Physics Internal Assessment

Correlation between the weights supported with Spaghetti Bridge and its length and thickness.

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Abstract

How does the weight supported by Spaghetti Bridge relate to the number of spaghetti strands and the length of the bridge? Spaghetti bridges break by adding force on their area, the aim of this experiment is to figure out the stress point of these spaghetti bridges, the relation between the number of spaghettis used and the amount of weight that they can handle, and also the correlation between the length of the bridge and the weight supported by the bridge. For this experiment, we place marbles in the cup till the spaghettis break and we find the weight spaghetti supported based on the dependent variables like thickness. By gathering data, we realize that by increasing the number of spaghettis, the weight supported increases; it means that the bridge is stronger but by increasing the length of the bridge, the amount of weight supported by the bridge decreases, the bridge is weaker.

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Research Question

How does the weight supported by Spaghetti Bridge relate to the number of spaghetti strands and the length of the bridge?

Introduction

Spaghetti Bridge is a bridge made of different number of spaghettis in variable lengths. Spaghettis used in this experiment break easily but if we change the dependent variables, we can make the bridge weaker or stronger. Stress point has a significant role in this experiment. Stress point is a measurement of force spread over area. Stress point in Spaghetti Bridge is where we put the force and it can be calculated by having the width of the spaghetti and the force added to it.

$$stress\ (\sigma) = \frac{F}{A}$$

F= Force (Newtons)
A= Area (mm^2)

This equation mathematically shows us that if the area decreases, stress point increases and also by increasing the force, the stress point increases.
This formula can be used to measure stress works for all objects, which are experiencing all sorts of force. This is the reason why Spaghetti Bridge breaks by increasing force.
By increasing or decreasing the number of spaghettis the area changes and this is how the thickness of the bridge affects the stress point of the bridge.

Variable List

- Dependent variable
  I. The weight supported by the spaghettis
  II. The length of the bridge
  III. The thickness of the bridge (number of spaghettis used)
- Controlled variable
  I. Weight of the cup and rope
  II. Weight of the marbles
  III. The place where the cup is placed

Controlling the variables

- Weight of the cup and rope should be measured before the experiment in order to reduce uncertainty.
- Weight of the marbles should be known to reduce the uncertainty.
- The place of the cup should be in the middle of the spaghetti and we need to make sure that it doesn’t change.

Materials

- Graphing calculator
- Cup
- Spaghettis
- Marbles
- Dynamometer

Method

- Collecting data in 20 trials with four different lengths (2.0, 3.0, 4.0 and 5.0 cm) and 5 different numbers of spaghettis.
- Measuring the amount of weight using a cup and marbles
- Using dynamometer, we can find the force supported by the bridge
- Find the correlation between length and weight supported.
- Calculating the stress point of each trial

Procedure

At first, we need to measure the weight of the cup and rope. Second, we measure the length and thickness of the bridge and then, we place the cup in the middle of the spaghetti bridge. After placing the cup, we start adding marbles to the cup slowly till the time that the bridge breaks. Then, by using dynamometer, we can find out the weight of the cup with marbles and subtract the weight of the cup from the total weight. We do this trial for twenty times and gather the data on a table.

Data Presentation

Number of spaghettis (n)/length (L)	2.0 cm $\pm$0.1	3.0 cm $\pm$0.1	4.0 cm$\pm$0.1	5.0 cm$\pm$0.1
1	0.150	0.120	0.080	0.060
2	0.400	0.200	0.170	0.130
3	0.520	0.365	0.280	0.225
4	0.740	0.510	0.430	0.315
5	0.920	0.735	0.520	0.450

Table 1- weight (kg $\pm$0.2) supported by different number of spaghetti and the length of the bridge (cm$\pm$0.1)

