Packaging Materials Research Project

What is the most effective packaging method, price wise, and performance wise?

By: The Rocking Rover Team

Introduction

Our project question is "What is the minimum package required to safely package an item". Things we needed to figure out for the project include...

- Not too much packaging because of the price
- Not too little because then the object will break
- Best packaging material because you won't have to buy as much of it if it works better, saving you money

We decided to drop an egg out of all items because eggs are really fragile, and if we can safely package a fragile item, we can package a lot of other stuff.

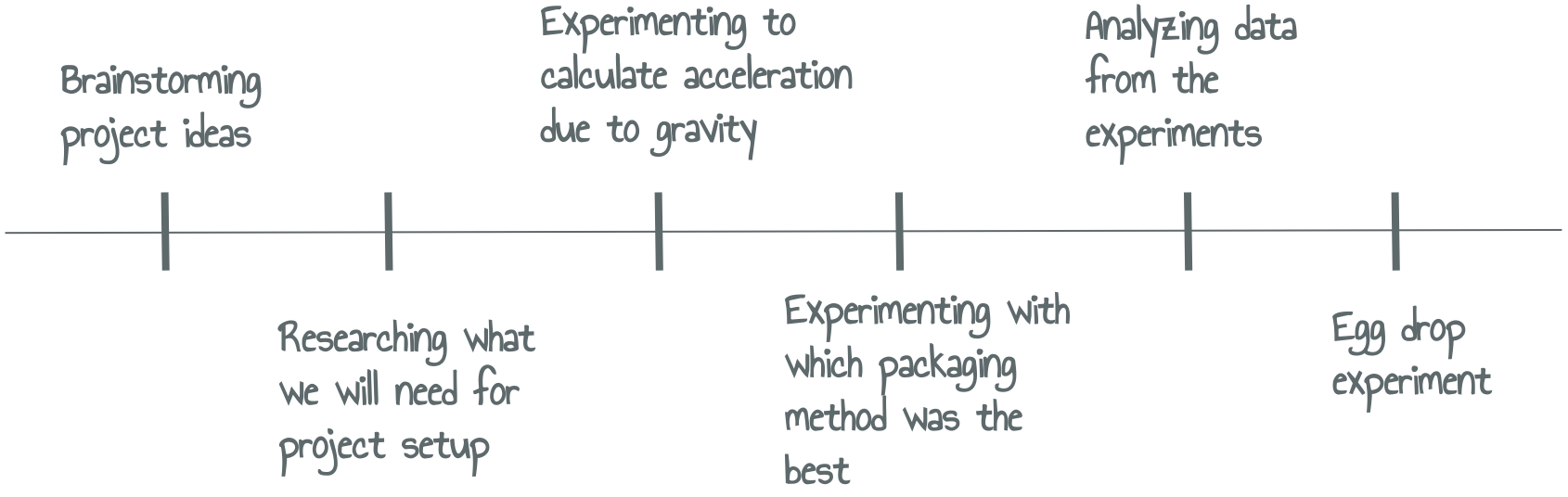
Brainstorming

- While brainstorming, we came up with many project ideas related to cargo, and we came up with things like transporting instruments, and other problems that affected us
- We all voted on a project idea, and we eventually came to agree upon this project idea because most of our team had this problem

How we came to this project

- Because of the pandemic, people started ordering products not meant for shipping such as eggs and other produce
- Recently, our team had been getting either over packaged products, or under packaged products that had gotten destroyed
- We needed a project related to Cargo Connect

Project timeline



Project Setup Research

- We learned about gravity(so we understand more about what happens after somebody drops a package)
- We used a cart with sensors that detect the force applied on it, and a near frictionless ramp, and tested how much each packaging material helped to cushion the cart

Experimental Setup with Ramp

- We decided to simulate dropping of the package using a collision ramp after discussing about multiple different stimulations.
- We originally started with measuring the forces, and later on we used dynamic cart system from vernier to do the force measurement experiment.
    - We used the Mindstorm EV3 to find the force is Mass * Acceleration for Gravity
- The collision ramp is a ramp which you can use to push a cart, the cart has a sensor on it that detects how much force is on it


DIS-MASS

Findings from our Ramp Setup

We created a graph to plot the results of the drop tower, ramp and egg drop. We used a graph to find the results of the egg drop experiment. Due to the graph, it made it easier to find the results of what wrapping for the egg was better. We were able to find this out due to the expansion of the time of impact.

