Fly Rocket Fly:Rocket Design Report

January 22, 2016

Abstract

Our mission was to create a rocket that would go the maximum distance without the rocket exploding. The rocket must be durable for multiple launches and survive the impact of up to 15 launches, it can't have air resistance, and it must be balanced to achieve the "maximum distance".

Question:

How do you build a rocket out of a soda bottle so that you can make it fly a maximum distance? What changes could you do to your rocket that could affect your performance and have it go the farthest distance possible?

Background:

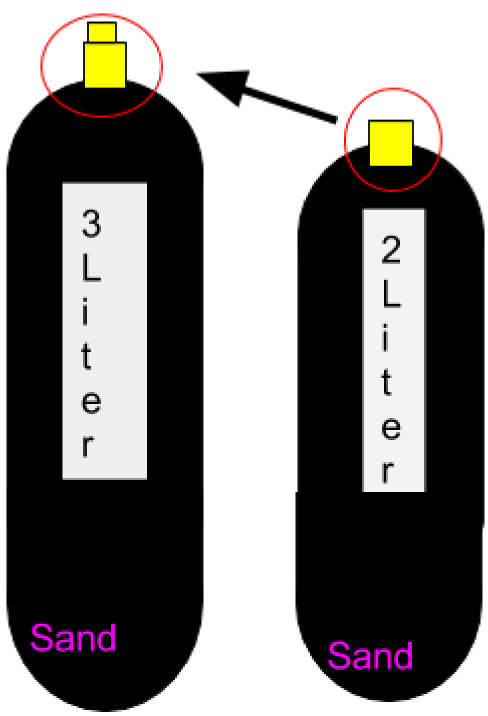
In the beginning of the rocket lab, my group wanted to test to see if a three-liter bottle would go further than a traditional two-liter bottle thinking the rocket would hold more water and more pressure resulting the rocket will go further . When we did research, we found that a former student (Brady Smith) had tried a three liter bottle but the mouthpiece of the bottle did not fit on the Sherman Launcher. With that information, a mouthpiece was cut from a two-liter bottle then spliced over the three-liter mouthpiece so it fit the launcher. After the top was put on the three liter bottle, the weight was added and the overall weight was about 588.8 grams which in the initial research of building a rocket, we did not take into consideration that there would be an ideal weight of a rocket. The last factor of our first rocket, was choosing wings and what material would work well enough to keep the rocket stable. With the research that was done we ended up using plastic binder dividers and we had three fins and spaced them out as equally as possible. When building the original rocket, we left the nose cone off and out the weight in a separate bottle then cut the bottom off that the sand was put in and then we glued it onto the three liter bottle so it could be a "chamber" for the weight.

TEST ONE:

Set Up/materials:

1. three-liter bottle
2. 16-oz bottle- only the mouthpiece
3. adhesive spray
4. hot glue
5. torch/ PB welding compound
6. heat gun
7. sand/ small rocks
8. gorilla, electrical tape
9. plastic dividers

Figure 1



Test objective: Durability of launcher nozzle

On September 22, my group tested our first rocket and looking at figure one we had decent results for the amount of research done. Our rocket that we made consisted of a three liter bottle that had a mass of approximately 599.8 grams and it did not have a nose cone or very sturdy wings. our goal on the first launch was to see if the splicing of a two liter bottle top onto a three liter soda bottle would work and be strong enough to withstand a maximum of 150 psi. Considering our rocket didn't have a nose cone on the first launch our rocket did decent and was extremely durable. Basing our results from the first rocket launch and just seeing what worked for other people, our wings needed to be a lot sturdier than just slapped on with some tape. Also another thing that needed to be added to our rocket was a nose cone to make it more aerodynamic so it can go further. the last thing that we needed to do to our rocket was talking about 400 grams of weight to make it less heavy.

Figure 2:

Test number 9/22/15	**Mass**	**Distance**	**PSI**
Test One	599.8 grams	66 yards	60 psi
Test Two	599.8 grams	67 yards	80 psi
Test Three	599.8 grams	66 yards	80 psi

Basing our objective off of our results, My group agreed that our nozzle is durable and that we can focus on "updating" our rocket to fit the ideal standards of rocketry.

Test Two:

Objective: Even the distribution of weight/ reduce weight.

On September 28th, our class had our second launch and with our updated rocket, we decided to reduce the amount of weight that was in our rocket and add a nose cone to our rocket to make it more aerodynamic.