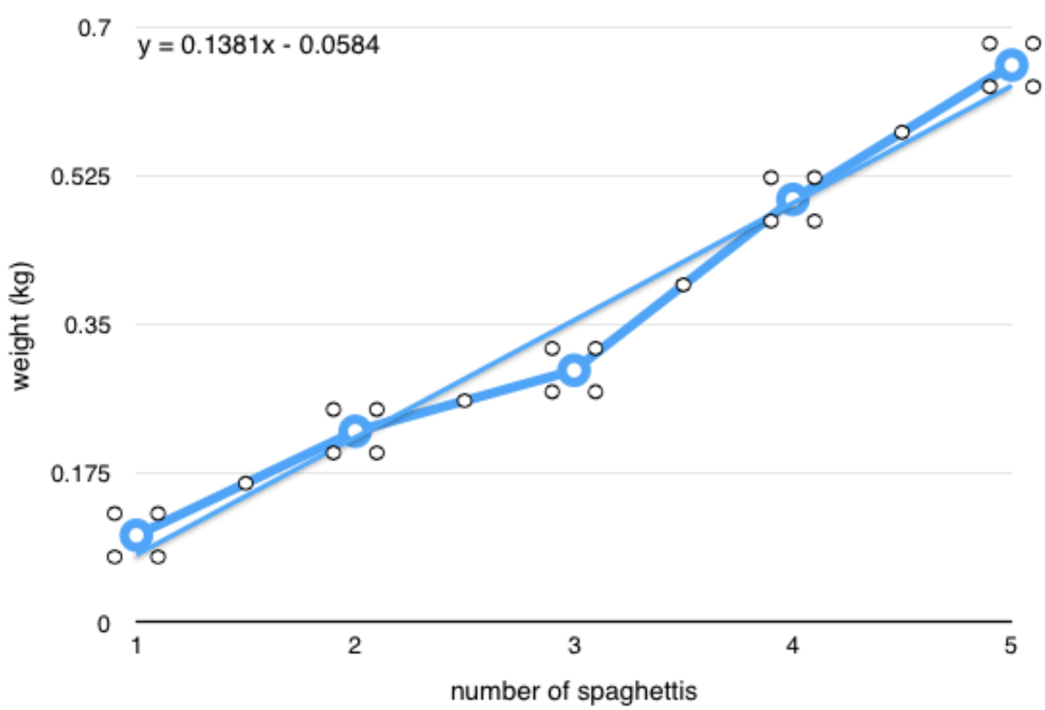
As we can see in the table above, by increasing number of spaghettis, the weight supported by them increases and by increasing the length of the bridge, the weight supported by bridge decreases.

Number of spaghettis (n)/length (L)	2.0 cm±0.1	3.0 cm±0.1	4.0 cm±0.1	5.0 cm±0.1
1 (2mm±0.5)	7.5×10^5	6×10^5	4×10^5	3×10^5
2(4mm±0.5)	10×10^5	5×10^5	4.25×10^5	3.25×10^5
3(6mm±0.5)	8.6×10^5	6.1×10^5	4.67×10^5	3.75×10^5
4(8mm±0.5)	9.25×10^5	6.4×10^5	5.4×10^5	3.94×10^5
5(10mm±0.5)	11.5×10^5	9.2×10^5	6.5×10^5	5.6×10^5

Table 2- Stress point (Newton/m^2)

As we can see in table2, the stress point increases as the number of spaghettis increase. The stress point decreases as the length of the bridge increases. According to this data table we can see that the correlation between length and force supported and thickness and force supported is linear.

Data Analysis



Graph 1- weight versus number of spaghettis graph

As we can see in the graph, the correlation between number of spaghettis and weight is almost linear. The line of best fit for this graph is $y = 0.1381x - 0.0584$ with the slope of 0.1381 which presents the increase in the weight by increasing the thickness (number of spaghettis).

