Fly Rocket Fly: Rocket Lab Report

Rocket: Black Hawk & Velocity Nine

Submitted:

Black Hawk Max. Launch Distance: 257 yd.

Velocity Nine Max. Launch Distance: 244 yd.

Purpose

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Using bottles that total at least two liters in capacity, design, build, and test a rocket that will fly as far as possible. This rocket must be durable, aerodynamic, well balanced, and must have the nozzle of a two liter bottle so that it will fit the launcher. The rocket should, most likely include fins that are large enough to keep the rocket stable, but not too large as to cause unnecessary drag and a weighted nose cone that is in balance with the weight of the amount of water that will be used.

Literature Review

Fins:

The combination of fins and body shape of your rocket are what determine its stability, as it is flying. If the fins of a rocket do not provide sufficient stability, the rocket will roll in the air, have more drag, and not go very far at all. Long, thin rockets are easier to stabilize than rockets that are short and fat. In other words, as rocket length increases, fin size can decrease. The further back fins are on a rocket, the smaller they can potentially be, decreasing drag and increasing aerodynamics. One way to move fins further back on a rocket would be to attach the fins to a ring that can extend beyond the body of the bottle. Another way to do this would be to have elongated fins that extend beyond the body of the bottle. Furthermore, it seems that the rockets whose fins were the most stable, went the furthest.

Nose Cones:

A nose cone on a rocket exists in order to minimise drag. For our purposes, a rounded nose cone will provide the least amount of drag. Anything going faster than the speed of sound, however, would improve with a sharper point for a nose cone. This is most likely irrelevant in bottle rocketry. The most efficient nose cone shape is the Von Karman ogive. However, achieving a perfect Von Karman ogive will not give your rocket a significant competitive edge, compared to other improvements that would be easier to make.

Securing Pieces to the Bottle:

Various pieces need to be attached to the body of the rocket in order to complete it. There are a number of different ways to attach both nose cones and fins to the bottles. Fins need to be attached to the body of the bottle as securely as possible. The best way to do this is to use glue that is as strong as possible. The more stable a specific glue is, the more stable your fins will be.

Furthermore, strong tape can be used to reinforce or angle fins, so that they are perfectly perpendicular to the body of the rocket. There are different ways to attach nose cones, depending on your goals for your rocket. If you want a ballasted nose cone, such that the weight can be changed, you may want something easily removable. An example of this could simply be duct tape, because it is strong, yet easily removable. However, if your goal is to keep a nose cone stable on a bottle, you may want to use something similar to what you used to affix your fins to the bottle.

Ideal Mass:

The ideal mass of a rocket will be different, depending on the style of a specific rocket. A smaller design's ideal mass would be significantly lighter than a rocket made from three two liter bottles spliced together. If a rocket is too light, air resistance will be too significant and the rocket will spiral and plummet. If a rocket is too heavy gravity will pull it down much more quickly. Finding an ideal mass for a specific rocket is best achieved through trial and error. A good way to do this is to have a ballasted nose cone. This means that weight, in the form of sand or clay for example, can be added to or removed from the nose cone easily. When testing out different weights, all other variables should be kept the same. However, keeping all variables the same through every launch can be difficult in the field due to varying wind speeds and possible damage to the rocket from launch to launch.

Bottle Splicing:

Bottle splicing is an effective way to achieve a larger bottle. One may want to splice two bottles together because more room means more zoom. Or in other words, having a larger capacity means that more water and air can fit in the bottle, meaning more fuel will be available to propel the rocket. Another reason one may want to splice bottles together would be to decrease the diameter of the rocket. If multiple smaller diameter bottles are spliced together to total the capacity of a normal two liter rocket, the body will be thinner, thus decreasing drag. Splicing bottles can be a difficult endeavor, because spliced bottles are far more likely to fail under high pressures due to an added weak point. For this reason it is very important to ensure that the splice between the two bottles is stronger or equally as strong as the rest of the bottle. There are a number of different methods to achieve this. Ultimately, the two bottles will probably have to be glued together. This glue needs to be very strong. An example of a glue that is strong enough is PL Premium glue. This glue is incredibly strong and will not fail until around 240 psi, which is much higher than the plastic bottle itself. However, this glue is also porous, so it may need to be used in conjunction with a sealant of some sort. The bottles will need to be glued together with a liberal amount of glue. Also, the two bottle will likely be the same size, so if they are forced together creases will be made. An effective way around this problem would be to shrink one of the bottle in hot water, so that they fit together seamlessly[1].

