<u>Fly Rocket Fly: Design Lab Report</u>

"The Zlatan 10W"

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Max Distance: 210 yds

Purpose

Question: What is the best way to design a water rocket in a way that it will be able to withstand an impact and be aerodynamic enough to travel a long distance?

Literature Review

Lessons Overview: There were several things that I had learned through researching that proved to be vital to making a successful rocket. I learned that in order to create a rocket that functions and performs the prior purpose you must go through several designs and there is a lot of trial and error. There is no perfect rocket design, in order to be successful you have to create a rocket and stick with what works for you and your partner. However, there are several factors that are crucial in order to make your rocket fly: a semi aerodynamic nose, fins that improve the rocket's flight and trajectory, and also the weight must be unbalanced throughout the body to compensate for the water in the rocket during launch[3].

When designing a rocket you must keep in mind not only the shape of its fins but also the size. Usually a larger fin is associated with a smaller rocket and vice versa. These larger fins provide more stability for the smaller rockets that the larger rockets just don't need. The fins should also be quite durable, your rockets will be subject to a lot of hard landings and it will need to be able to withstand all of them. There are several different shapes of fins for rockets that seem to be successful but what seems to work best is the classic acute triangle shape, this design provides stability for the rocket during flight and don't protrude from the sides too much to limit resistance[1]. Another design that was popular was a half trapezoid shaped fin. This fin design was experimental but depending on the rocket could be successful. Materials that are used for the fins should be a durable plastic or a hard cardboard but should be thin regardless[3].

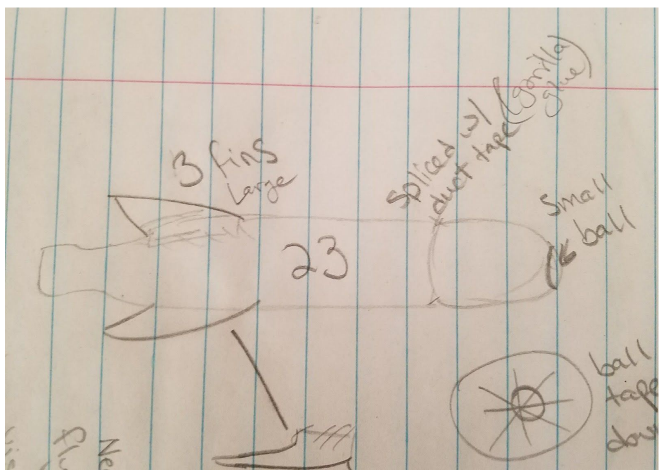
The nose cone plays a huge part to your rocket and is arguably the most important piece to perfect with your design. A common misconception was that the cone shape would be best or most aerodynamic for the rocket but that is incorrect. A spherical design outperforms all other shapes by far from testing[3]. Nose cones should also be durable because this is the most susceptible to damage due to its location on the rocket. It should be able to resist damage and hold up from the force of impact each time[2]. The nose cone should also have the appropriate mass not to disturb the flight of the rocket.

When securing pieces to the rocket, pieces should be in place and not move. There are many different products that can be used to keep things from moving on your rocket. For the best results, a combination of both glue and tape should be used to attach your fins to your rocket[1]. The amount will vary depending on the size and shape of the fins and also the surface are that they have. The ideal material to keep the nose cone in place depends heavily on what you’re design is. I have seen that it is best to use tape that is placed in a way that it won't allow things to move but also isn’t bulky enough to affect the rocket’s flight and mass.

The ideal mass of the rocket should be between 350-400 grams and should be well balanced throughout the the body of the rocket[3]. When measuring mass you should also keep in mind that about a liter of water will also be in the tank. This is important to consider because the overall design should be centered on the mass of the water in the tank.

Throughout the literature review I have learned many things. Firstly, when designing your rocket you should keep in mind that your design is flexible and should change over testing to get the best end results. Also, when designing your rocket decide the fin shape and size after you have thought about every other aspect first. This is important because the fin design is greatly dependant on what the rest of the rocket looks like.

Figure 1: Original Design Sketch



Testing and Development

Misson #1: 2016 - September, 30

Mission #1: Preparation

We are testing the splicing done on the large tank. We are also testing the mass of the front of the rocket.

Mission #1: Results

The rocket had exploded on the launch pad after being compressed with air. Launch Failure.

