Rocket Design Report

MEH

2016-December, 22

210 yards

Purpose

How can you design a rocket by using a two-liter bottle to fly a distance over a hundred yards? That should have some type of cone and wings to help fly through the air. What shape of cone will you create? How many fins will you have? How far apart? What shape? It can not have air resistance, the rocket needs to be aerodynamic. How much mass will the rocket have? Will it be light or heavy? The rocket needs to be able to survive through multiple severe impacts. It also must hold at most one liter of water and needs to withstand air pressure. The bottle needs to durable enough to be powered by air and water. What pressure will you launch at? How much water will you use? One liter? Two-thirds of a liter? How will you design your rocket? How successfully will you use the launch days?

Literature Review

After researching techniques of how to build a good rocket and testing my rocket on launch days. I came up with conclusion about all different characteristics of the rocket itself.

Fins are important to get your rocket going the right direction and create a good spin to the rocket. Sturdy fins are necessary. They have to withstand the launch and the flight with the rocket. They need to also be durable enough to withstand a hard landing. Fins need to be oriented around the rocket, the most aerodynamic fins face the wind which is forward. Fins should be near the rear or the rocket around the neck of the bottle, three equally spaced fins around the rocket is perfect. This causes lateral air resistance to pull the rear of the rocket rearward, creating better stability. [1]

Nose cones aren't very efficient. Parabolic or spherical cones are much more efficient than the original nose cone design .[1] The cone of the rocket must be sturdy enough to withstand the landing. Place a nice sturdy weight in the center of the cone tip to keep the rocket sturdy. A bouncy ball or a golf ball for the tip of the cone helps absorb some of the harsh impact.[2] Keep wind in mind, you want a durable, aerodynamic cone. If you use a golf ball, do not sand down the visible part, so there are no longer those little circles because then the ball makes the cone more aerodynamic. That is incorrect, the little dimples in the balls makes the ball aerodynamic.[3] Keep in mind that you want your weight in the nose cone to be spread out. You don't want the tip to be heavier than the bottom of the cone, that will end in a nose dive. If you use clay for the weight in the cone make sure the clay dries before attaching the cone to the base of the rocket to avoid the clay drying a different way then planned.

Stable rockets are the best ones. The rocket itself has to be light to be aerodynamic. It can't be too light but it can't be too heavy. A rocket with too little mass will be influenced by wind and air resistance. But a rocket with too much mass, won't be able to accelerate adequately. The ideal mass is 350-400 grams.[1] Our ideal mass was about 140-170 grams. Every rocket differs due to their different designs.

The bottle has to be durable. The rocket has to withstand pressure. The ideal pressure is about 120 psi.[1] Test the rocket to make sure it can withstand the psi. Sometimes the bottle itself takes too much pressure and you need a new plastic bottle.The rocket has to also be strong but rigid, it has to withstand force too. Ground can cause damage. The rocket needs to be able to withstand a significant acceleration but also an impact.[1]

Hot glue can hold the bottle and pieces together. Sanding the hot glue down at the end is more efficient for the rocket. Be careful not to melt the plastic bottle with the hot glue.

Duct tape might be helpful but it causes a lot of drag on the rocket. Keep wind in mind while building the rocket at all times.[5]

Be careful combining bottles, there can be a leak or a tear in the rocket that will blow it up. If you decide to have a multi-chamber rocket you need to make sure you have a good seal. [4]

<u>Work cited:</u>

[2] Hammerhead

[4] Jefferson Starship Bravo

[1] Northup,Graham: *General Guidelines for Bottle Rocketry*

[3] N.p., n.d. Web. 5 Dec. 2016.