General Lessons Learned:

Making a flawless bottle rocket can be more difficult than it seems at first. The data available on how to build a water bottle rocket the best way is relatively inconclusive. However, the more research that is done prior to building your rocket: the better. Attempt to compile as much data from as many different sources as possible and build your rocket the best way you think you can. If it's not perfect right off the bat, don't sweat it. That is what the coming weeks are for. Also, the most commonly made mistake is not having fins that are the correct size or stability. Spend a good amount of time researching fins until you have something that you are confident will work. Furthermore, strong glues can be difficult to work with. It is important to wear gloves at all times while using a strong glue. Finally, take good notes during every step of the process. It would suck to get to the point where you have to write a rocket report and you don’t have all of the necessary information.

Testing and Development

Mission #1: 2016- September, 30.

Mission #1: Preparation

In order to prepare for the first launch a rocket needed to be created. It was determined that two separate multi tank rockets would be created. The body of the first rocket, was made of two 2-liter bottle. This rocket is Black Hawk. The second rocket, Velocity Nine, was made out of 4 1-liter bottles. The same process was used to create both Black Hawk and Velocity Nine at the same period of time, however, Velocity Nine did not get finished until a much later date due to complications in connecting the two separate bodies of two 1-liter spliced tanks. In order to create the rockets the bottles were first stripped of all labels. Then, glue residue was removed with acetone. Next, all bottles were cleaned thoroughly with soap and hot water to remove any debris which would allow glue to adhere to the bottles effectively. Then, two 2-liter bottles, and four 1-liter bottles were all cut along an existing line on the bottom of the bottles. The line in question can be found in Figure 1. The next step to splicing the bottles to form a solid body is to ensure that one bottle fits snugly inside of the other bottle. In order to do this, one of the bottles for each tank, or two 1-liter bottles and one 2-liter bottles was submerged, bottom side down, in 3 cm of 72C water for about 20 seconds each bottle. Then, in order to create a smoother edge on the bottom of the melted bottles, they were placed onto a hot pan, so that the edges would curl in slightly. Then, the outside of the shrunken bottle was sanded, and the inside of the regular bottle was sanded, about two centimeters up from the bottom edge on each. This made the surface rough, so that the glue would adhere better to the bottle. Next, a generous

Figure: 1

amount of PL Premium glue was applied to the outside of the shrunken bottle. The bottles were then fitted together, ensuring that the bodies would be as straight as possible. The three separate body assemblies were then left to dry overnight. This is as far along as the rocket building got. As a result, it was decided that a test bottle would be launched in order to gather some data for the first launch day. The test bottle was simply launched as a control in order to determine how much proper weight and fins help a bottle. In order to prepare the test bottle, all contents were removed from the bottle, and the label was removed.

Mission #1: Results

The control rocket was only launched once. The launch of the rocket was very erratic. Once airborne, the rocket simply did a loop into the air, then spiraled to the ground

Angle	Pressure	Water	Distance
45 Degrees	110 Psi	1 Liter	22 Yards

Figure 2

Mission #1: Recommendations

The bottle blank performed as expected. It achieved a very poor distance, due to a lack of stability and proper weight. For the next launch, Black Hawk and Velocity Nine should be finished. Adding weight to the nose of these rockets and fins toward the tail-end would be beneficial.

Mission #2 : 2016- October, 4.

