Investigating the amount of marbles to break the spaghetti strands

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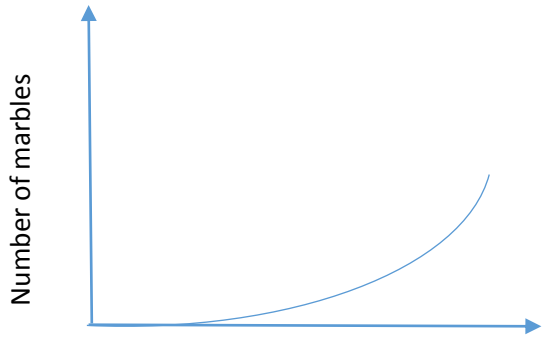
Introduction: A car going down a plane without any velocity will have a constant acceleration. The speed will increase constantly but not exponentially in regards to time. However, does the case similar to the relationship between the amount of marbles and spaghetti strands? Does it required more and more marbles if the strands increase gradually? Or does it required the same number of marble per strands? In order to figure out the answer for this question, I will conduct an experiment and do some through analysis from the collected data.

The investigation:

Research Question: Is the number of marbles required to break the strands rise exponentially relatively to the amount of spaghetti strands?

Hypothesis/Prediction: The number of marbles required to break the strands will increase exponentially. In the other words, in the long run, it will required much more marbles to break the bridge with an addition strand.



Graph 1: Hypothesis about the relationship of strands and marbles

Independent variable: Number of Spaghetti Strands

Dependent variable: Number of marbles

Controlled variable:

- Distance of the spaghetti bridge
- Same type/weight marbles
- Same type spaghetti strands

- Distance of the cup to the strands
- Placement of the cup (In the middle of the strands)
- The way to drop the marbles into the cup

How to control the variable:

Number of Spaghetti strands/Number of marbles: Carefully count

Distance of the spaghetti bridge: No shifting during the experiment

Same type of spaghetti strands: Use the spaghetti strands from the same package

Same type of marbles: Use marbles with the same weight

Distance of the cup to the strands: Use the same string to hang the cup

Placement of the cup (In the middle of the strands): Use ruler to measure the middle point of the strands bridge

The way to drop the marbles into the cup: Slowly and carefully drop the marbles into the strands

Equipment:

- Spaghetti strands
- Marbles
- 2 separated tables
- Cup with string

Experiment set-up:

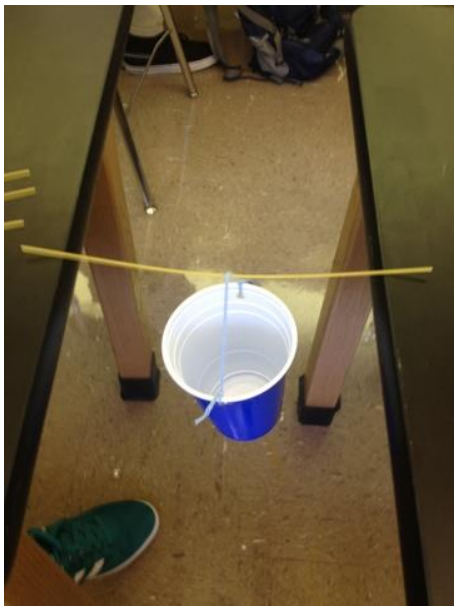


Figure 1: Setting up of equipment

Two tables have the same height and the distance between them will be 18 centimeters (Shorter than the length of a Spaghetti strand, which is roughly 26 centimeters each). The string is approximately 12 cm long so that the cup is about 6 centimeter below the strands.

Method to gather data:

1. Put 2 tables next to each other, the distance of separation is 18 centimeters.

2. Add two spaghetti strands and place between the tables.

3. Hang the cup with the string connected in the middle of the spaghetti strands.

4. Add 1 marbles into the cup carefully and wait for a second to see if the strands break.

5. Repeat step 4 until the strands break into parts.

6. Write down the number of marbles required to break the strands.

7. Start new trials with 2 more strands.

8. Repeat step 3 to step 6.

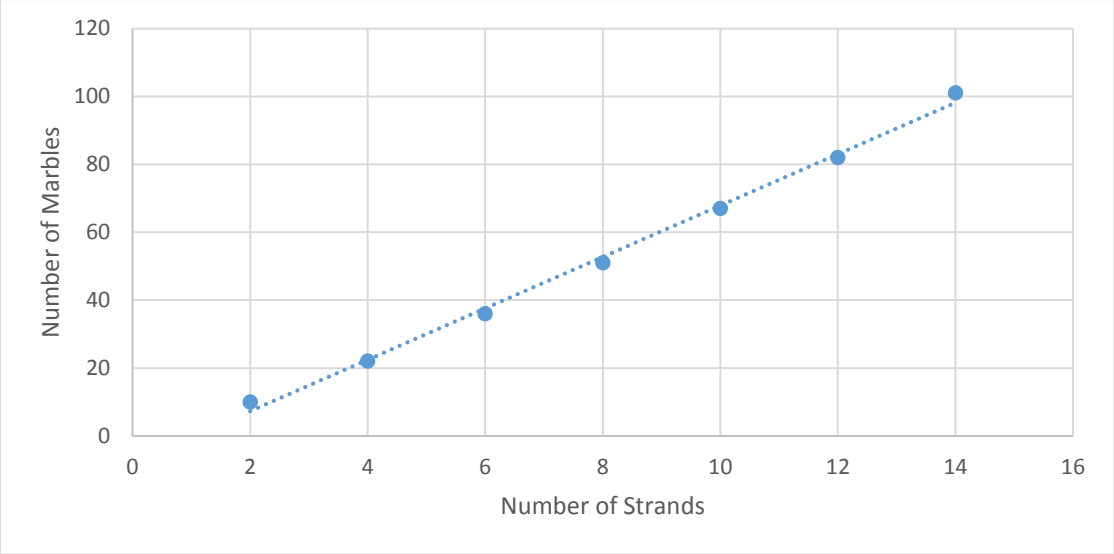
9. Repeat step 7-8 until the 14-strands trial break.