By adding a nose cone and reducing weight of the rocket, we took out about 180 grams of weight because on the size of the rocket since it was a three liter bottle, we needed to have more weight than a typical two liter bottle. When doing research we couldn't find what weight would work the best for the three liter bottle only because many of the sites we visited said the larger bottle created air resistance and were harder to gain momentum. on our second test our rocket had a mass of about 420 grams and we also distributed the weight so some was in the middle of the rocket between the water/pressure "chamber" and the bottle that held the weight. By doing this to our rocket we had the idea that it would help keep the rocket balanced while in the air.

Basing the setup of our second rocket off of our first rocket we needed to add the nose cone. We chose to use a kitchen funnel because there was a point at the top so there would be little air friction due to flat smooth sides. Some of the research done when deciding what nose cone to use showed us that some people had better results with rounded nose cone and some had better results with a pointed nose cone so we chose a pointed cone.

Figure 3

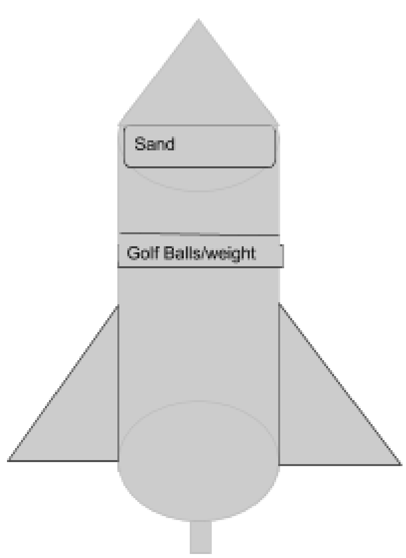


Figure 4:

Test number 11/28/15	**Mass**	**Distance**	**PSI**
Test one	420 grams	29 yards	80
Test two	420 grams	86 yards	100
Test three	420 grams	138 yards	120

After launching our rocket with the added nose cone, reduced and distributed weight, we found that our rocket did well all three times we launched it so we figured that we needed to fine tune some things and fix the wings.

TEST THREE:

Test objective: Fix the wings

Our third launch took place on October 2, 2015 and the main goal of that launch was to fix the wings and make them sturdier, straighter, better spaced out etc. The use of wings is to keep the rocketbalenced and straight. When putting on the wings they have to be evenly spaced out and ensure that the rocket goes straight. When building our first rocket we didn't pay too much attention to our wings but then when we figured out that our nozzle worked we focused on the wings. We had decided to do a triangular wing shape and we had three of them. When placing the wings on the rocket we wanted them as far back on the rocket as possible so it stabilizes the back of the rocket and keeps it straight. Since we had three wings each wing was placed evenly around the bottle with a distance of 13.3 cm apart from each other.

Figure 5

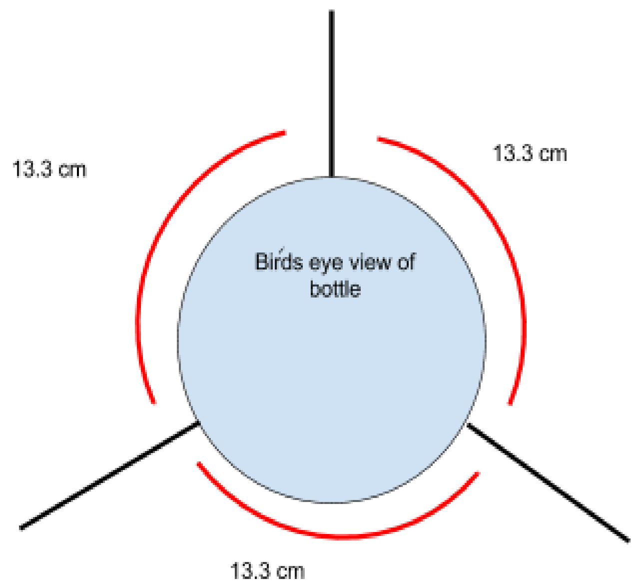


Figure 6

Test number 10/8/15	Mass	PSI	Distance
Test One	420 grams	100	108 yards
Test Two	420 grams	138	14 yards- Exploded

