LARI-JUNO WA0295

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Our team has put a lot of time an effort meeting multiple times a week since the beginning to collaborate and make the best final result possible. I hope you enjoy! (Team roles and responsibilities shown through table of contents.)

MO-3: Getting to the Moon

Checkpoint Guidelines

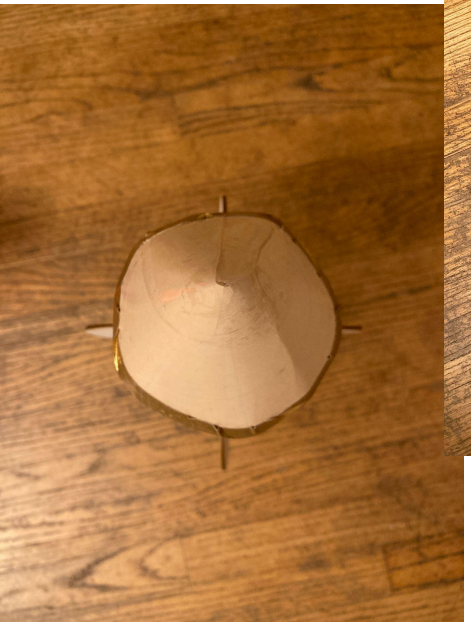
- For Checkpoint #2 (Injection Burn)
  - This could be one of the three additional MOs that you submit
- Check Submission Guidelines!

Final Submission Guidelines

- Complete the next slide
- Add more slides after that with videos, data tables, and additional descriptions of your work
- Visit the Challenge manual for more details on deliverables for this Mission Objective
- Check Submission Guidelines!

MO-3: Getting to the Moon - Overview

Date Completed	Lead Student	Participating Students
3/10/24	Audrey M.	Audrey, Leena, Adlai, Isabella



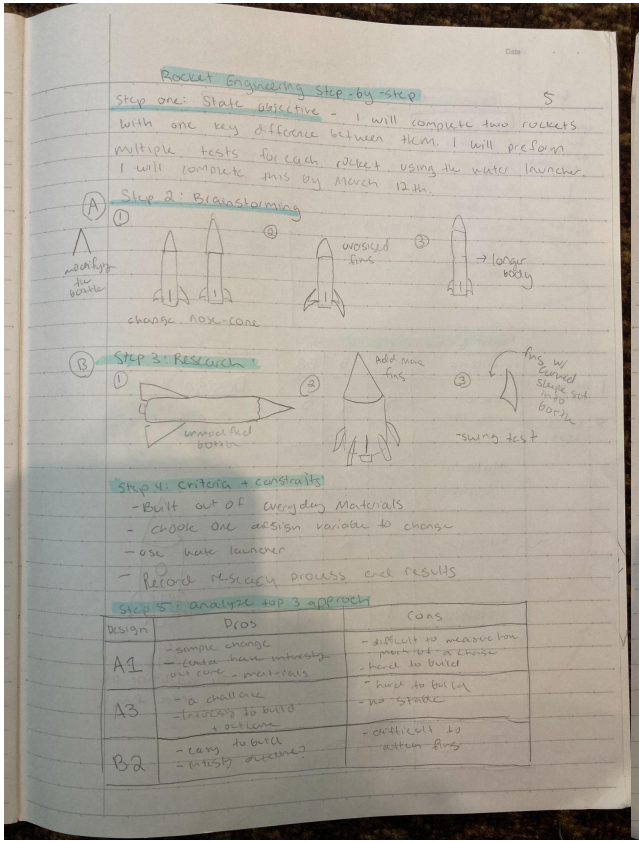
Briefly summarize your work on this MO here in one to two paragraphs. Include what you changed about the design and your analysis of the best design. Include your safety checklist, procedures, and protocols.

