Rocket Design Report

Filled with Tears

12//16

220 yards

Purpose:

You need to design a water rocket. Your water rocket needs to have a 2-liter bottle as the nozzle. Your goal is to launch the rocket as far as you can by creating an aerodynamic rocket and by manipulating your air pressure and also your launch angle. The goal is to get the maximum distance for your rocket. How are you going to do it?

Literature Review:

Fin shapes:

Fin shape is one of the most important elements in designing a rocket. The fins can make the difference between a floppy rocket going almost nowhere or a stable rocket flying over 200 yards. When Ben and I started thinking about how we were going to build our rocket, how good our fins were going to be was the last thing on our minds. We did still do research on them but it was the minimal amount. We knew they needed to be strong and attached well but we didn't know the difference between sizes and how it would affect the rocket. When thinking about building the rocket we saw that three fins worked well in the past and decided we wanted three fins. Like I said, fins were the last of our worries so we just went with the first dimensions we saw which were 5.5 inches by 3 inches by 6.2 inches.

Nose cones:

One major thing that Ben and I read during the Literature Review part of the project was that security and protection are the biggest problems with most rockets. So with this, Ben and I came up with the idea to use a hard plastic funnel as a nose cone. The funnel would give the rocket a cone shape at the point, which would increase the aerodynamics of the rocket, and the hard plastic would serve as a head that won't bend or break when it hits the ground. This was very important because when the rocket first hits the ground, the nose cone is what takes most of the force. Using a hard plastic funnel nose cone was the most vital piece of our rocket.

How to secure objects to the rocket:

Securing your pieces to your rocket is important. If your rocket had a badly secured fin it could completely mess up the stability of your rocket and ruin that launch. We had a lot of information on how to secure fins. We learned that duct tape worked well and it is the easiest option when constructing your rocket. One thing we learned to stay away from was hot glue. Hot glue is so hot that it can melt the plastic of your bottle. If you use hot glue to secure things to your bottle at all, it can warp or misshape your bottle which can ruin a rocket. Also a badly secured piece of your rocket can not only hurt your launch and if you can launch multiple times a class period, it can waste your time.

Ideal mass:

Mass is another important aspect of your rocket. You don't want to little or it won't fly right and you don't want too much because that would prevent your rocket from going as far as it can go. For our two chamber design we found that an optimal weight would be between 350g and 400g, but for the more common single chamber rocket an optimal weight is around 250g.

General lessons learned:

While reading about this project we learned many things about how to improve our rocket and make it the best it could be. One big thing was the width of a two liter bottle. Our first idea was to use a three liter bottle to increase the volume so we could have more fuel for the rocket therefore making it go farther. Soon we found that we needed a two liter nozzle to launch the rocket. Then the goal was to either find a three liter bottle with a two liter nozzle or splice the three liter and a two liter together so that we got the increased volume. Other things we learned were; protection of the rocket is vital, be careful with your pressure because if you go too high, it will explode, try different angles when launching because 45 degrees isn't always the best, the cap diameter of a two liter bottle is 30.82 mm, and gorrilla glue is effective for attaching things strongly, but it takes long to dry.

Splice:

Once we found out about the launch rod needing a two liter nozzle for a launch we immediately decided to splice the two liter bottle with a three liter bottle. The three liter bottle was much larger in circumference than the two liter bottle and we didn't really do any research about how to fill that hole effectively, so our splice design didn't work well and that is why we eventually ditched it.

Testing & Development:

Mission 5 Launch Day 1 ~ 2016 - September, 30:

Mission 5 Preparation:

Once we built our rocket it came out to be around 520 grams. We did no prior tests to see if it was waterproof or anything we just winged it and we were hoping for a successful launch.

Mission 5 Results:

Right off the bat, as soon as we added water to the rocket it started to leak. Although this was happening we loaded it up to the launcher and started to pressurize it, seeing if we could launch it before it loses too much water. When we began to pressurize it, the weakened Play Doh made it easy for the top chamber of the rocket to slide off and only the top part of the rocket flew, which was not far and actually not recordable.

Mission 5 Recommendations:

The plan was to try and salvage the rocket. We decided to change the spot we had Play Doh in and replace it with silicone glue. The silicone glue is waterproof so it should hold the two chambers together, prevent the top from popping off, and keep the water inside the rocket.

Pressure	Angle	Distance
115	33	Blew up.

(For all charts the pressure is in psi, angle is in degrees, and distance is in yards.)

