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Correlation of spring constant and bungee length

Abstract; The purpose of this experiment is to correctly see the relation of the unstretched length of bungee and the constant K, and to see if this relation can yield an equation that determines the total stretched distance a bungee cord will undergo. We are assuming the bungee mass system operates closely to an ideal spring. In order to discern this relationship my lab varied X_l, an unstretched bungee length, then added a fixed mass of 150 grams onto the system and measured the displacement the bungee stretched to attain a new X value, X_0. With these values and the known value of force being $F = mg$. We're able to determine K with the Hooke's law equation. After graphing and linearizing our results we came to the conclusion $K=1.25X_l^{-1} \pm .035$. This result was than used along with the conservation of energy theorem in order to determine the total length our bungee cord will stretch.

Introduction; The relation between K and X_l is important because when the discerned equation is used in conjunction with the work energy theorem the result can be used to find maximum displacement the bungee cord will experience. With this we can accurately design a bungee cord system that will be able to successfully bring an egg close to the ground without the egg incurring damage. The relevant information needed stems from hooke's law, which we used to model the behavior of our bungee system. Hooke's law states that the force needed to move a spring is proportional to the distance you stretch it, which is represented as $F = kx$. For our system $x=(X_l-X_0)$ or The unstretched length - the length with a mass fixed onto it. Hooke's law for our system can be rewritten into $K=F/(X_l-X_0)$ which is the formula used to determine K. additionally an understanding of conservation of energy is needed for the second part of this experiment. Which states energy is neither gained nor loss in an isolated system. Represented by the equation $mgh=.5kx^2$ for our system.

Methods;

Fig.1 unstretched length

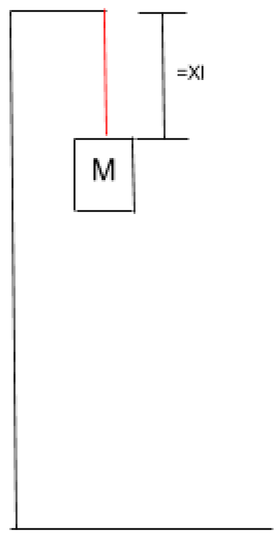
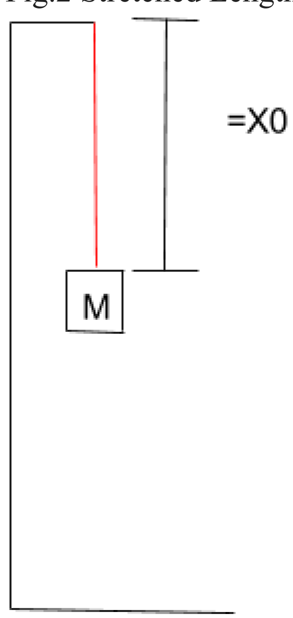


Fig.2 Stretched Length



This procedure was set up and executed by

- First we attached a bungee cord to a structure and let it hang freely
- We than measured the length to find X_l and fixed a mass M onto the cord
- Than we measured the new length X_0

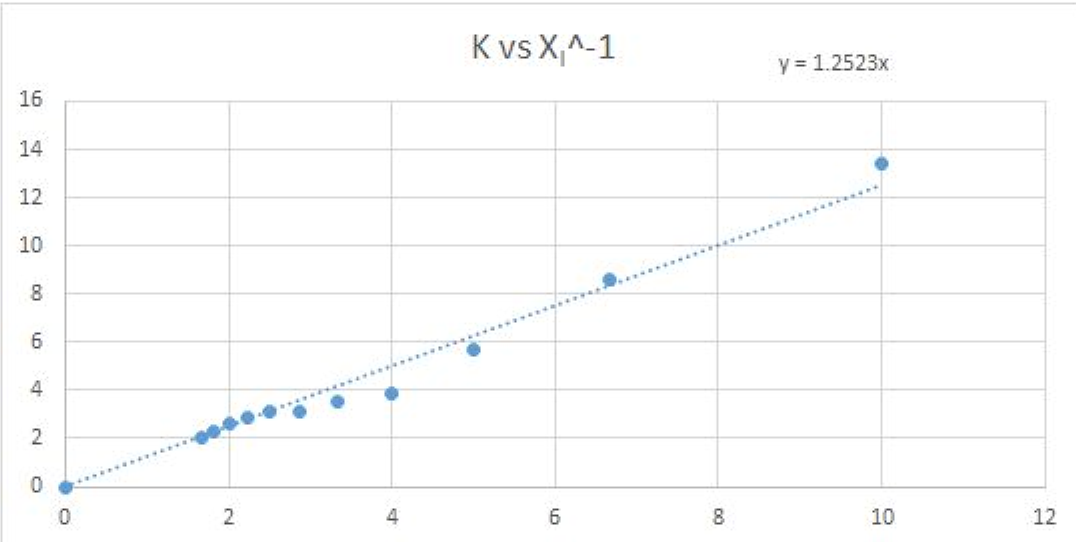
- After repeating these steps with varied X_l lengths we used the equation $K=F/(X_l-X_0)$ to find K
- We than plotted these into an excel and linearized the graph
- Through this we ascertained $K=1.25X_l^{-1} \pm .035$