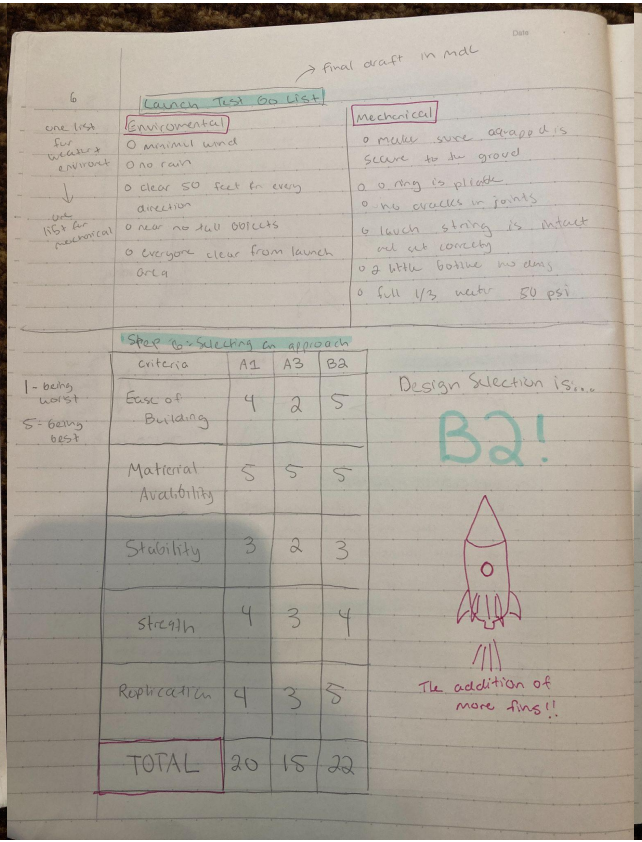
In this MO I worked to make two different rocket designs to compare. I went through a full design process and made many changes to my design in the process of brainstorming and building it. Many challenges and setbacks popped up that I needed to overcome.

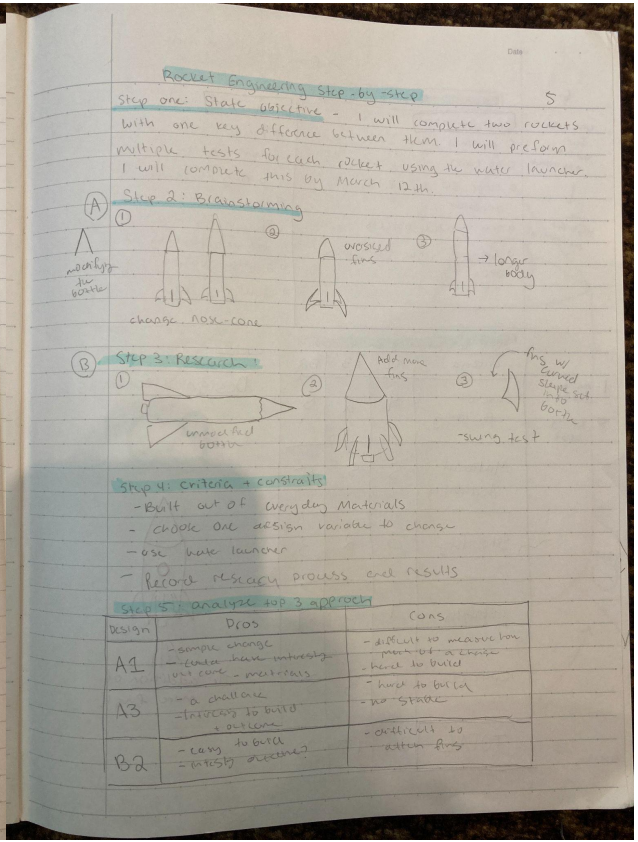
The variable I changed for my rockets was the number of fins on the design. I tested one with 3 fins and one with 4 fins. From my testing I determined that the design with 4 fins was the best as it had the most stable flight and had the same average height as the 3 fin design. After analyzing the data from my launch I reflected on improvements I could make and what a redesign of my rocket would look like.

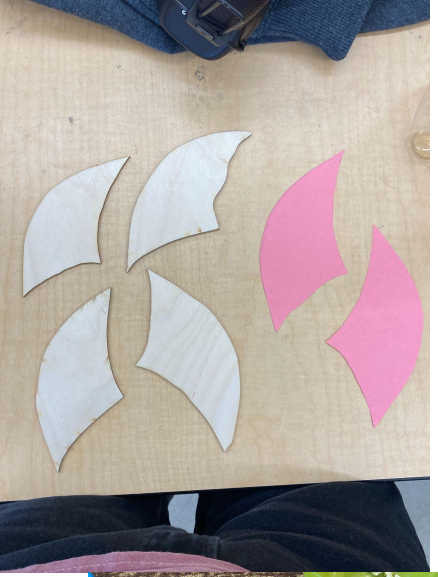
Design Process

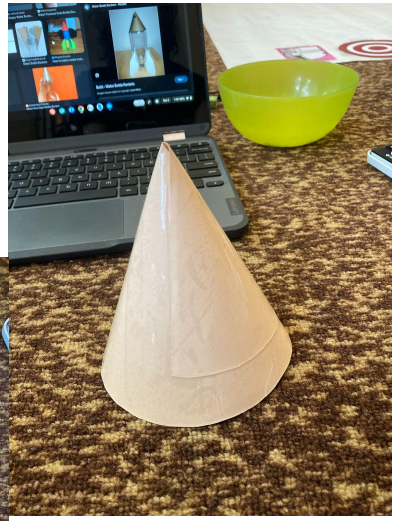
First I began by working through the step-by-step engineering design process to make my design. I also outlined the launch checklist.