Mission 6 Launch Day 2 ~ 2016 - October, 4:

Mission 6 Preparation:

We changed the sealant between the two chambers from Playdough to Loctite clear silicone. We put sand inside a plastic sandwich bag and placed that inside the nose cone. We kept the cork shell to strengthen the body of the rocket. We used three triangular fins that were 5 inches by 3 inches, not including the hypotenuse.

Mission 6 Results:

We did not launch because there was an air leak between the two chambers, we missed a very tiny hole with the silicone. There was also a water leak in the same spot, that's actually how we found it.

Mission 6 Recommendations:

We decided to scrap the two chamber design because if not done 100% right it causes a lack of pressure. It will prove to be too complicated to launch day in and day out and to keep it in proper order for launches. We also didn't want the three liter bottle to go to waste so we decided to keep it but just as an outer shell to protect the rocket.

Pressure	Angle	Distance
-	-	No Launch

Mission 7 Launch Day 3 ~ 2016 - October, 6:

Mission 7 Preparation:

We replaced the half two liter bottle that was spliced with the three liter bottle and replaced it with a full two liter bottle with the three liter bottle serving as an outer protective shell for the rocket. The seal between the bottles was Loctite silicone and duct tape over that to try and smooth out the rocket for less air resistance. We also enlarged the fins a little and made them 6 inches by 3 inches, excluding the hypotenuse.

Mission 7 Results:

We had our first successful launch! Although it wasn't great it was the first big step in the project. We realized it needs to be stabilized because of how shaky and wobbly the launch went.

Mission 7 Recommendations:

We decided to ditch the three liter bottle completely, it was just a waste of space and pretty much pointless. It just made the rocket less aerodynamic. Also the rocket weighed too much, we needed to lower the amount of sand in the nose cone. Using the funnel as the nose cone itself works impeccably, it does a great job of protecting the rocket.

Pressure	**Angle**	**Distance**
110	32	58
118	41	59

Mission 8 Launch Day 4 ~ 2016 - October, 13:

Mission 8 Preparation:

We changed our design from a double chamber rocket to a single chamber rocket so that there would no longer be any problems with air leaks or anything. The funnel as the nose cone has worked spectacularly in protecting the rocket and so has the cork.

Mission 8 Results:

We didn't actually launch this day because Ben and I went on a field trip to Salem and even though we made arrangements for the rest of the class to bring our rocket outside for launch and nobody did.

Mission 8 Recommendations:

If you miss a launch for any reason, make sure you have a reliable person to take your rocket outside and launch it so that you don't miss out on any launch days and trials to make your rocket better.

Pressure	Angle	Distance
-	-	No Launch

Mission 9 Launch Day 5 ~ 2016 - October, 19:

Mission 9 Preparation:

As just a quick fix before the launch we made the fins thicker, just to see if that would help stabilize the rocket. This was our first launch with the new rocket and we were stoked to see how it did. Everything else we kept the same from the rebuild of last week.

Mission 9 Results:

The first launch was the best so far. It wasn't a great launch but we made it a bit farther than the last few launches. The rocket still had trouble with stabilizing, and we still needed to improve the fins. On the second launch with the new rocket, it exploded. It sounded like a bomb went off. We over pressurized it and all our hard work on a finally working rocket went out the door.

Mission 9 Recommendations:

Our goal for the next rocket was to build something similar but we needed to adjust the weight in the nose cone and also find a way to stabilize the rocket.

Pressure	Angle	Distance
120	41	81
138	41	Blew up

Mission 10 Launch Day 6 ~ 2016 - October, 25: Filled with Tears was born!

Mission 10 Preparation:

We built a new rocket, this would end up being our final rocket. It's name, Filled with Tears because of all the pain we've endured through this project up to this point. We have a new nose cone with a golf ball as the weight and also the plug for the hole in the nose. We also improved the fins in trying to help it stabilize. We also secured the fins better with duct tape.

Mission 10 Results:

The launches went okay. They weren't great but the rocket didn't blow up so that was a plus. We still needed to find a way of stabilizing the rocket.

Mission 10 Recommendations:

We think that the rocket itself is good, we just need better fins. We decided to improve them by making them longer and wider.

Pressure	Angle	Distance
115	40	80
110	40	50

Mission 11 Launch Day 7 ~ 2016 - October, 27:

Mission 11 Preparation:

We trashed the old fins and made new ones out of an old Xbox game case. The dimensions were about 3 inches by 2 inches by 1 inch. Not only were these made of a different material, we also changed the shape from a triangle to a trapezoid with one side having a 90 degree angle.  (rough sketch)

Mission 11 Results:

This was the first ever rocket launch in the snow. It was very cold and we ended up going inside early. The first launch wasn't actually a launch, there was an error by the launch team and it blew off before it was fully prepared for launch. The fins were misaligned after the launch so we needed to secure them better. Also the fins helped stabilize it but it needed to be even better.

