Caroline Burke, 11/8/17 Partners: Duncan Maxwell, Olivia

Bungee Lab 2: Dynamic Drop

Summary:

This experiment was designed to determine a relationship between mass and the resulting K value from the equation $PE_{spring}=1/2KX^2$ in a dynamic drop. To do this, the total energy right before the cord's constant equilibrium was calculated using the law of Conservation of Energy. The potential energy at the top of the drop was set equal to the potential energy and the kinetic energy right before the weight stretched the cord past equilibrium. ($mgh_i= mgh_f + 1/2mv^2$) The energy found right before the drop, $mgh_f + 1/2mv^2$, is the energy transferred into the potential energy of a spring. Therefore, it is set equal to $1/2KX^2$.

Overall, using the equation $mgh_f + 1/2mv^2=1/2KX^2$ and measuring the change in distance from equilibrium (X) upon dropping masses of .01kg, .03kg, .05kg gives a way to calculate the K value for each mass. Each weight was dynamically dropped five times and recorded on a slow-motion video for a more accurate measure of the change in distance from the weight. Overall, the 0.01 kg weight stretched the cord an average of 0.135m resulting in an average K value of 7.919 N/m. The .03 kg weight stretched the cord an average of 0.362m yielding an average K value of 4.133 N/m. Lastly, the .06 kg weight stretched the cord an average of .678m resulting in an average K value of 3.274. These average K values were plotted against mass. Excel showed a power relationship between mass and the K value of a dynamic drop of $K= 0.7635M^{-0.502}$. The R^2 value was calculated at 0.982. The power equation yielded an answer with an average standard deviation from our found average K values of 0.155 for all of the masses.

This experiment will be helpful in future applications. This provides a way to find the K value in a dynamic drop for different masses. This is expected since a bigger mass should yield more energy. However, there could have been human error in reading measurements and keeping proper techniques. There are uncertainty values considered for all the measurements.

Diagram:

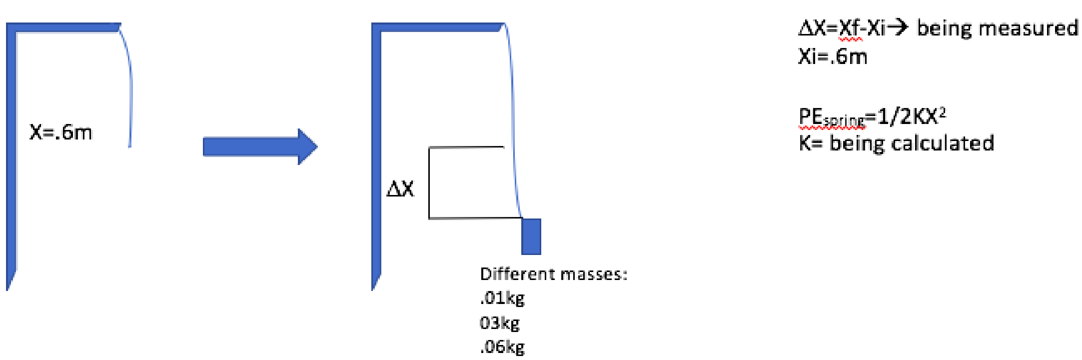

Figure 1. Diagram of Experiment set up. This figure shows the setup used in order to calculate the variables of interest. As shown the X value, distance change from equilibrium, is being measured and then using this experimental value will be used to calculate the K value for different masses.

Tables and Graphs:

Trial Number	Change in X(m) +/-.004	K Value (N/m) +/- .4
1	0.135	7.907
2	0.130	8.469
3	0.140	7.403
4	0.135	7.907
5	0.135	7.907

Figure 2. Measurements from .01kg Weight Dropped. The change in X of the cord stretching past equilibrium was measured five times and used to calculate the K value for each drop.

Trial Number	Change in X(m) +/-.01	K Value (N/m) +/- .4
1	0.360	4.357
2	0.370	3.689
3	0.370	3.689
4	0.345	4.670
5	0.365	4.260

Figure 3 Measurements From the .03 kg Weight Dropped. The change in X of the cord stretching past equilibrium was measured five times and used to calculate the K value for each drop.