[5] Siren

Testing and Development

Mission #5: 2016-September, 30

Mission #5: Preparation:

Today, we were testing the quality of the cone and the mass of the rocket. We had one whole 2 liter soda bottle as the base. We used a second 2 liter bottle as the cone. We cut it in half, then cut off the neck of the bottle with the threads just enough to form a hole where a golf ball peaks out. We left the bottle cut in half, we did not trim it until the end. We sanded the golf ball and glued it in place of the hole. Then we surrounded it with clay to help keep the ball in place and even out the weight. We surrounded the golf ball with more clay, but make sure there is not an air hole between the plastic hole and the golf ball. Make sure the golf ball is tight to the plastic. Then we surrounded the golf ball and clay with three evenly spaced ping pongs. Then we placed clay around the ping pongs to evenly distribute the weight. The cone had a mass of 358.1 grams. We cut off the extra unneeded length of the plastic bottle piece of the cone, to allow the cone to seal on the base of the rocket. We cut enough plastic of the cone off so the ping pong balls touched the bottom of the soda bottle. The seal of the two bottles was tight. But we sealed it even more with some duct tape. We put duct tape around the cone, around the clay to support it. Then we put some more glue around the plastic and golf ball. The total mass of the rocket is 408.1 grams.

Figure #1: Sketch of Rocket

Mission #5: 2016-September, 30

Mission#5: Results:

Hannah dropped the rocket in the hallway before leaving to go launch the rocket, so the golf ball was not sturdy in it's place. The rocket launched once, with a good spin, it shot out good. But the second launch, the base of the bottle blew up. Was it the launcher's fault or was it a weak bottle? The ping pong balls blew up with the base of the rocket, causing the seal of the rocket to be weak. We used one liter of water for both launches.

Figure #2: Rocket Blew up

Figure # 3: Results of Launch

Rocket:	Psi:	Distance: (yards)

Madhans	**100**	**26**
Madhans	**118**	**22, blew up**

Mission #5: 2016-September, 30

Mission#5:Recommendations:

Wings are needed to get the distance that the rocket needs. We need a stronger base bottle to withstand pressure. No ping pong balls, they blow up with pressure and break the seal of the cone and base. Allow the golf ball to be glued and dry completely before adding clay. Let the clay dry before connecting the base and the cone. The plan for the next launch day is to divide and conquer. I will be improving the cone and Hannah will be making the wings, instead of doing the whole rocket together. For the cone, I plan on placing the golf ball in the place and allowing it to glue. Then, surround clay around the border of the cone. Allow the clay to harden to have a sturdy cone. For the wings, we will have to measure the bottle to determine the length of the wings.

Mission #6: 2016-October, 04

Mission#6: Preparation:

Today, we tested the overall rocket design for this launch. The wings especially, because they should improve the rocket extremely. For the cone, we cut a two liter soda bottle in half. Where the nozzle of the bottle is located. We cut the threads off, and a little extra off so the golf ball peeks out but is sturdy in place. We put the ball in place and glued it then let it dry all the way. After it dried all the way, we put glue on the border of the ball and bottle to create extra sturdiness. Then we surrounded the golf ball with a small border of clay. We used a whole soda bottle as the base. The three wings are made out of a plastic planter. We super glued the wings in place, then secured them with duct tape.

Figure #4: Measurements for Wings

Diameter of bottle:	**14”**
Wings:	**4.6”**
Distance: Wings to nozzle	**4”**

Figure #5: Sketch of rocket

Mission #6: 2016-October, 04

Mission #6: Results:

The rocket had a mass of 274.9 grams. There wasn't a lot on wind this day. Wings made a dramatic change in our rocket. The nose cone got dented, but the wings were very sturdy. Was the weight in the cone not evenly distributed? We used one liter of water.

Figure #6: Prelaunch

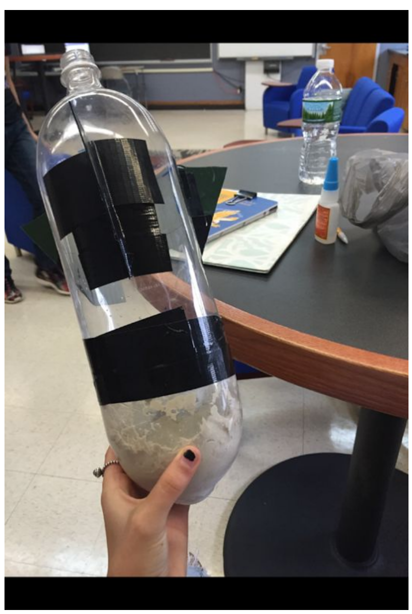


Figure #7: Results of Launch

Rocket:	PSI:	Distance(yards):
Madhans	**110**	**144**

Mission #6: 2016-October, 04

Mission #6: Recommendations:

We kept the same general design. Make sure weight is more evenly distributed. Maybe try less weight. Make wings a little more sturdier and push them forward to the nozzle more to have better effect. Change up the pressure. Test and experiment more.

