Lab Report Outline—the Bones of the Story

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TITLE: How does the number of cords affect the force experienced by the egg?

ABSTRACT:

We want to find how the number of bungee cords attached to the egg will affect the force that the egg experiences, and to put this into a more usable context, we express this as the force to weight ratio, since for our final bungee jump the force must not exceed 3mg. To do this, we chose a constant mass similar to that of an egg, kept the length of the bungee cord constant, and measured the force exerted on the mass using different numbers of bungee cords. To put our results in perspective, we expressed the force as a ratio to the mass' weight, so we could solve for what number of cords would exceed a force of 3mg. We found that this relationship between the force to weight ratio and the number of cords used can be modeled as F/mg = .39x + 2, where x is the number of cords. Using this formula, one can find that using more than two cords will result in a force that exceeds 3mg.

INTRODUCTION:

For our bungee jump, we must not allow the egg to experience a force greater than 3 times its weight. We want to explore how the number of cords attached to the egg affect how much force the egg experiences.

Relevant equation(s) specific to this experimental purpose or setup, identifying variables:

$\mathbf{F_{spring} = -kx}$, or Hooke's Law where k is the spring constant and x is the amount the cord stretches for equilibrium. We will be measuring F_s, or force of the spring, in this experiment. In order for the egg to stay safe, the force of the spring must not exceed 3 times the weight of the egg.

Hypothesis (or expectations): The more cords that are added to the mass, the greater a force it will experience.

METHODS:

To measure the effect adding more cords has on the force applied to the dropped mass, we chose to use a constant mass with a mass approximately equal to that of an egg, based on prior knowledge (.170 kg). By using a constant mass and cord length, we see purely the effect different numbers of cords have on the force exerted on an egg-like mass.

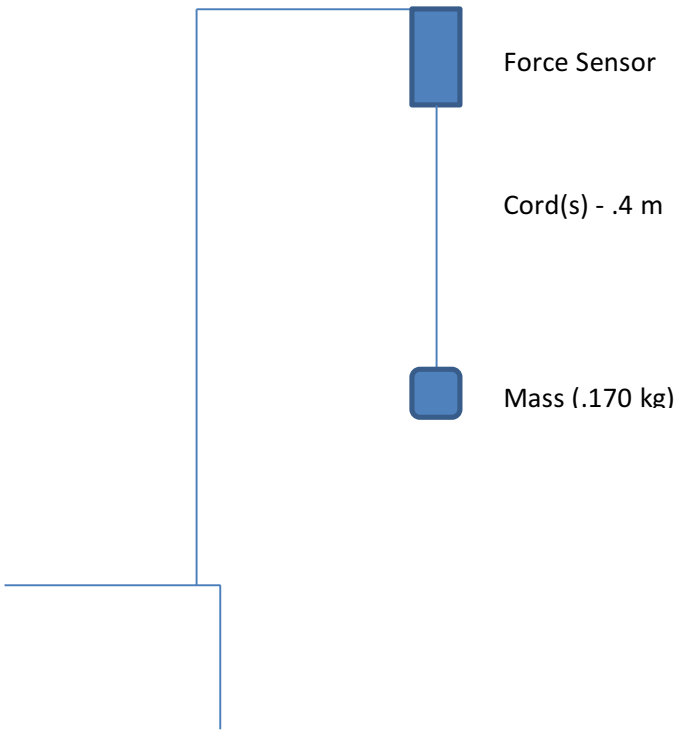

Figure 1: Diagram of Setup. The length of the cord and the mass are kept constant.

Procedure

- Set up force sensor on bracket, and connected to Capstone software on computer
- Attach bungee cord to force sensor and mass
- Drop mass from a height even with the force sensor, record the maximum force experienced by the mass
- Add another bungee cord, and repeat this process. Do three trials for every number of bungee cords
- Continue this until maximum force reading have been gathered for drops with 1-5 bungee cords

RESULTS:

The data that was gathered was the force experienced by the mass. To put it into more usable context, we expressed this as the force to weight ratio of the mass, since this ratio must not exceed 3 for the bungee jump.

			Max Force (N)					
Mass (kg)	Cord Length (m)	# Cords	Trial 1	Trial 2	Trial 3	Avg. Max Force	Uncertainty of Max Force	Ratio of Force to Weight
0.17	0.4	1	4.19	4.12	4.08	4.13	.06	2.48
0.17	0.4	2	4.43	4.53	4.45	4.47	.05	2.68
0.17	0.4	3	5.24	5.23	5.21	5.23	.02	3.13
0.17	0.4	4	5.88	5.87	5.93	5.89	.03	3.53
0.17	0.4	5	6.72	6.62	6.65	6.66	.05	4.00

Figure 2: Data Table. The mass being dropped and the cord length we kept constant throughout the experiment. 3 trials were done for every number of cords. The average of these 3 trials was used for our data. The ratio of the force to the weight is equal to F_{max}/mg. This number is used as a reference for the egg drop, which may not exceed a force of 3 times the weight of the egg.