Mission 11 Recommendations:

We planned on making new fins out of the same material but just longer and wider. Generally the bigger the better for the fins.

Pressure	Angle	Distance
125	40	Blew off
130	40	60

Mission 12 Launch Day 8 ~ 2016 - October, 31:

Mission 12 Preparation:

We improved the fins for the final time and by now the dimensions were about 4 inches by 2 inches by 2 inches. We kept the trapezoid shape but we used new tape called 100 mile per hour tape to secure the fins to the rocket.

Mission 12 Results:

Most of the launches were successful, definitely the best we've had, by far! We even almost broke 200 yards! On our last launch of the day our rocket took a big gust of wind and when we launched it from the side of the bus garage, it ended up at the home dugout of the baseball field. After we recovered the rocket we discovered a small hole in the nose cone which we just covered with some 100 mile per hour tape.

Mission 12 Recommendations:

We still had the problem of the fins needing to be realigned after each launch so our goal was to find a way to secure them a little better. Also we needed to cover that hole in the nose cone which was a quick fix.

Pressure	**Angle**	**Distance**
125	45	121
130	45	162
130	45	191
135	47	Home dugout

Mission 13 Launch Day 9 ~ 2016 - November, 2:

Mission 13 Preparation:

We completely focused on the security of the fins, make sure they don't pop off and also try to make it so we don't have to realign them each launch. We used the same 100 mile per hour tape, it seemed to work the best. Also we covered the whole nose cone with the 100 mile per hour tape just to make sure no air would pass through the rocket and have it end up the same as last time.

Mission 13 Results:

We had even better launches then last time. The first one was a little disappointing because when we put the rocket into the backpack to bring it to school and to class it misaligned the fins but after realigning them we broke 200 yards. We figured out that if we realign the fins after each launch, the rocket flies better.

Mission 13 Recommendations:

Our launches went so well we didn't want to change anything. Just realign the fins and keep things the same. Rocket worked amazingly and as my coach used to say, "If it ain't broke don't fix it."

Pressure	Angle	Distance
135	45	133
135	45	215
135	45	111
135	45	201

Mission 14 Launch Day 10 ~ 2016 - November, 4:

Mission 14 Preparation:

We secured the fins and eliminated anything that would make the rocket less aerodynamic, which really was no changes other than realigning the fins again.

Mission 14 Results:

No launch, Ben and I were both absent for class this day.

Mission 14 Recommendations:

No changes, just keep everything the same and don't mess anything up for rocket day.

Pressure	Angle	Distance
-	-	No Launch

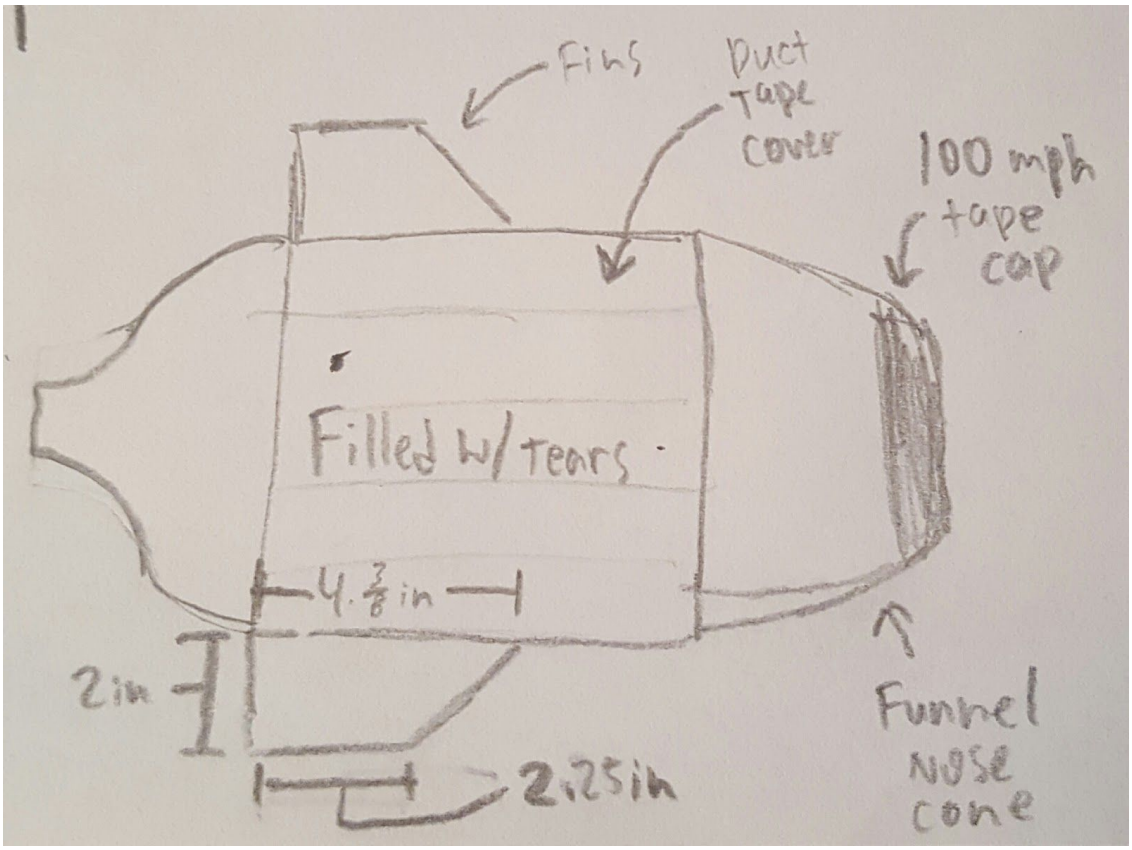
Rocket Day Conclusion:

