

P2.1.7 Rocket Design

Project Date: *3/15/2023 - 3/31/2023*

Designers: *Kobe Chen, Joseph Ficarra, Ayaan
Muhammed, Kaito Suzuki*

Class: *Principles of Engineering - Mr. McGarran (F-101)*

Period: *4th*



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Design Brief

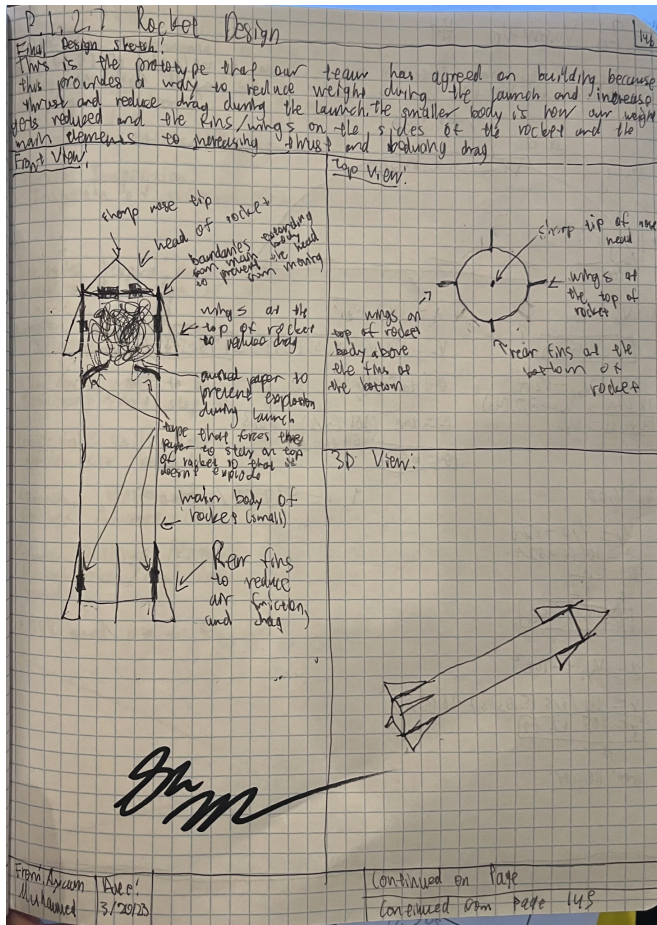
Client:	Nitro Planes
Designers:	Kobe Chen, Joseph Ficarra, Ayaan Muhammed, Kaito Suzuki
Problem Statement:	We, the Nitro Planes, are devoted to entertaining kids throughout the world by manufacturing toy projectiles. Our new product will be a plane or a rocket capable of receiving power from a launcher. However, we do not have the knowledge in kinematics and aerodynamics to produce a projectile with optimum flight.
Design Statement:	Design and model a projectile with construction papers to fly over a football field and through the field goal.
Constraints	- Materials provided - Paper products - Tape - Anything approved - An insert to fit a $\frac{3}{4}$" PVC pipe launcher - Body length between 10"-15" - Wingspan less than 2' - Launched at 80 psi with the launcher - Calculate the angle of launch - 2 weeks and 2 days
Deliverables	Group: - Title page - Table of Contents - Design Brief - Original Design Proposal - For each of the two testing: - Photo of rocket with labels - Description of rocket - Data Table with Calculations - Future Improvements - Teams Norms/Consequences - NetLogo Projectile Simulation - Reference List Individual: - Design brief - Team Norms/Consequences - Two Brainstorming Sketches with Descriptions - Data Table with Calculations - Daily Log - Conclusion Questions

Decision Matrix

	Build Time (How easy to do with time constraint)	Probable Distance (Depending on weight / aerodynamics)	Stability (Will it stay together, and stay stable)	Total
Ayaan's Sketch 1	4	4	4	12
Ayaan's Sketch 2	4	3	4	11
Kaito's Sketch 1	1	4	5	10
Kaito's Sketch 2	5	5	3	13
Kobe's Sketch 1	5	5	4	14
Kobe's Sketch 2	4	3	4	11
Joseph's Sketch 1	5	2	5	12
Joseph's Sketch 2	3	2	4	9