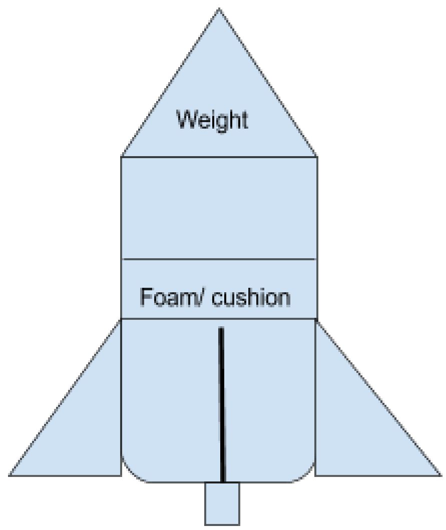
After launching our rocket with the "improvements" that we made we found that hot glueing plastic did not work and it just melted the bottle. Since the plastic was weakened, the wings were not stabilized properly and they weren't as straight as they should have been.

TEST FOUR:

Test objective: adding cushion to reduce impact.

After our previous launch, we had a lot of room for improvement and the one thing we decided to add was a cushion to the rocket to help reduce the impact on the landing. The material used for the cushion was foam from a couch cushion. We put the foam in the middle of the rocket where we had weight previously, right between where the two bottles attached. Instead of glueing the bottle that had the nose cone on it we duck taped it so it would allow the top bottle to move upon impact rather having it stuck in one place.

Figure seven:



Looking at our results by using the cushion it did work on keeping our rocket more intact on the landing and it did work because it did bounce when it hit the ground rather than getting the nose cone bent and weakened.

Figure eight:

Test number 10/8/15	**Mass**	**PSI**	**Distance**
Test one	420 grams	130	30 years

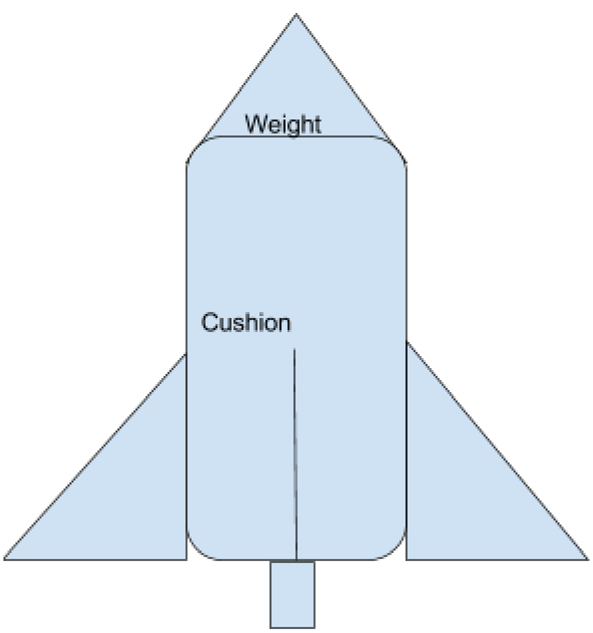
The results shown in figure eight reflect how bad our rocket did during that launch specifically. After this launch we needed to reevaluate the two liter nozzle on the three liter bottle because even when we fixed the wings our rocket still never went very straight and the past two lunches our rocket crashed both times.

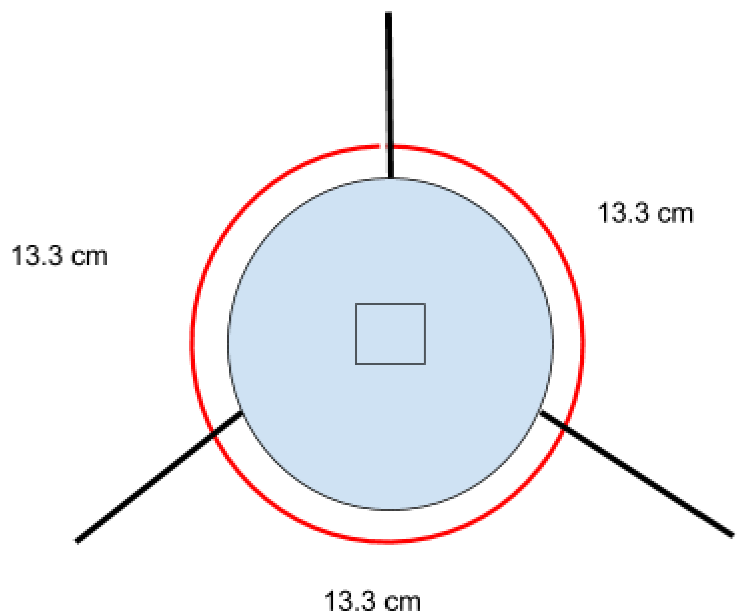
TEST FIVE

Test objective: Balance

With the results from our past few launches we found that balance was our biggest issue and that we needed to fix whatever the problem was so we looked at the wings because since the nozzle that was spliced to the three liter bottle couldn't move or be rotated. By fixing the balance we tried adjusting our wings and used a different material for our wings and we used cardboard for our wings instead of plastic thinking it would be stronger and sturdier to hold the rocket straight and keeping them located far back on the rocket. One thing we changed on our rocket is the material used for the weight and we used golf balls because it weighed the same amount but it was more compacted than dirt.