Results;

Fig.3 K and X values

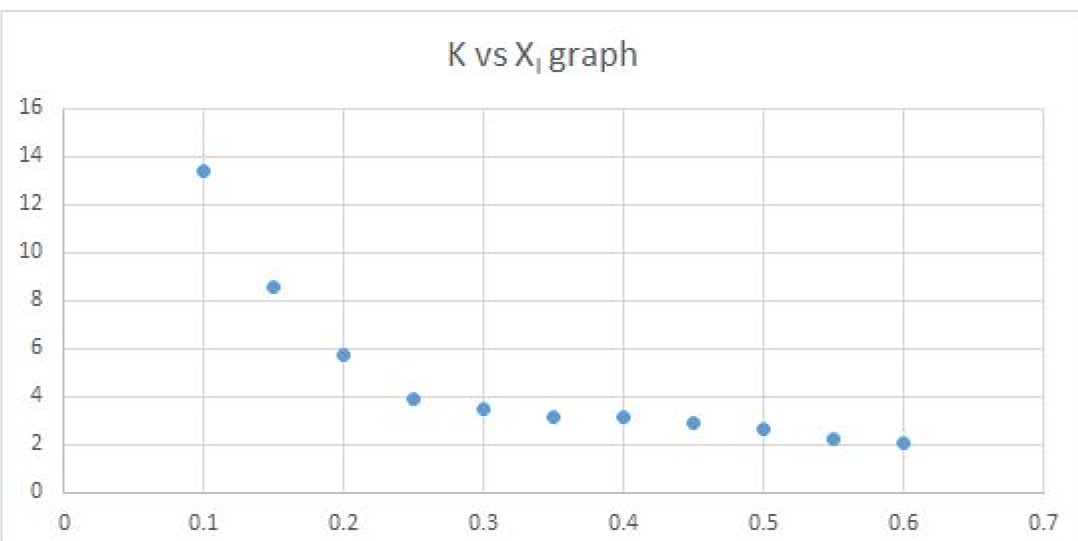
K ± .1 (Newtons /Meter	X_l^-1 ± .02 Meters	X_l ± .02 Meters
13.4	10	0.1
8.6	6.666667	0.15
5.7	5	0.2
3.9	4	0.25
3.5	3.333333	0.3
3.1	2.857143	0.35
3.13	2.5	0.4
2.88	2.222222	0.45
2.63	2	0.5
2.26	1.818182	0.55
2.07	1.666667	0.6

Fig. 4 K and X_l^{-1} This is our linearized graph which measures the spring constant and its relation to X_l. This gives the equation needed to find K from X_l



uncertainty for slope= .047 % uncert=4.7%
uncertainty for y-intercept= .035 % uncert=3.5%
The uncertainty was obtained through regression analysis

Fig.5 K and X_l This shows the data preceding the linearized graph



uncertainty in coefficient(s)= .101 % uncert= 10.1%

The uncertainty was obtained through propagation of uncertainty.

We found the relationship of K and X to be $K=1.25X_l^{-1} \pm .035$ Through linear regression of the k vs X_l graph. Which is essential to our purpose in that it allows us to write the conservation of energy law with only one unknown variable, the maximum the bungee can stretch. With the conservation of energy formula $mgh=.5kx^2$ and substituting h (height) and x (displacement) with our corresponding values we determined the formula $X_l=MgX_{max}/.625$.

Discussion;

The experiment had sources of error that could be contributed to the bungee system not being isolated and thus losing energy and affecting our final result. Error can also be attributed to the amount of elongation our bungee received throughout the experiment, it is possible this affected the values ascertained for k. There are no range of values to hold ours to, however we determined the final equation to be acceptable through testing how closely it could predict X_{max}. we fixed the mass to the bungee and dropped it under the view of a slow motion camera. This allowed us to see we were within .03 meters of our predicted value.

Conclusion; This experiment presents us with a new way of finding the maximum displacement of our bungee cord through the equation $X_l=MgX_{max}/.625$. and shows us the relation of K and X to be $K=1.25X_l^{-1} \pm .035$. This formula makes it possible to discern the maximum distance of a mass on a bungee string only knowing the unstretched length of the cord.