Lessons:

Throughout testing and development we did learn a lot of key things that if we knew sooner would have helped. One major thing is that Play Doh is terrible to use as a seal. If it collects moisture of any type it can become very slippery and will not hold your rocket together. We sadly had to learn this the hard way. This slipperiness led to a rocket failure on our first launch and it led to us never using Play Doh in a future rocket design. Also we learned that when it comes to fins, bigger is generally better. I would confidently tell a future team that if they are having troubles with distance or stabilization, to just increase your fin size. Along with that I would say that a team should definitely invest in strong, light, and durable fin material Once we did our rocket's launch numbers were insanely better compared to before we used the new fin design. Also we did create new ideas that I'm happy about. We were the first team, of our knowledge, to use a funnel as our nose cone. This is without a doubt our rockets best feature. We never had problems with nose cone strength. It served its purpose in protecting our rocket and it accomplished that goal glowingly. I hope future groups will try our idea because we believe, we have the best nose cone yet, and the results show.

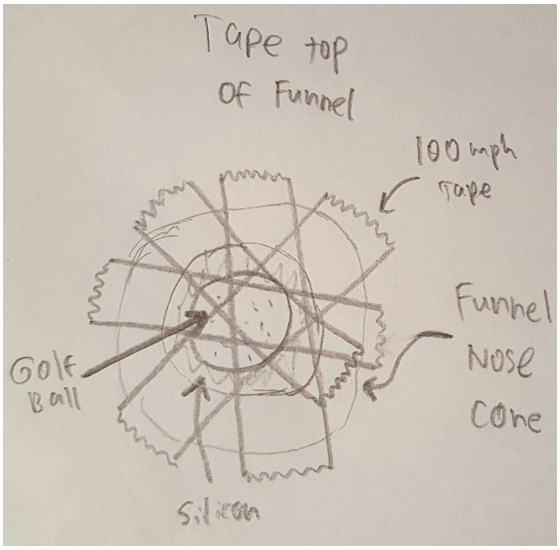
Final Design:

Walkthrough of final rocket from top to bottom of the rocket.



<u>Nose Cone:</u>

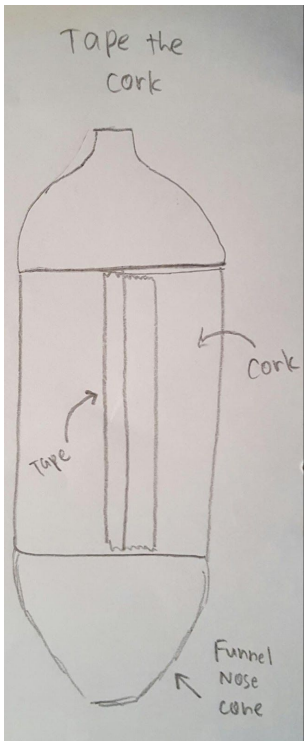
Our nose cone is a funnel bought at Walmart. A red long skinny oil funnel that we cut with shears to be smaller and more practical for the rocket. Then we filled the hole in with a golf ball, GE silicone (which is better than the Loctite silicone), and 100 mph Tape. This was slightly weak at the top but got the job done. Inside we used a hard plastic cylinder but we could never get it to stay in place and if a group plans to use this design I suggest that you find a way of doing so. This would prevent your golf ball from going inside of your nose cone and could possibly make your rocket more aerodynamic. Another thing I suggest is to go heavy with the 100 mph tape with overlapping pieces in different angles to seal any holes (Shown below). The nose cone and bottle gap is connected with duct tape (Go vertical with the bottle rather than horizontal).