***Linearized* graph**

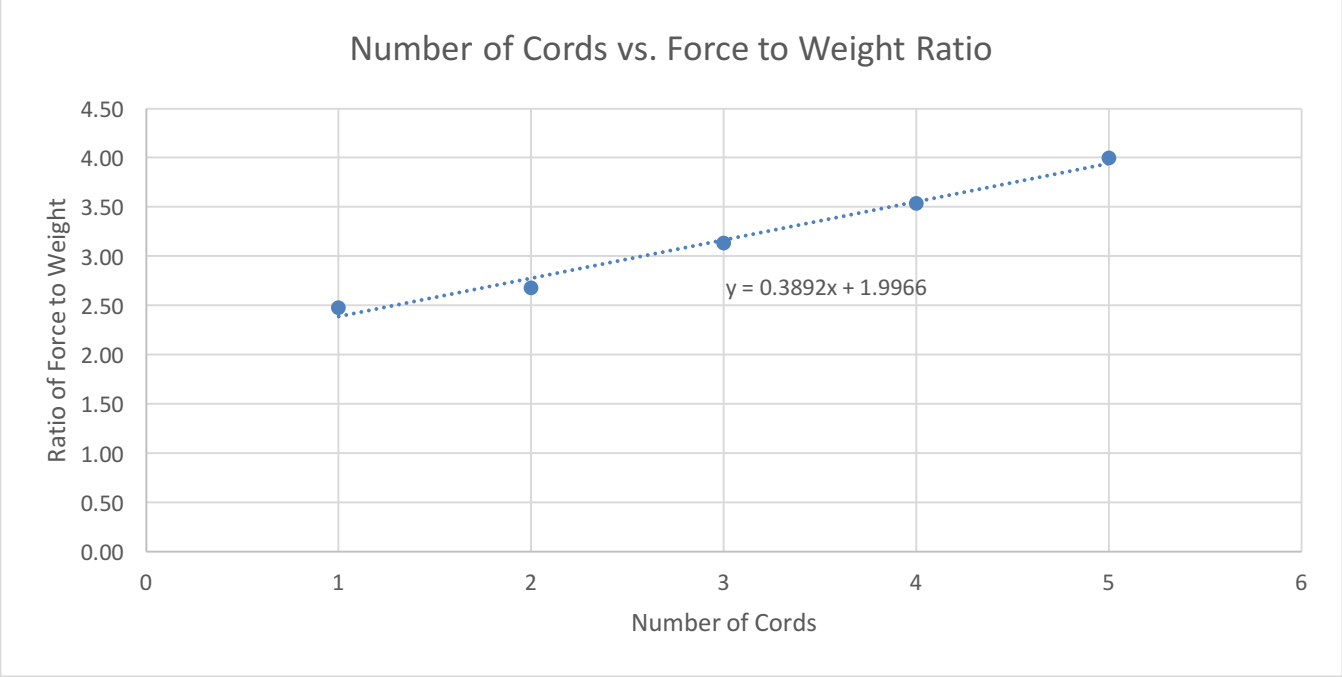

Figure 3: Graph of Number of Cords vs. Force to Weight Ratio. The equation indicates that the force to weight ratio can be found by multiplying the number of cords by .39 (±.03) and adding 2.00 (±.09). Simply by looking at the graph, one can see that using more than 2 cords will likely result in a force greater than 3mg.

Linear equation

F/mg = .39x + 2.00, x being the number of cords used.

Use *Excel* regression analysis on any graph that has a **linear** fit only (see EG), to obtain:

uncertainty for slope= .03 % uncert= 7.7%

uncertainty for y-intercept= .09 % uncert= 4.5%

Experimental value of interest

value obtained = 2.56 is the number of cords we determined would result in a force of 3mg on the egg. Obviously, a partial cord does not exist, so realistically using more than 2 cords would subject the egg to forces greater than 3mg.

uncertainty of experimental value(s) = .2 % uncert= 9.5%

name the technique used for propagation of uncertainty (see *UG*), or where/how uncert was obtained:

$$\%\ uncert\ of\ R\ = \sqrt{(\mathrm{n} \times \%\ uncert\ of\ a)^2 + (\mathrm{m} \times \%\ uncert\ of\ b)^2 + (\mathrm{p} \times \%\ uncert\ of\ c)^2}$$

Summary of Results

The force to mass ratio that will result from using a certain number of cords can be expressed as F/mg=.39x+2, where x is the number of cords. Using this formula, we deduce that using more than 2 cords will result in a force greater than 3mg on the egg, which is the maximum it can endure.

DISCUSSION:

I think our results are very acceptable and useful. We found that the relationship between the force and the number of cords to be very linear, with a low uncertainty of slope and intercept. Our needs were to find out how many cords could be used to not subject the egg to a force greater than 3mg, and because we found the number of cords that would equal 3mg to be 2.5, we can feel pretty confident about saying that using more than 2 cords will result in the egg experiencing too great a force.

Sources of uncertainty

- Length of the cord measured with eyeball measurements in relation to a meter stick
- Knots in the cord used for attaching it to the force sensor and mass may affect its elasticity.
- The mass may not have been dropped perfectly perpendicular to the ground
- The mass of the cord may become a factor, especially as more cords are added

Our results were in agreement with our hypothesis, as the more cords were added, the greater the force experienced by the egg. This relates back to Hooke's law, F=-kx, as adding more cords increases the value of k by a greater factor than the value for x is decreased, making the Force exerted by the cord greater.

CONCLUSION:

Clearly and definitively state the experimental outcome(s) in terms of your question or purpose:
In order to prevent the egg from experiencing a force greater than 3mg, no more than 2 bungee cords should be used.

The next step would likely be to experiment with static cords to find the perfect balance for the jump itself.

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

Pledged: Philip Kensinger