A thorough analysis of the brainstormed ideas with the decision matrix led us to the conclusion Kobe's Sketch 1 was optimal for the original design. Another possible choice was Kaito's Sketch 2. They were mostly similar in their structure and aerodynamics. They implemented a rocket composition with a conehead and fins on the tail. The conehead minimizes drag; the fins balance the weight to position the centroid near the body center. However, they had a significant difference in their stability. The stability is not regarding the potential rotation around its axis but the ability to endure the thrust. In this project, the projectile receives thrust from an 80 psi air pump. Without a proper composition to stop the air, the rocket may disintegrate into debris before ejecting. Kobe's idea depicted the method with more detail than Kaito's. Thus, we decided to use Kobe's Sketch 1.

Original Design Proposal



Ayaan Muhammed
3/27/23

This sketch focused on having a very thin body while having tiny but narrow fins to be able to reduce the drag. This focused on making the body of our rocket as thin as possible so that it would be able to fit onto the pole without having it too tight where it would explode and being able to take 80 psi during the launch. This rocket had fins on the top as another way to reduce drag but still adding a little bit more weight to the rocket. The nose of the rocket is supposed to be a cone with the same base radius as the rocket body so that it would be easier to tape together and attach. Once we did all of that, we would have a nice rocket ready to launch during the football field trials.

Designer: Ayaan Muhammed

Final Rocket Designs



Yellow paper (fins)
Pointed duct tape (nose)

*Joseph Wynn
3/27/23*

*John Owen
3/27/23*

Rocket Design #1: Musk

When thinking of designs for a potential rocket, our group decided that going with the basic design of a pointed nose with four fins at the bottom was the best idea. When designing the dimensions of the wings, we came to a conclusion that the bigger the wings were, the more stability it would provide to the rocket throughout the flight. Although it isn't as creative or visually appealing, it can go a long distance given the right amount of launching force. Our goal was to build a rocket that could go far, and this design reached our goal.

Over a course of 3.55 seconds, *Musk* reached a net distance of 62 yards (186 feet), ranking 4th within our class, falling short of 3rd place, who had reached around 70 yards (210 feet).



White paper (fins)
Pointed duct tape (nose)

*Joseph Wynn
3/27/23*

*John Owen
3/27/23*

Rocket Design #2: McQueen

Our second rocket design, the *McQueen*, was built in roughly 40 minutes. While brainstorming possible designs for this rocket, we decided to stick with basically the same design as the *Musk*, except we changed the amount of fins from four to three, and we made the fins become rounded off. We wanted to see how this design would match up with our original design, and if it would provide better results, given that it was much smaller. Over a course of 4.03 seconds, the *McQueen* traveled a net distance of 33 yards (99 feet), ranking near the middle of the class. The main issue that we noticed when the rocket was launched was that the rocket was being pushed around the wind because it was too lightweight, and possibly because it was also too short.

Data Table

Launch Day 1: *Musk*

<u>Launch angle</u> $\theta = 35^\circ$	<u>Final time (sec)</u> $t = 3.55 \text{ sec}$	<u>Final distance (feet)</u> $x = 186 \text{ ft (62 yards)}$
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Initial Velocity:

<u>Formula:</u> $V_o = \sqrt{(-gx)/\sin(2\theta)}$	<u>Substitution:</u> $V_o = \sqrt{[-(-32 \text{ ft/s})(186 \text{ ft})]/\sin(2(35^\circ))}$	<u>Answer:</u> $V_o = 79.586 \text{ ft/s}$
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Initial Velocity (horizontal component):

<u>Formula:</u> $V_{xo} = V_o \cos\theta$	<u>Substitution:</u> $V_{xo} = (79.586 \text{ ft/s}) \cos(35^\circ)$	<u>Answer:</u> $V_{xo} = 65.193 \text{ ft/s}$
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Initial Velocity (vertical component):