Figure nine:





Using figure nine, there weren't many changes made to our rocket because the setup didn't need many changes.

Figure ten:

Test Number 10/14/15	Mass	PSI	Distance
Test one	420 grams	138	116- Blew up

Concluding this launch, we have found that our roced still sucked and that we need serious help. With the idea from the conclusion of the launch on October 8th, the next step was to evaluate and figure out what kept making our rocket blow up every time we launched it.

TEST SIX:

Test objective: Adjusting the nozzle

On October 20, 2015 we had our sixth launch and my group needed to try re adjusting our nozzle from a two liter bottle onto a three liter bottle. We knew that it was strong enough to withstand up to 140 psi. Since we knew the nozzle worked and the bottle itself was strong and durable we tried finding a way to straighten the nozzle so when the rocket was launched, it would go straight and the wings can actually do their job instead of getting ripped off because the bottle is not launched balanced.

Another thing that was done to the nozzle was adding epoxy to the nozzle to help make a tighter seal when put on the launcher. At first when the rocket was put on the launcher, the seal was too tight and our rocket didn't fit on the launcher. After some time we were able to remove some of the epoxy and it was able to be launched. With the amount of epoxy used on the rocket it did help but the results weren't the best. Looking at figure eleven, the distance our rocket went was not good at all so we needed to once again try and fix the nozzle because at that point in our tests we knew it was the nozzle and we needed to figure out a way to fix the nozzle without having to rebuild a whole new rocket or just fail every time until rocket day.

Figure eleven:

Test number 10/20/15	**Mass**	**PSI**	**Distance**
Test one	420 grams	138	Didn't fit the launcher
Test two	420 grams	138	31 yards

After launching our rocket during this test, my group learned not to epoxy the nozzle to our rocket and if we did we needed to do a very thin layer. Also after this test the best idea seemed to be starting from scratch with a new rocket. Doing that would have been much easier and wouldn't have taken up too much time because we already knew what worked and that didn't work considering we had as many fails that we did with the three liter bottle.

TEST SEVEN: (Bloodiest day in rocket history)

Test objective: The nozzle.

After the sixth test we found that our three liter rocket wasn't the best because when the spliced nose piece was put on the bottle it wasn't on completely straight which cause the rocket to get launched unbalanced and no matter what was done with the wings they would just get messed up when the rocket was launched into the air. Knowing this made us realize that once we payed attention to the wings it was the unbalanced rocket that was making our wings fail. Shown in figure nine, our rocket setup hasn't changed in the past few launches because no matter what we did our rocket still had poor results and since it was the bloodiest day in rocket history, the launcher broke twice and more than half the rockets blew up upon impact.

Figure twelve:

Test number 10/22/15	**Mass**	**PSI**	**Distance**
Test one	420 grams	138	50 yards
Test two	420 grams	140	69 yards
Test three	420 grams	140	BLEW UP

Each time our rocket was launched on this day since my job was putting the rockets on the launcher, I tried rotating the rocket since the nozzle was stuck in place not straight so it would launch pointed slightly up along with the original forty-five degree angle that the launcher was set at. The last time the rocket was launched, it completely exploded when it hit the ground and was no longer able to be fixed. (bummer)

TEST EIGHT:

Test objective: Build a new rocket.

After the bloodiest day in rocket history, we needed to start over with a new rocket because our three liter rocket was unfixable. When we built the new rocket, we knew what worked and what not to do since we had tested all our bad ideas out and we were able what worked and what didn't with other people's rockets. For the nose cone on our new rocket we used the top of a second soda bottle with the mouthpiece cut off to create a smooth, even and perfectly rounded surface to have minimal air resistance. When we had to decide what weight to use we used one baseball and put it inside the nose cone which ended up being 321.1 grams. With the new rocket a lot of the ideas and setup were used for the second rocket because we had much better results.