Building Process

- First I selected the bottles I wanted to use.
- Than I laminated paper and folded them into the cones pictures to the left.
- For the fins I used paper to map the curvature of the bottle and than traced it in Onshape. I had to try many different designs before I could get the one that sat perfectly against the bottle.
- The fins I had made ended up being to long to fit on the Aquapod launcher so needed to cut off the curved part and have my fins sit higher on the bottle like the next slide.
- Finally I assembled everything with tape and epoxy and got ready to test!

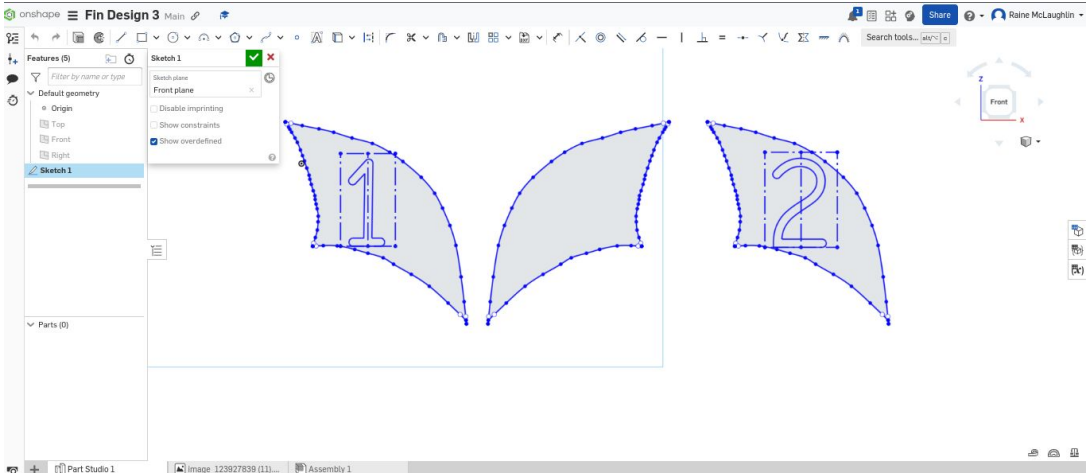
Resources I used:
https://www1.grc.nasa.gov/beginners-guide-to-aeronautics/flight-of-a-water-rocket/
https://www.nasa.gov/wp-content/uploads/2012/03/rockets-educator-guide-20-water-rocket-construction.pdf

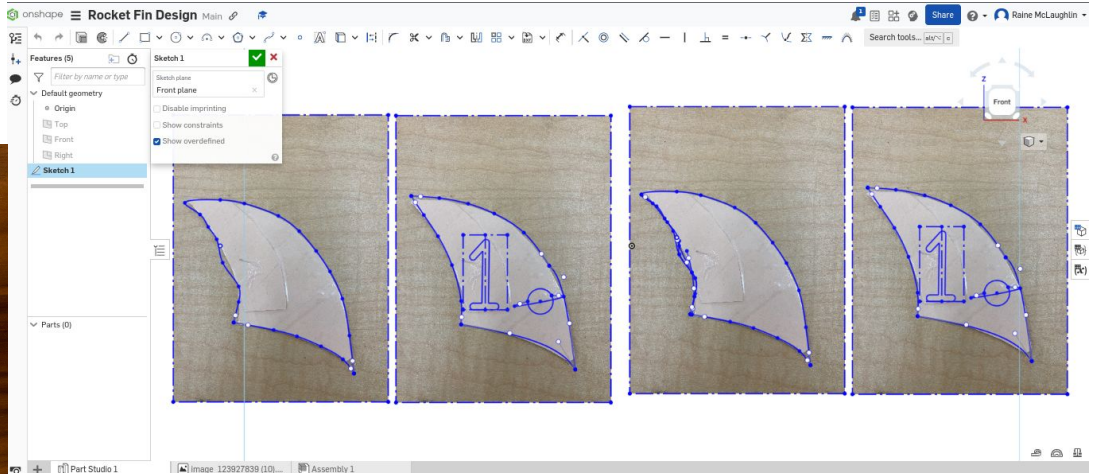
Fin Design

To the right are the Oneshape designs I tried in the process of making my fin design. The lower picture are earlier designs that did not fit the bottle at all.

