to drop the egg from, we must first determine the k value of the bungee cord. To do this we calculated the k value of the bungee cord at different lengths and with different masses attached to the bottom of it.

Methods

As stated in the introduction, the goal of our experiment was to determine the spring constant and thus determining the relationship between the attached weight and the displacement experienced by the bungee cord. The experiment consisted of 6 sets of test, each with a different equilibrium bungee cord length. We performed 5 sub-trials for each of the 6 sets. In each sub trial we added additional hanging mass. The initial set up is modeled in figure 1.

		Set 1	**Set 2**	**Set 3**	**Set 4**	**Set 5**	**Set 6**
Equilibrium Bungee length (cm)		**0.795**	**0.72**	**0.615**	**0.43**	**0.31**	**.072**
Hanging Mass (kg)	Sub-trial 1	0.05	0.05	0.05	0.05	0.05	0.05
	Sub-trial 2	0.07	0.07	0.07	0.07	0.07	0.07
	Sub-trial 3	0.09	0.09	0.09	0.09	0.09	0.09
	Sub-trial 4	0.1	0.1	0.1	0.1	0.1	0.1
	Sub-trial 5	0.12	0.12	0.12	0.12	0.12	0.12

Figure 1: Initial data table

As Shown in figure 1, the bungee had a different equilibrium length in each of the six sets. Underneath each set are the equilibrium bungee length and the hanging mass for each of the sub trials.

This is the procedure we followed for the 1st set.

1. Tie two knots on the bungee cord so that the length between the knots is 0.795 cm.
2. Attach one of the knots to the top of the stand
3. Measure distance the bungee hangs down from the stand; in this case it is 0.795 cm (the equilibrium length).
4. Attach hanging mass (.05 kg) to the knot at the bottom of the bungee.
5. Measure the length of the bungee.
6. Then subtract the length from step 5 from the equilibrium length, which gives you the displacement (x value).
7. Add .02 kg to the hanging mass, measure the bungee (step 5) and calculate displacement (step 6)
8. Repeat step 7 three more times.

Then repeat steps 1 through 8, but decrease the length of the bungee with each set. The set up of the experiment is portrayed in figure 2 below.