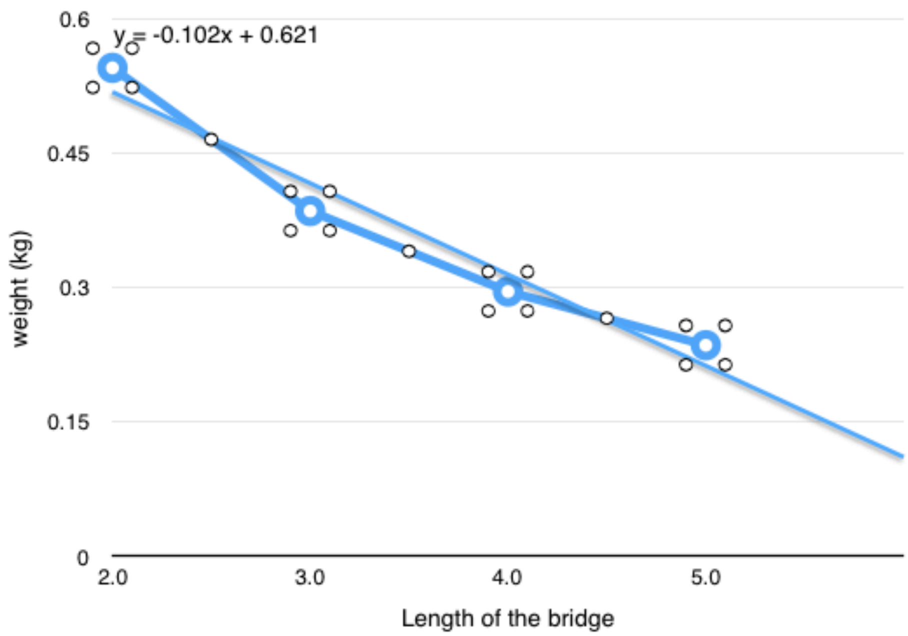
From this graph it can be seen that the weight supported by the bridge is directly proportional to the number of spaghettis.

$$m \propto n$$

After this data, we can see that the correlation between "n" and "m" follows a specific pattern of

$$y = ax + b$$

This is how the line of best fit for this measurement has been found.



Graph 2- weight supported by spaghettis versus length of the bridge

As we can see in the graph above, the correlation between weight supported by the spaghetti bridge and the length of the bridge is linear. The line of best fit is $y = -0.102\,x - 0.621$ with the slope of -0.102 which presents the decrease in the weight by increasing the length.

From this graph it can be seen that the weight supported by the bridge is directly proportional to the length of the bridge.

$$n \propto L$$

After this data, we can see that the correlation between "n" and "L" follows a specific pattern of

$$y = ax + b$$

This is how the line of best fit for this measurement has been found.

Conclusion

The aim of this experiment was to investigate the correlation between the weight supported by Spaghetti Bridge and its length and thickness. I predicted that there should be a linear pattern and also decrease in weight by increasing the length and increase in weight by increasing the number of spaghettis or thickness. I also tried to support my hypothesis by calculating the stress point of the bridge to visualize the affect of my variables on the strength of the bridge. Based on the data, my hypothesis was correct and I could proof them by using tables of data and graphs and their analysis. The only thing I was wrong about was that I thought graphs should be completely linear but according to my data they are not totally linear which can be because of errors during the experiment.

Evaluation

In general, the method used in this experiment was helpful and lead this investigation to the right conclusion; although, there were some confusion related to having both variables in one experiment, these confusions didn't affect the investigation.
Some errors occurred while measuring. For example, random error occurred while reading the ruler for the length of the bridge or reading the dynamometer while measuring the weight of the cup. Random error also occurred while doing the experiment for the bridge with five spaghettis because the number of spaghettis was a lot and it needed more marbles to break so it made it a little inaccurate.

Suggested Improvements

The investigation would be more accurate if the trials could be examined five times so I could have much accurate data for each of trials. A digital dynamometer would make the measurements much accurate but the dynamometer, which I used, were analog.
For the next time I prefer measuring more variety of lengths such as 1.5, 2.5, 3.5 and 4.5.