Mission #2: Preparation

After the glue was dried on the rockets, in order to add additional stability to the seams, another layer of PET plastic was added overtop of the seams. Three separate 5 cm wide sleeves were cut to go over the seams of the splices. The seems of the splices and the inside of the sleeves were both sanded. Then, another layer of PL Premium glue was applied to the sleeve, and it was placed on the bottle over the seem. This was left to dry overnight. Due to the fact that the sleeve is the diameter of the bottle, once the glue was added, there was a significant gap that the sleeve didn't cover. In order to rectify this a 5 cm x 5 cm patch was cut to cover this spot in the seam. Both the inside of the sleeve and the uncovered area of the bottle were sanded. Then, another layer of PL Premium glue was added to the patch and the patch was placed on the bottle. This was then left to dry one last time. This step in the process can be seen in Figure 3. After the patch was done drying, in order to add extra structural integrity to the whole bottle, so that it could stand up to a lot of pressure, a bottle sheath was added over each end of the rocket bodies. This was done by first cutting the bottom and nozzles off of two 2-liter bottles, and four 1-liter bottles. Three equidistant slits were cut up the sides of each bottle sheath to allow the sheaths to fit over the bottles. The sheaths were slid over the ends of the bottle and were secured in place by wrapping the entire body of each rocket in glass-strapping tape. Theoretically, these rockets should be able to stand up to 180 psi. Next, fins were cut from tapered cedar. The tapered cedar would theoretically decrease drag due to the

Figure 3

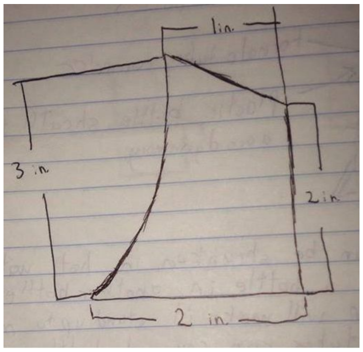

Figure 4

thin leading edge, while maintaining stability. The dimensions for the fins can be found in figure 4. Finally,the bottoms and nozzles of a 1-liter bottle and a 2-liter bottle were cut off to form nose cones. Three equidistant slits were cut up the sides of the nose cones, so that they would fit over the bodies of the rockets. Next, a bouncy ball and clay were added to the ends of the nose cones in order to form a parabola, and put more weight at the nose of the rockets. Finally, the nose cones were taped onto the body of the rockets using duct tape. The two separate bodies of Velocity Nine were not connected before the first launch.

Mission #2: Results

As Black Hawk left the launcher, it turned upward. As the rocket reached the peak of it's flight, it began to spiral out of control, bringing it back down very quickly.

Angle	Pressure	Water	Distance
45 Degrees	120 Psi	1.2 Liter	85 Yards

Figure 5

Mission #2: Recommendations

Due to the uncontrolled spiralling of the rocket, it can be concluded that the fins were not big enough to hold the rocket stable. Also, the fins of the rocket broke in half or broke off of the rocket. In order to rectify this, larger, more sturdy fins need to be created for Black Hawk. In order to get Velocity Nine able to launch, a connector piece needs to be made.

Mission #3 : 2016- October, 6.

Mission #3: Preparation

A connector piece was created in order to connect the two separate tanks of Velocity Nine. This was done by taking two caps to the bottles, holding them over a flame to melt the tops and pressing them together. This formed what seemed to be a weak seal between the two caps. In order to strengthen the seal, the outside of the cap assembly was covered in PL Premium glue and a layer a PET plastic. This was left in a clamp to dry overnight. The next day a ½ in. diameter hole was drilled through the center of the assembly in order to allow water and air to pass between the tanks. This connector was screwed onto both of the bottles. Next, a sheath that was cut from a 1-liter bottle was wrapped around the space between the two bottles, in order to increase aerodynamics. Also, larger fins were cut out of vinyl house siding for both of the rockets. The fin's design can be found in figure 6. The fins for Velocity Nine protruded from the rocket body less, because longer rockets can stay stable with smaller fins. The launch will test different launch angles.