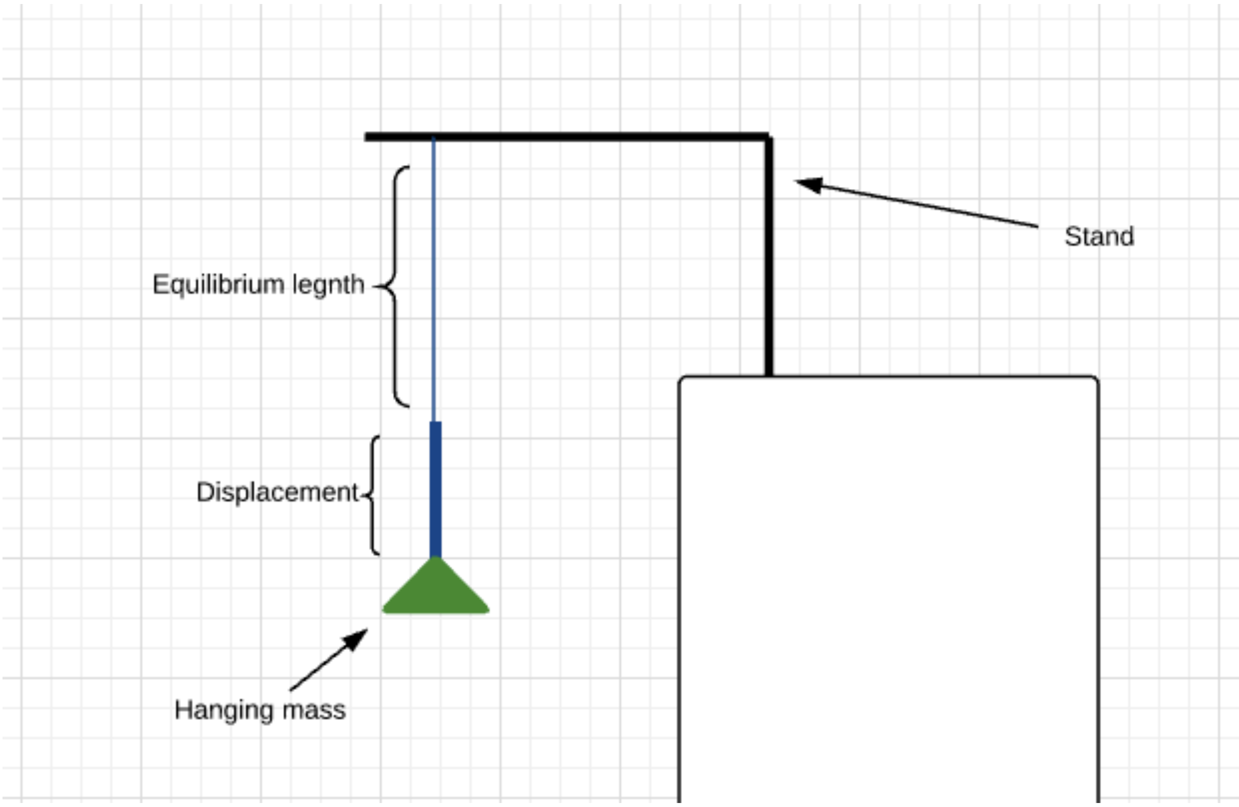


Figure 2: Experiment set up.

Results

The chart below, figure 3, displays the data we collected from our 6 sets of test. The first column is the weight of the hanging mass in kg. The displacement can be found in the third column. We calculated the displacement by subtracting the final length of the cord (shown in column 4) by the initial length.

The second column is the force downwards which we calculated by multiplying the weight of the mass by the gravity constant of 9.81.

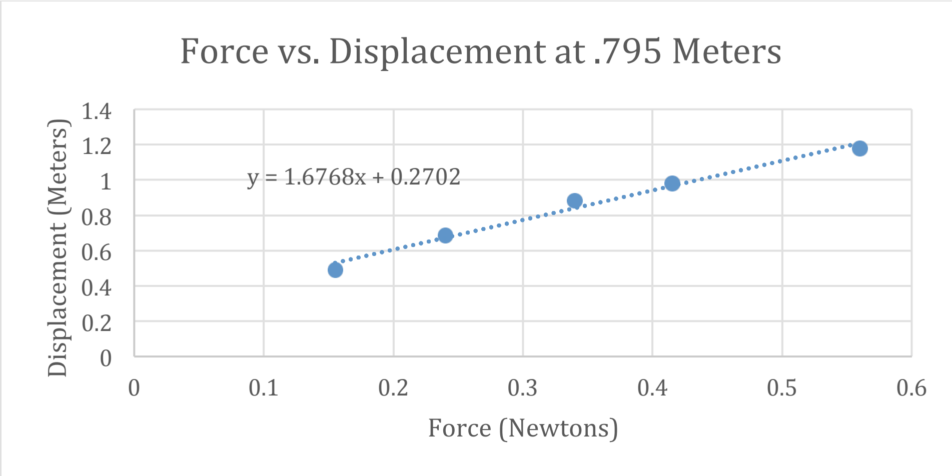
Initial Length = 0.072 cm				Initial Length = 0.31 cm			
weight (kg)	**m*g (g)**	**disp. (m)**	**F. Length (m)**	**weight (kg)**	**m*g (g)**	**disp. (m)**	**F. Length (m)**
0.05	0.4905	0.06	0.37	0.05	0.4905	0.06	0.37
0.07	0.6867	0.095	0.405	0.07	0.6867	0.095	0.405
0.09	0.8829	0.135	0.445	0.09	0.8829	0.135	0.445
0.1	0.981	0.162	0.472	0.1	0.981	0.162	0.472
0.12	1.1772	0.215	0.525	0.12	1.1772	0.215	0.525
Initial Length = 0.43 cm				Initial Length = 0.615 cm			
weight (kg)	**m*g (g)**	**disp. (m)**	**F. Length (m)**	**weight (kg)**	**m*g (g)**	**disp. (m)**	**F. Length (m)**
0.05	0.4905	0.082	0.512	0.05	0.4905	0.12	0.735
0.07	0.6867	0.13	0.56	0.07	0.6867	0.185	0.8
0.09	0.8829	0.19	0.62	0.09	0.8829	0.25	0.865
0.1	0.981	0.23	0.66	0.1	0.981	0.325	0.94
0.12	1.1772	0.305	0.735	0.12	1.1772	0.375	0.99
Initial Length = 0.72 cm				Initial Length = 0.795 cm			
weight (kg)	**m*g (g)**	**disp. (m)**	**F. Length (m)**	**weight (kg)**	**m*g (g)**	**disp. (m)**	**F. Length (m)**
0.05	0.4905	0.018	0.09	0.05	0.4905	0.018	0.09
0.07	0.6867	0.026	0.098	0.07	0.6867	0.026	0.098
0.09	0.8829	0.034	0.106	0.09	0.8829	0.034	0.106
0.1	0.981	0.04	0.112	0.1	0.981	0.04	0.112
0.12	1.1772	0.065	0.137	0.12	1.1772	0.065	0.137