Materials used:

1. (2) -liter bottle
2. baseball
3. foam/couch cushion
4. Realestate sign
5. duct tape
6. glue

Figure thirteen:

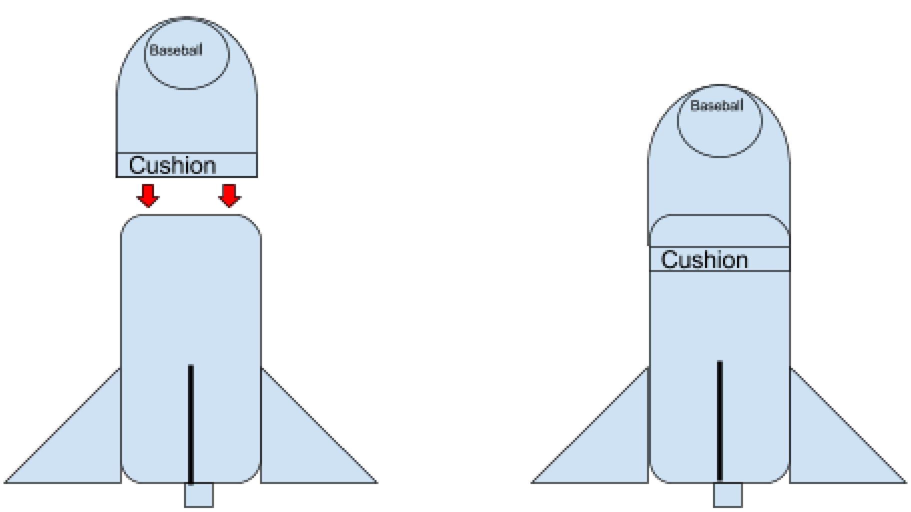
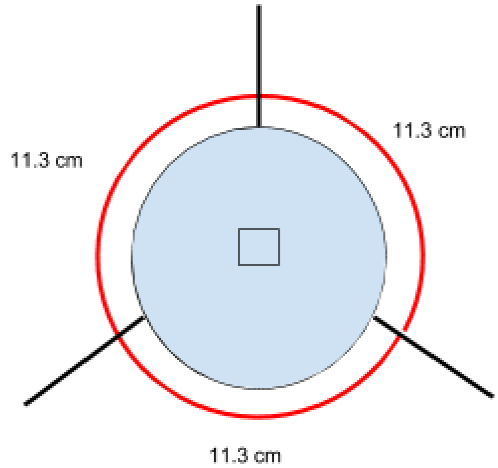


Figure fourteen:



When my group was making our two liter bottle rocket, same process as our three liter bottle, we took a second two liter bottle and we cut it in half to create a separate chamber away from the water and pressure and we pushed the second bottle over the first as figure thirteen shows. We left just enough room to have a layer of cushion which was about an inch of foam. instead of glueing the half bottle to the rocket, we duct taped it so there would be a small about of give when the rocket hit the ground. When we made the new nose cone we used the bottle that was cut in half and we used the half that had the mouthpiece on it and then we cut the top off. We did that because we needed a smooth, light and aerodynamic surface as the nose cone and by doing that we were able to put the baseball inside the nose cone and stabilize it easily. We then taped over the hole in the top so it was closed completely.

When designing the wings, we ended up using a different material that would hopefully be lighter but still hold the rocket straight. We used the material that earl estate signs are made out of and then we placed them 11.3 centimeters apart from each other around the rocket as far back on the rocket as possible to ensure stability.

Figure fifteen:

Test number 10/30/15	Mass	PSI	Distance
Test one	321.1 grams	138	178 yards

After launching our new rocket, we found that the two liter bottle had much better results. Looking at how far our rocket went the first time launching it we realized that the smaller bottle was a much better idea and that we should have made a two liter bottle much earlier in the rocket testing.

TEST NINE:

Test objective: Strengthen

After seeing the results of our new rocket the first time we launched it we found that a two liter bottle was much better that the three liter bottle. In this test we just wanted to make it stronger and improve anything that we could in order to make it the best it can be. With having one test left we kept the same design, wings and cushion because we found that all three worked well.

