Pi, Phi, and Py

Mathematics in Architecture and Engineering

M3 – 13 PHYSICS

Question

How does the incorporation of different mathematical properties affect the structural stability of popsicle stick towers?

Abstract

My motivation to do this project is a mix between personal interest in physics, engineering, math, and our quickly advancing world. I am using mathematical properties because math in nature is the best and most advanced tool. The three math properties being used are found in nature. After going through about 4 billion years of evolution, you can expect it to be very refined. With this experiment, I hope to open up the world of math and nature being used in buildings and electronics.

Hypothesis

If popsicle stick towers are designed with math properties are tested for efficiency with weights, the one built with phi will be the most efficient because phi is found throughout nature and earth.

Materials

- Popsicle Sticks
- Glue or other Binding material
- Ruler with Centimeters
- Weights (Preferably in large measurements)
- Flat Surface (As a base for the towers)
- Sturdy Flat Surface or Board (To put the weights on)
- Woodcutter, paper cutter, or strong scissors

Procedures

- Make a blueprint of popsicle stick towers
- Cut popsicle sticks to proper length
- Construct 5 towers of each variable
  - Make sure to use ample amounts of binding material and press sides together
- Set up tower and bases for testing
- Choose a tower to test and gradually add weights until the tower breaks
- Record data
- Repeat the past 3 procedures until all of the towers have been tested
- Analyze data

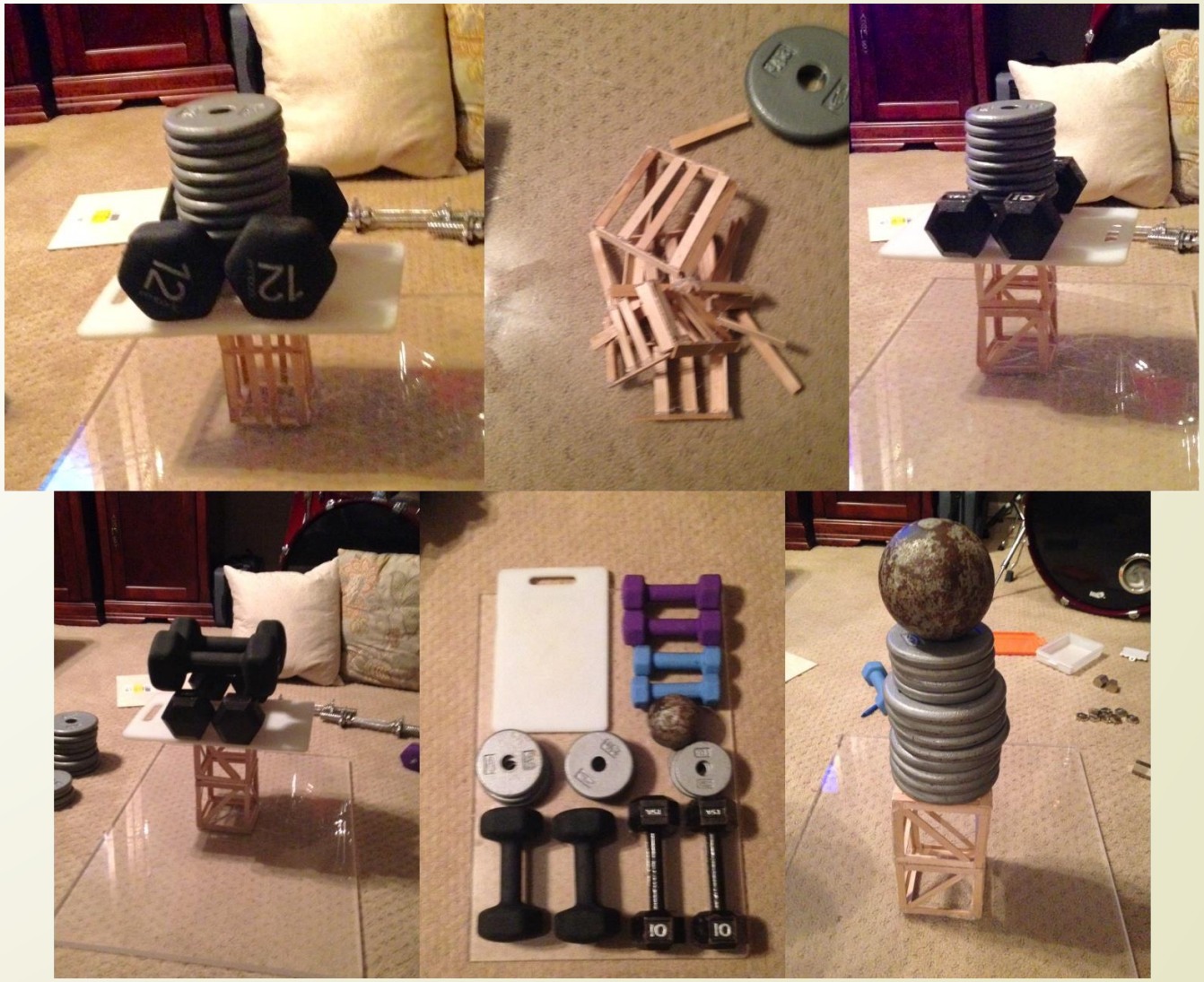
Variables

Independent: Design of Popsicle Stick Tower

Dependent: Efficiency of the Tower/Weight Tower can hold

Control: Weights used, base set on, popsicle stick type and brand, adhesive, test location, and conditions