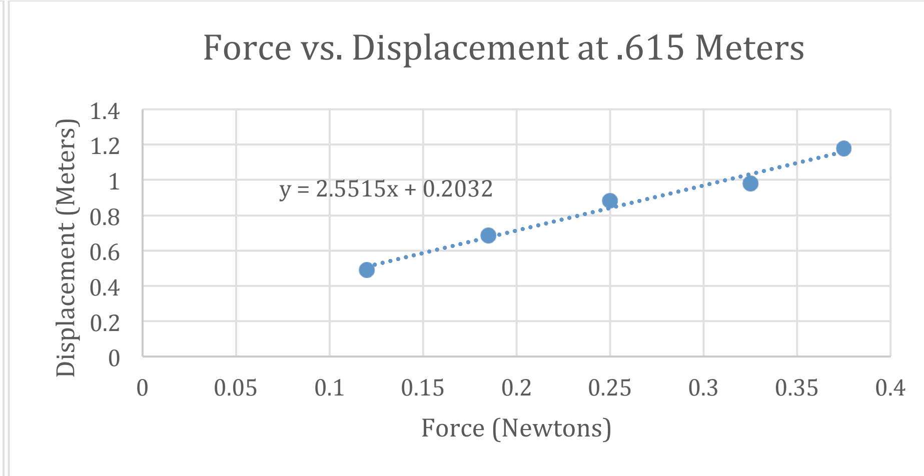
Figure 1: Data Table

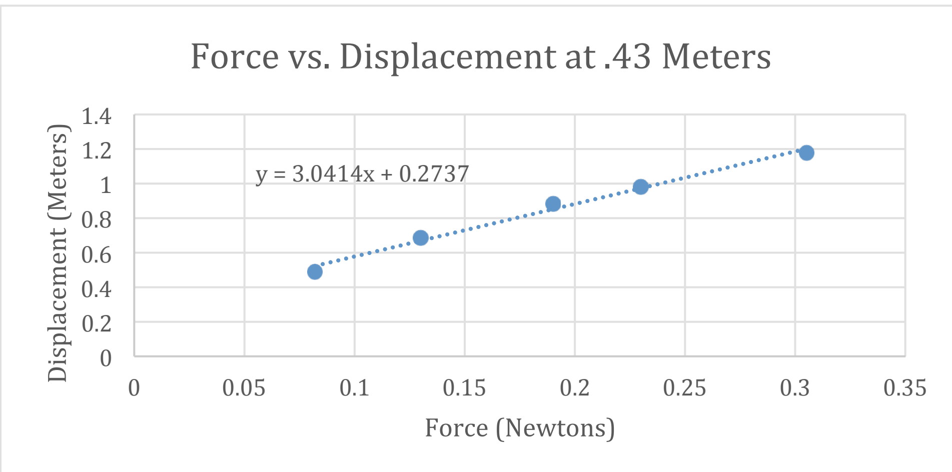
We produced a graph for each of the six sets with displacement on the y-axis and force on the x-axis. All six of the graphs are displayed on the next page. We determined the average k value for the set by finding the slope of the graph's linear trend line. Another way to determine the k value would be to use the equation F=kx. The k values are listed below in figure 4.