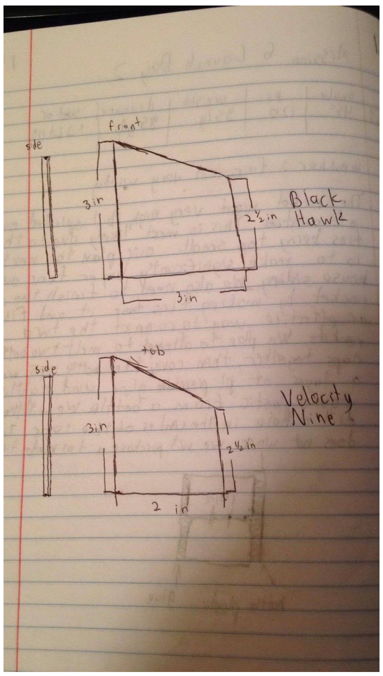

Figure 6

Mission #3: Results

When Velocity Nine was filled with water, it became apparent that the connector piece was very leaky and would not work. For this reason, it was not launched. Black Hawk had two very successful launches at different angles. However, the flight path was erradic. It is believed that this is due to the fins not being perfectly perpendicular.

Launch #	Angle	Pressure	Water	Distance
Launch #1	32 Degrees	135 psi	1 Liter	205 yds.
Launch #2	41 Degrees	135 psi	1 Liter	238 yds.

Figure 7

Mission #3: Recommendations

A tornado tube should be purchased in order to connect the tanks of Velocity Nine so that it will be launchable. Also, closer to 45 degrees seems to be the best launch angle. Also, the larger fins made a huge difference on the flight of the rocket. Having fins that are large enough to keep the rocket stable seems to be the most important step to having a rocket that flies well. Also, for the next launch, the fin angle should be fixed.

Mission #4 : 2016- October, 13.

Missions #4: Preparation

In order to rectify the fin angle, the fins were removed, and reattached using gorilla tape and PL Premium glue. Also, a protractor was used in order ensure a perfect fin angle. The tornado tube for Velocity Nine was purchased, but it had not arrived. Different amounts of weight will be tested on this day. The starting weight of the rocket, in previous launches, was 351.2 grams. The first launch of the rocket will be at 374.2 grams.

Mission #4: Results

Angle	Pressure	Water	Distance
45 Degrees	140 Psi	1 Liter	247 Yards

Figure 8

Mission #4: Reccomendations

The rocket, upon impact with the ground, was damaged very badly. This is the reason there was only one launch. The entire bottle was indented, and the nose cone was irrepairably damaged. In order to continue launching, a new nose cone needs to be created. This clay in the nose cone should be spread out more evenly for the next nose cone, in order to create a more even buffer and add structural integrity to the plastic of the bottle.

Mission #5 : 2016- October, 19.

Missions #5: Preparation

No changed were made to the physical body of the rocket, besides the replaced nose cone. The mass was kept the same, using the same amount of clay. The primary difference that will be tested today will be different water levels.

Mission #5: Results

Launch #	Angle	Pressure	Water	Distance
Launch #1	41 Degrees	140 psi	2 Liters	202 yards
Launch #2	41 Degrees	140 psi	1.625 liters	

Figure 9

Mission #5: Reccomendations

The increased amount of water made the rocket too heavy, bringing it to the ground more quickly. Also, the second launch did not yield the results that it should have, due to damages sustained in the first launch. The bouncy ball got knocked out of the nose cone, so that it was free to move within it. This created a large hole in the nose of the rocket and uneven weight distribution. Also, some damage was sustained to the actual body of the rocket

Mission #6 : 2016- October, 25.

Missions #6: Preparation

The tornado tube finally arrived and was used to connect the two rocket tanks of Velocity Nine. Also, the nose cone of Black Hawk was replaced once again. The mass of Black Hawk was decreased to 364.8 grams. Today will primarily be used to try to get the best launch possible for Black Hawk and to simply launch Velocity Nine.