Trial Number	Change in X(m) +/-.007	K Value (N/m) +/- .05
1	0.675	3.30
2	0.675	3.30
3	0.685	3.22
4	0.685	3.22
5	0.670	3.33

Figure 4. Measurements From the .06kg Weight Dropped. The change in X of the cord stretching past equilibrium was measured five times and used to calculate the K value for each drop.

Mass (kg) +/- .000001	Average K Value (N/m) +/- .04
0.01	7.92
0.03	4.13
0.06	3.27

Figure 5. The Average K Value For Each Massed Weight Dropped. This data shows a downward trend in K Value corresponding with an increase in Mass. This is expected in a dynamic drop since a bigger mass will have a bigger force and energy on the cord. Left in multiple significant figures for increase accuracy in the graph and resulting equation.

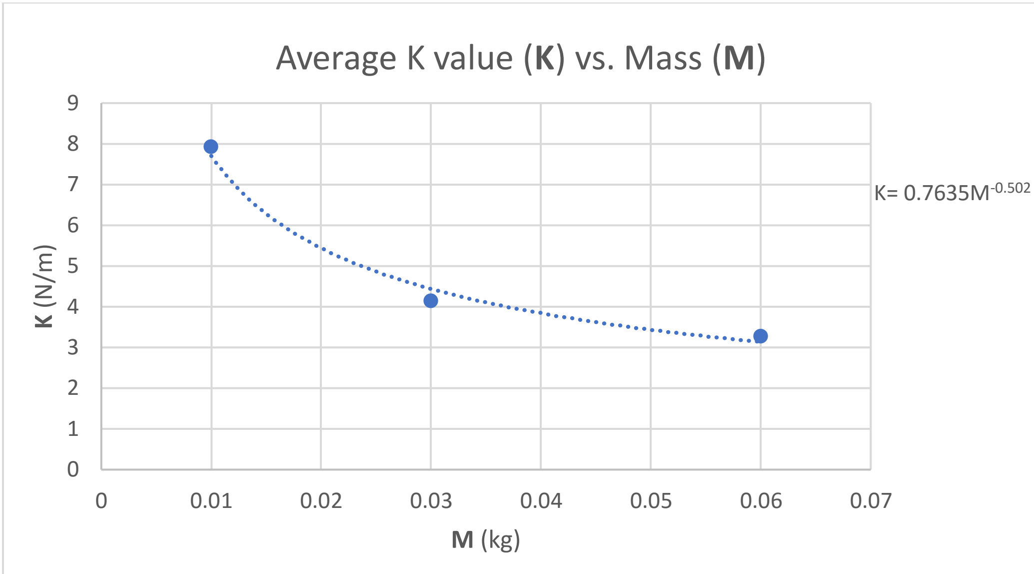

Figure 6. Graph of Mass Versus Average K Value. This graph shows a power relationship between the K value and the mass in a dynamic drop. It is expected that the K value would decrease with a bigger mass. Linearized graph was not needed since the measured relationship is value of interest.

Values of Interest:

The value of interest is the equation found in the graph, $K= 0.7635M^{-0.502}$. This equation will provide us with a K constant for different masses. This can be used in the final bungee jump to evaluate the K value we will expect with the given mass in a dynamic drop.

Error Analysis

Once excel gave equations that could best fit the graph, we compared two equations with the highest R^2 value to decide which equation more correctly represented the data trends. This was done for the power equation and the logistic equation since both R^2 values were close to 1. We plugged each of the three masses into the separate equations and compared the K calculated from the equation to our average experimental K value found for each mass. Using this method, we could find the standard deviation between our measured average K values and the K values the equation gave us. The standard deviation between the power equation's K value and our average was 0.155. The standard deviation between the logistic equation's K value and our average was 0.290. This proves the Power equation is a better representation of the relationship between mass and K-Value. Also, this decrease in K value with a bigger weight and a bigger displacement of the spring is what we experimentally expected.