The upper designs fit well even though the fin design changed completely later they were a very polished design. Below is the final design I used.

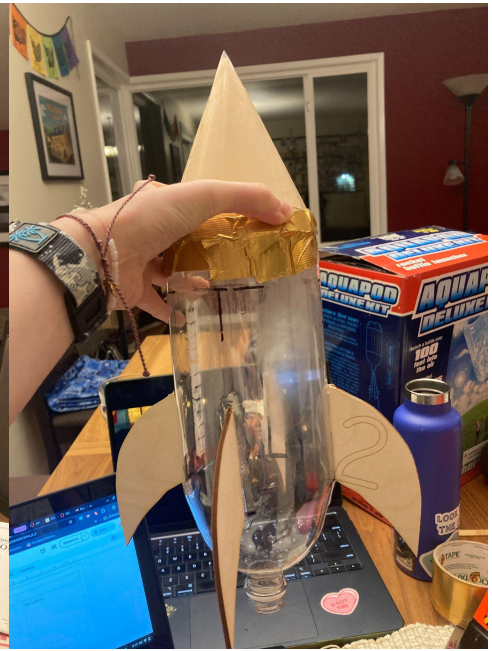
Once I perfected the online design I laser cut them and had the printer make the numbers as etchings in the wood.





Fully built Rockets!

1st design with 3 fins!



2nd design with 4 fins!

- After assembly the rockets are done!
- As I mentioned before the fins were moved higher on the sides of the bottle to help them not interfere with the launcher.
- The change between the two rockets are the number of fins I added.

Final Testing - Images & Data

Launch Go Checklist:

Environmental:

- ❑ Minimal wind
- ❑ No rain
- ❑ Clear 50 feet in every direction
- ❑ Launch area near no tall objects
- ❑ Everyone free from launch area

Mechanical:

- ❑ Make sure Aquapod is secure to ground
- ❑ O-ring connecter is pliable and free of cracks
- ❑ No cracks in plastic joints
- ❑ 2 liter bottle free of dents
- ❑ Launch string intact and set correctly
- ❑ Bottle full ⅓ with water and pressurized to 8 pumps

We did have to postpone the launch one day on account of wind and rain.

On the day of launch it was raining quite heavily but we found a window of about 45 minutes where the rain stopped and we were able to test. The full launch- go checklist was completed and we were a go for launch!

Flight Testing - Part 2

Each rocket was filled with 500ml of water and pressurized by 8 pumps of a bike pump. (neither this pump nor the one received with the Aquapod were able to show a pressure gauge so this method was used instead)

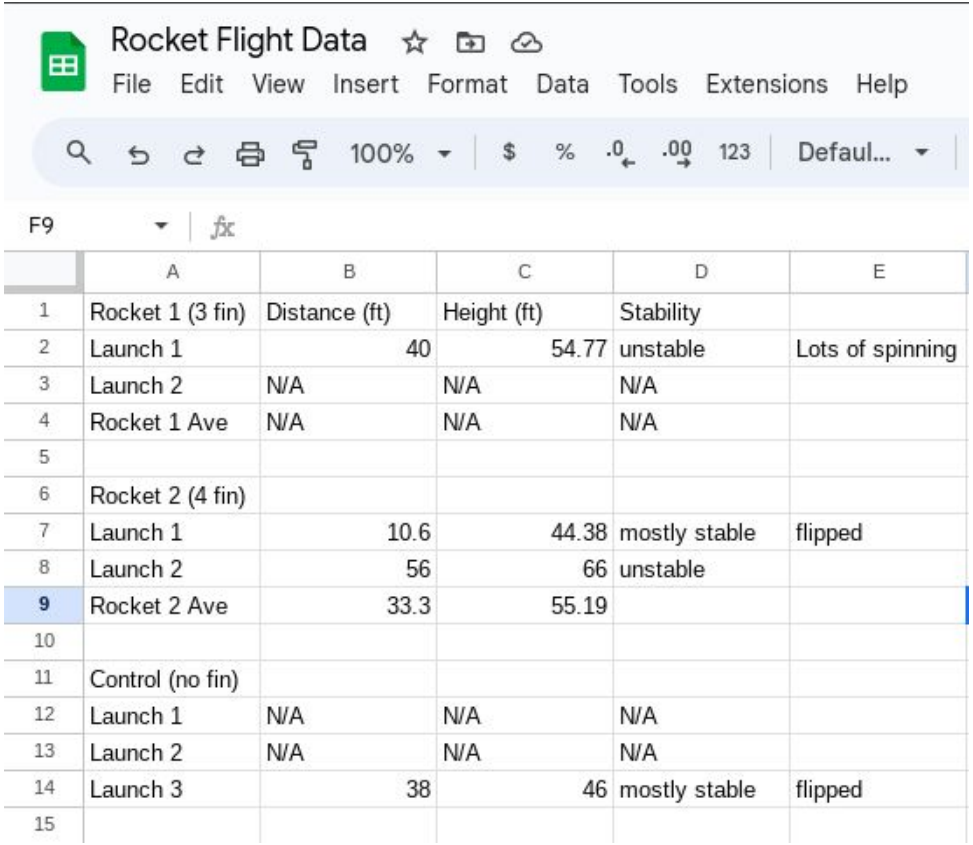
We had one person back 100 feet to use the altitude tester, one person recording video and distance landed from launch site and one person pulling the launch tether to release the rocket.