Mission #7: 2016- October, 6

Mission #7: Preparation:

Today we used the same base bottle. But we decided to fix the nose cone again, we used less weight. The rocket had a mass of 174.6 grams. We made sure to evenly distribute the weight,. The rocket was shorter because the nose cone was smaller and touched the base bottle more.

Mission#7: Results:

There was a little bit of wind today. For launch 1 and 2 we used 1 liter of water. Launch 1 went to the right of the goal post. We had a very good launch with the choice of low pressure. After the launch there was an indent in the cone. Launch 2, we lost a lot of water. We used a higher angle and a higher pressure. There was a bad spin but luckily no damage to the rocket.

Figure#8: Results of Launch

Launch:	**Distance:(yards)**	**PSI:**	**Launch angle**
1	**210**	**95**	**32**
2	**156**	**105**	**41**

Figure#9: Flight of the rocket

Mission #7: 2016-October, 6

Mission#7:Recommendations:

Move wings farther back, and make the wings sturdier. Stay with the design of a light rocket. Continue testing angles and pressures. Design a new nose cone. Have no space between base bottle and cone, for a better impact.

Mission#8: 2016- October,13

Mission#8: Preparation:

We decided to use a new cone. We used the end of the soda bottle. We cut out the center, and glued the golf ball in place. We used hot glue to fill in the space between the bottle and ball. Then we put a little bit of clay in, evenly distributed. The extra length of the cone was cut so the golf ball touched the main bottle. Then the same previous sized fins, we're placed on the rocket. Hannah cut slits into the base bottle and then super glued them in place and ducted taped them to create sturdier fins. We are testing the whole overall rocket. Will the new cone allow the rocket to go further? Will the fins work better? Will the rocket fly further?

Figure#10 and #11: Photos of rocket

Mission#8: 2016- October,13

Mission#8: Results:

Since we made a risky chance and cut slits into the base bottle that holds the one liter of water. We needed to make sure the slits were sealed all of the way. The slits were not sealed all the way. Creating a huge leakage of water. Allowing the rocket to not launch.

Figure#12: Results of launch

Launch	Distance(yards)	PSI	Launch Angle
1	---------------	--------------	----------------
2	----------------	----------------	----------------

Mission#8: Recommendations:

Do not cut your base bottle. Steal and use a political sign for the wings. Sturdier wings= sturdier materials. Stay with light rocket and a low pressure. Go back to original idea with cone. Other cone design probably wouldn't be aerodynamic.

Mission #9: 2016- October, 19

Mission#9:Preparation:

We went back to our original cone idea, where we cut the threads off and placed the golf ball in the hole and let the ball dry in place. We cut the cone so the golf ball touches the bottom of the base bottle. We used hot glue and super glue to make sure the golf ball was sturdy in place. We put a little bit of clay around the golf ball again. We let that dry and then we assembled the whole rocket. The cone was a little too small. So we used duct tape to make up for the missing space. The rocket had a mass of 143.8 grams. For the wings, we made them out of a political sign, 4.6 inches apart. We attached the wings with superglue and duct tape for some extra support.

Mission #9: Results:

Today was a little windy. Overall, we had some technical difficulties with the launcher because we were trying the new aluminum rod, the seal was too strong and water was leaking out. We needed to find a new O ring. For all launches we used 1 liter of water. Launch 1 went extremely high. Launch 2 flew wobbly, but also very high. Launch 3 flew gracefully but had a very long hang time.

Figure #13: Results of Launches

Launch	Distance (yards)	PSI	Launch angle
1	154	110	41.1
2	146	130	41.1
3	123	90	42

Mission #9: 2016- October, 19

Figure#14: Image of rocket

Mission#9: Recommendations:

Make a longer nose cone. Try the launch angle 32 and the pressure of 95.