+++

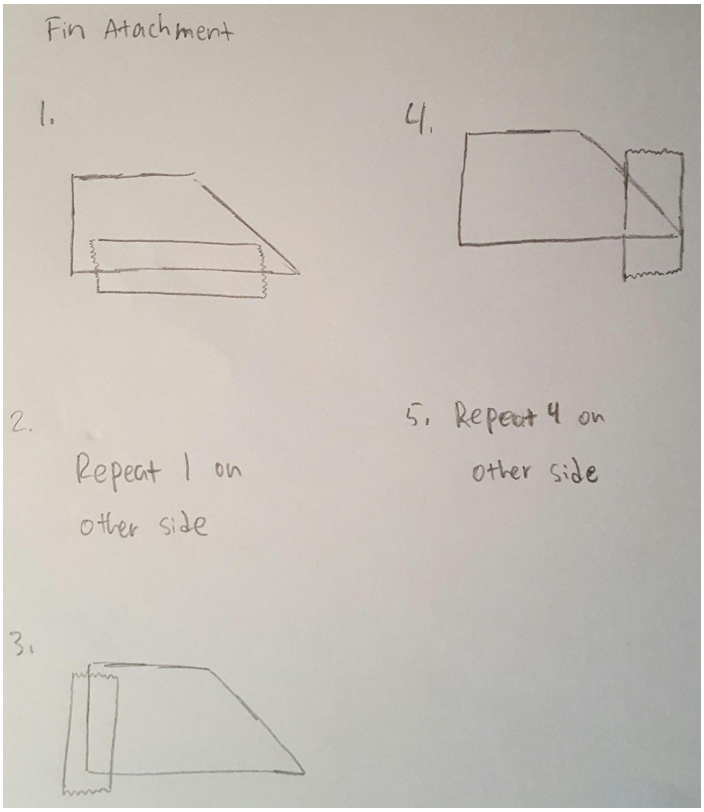
Bottle:

We used a non-cut 2 Liter bottle with the butt end attached to the nose cone. We wrapped the bottle in the flat, not rounded portion with durable cork wrap found at A.C. Moore or any other craft store. Then tape over the two edges on the side they meet all the way down with duct tape. Then we covered the remaining cork in duct tape to give it, what we thought, a better look.



Fins:

The fins were a very hard challenge in the fact that they had to be very precise. We cut three fins out of 1 former Xbox game case. They all had to be equal in size as this can be crucial to your launch according to both research and personal experience. They were then attached symmetrically at the end of the bottle with their back edge meeting up with the edge of the cork cover. They were attached on each side with 100 mph tape. Our strategy for attaching these fins was to have two strands on each side of the fin then one on the back, then lastly one across the front, but try your best not to create an air hole, it can be difficult.(Shown below).



Advice:

I would say the biggest piece of advice I could give is that it is okay to step out of your comfort zone. When we were building our rocket we looked around and we were the only group with a funnel nose cone and we were constantly made fun of for our designs. This is good though because by trying new stuff, it's the only way to get better. If it is a failure, then you learn a lesson from it, if it succeeds, you may have just made a huge advancement in your rocket design. We did try new stuff and we turned out to have the best nose cone in the class. Taking risks in this project is scary but it can be very valuable in the end. Plus don't panic when things don't go your way. For the first six launches we had the shortest maximum distance in the class. On rocket day we finished with the second farthest distance for any group. Things can change really quick but they will only change if you make the attempt to fix them. If your rocket is not producing as well as you want, make changes. Make larger fins, try shedding weight, try more water. Whatever you have to do, to do better in your future launches. If you do, you're guaranteed to be successful. I wish someone would have told me that sooner. Because once you have accepted that, only then, you can truly succeed in this project.

Launch Team:

It is very important that the launch team works well together and everyone contributes and does their job. If your launch team isn't good, you'll be lucky to get two launches in a day, which isn't good. If everyone contributes and does their job you can get four, or even five launches in a day. My role in the launch team was the head of retrieval. I was in charge of having people out in the field to grab rockets and bring them back in quick. That meant before the launchers had run out of rockets to launch. It is important to have quite a few people do this or you'll be stuck running in and out many times a day. The other important thing about retrieval is that your team has to measure the distance of each launch so make sure you don't pick up the rocket before they are done measuring the distance. One tip with retrieval is to wait until you have two or three rockets before you bring them in so that you aren't running back and forth multiple times a class period.