Experiment Photos



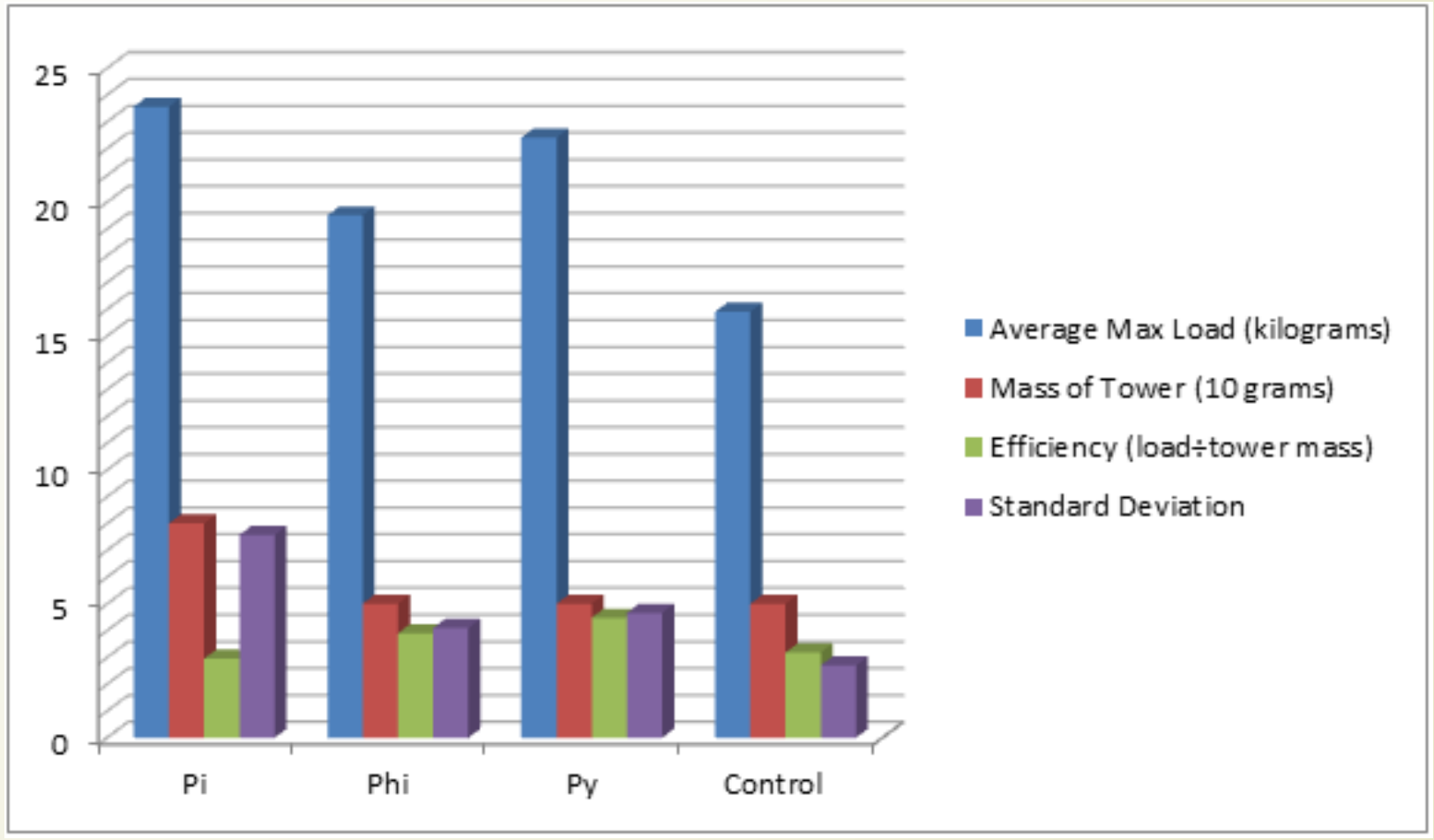
Results and Data

Comparing the bare load the towers held would be an inaccurate representation of tower strength because different types of towers have different masses. In order to compare the towers' efficiency correctly, we can use efficiency = mass of the load in grams ÷ mass of the tower in kilograms to compare. However, for the sake of having raw numbers, I will be including 3 category bar graphs to represent load, tower mass, as well as the efficiency.

After analyzing this data, we can see that the Pythagorean Theorem is the most efficient tower with Phi, Control, and Pi as the other places in order.

	Pi	**Phi**	**Py**	**Control**
Avg. Load (kilograms)	23.564kg	19.48kg	22.407kg	15.8757kg
Mass of Tower (grams)	80g	50g	50g	50g
Efficiency	0.29455	0.3896	0.44814	0.317514
Standard Deviation	7.57	4.1	4.66	2.7

Graph


25
20
15
10
5
0
Pi
Phi
Py
Control
Average Max Load (kilograms)
Mass of Tower (10 grams)
Efficiency (load÷tower mass)
Standard Deviation

Conclusion

In conclusion, the tower built with the Pythagorean Theorem is the most efficient tower. This is most likely due to right triangles present in the design, as triangles are the most structurally sturdy shape in architecture and engineering.

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