Mission #6: Results

Angle	Pressure	Water	Distance
40 Degrees	Max Psi	1.6 Liters	257 Yards

Figure 10 (Black Hawk)

Angle	Pressure	Water	Distance
40 Degrees	130 Psi	1 Liter	107 Yards

Figure 11 (Velocity 9)

Mission #6: Reccomendations

Black Hawk flew very well today. The decreased mass may have contributed to the success of the launch. Also, there was some leakage in the tornado tube of Velocity Nine. Silicon sealant and plumber's tape can be used to fix this. Also, the rocket's launch was poorer than expected. It seemed that the rocket was too top heavy and was brought to the ground too quickly. In order to fix this, the launch angle should be increased, and all water should remain at the tail of the rocket.

Mission #7 : 2016- October, 27.

Missions #7: Preparation

Two new nose cones were created for Black Hawk, so that they could be readily replaced. Black Hawk will not be launched today, because Velocity Nine needs more testing. For the first launch of Velocity Nine, one liter of water will be centered in the top of the rocket. The thinking behind this is that due to the ½ in diameter hole between the bottles, the water will evacuate the rocket less rapidly, extending the length of the flight. The second launch will center all of the water at the tail of the rocket.

Mission #7: Results

Launch #	Angle	Pressure	Water	Distance
Launch #1	40 degrees	135 psi	1 Liter	0 yards
Launch #2	40 Degrees	135 psi	1 Liter	128 yards

Figure 12

Mission #7: Reccomendations

The first launch of Velocity Nine did not even come off of the launcher. The weight of the water in the end of the rocket created a lever action, applying friction to the inside of the launcher. This friction held the rocket on the launcher. The second launch performed slightly better, but has a lot of potential to improve. Also, in order to prevent future damage to the body, a significant buffer zone will be added between the body and the end of the nose cone. This will allow the nose cone to sustain most of the damages and prevent the body from being irrepairably damaged. It is much easier to replace each nose cone, instead of the body of the rocket.

Mission #8 : 2016- October, 31.

Missions #8: Preparation

In order to prepare for the next launch, nose cones were replaced on both rockets, with the buffer zone included. Also, the weight of Black Hawk and Velocity Nine were both slightly decreased. The primary source of testing for the day will be the weights of the rockets and the water levels for Velocity Nine.

Mission #8: Results

Launch #	Angle	Pressure	Water	Distance
Launch #1 Black Hawk	45 degrees	135 psi	1.6 Liter	219 yards
Launch #2 Black Hawk	45 Degrees	135 psi	1.6 Liter	196 yards
Launch #1 Velocity Nine	45 degrees	135 psi	1.5 Liter	244 yards
Launch #2 Velocity Nine	45 Degrees	135 psi	1.7 Liter	186 yards

Figure 13

Mission #8: Reccomendations

The first launch of Black Hawk wasn't great. It is believed that this is because of the added buffer zone. Also, the body of the bottle was damaged during this launch, indicating that the buffer zone did nothing in terms of protecting the body of the rocket. Also, the increased water and increased angle benefited Velocity Nine's launch greatly. This was the best launch yet for the rocket. The second launch wasn’t as far due to damages from the first launch. The buffer zone should be removed from

Mission #9 : 2016- November, 2.

Missions #9: Preparation

New nose cones were created for both rockets. Today will primarily test weight. It is believed that both rockets are too heavy. About 30 grams was removed from each rocket in the form of glass-strapping tape.

Mission #9: Results

Launch #	Angle	Pressure	Water	Distance
Launch #1 Black Hawk	45 degrees	135 psi	1.6 Liter	218 yards
Launch #2 Black Hawk	45 Degrees	135 psi	1.6 Liter	220 yards
Launch #1 Velocity Nine	45 degrees	135 psi	1.5 Liter	207 yards
Launch #2 Velocity Nine	45 Degrees	135 psi	1.5 Liter	160 yards

Figure 13

Mission #9: Reccomendations

All of the launches did relatively poorly on this day. The decrease in weight theoretically should not have been enough to make this much of a difference in the launch distances. It can be concluded that weather on this day may have had a negative effect on the launches. For the next launch day, a new nose cone will have to be created for Black Hawk.