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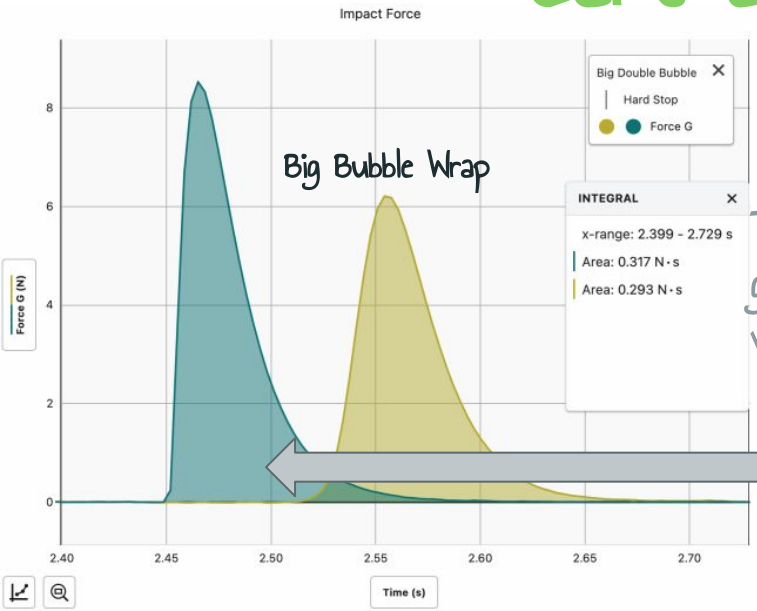
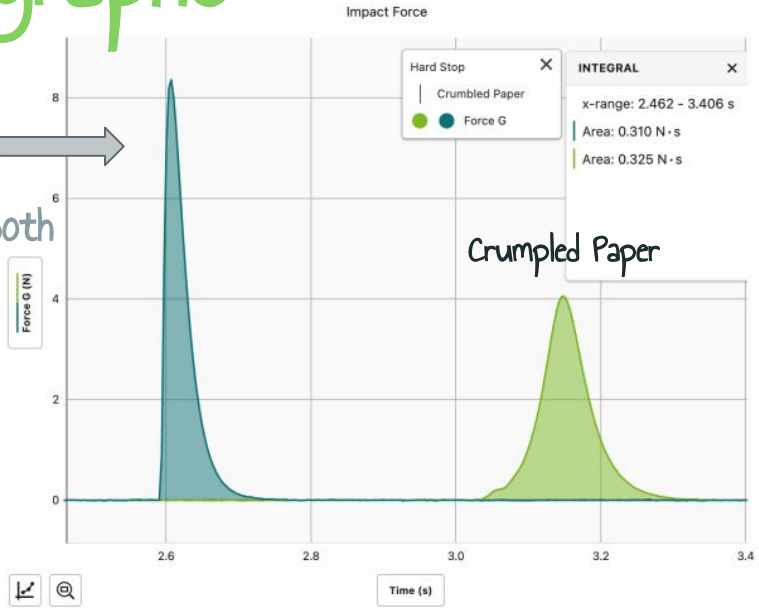
Cart experiment graphs



The leftmost spikes on both graphs are the impacts without a cushion.



In other words, the longer the impact lasts, the less force the object will be subjected to.

The graphs represent the time of impact. The y-axis is the amount of force applied, the x-axis is the amount of time that passed. The longer amount of time the impact lasts, the lower the amount of force applied to the object.

This is how packaging materials work, they increase the amount of time the impact lasts, lowering the amount of force.