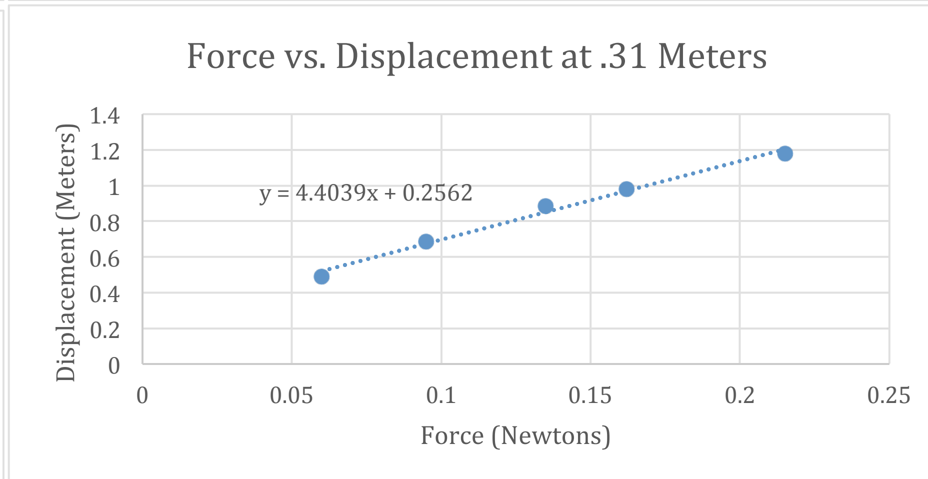
Figure 4: K Values

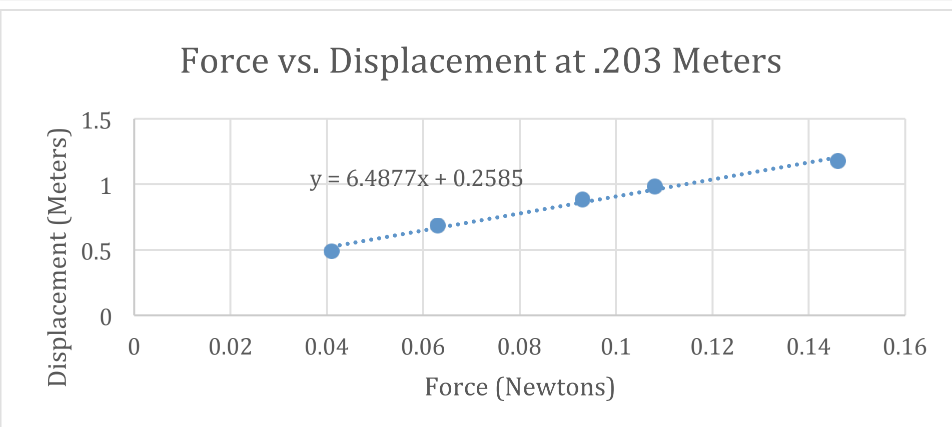
Unstretched Length (m)	**0.072**	**0.203**	**0.31**	**0.43**	**0.615**	**0.795**
K Value (N/m)	0.0643	0.1523	0.2247	0.3253	0.3847	0.5861

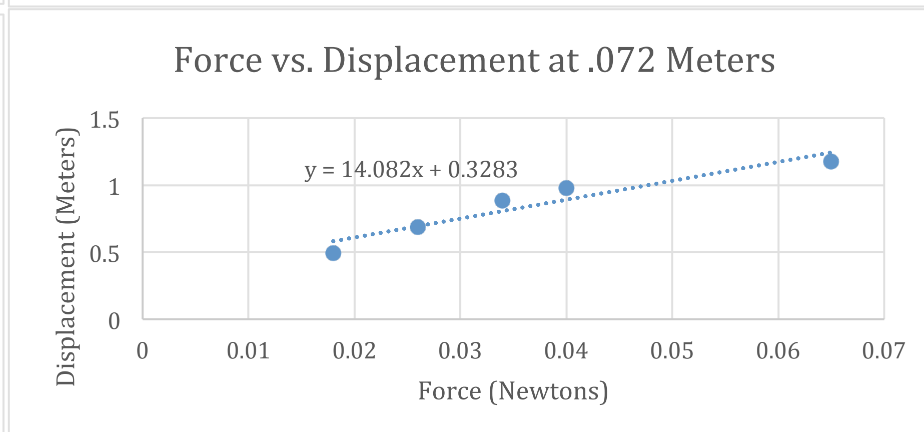

Force vs. Displacement at .795 Meters
y = 1.6768x + 0.2702
Displacement (Meters)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0 0.1 0.2 0.3 0.4 0.5 0.6
Force (Newtons)


Force vs. Displacement at .615 Meters
y = 2.5515x + 0.2032
Displacement (Meters)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4
Force (Newtons)