We first launched the bottle that came with the launch system as a control for the system and had 2 faulty launches before figuring out the perfect combination of water and pressure to get the rocket going.

We launch Design 1 (3 fins) first and it had a successful launch but lost 2 fins upon impact with the ground so we were not able to launch Design 1 twice as originally planned.

Design 2 (4 fins) was launched successfully but lost 1 fin during flight. We did fly it one more time as it was more intact than Design 1 and had another successful launch.

Final Testing - Part 3



	A	B	C	D	E
1	Rocket 1 (3 fin)	Distance (ft)	Height (ft)	Stability	
2	Launch 1	40	54.77	unstable	Lots of spinning
3	Launch 2	N/A	N/A	N/A	
4	Rocket 1 Ave	N/A	N/A	N/A	
5					
6	Rocket 2 (4 fin)				
7	Launch 1	10.6	44.38	mostly stable	flipped
8	Launch 2	56	66	unstable	
9	Rocket 2 Ave	33.3	55.19		
10					
11	Control (no fin)				
12	Launch 1	N/A	N/A	N/A	
13	Launch 2	N/A	N/A	N/A	
14	Launch 3	38	46	mostly stable	flipped
15					

Here is the data collected from the launches! The next slide contains all of the launch videos as well as some images capturing the day.

Final Testing - Part 4 - Media

Not pictured - Control Launch 1 (faulty)
Similar outcome to launch 2

Design 1 - launch 1

Control - launch 3

Control - Launch 2

Design 2 - Launch 2

Design 2 - Launch 1

Reflection - Possible Improvements

Fins-

During the launches I had a lot of difficulty with the fins that I had and attached with epoxy. The epoxy held them well but under any amount of stress or buckling of the bottle they would almost peel off. I believe this is because epoxy is not the best tool to attach to plastic because it is also plastic.

I think trying a different method of attaching the fins as well as a more flexible material to make the fins a more sturdy design for multiple tests and less structural issues.

Stability -

None of the rockets really showed total stability and I think that is a main thing that could be improved. Having a weight in the base perhaps made of lead wire or something similar could prevent as much movement in flight. I would add this if I were to redesign as well as conduct test flights along the way.

Additionally as I stated before having a design that can withstand multiple trials would be beneficial to get the most accurate results.

Flight Conclusions

Best Design:

The best design based on my research would be the 4 fin design. In the launches it launched the straightest and did not spin or flip as much as other ones. Although it did not go quite as high as the 3 fin design during its first launch the second trial went much higher and the average ended up being 55 feet which is the same as the 3 fin design. Although stability is more important than the max height for this type of test the fact that it could almost preform to the same standard as the 3 fin means it has the most potential in a redesign to go the highest.

A redesign of this 4 fin rocket would look have a skinnier profile and larger fins proportionally as well as weights in the bottom to provide a more stable base. In addition to that the nose cone would be taller and skinnier to fit the body of the rocket and be more aerodynamic. I would use a binding agent other than epoxy and the fins would be made of something flexible and strong like laminated paper or plastic. With this redesign I think I could see many improvement in both the maximum height as well as the stability in flight. If I was feeling fancy I might even make a parachute system.