Mission#10: 2016- October, 25

Mission#10: Preparation:

We decided that we will make a whole new nose cone, so we made a longer one! Exactly the same as the last but longer. We wanted to pop out the base bottle with pressure before attaching the nose cone, just for more accuracy. So we needed to bring duct tape down to the field with us. We keep the base bottle and wings exactly the same. The rocket had a mass of 149 grams.

Mission #10: Results:

Today, Hannah and I, both had to leave to go to WAC for cross country. So lucky our classmates wrote down our distances but we didn't get to see how the rocket flew and what was wrong. But, for each launch we used one liter of water.

Figure#15: Results of launch:

Launch	Distance(yards)	PSI	Launch Angle
1	192	115	40
2	162	110	40

Mission#10: Recommendations:

Launch the same rocket, next launch day so we can see the results of the launches to see what we need to improve.

Mission#11: 2016- October, 27

Mission#11: Preparation:

We used the exact same rocket as the last launch day to test it and see and results.

Mission#11: Results:

It was snowing and windy this day. We went inside early this launch day due to the weather. But we used one liter of water for our launches and we know we need to build a better rocket. Did the cold weather interfere with the launches?

Figure#16: Results of launch:

Launch:	Distance(yards):	PSI	Launch Angle
1	134	100	40
2	174	135	40

Mission#11: Recommendations:

Use the same rocket as last time. To test water levels. Use it as a test dummy to test different levels of water amounts. Will different water levels affect the distance of the rocket?

Mission#12: 2016- October, 31

Mission#12: Preparation:

We used the same rocket as before. We are using this launch day as a test day to test change of water levels and pressure. Will different water pressure affect how well or far the rocket flies? Also higher and change the angle. Test day.

Mission#12: Results:

Today's launch day was little windy. Launch 1 we used half liter of water. When the rocket landed the cone got busted again. Launch 2, we used one fourth liter of water. Launch 3 we used one third liter of water. Launch 4 we used one liter of water, good spin but went to the left. All launches flew very high.

Figure#17:Results:

Launch :	Distance:(yards):	PSI	Launch Angle
1	**198**	**135**	**45**
2	**193**	**135**	**45**
3	**127**	**135**	**55**
4	**130**	**135**	**47**

Mission#12: 2016- October, 31

Mission #12: Recommendation:

Make a new rocket, use a bouncy ball instead of the golf ball. See if that takes a better impact than the golf ball. Continue with a light weight rocket .

Mission#13: 2016-November, 2

Mission#13:Preparation:

For this launch day, we cut one bottle in half. We cut off the threads. We had to cut off more than before so the bouncy ball could peak out because it was bigger than the golf ball. We hot glued the bouncy ball in place. The bouncy ball has to be evenly glued in the middle of the cone so the weight is evenly distributed. We cut off the length of the cone, which had to be longer before since the bouncy ball is bigger than the golf ball. The bouncy ball touched the base of the main bottle and we duct taped the two bottles. We used the same wings as before, we attached the wings with a little bit of duct tape as well. The rocket had a total mass of 148 grams. We renamed our rocket MEH,(Maddy, Emily, Hannah), because Emily joined our group, so we wanted to include her in the name.

Mission#13: Results:

It was windy today. Launch 1, we used half of liter of water, the rocket had a very good spin and went very high. No damage to nose cone. Launch 2 we used one third liter of wing, the rocket flew off the launcher. There was damage done to the base bottle's threads. Launch 3 we used half of liter of water, the rocket had a good spin. Launch 4, we used one liter of water there was also a good spin on this launch.