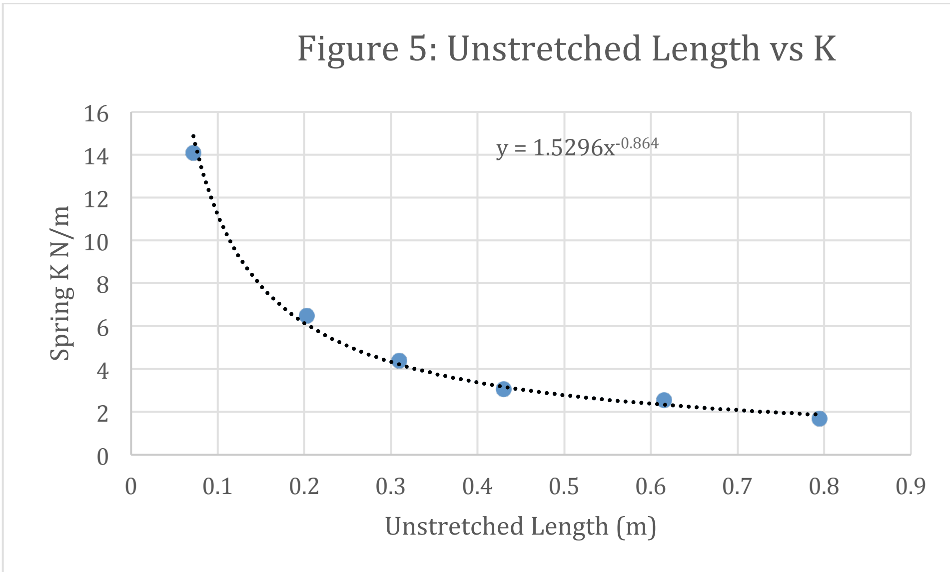

Force vs. Displacement at .43 Meters
y = 3.0414x + 0.2737
Displacement (Meters)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0 0.05 0.1 0.15 0.2 0.25 0.3 0.35
Force (Newtons)


Force vs. Displacement at .31 Meters
y = 4.4039x + 0.2562
Displacement (Meters)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0 0.05 0.1 0.15 0.2 0.25
Force (Newtons)


Force vs. Displacement at .203 Meters
y = 6.4877x + 0.2585
Displacement (Meters)
1.5
1
0.5
0
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16
Force (Newtons)


Force vs. Displacement at .072 Meters
y = 14.082x + 0.3283
Displacement (Meters)
1.5
1
0.5
0
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07
Force (Newtons)

After collecting our data, we graphed the spring constant, K, with the unstretched length of the cord, as displayed in figure 5.



Discussion

The graph in figure 5 shows an inverse relationship between the unstretched length of the bungee and the spring constant. This answers the initial question we had as to whether or not the spring constant remained the same regardless of the length of the bungee. We have determined that the answer to this question is **no!**

We found that as the unstretched length of the cord increases, the spring constant decreases. So when we conduct our actual experiment we will be able to determine the best length for the bungee cord by taking into account the spring constant.

Essentially then, the most significant take away from our experiment thus far are the k values that we have derived. We have determined that we cannot simply use the basic Hooke's Law to build our model since our cord does not act in a universally consistent behavior pattern. With that said, Hooke's law is a key foundation for our model, but it is essential to account for the fact that we are performing the experiment in a real world setting rather and not in an ideal one, with an ideal spring.

We have determined that there is an inverse relationship between K and the unstretched cord. As a result, we can construct a more accurate model that is tailored to the specific length of the bungee cord and the mass of the weight attached to it.

If we had not conducted the six different sets with differing lengths, but rather with just one length, say 0.1 meters, the spring constant we would have resulted in poor consequences in the bungee test with a much longer equilibrium bungee length. This is because we would have accepted the k value from the 0.1 test as the k value for whatever length we use in the real bungee experiment, and as a result we would have anticipated the bungee experiencing a much larger k value than it actually does.

Conclusion

This lab report outline encompasses the beginning of what will be a three-part experiment, which will conclude with a live test of our bungee cord model with an egg attached to the bottom. The goal of our work in the first two parts is to determine an equation that we can use to specify the optimal bungee length for the final experiment.

In the first part of the experiment, which is covered in this lab report outline, our objective was to examine and analyze one critical aspect of the bungee that will be used for the real experiment. Our group sought to find the spring value of k, determine if k was consistent regardless of the bungees equilibrium length and ultimately determine if we could use Hooke's law to model our bungee experiment with the egg. We accomplished all three of our goals. With regards to using Hooke's law, we found that we can use the equation as long as we have tested and determined the length of the drop.

Ultimately, the information and data we have ascertained thus far will allow us to develop an accurate bungee model that will be tested in the coming weeks. When the time comes to test our egg, we will enter our data into an equation.