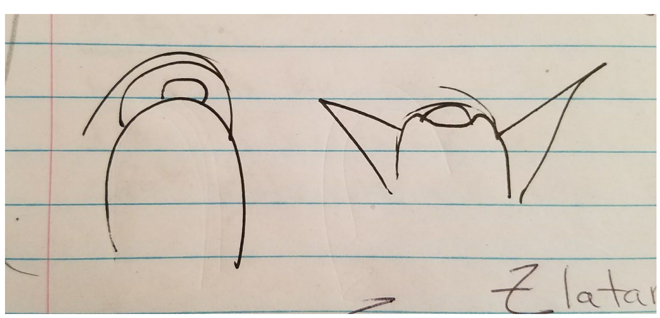
Figure 2: Mission #1 Data

Trial #	PSI	Distance (yards)
1	120	0 (Explosion)

Mission #1: Recommendations

A new design is needed without splicing, the front of the rocket blew off after compression. One tank, 1 liter capacity, with a golf ball for more mass in the nose cone and small fins on the rear made from a sturdy cardboard.

Figure 2.1: Nose Cone Idea



Misson #2: 2016 - October, 4

Mission #2: Preparation

A new rocket has been built with small cardboard fins and a nose with a golf ball secured by duct tape. We are testing its weight distribution and nose cone.

Mission #2: Results

Our rocket wasn't launched due to not having enough time.

Mission #2: Recommendations

The rocket should be in one piece and functional for the next testing day.

Misson #3: 2016 - October, 6

Mission #3: Preparation

Small cardboard fins have been attached with thinly sliced duct tape. Also a nose cone with a golf ball secured by duct tape has been added. Both are being tested.

Mission #3: Results

Figure 3: Mission #3 Data

Trial #	PSI	Distance (yards)
1	130	50

The rocket rolled in the air and did not travel as expected.

Mission #3: Recommendations

A new nose cone is needed with the ball dented into the front and larger more stable fins.

Misson #4: 2016 - October, 13

Mission #4: Preparation

Larger fins made of house siding have been added and tested. The nose cone has been remade with significantly less tape.

Mission #4: Results

Figure 4: Mission #4 Data

Trial #	PSI	Angle (Degrees)	Distance (Yards)
1	120	45	94
2	120	45	54

The rocket was much more successful and flew further than the previous launch date.

Mission #4: Recommendations

The fins need to be adjusted with less tape to reduce wind drag. The nose should be more efficient with less tape as well.

Misson #5: 2016 - October, 19

Mission #5: Preparation

The fins have been readjusted but the nose cone has been unchanged.

Mission #5: Results

Our rocket exploded for the second time. The O-ring on the launch pad was too loose and caused the mouth of the bottle to break.

Mission #5: Recommendations

A new rocket is needed. New design ideas include: Large sturdy fins from house siding, golf ball in the nose for better weight distribution secured by a small amount of duct tape, and a single unspliced body.

Misson #6: 2016 - October, 25

Mission #6: Preparation

A new rocket has been made, The “Zlatan 10W” is it’s name. Large fins from house siding are attached (idea from The Flying lady), nose cone has a huge amount of tape surrounding a golf ball. We are hoping to achieve 100 yrds.

Mission #6: Results

Figure 5: Mission #6 Data

Trial #	PSI	Angle (Degrees)	Distance (Yards)
1	120	45	185
2	130	45	124

The rocket suffered some damage on the first impact resulting with a lower distance on the second launch.

Mission #6: Recommendations

The fins are finalized and do not need any alterations. The nose should be adjusted to be more efficient possibly a second golf ball is needed.

Misson #7: 2016 - October, 27

Mission #7: Preparation

The rocket's fins have been left unchanged however the nose cone has been given a second golf ball for better weight distribution.

Mission #7: Results

Figure 6: Mission #7 Data

Trial #	PSI	Angle (Degrees)	Distance (Yards)
1	125	40	109
2	130	40	141

The addition of the second golf ball made the rocket too front heavy and impacted the flight poorly.

Mission #7: Recommendations

The nose cone is too heavy and needs to be lightened by removing one golf ball.

Misson #8: 2016 - October, 31

Mission #8: Preparation

Some duct tape has been removed however the second golf ball is still in the nose cone.

Mission #8: Results

Figure 7: Mission #8 Data

Trial #	PSI	Angle (Degrees)	Distance (yards)
1	135	45	169
2	135	45	182
3	135	45	122

Mission #8: Recommendations

The second golf ball needs to be removed and the nose cone, instead of being held together with tape, be attached with clay.