Mission #10 : 2016- November, 4.

Missions #10: Preparation

The intent of this mission was to ensure that the rockets would have distances similar to their previous launches. This would reinforce the idea that the last launches were poor due to weather. Also, ensuring that the rockets were in good working condition for rocket day is important. The rockets will also be launched at a slightly lower pressure in order to prevent damage from being done to the body immediately prior to rocket day.

Mission #8: Results

Launch #	Angle	Pressure	Water	Distance
Launch #1 Black Hawk	45 degrees	110 psi	1.6 Liter	211 yards
Launch #1 Velocity Nine	45 degrees	110 psi	1.5 Liter	187 yards

Figure 13

Mission #10: Reccomendations

The rockets did relatively well, considering the lowered psi. These results should indicate that the rockets will do well on rocket day. In order to prepare the rockets for rocket day, the nose cones should be replaced and both rockets need to be painted, so that they are aesthetically pleasing.

Rocket Day Conclusion

Lessons Learned

The absolute most important step to having a successful launch is preparation and planning. Deciding which variables to test on which days ahead of time is imperative to success. Also, changing one variable at a time is important. Stick to the scientific method in order to have scientific findings, rather than guesstimates. In general, if more than one variable is changed at a time, it will be hard to determine which variable had what impact. Finally, be willing to try things differently. Do not be determined to stick with your original plan. Be adaptable and willing to completely redesign the rocket.

Final Design

The final design of the Black Hawk and Velocity Nine were very similar to how they were first created, as is outlined throughout the report. The only differences were fins, weight, and nose cone position. The fins were made of vinyl, instead of tapered cedar. They were also larger and a different shape. Dimensions of the fins can be found in figure 6. The weight was slightly decreased compared to what is was initially on both rockets. Black Hawk started at around 360 grams and ended at around 330 grams. Velocoty Nine started at 410 grams and ended at around 370 grams. Also, the nose cone sat flush with the vbody in the final design, whereas there was a small space between the body and the end of the nose cone in the initial design.

Advice

The most effectual piece of advice that I wish I had known when designing the rockets was that the air compressor only goes up to 140 psi. We designed our rocket so that it would stand up to the most psi possible, however, this proved to be pointless. Also, do as much research as possible. Actually read through previous rocket reports, don’t just look at the graphs. Furthermore, dress for the weather. It may snow on some days. It is not fun to be launching rockets in the snow in a thin jacket and frozen sneakers. Finally, never drink orange juice after brushing your teeth. That has nothing to do with rockets, but trust me.

Citations

Command, Air. "Water Rocket Bottle Splicing." *Instructables.com*. N.p., 25 Feb. 2011. Web. 26 Sept. 2016.

Launch Team

On the launch team I was primarily the pin-puller. As such, I had to pull the pin from the launcher at the right time, in order to send the rocket. This job is important, because if the pin is not pulled right, a launch may fail and it may be your fault. You are responsible for ensuring that every rocket is launched to the best of the rocket's ability. Also, as the pin puller, you are always close to the launcher. Therefore, it also becomes your duty to help set up the rockets on the launcher. This includes adjusting the angle of the launcher, placing the bottles over the launch tube without losing water, and putting the pin over the collar of each rocket. The steps of a typical rocket launch are as follows. The pin-puller and rocket-setter place the rocket over the launch tube. The pin is placed over the collar by the pin-puller. The pin-puller then signals to the pressurizer that it is okay to pressureize the bottle. Then, once the vuvuzela is sounded, the pin is pulled. The pin-puller has a lot of responsibilities, and can often be primarily responsible for how fast or slow things are going.