Data collection:

Number of Spaghetti Strands	Number of Marbles
2	10
4	22
6	36
8	51
10	67
12	82
14	101

Table 1: Number of marbles required to break the strands

Data presentation:



Graph 2: Relationship between number of marbles and strands with line of best fit

Data analysis:

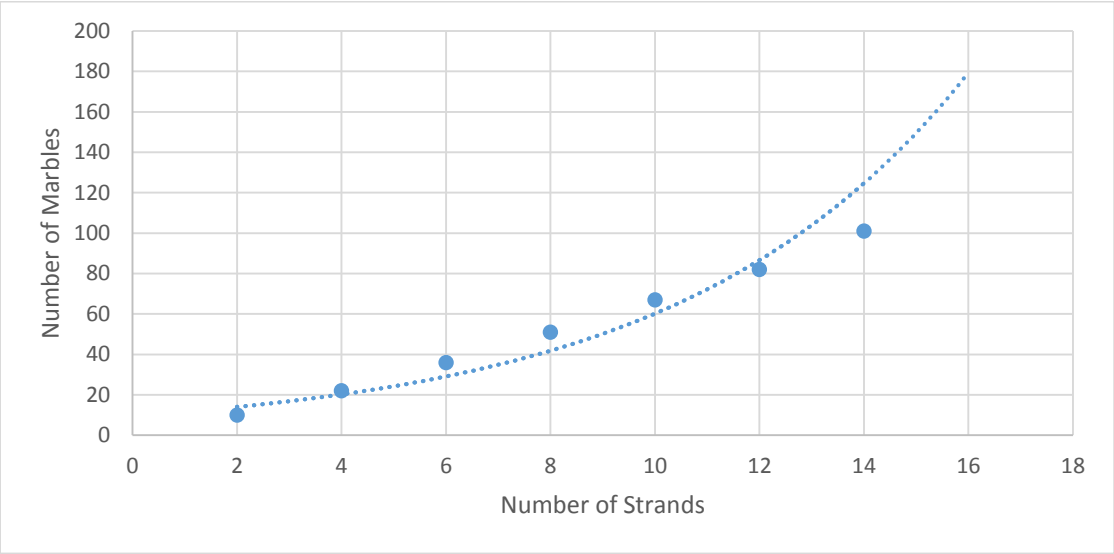
The line of best fit is a linear line, which mean the number of marbles is increasing at a constant rate. Gradient of the best fit line: $\frac{y2-y1}{x2-x1} = \frac{101-10}{14-2} = 7.58$

However, if we look into details, it is true that the number of marbles increase at a greater rate than that of strands. So I come up with a table that show the average number of marbles to break the strands at specific value.

Number of Spaghetti Strands	Number of Marbles	Marbles /Strands
2	10	5
4	22	5.5
6	36	6
8	51	6.38
10	67	6.7
12	82	6.83
14	101	7.21

Table 2: Average number of marbles to break the strands at specific value

From the table, we see that the more strands there are, the higher the average amount of marbles are required to break the strands. Although the rate may not be constant and too significant, the average marbles needed to break the strands is still increasing and clearly shown. Therefore, I suggest that if the trials with number of Spaghetti Strands continues, the average will continue to rise. In the other words, finally, the line of best fit will become an exponential line rather than a linear.



Graph 3: Relationship between number of marbles and strands with exponential forecast line

Conclusion:

The aim of this experiment was to see how the number of marbles related to the number of the spaghetti strands. In the other words, the strength the strands has to deal with the mass from the marbles. We see that the marbles have to be added at a slightly faster rate. At first, the average marbles per strands is 5; later on, it is 7.21 and likely to increase afterward. Therefore, we can conclude that if the strands are together, its strength will be greater compared to when they are separate.

The results are identical to the prediction/hypothesis that I made earlier on. Both amount do increase after one another; however, they are not directly proportional as stated above. The amount of marbles is increasing at an exponential rate rather than a consistent rate. If anyone wants to conduct the same experiment with different size and mass of marbles or thinner or thicker strands, I, according to my hypothesis, believe that the average marbles required to break the strands will increase overtime.

Suggested improvement:

I can say that the experiment worked out well and not much problems happen during the experiment. However, if I have the chance to redo the experiment, I will make the following changes:

- Putting the marbles into the bottom of the cup rather than dropping it from the top of the cup. It will be much more stabilize since there will be less force applied to the strands
- The spaghetti should be stick to the table with tape. While dropping the marbles into the cup, it may lead to some shifts, which consequently make the data less accurate.
- Rather than wait for one second after dropping the marbles, I should wait for the strands to be motionless to drop the next marbles.