Misson #9: 2016 - November, 2

Mission #9: Preparation

A new nose cone design has been made with clay and one golf ball to replace the tape.

Mission #9: Results

Figure 8: Mission #9 Data

Trial #	PSI	Angle (Degrees)	Distance (yards)
1	135	45	160
2	135	45	182
3	135	45	168
4	135	45	170

The clay design proved to be much better and the rocket flew much straighter than it ever has.

Mission #9: Recommendations

The clay is too fragile and cannot withstand the impact. Some tape over the clay is needed.

Misson #10: 2016 - November, 4

Mission #10: Preparation

A new nose sone is being tested with clay and one golf ball.

Mission #10: Results

Figure 9: Mission #10 Data

Trial #	PSI	Angle (Degrees)	Distance (yards)
1	135	45	168
2	135	45	177
3	135	45	170

The rocket is flying much more consistently but the distance should be further,

Mission #10: Recommendations

With Rocket Day being tomorrow not any drastic changes should be made to avoid a poor distance. That being said, the rocket should be restored to the ideal conditions to ensure a good launch for tomorrow, i.e. taking out dents, adjusting tape and making sure fins aren’t moved.

Rocket Day Conclusion

Rocket Day Conclusion:

The two tank approach is a good idea in theory but challenging to actually pull off. Our first rocket had a two tank combined design, however, the splicing was much more difficult that we had imagined. The bottles were slightly different circumferences around the middle therefore didn't line up correctly when gluing. This resulted in a poor seal and when the rocket was compressed it exploded on the launch pad. The lesson learned from this was that a simpler design is a better design when making a rocket. This led us to develop a rocket with only one tank with around two liters.

Another struggle that needed to be overcome was the design and material of the fins. The original design of the "Zlatan 10W" had small fins made from cardboard. As the launches progressed we realised that the rocket needed something larger in order to stabilize it during flight. Also the fins kept being flung from the rocket each time it would impact the ground. This meant that larger fins were needed and the material must have been upgraded to something that could withstand the impact. This led us to our final fins made from house siding (Credit to The Flying Lady) that seemed large and were secured by two small pieces of duct tape.

The nose cone was by far the most difficult part of the rocket to make work. Our original design was very unsuccessful and was a golf ball taped to the front. The next idea was to add a second golf ball, thinking more weight needed to be added to the nose cone. This was a mistake that hurt the rocket's results greatly, bringing the distance down as much as 45 yards. The final design that performed the task well enough was a single golf ball held on the rocket with clay and putty.

Figure 10: Final "Zlatan 10W" Design

The rocket is approximately 425 grams and should be filled about halfway with one liter of water before being placed on the launchpad. The rocket is 34cm from nose to bottle opening. The three fins protruding from the base of the rocket 4cm from the bottle opening are 10cm in height and 5cm in width. The materials needed are: duct tape, a two liter bottle, a single golf ball, and around a square meter of house siding for fins.

A several general lessons I learned from designing and building a rocket is that throughout the process of experimentation you should be sure to record everything. The more detail the easier it will be for you to write your design report. You should also be very open to changing everything to produce better results. Regardless of what the other students around you say or do you should be concerned with your rocket and making it better. Another common misconception is that more pressure in the bottle means it will go further, this is incorrect. Unless your rocket is aerodynamically sound, a large pressure actually could hurt the distance that it can travel. The most important lesson I learned during all of this is to make a goal and stick to it. At the beginning of each launch I had a set distance I wanted the rocket to fly and that tip really made the labs go much smoother.

Launch Team

Launch team:

My title during both experimentation and rocket day was Airman. My responsibilities include: Making sure the compressor is running correctly, pressurizing the line to the launch pad at the PSI needed, and decompressing the system during a failed launch.

Citations:

[1] Dunbar, Brian. "Water Rocket Construction." *NASA*. NASA, n.d. Web. 19 Dec. 2016. <https://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Water_Rocket_Construction.html>.

[2] "Galway Rocket Day." *Galway Rocket Day*. N.p., n.d. Web. 19 Dec. 2016. <http://www.naturalphilosophers.org/flyrocketfly/>.

[3] Northup, Graham. *General Guidelines for Bottle Rocketry* (n.d.): n. pag. Web. 19 Dec. 2016.