<u>Formula:</u> $V_{yo} = V_o \sin\theta$	<u>Substitution:</u> $V_{yo} = (79.586 \text{ ft/s}) \sin(35^\circ)$	<u>Answer:</u> $V_{yo} = 45.649 \text{ ft/s}$
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Theoretical Displacement (Horizontal):

<u>Formula:</u> $x = V_{xo}t$	<u>Substitution:</u> $x = (65.193 \text{ ft/s})(3.55\text{s})$	<u>Answer:</u> $x = 231.435 \text{ ft}$
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Similar to Actual Final Distance in Feet? Yes or **No**

Theoretical Displacement (Vertical):

<u>Formula:</u> $y = V_{yo}t - 16t^2$	<u>Substitution:</u> $y = (45.649 \text{ ft/s})(3.55\text{s}) - 16(3.55\text{s})^2$	<u>Answer:</u> $y = -39.586 \text{ ft}$
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Similar to Actual Final Distance in Feet? Yes or **No**

Launch Day 2: McQueen

<u>Launch angle</u> $\theta = 45^\circ$	<u>Final time (sec)</u> $t = 4.03 \text{ sec}$	<u>Final distance (feet)</u> $x = 99 \text{ ft (33 yards)}$
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Initial Velocity:

<u>Formula:</u> $V_o = \sqrt{(-gx)/\sin(2\theta)}$	<u>Substitution:</u> $V_o = \sqrt{[-(-32 \text{ ft/s})(99 \text{ ft})]/\sin(2(45^\circ))}$	<u>Answer:</u> $V_o = 56.285 \text{ ft/s}$
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Initial Velocity (horizontal component):

<u>Formula:</u> $V_{xo} = V_o \cos\theta$	<u>Substitution:</u> $V_{xo} = (56.285 \text{ ft/s}) \cos(45^\circ)$	<u>Answer:</u> $V_{xo} = 39.8 \text{ ft/s}$
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Initial Velocity (vertical component):

<u>Formula:</u> $V_{yo} = V_o \sin\theta$	<u>Substitution:</u> $V_{yo} = (56.285 \text{ ft/s}) \sin(45^\circ)$	<u>Answer:</u> $V_{yo} = 39.8 \text{ ft/s}$
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Theoretical Displacement (Horizontal):

<u>Formula:</u> $x = V_{xo}t$	<u>Substitution:</u> $x = (39.8 \text{ ft/s})(4.03\text{s})$	<u>Answer:</u> $x = 160.394 \text{ ft}$
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Similar to Actual Final Distance in Feet? Yes or **No**

Theoretical Displacement (Vertical):

<u>Formula:</u> $y = V_{yo}t - 16t^2$	<u>Substitution:</u> $y = (39.8 \text{ ft/s})(4.03\text{s}) - 16(4.03\text{s})^2$	<u>Answer:</u> $y = -99.46 \text{ ft}$
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Similar to Actual Final Distance in Feet? Yes or **No**

Future Changes

Regarding changes we could make in the future, we all, as a group, felt that our design was too light for the *McQueen*. The performance showed us that the wind and air resistance made it very difficult for it to pierce through, creating additional drag. We could change this by maybe adding extra weight internally, such as crumpled paper. Also, the fins on *McQueen* were unstable and not fully taped up properly, causing them to crumple slightly post-launch landing. Making them more firm would also create a less wobbly, or shaky, mid flight. In addition to the unstable factors, due to the rushed timing of this rocket, the diameter of the overall body of the rocket was too small for the PVC pipe, causing extra, unneeded, friction during the launch. To do this, we could make the body slightly bigger in diameter, and preventing this friction would make the rocket launch much further than it did,

As for the *Musk*, we as a team feel that it was very nose heavy, and we could've added more to the lower half for greater stability. Furthermore, the 35° was too low for our rocket, and we believe that 40° to 45° would've been much more beneficial due to the height inclusion. A third inclusion we could've provided is curved fins. We noticed, while researching, that the fins of rockets are never flat, so we feel that the curved fins could provide a faster velocity, and a further distance because of this.

Overall, there are many changes we could make to our designs to prevent additional weight and friction.

Resources

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