Egg Drop Experiment

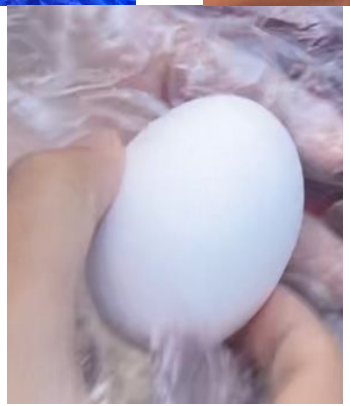
After doing the ramp experiment, it was time to test out the results for which type of packaging was best, and try it on an egg. We Started with three layers of each wrap, then went either up or down one layer depending on whether or not the egg broke

Results for our Egg Drop Experiment(Description)

Test Number:	Cushion Name & Amount of Layers:	Results:
#1	3 Layers of Big Bubble Wrap	The Egg did not break.
#2	2 Layers of Big Bubble Wrap	The Egg did not break
#3	1 Layer of Big Bubble Wrap	The Egg did break
#4	3 Layers of Crumpled Paper	The Egg did break
#5	4 Layers of Crumpled Paper	The Egg did break
#6	5 Layers of Crumpled Paper	The Egg did not break

We concluded that even though crumpled paper seemed like the best choice for packaging based on the ramp experiment, for eggs bubble wrap was the better choice because the force was equally distributed over the surface area of the egg.

Results (images)



Findings from our egg drop experiments

- We did 6 tests, #1: 3 layers of bubble wrap, #2: 2 layers of bubble wrap, #3: 1 layer of bubble wrap.
- Then, we moved on to a crumpled paper cushion. #4: 1 layer #5: 2 layers, #6: 3 layers.
- Bubble wrap was the best material out of all three, because when we dropped the egg, it did not crack. However, with most of the crumpled paper, it did crack. Therefore, bubble wrap was the best type of material for the egg experiment, and furthermore the "future" of packaging.

Sharing our findings

We were able to share our information via our Rocking Rover website. This website was a major help and we were able to give each other easy access to our websites and sources, this was one of the main resources that helped us on sharing our findings with one another.

Conclusion

Our conclusion is that bubble wrap was the best packaging material. From the dynamic ramp experiment, we learned that bubble wrap and paper were the best choices. Because of that, we chose to test those two materials for the egg drop experiment. However, for the egg drop experiment, the bubble wrap worked the best. Crumbled paper is typically the best because it absorbs the most force. On the other hand, it didn't work for the egg experiment because they were too fragile. From that, paper was the worst option. Therefore we prefer bubble wrap over crumpled paper as the best material for packaging.

Acknowledgments (credits):

- Coach Amit
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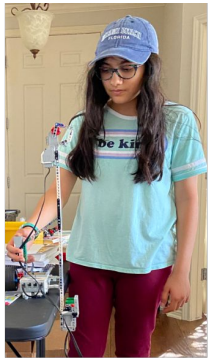
- Parents of teammates
- Rocking Rover Team
- First Lego League (FLL)
- BAE Systems

Rocking Rover



Using MINDSTORMS LEGO to find the acceleration due to gravity

$$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t}$$

where v_i and v_f are the initial and final velocities, respectively.
The ball is dropped from height h, so $v_i = 0$.

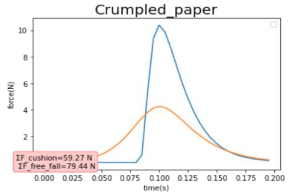
Hence $g = \frac{2v_{avg}}{t}$

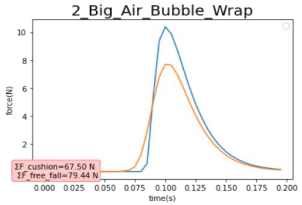
$$\because v_{avg} = \frac{v_i + v_f}{2} = \frac{h}{t}$$

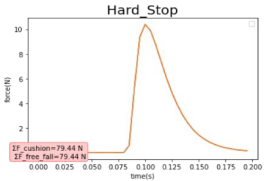
From this experiment we got

$$g = 10.48 \frac{\mathrm{m}}{\mathrm{s}^2}$$

Cushions we used (Hard sponge, bubble wrap, styrofoam, and crumpled paper)







When dropping the eggs, we used Crumpled Paper and Large Bubble Wrap because with the ramp, those were our most successful with force over time. When dropping with 2 layers of Large Bubble Wrap, the egg did not break. However with the paper, it matters how you crumple it. The tighter you tape it, the more prone it is to breaking. We found out that Large Bubble Wrap, wrapped twice is the best(meaning it gets the job done with the least amount of materials).