Mission#13: 2016-November, 2

Figure#17: Results of launch

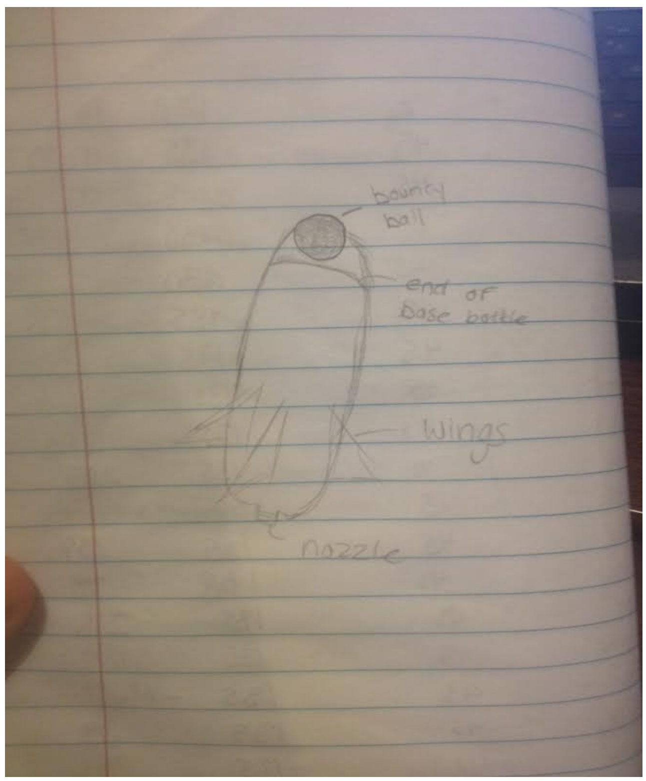
Launch:	Distance:(yards):	PSI:	Launch angle:
1	178	135	45
2	----------------------	135	45

3	**199**	**135**	**45**
4	**197**	**135**	**45**

Mission#13: Recommendations:

The bouncy ball can handle the hard impact better. Continue using the bouncy ball. We need a new base bottle so scenario in launch 2 doesn't happen again.

Figure#18: Sketch of Rocket:



Mission#14: 2016-November, 4

Mission#14: Preparation:

We kept everything the same from the previous launch, but replaced our base bottle with a new bottle.

Mission#14: Results:

I was gone due to Sectionals. But I know the results of the launch day.

Figure#19: Results:

Launch:	Distance:(yards):	PSI:
1	115	135
2	130	135
3	99	135

Mission#14: Recommendations:

Keep the same design and decorate the rocket for Rocket day. Write our name on the rocket.

Rocket Day Conclusion

I’ve learned many important lessons during the testing and development process. Wings are needed to get the rocket to shoot far. Don’t waste a test day without wings on your rocket. Do not cut slits into the base bottle. The base bottle holds the water and is influenced by air pressure. Cutting slits into the base bottle, creates nothing but leakage of water. Have a sturdy base bottle.

Weak plastic 2 liter bottles wouldn't be able to withstand the pressure. Ping pong balls are a bad idea, they blow up with pressure. Then, break the seal of the cone and base bottle. If you use clay for the weight. Allow the clay to dry all the way. Test and experiment new things. I should've tried the bouncy ball way sooner than the last test day. Experimenting is the way to go, to discover what works and what doesn't for your rocket. Last lesson I learned was, know when launch days are and know what the weather is like. If it's raining you might still go out if the class votes yes. One launch day could be hot and sunny, the next can be cold and snowy.

For the final design. We stuck with our basic design idea. We used one whole soda bottle as the base. We cut another bottle in half to make the cone, by cutting off the threads of the bottle. Just enough so the bouncy ball peaks out. We hot glued the bouncy ball in place. After, we made sure the bouncy ball was sturdy and wasn't going anywhere, we attached the cone to the base bottle with duct tape. We attached the fins that we made out of the political sign with duct tape. Then, we used a metallic duct tape to decorate the rocket. Lastly, we wrote 'MEH' on the rocket.

Figure#20 and #21: Photos of Rocket on Rocket Day:

Launch Team

My role as part of the launch team was recording the data. I had many responsibilities. I had to organize the process on the launch during the launch days. I had to make sure I knew what every launch team wanted such as psi and angle. The fact, I knew what everyone wanted from asking them, while setting up or walking down, allowed more launches. I was responsible for making a 'launch order', that never stayed the same because damage to the rockets. I made sure that every rocket that could fly, had the same amount of the launches. So that way, no one had more results than other groups. I recorded every group's psi, launch angle and distance. Recording the distances was hard when there were multiple rockets launched and Max, Emily and Hannah were recording the distances. I got a bunch of numbers at once, but I was able to multitask and stay organized. My final responsibility, was to give everyone their results. I made up a document with everyone results and passed it around one day so everyone could take a picture of it or record their results.