Figure sixteen:

Test number 11/5/15	mass	PSI	Distance
Test one	321.1 grams	138	193 yards
Test two	321.1 grams	138	145 yards

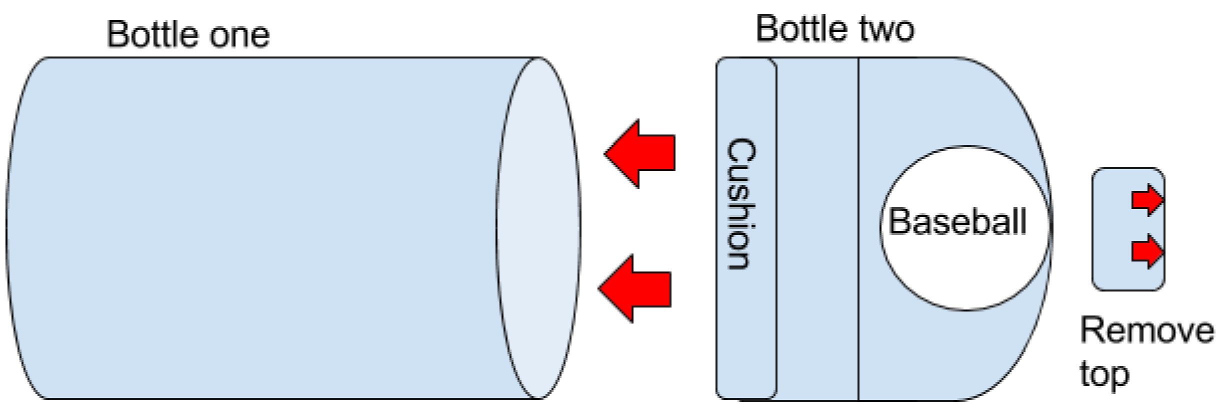
Since there weren't many improvements besides reinforcement done to our rocket, we found that we did have better results than the first launch with the new rocket because it was stronger.

Throughout the course of doing rockets, there are many things my group learned and some ideas aren’t the best and some we found out that taking risks is sometimes a good thing. When We build our first three liter bottle, we tried splicing a two liter bottle top onto a three liter bottle to ensure that it fits the sherman launcher. By doing this the initial idea worked and it was strong enough to withstand a PSI of 140 but we found that in order to have the three liter bottle to work, you need to make sure the nozzle gets put on completely straight. By having our nozzle on the slightest bit off, the rocket didn't launch straight once. Every time the rocket was launched it would be the slightest bit off balance and the wings were not able to keep the rocket straight.

When doing wings for our rocket, we found that triangle wings did work well and that in order to have strong wings you need to use something that is durable but light. While doing many tests we used several different materials such as thin plastic that you find on the cover of a notebook and we found that was too bendy and couldn't hold the rocket straight, especially if it is windy out. After the plastic wings we used a cardboard which worked but after getting bent and bashed up from impact it becomes less durable. The third material we used and found was most successful is the plastic that real estate signs are made of. The signs are light but the way they are made they don’t bend easily.

The third part of the rocket that is very important and was tough to get right is the nose cone. On our first rocket we used a regular kitchen funnel. The material the funnel was made out of was a really strong plastic yet it was light. When using the funnel on our first rocket the results weren't bad. We used the cone shape for a nose cone because we thought it would help reduce friction but it didn't really turn out that way. After our three liter rocket exploded we didn't use the cone for our nose cone, use used the rounded part of a soda bottle and cut the mouthpiece off. After putting the second bottle on top of the rocket, we put a layer of foam between the baseball which was used as the weight and then that was placed inside the bottle as shown in figure seventeen.

Figure seventeen:



The last important part of building a rocket it the weight. When building a rocket there is an ideal weight and six hundred grams is not it. The first rocket we build was far too heavy and it made the rocket top heavy causing it to crash. By doing research after we had already launched our three liter rocket we decided to use three golf balls. Using golf balls made the rocket have a mass of about 420 grams and then we had better results. The second rocket we made we chose to use a base ball because we saw a lot of other rockets using baseballs and they all did well. When we put the baseball in it the mass was 321.1 grams and our rocket was balanced well.

If I was to give someone advice on building a rocket, I would tell them to do as much research as possible before you do anything to your rocket. Research saves a lot of time and frustration when when your rocket fails every time it gets launched. Another thing I think is important is to take risks and be creative when building. As important as research is, you never know what will work and what won't such as splicing a two liter nozzle onto a three liter bottle. By doing that we found that it is possible but we now know you need to put the nozzle on straight or else it won't work as much.

While doing rockets I was on the launch team. The job of the launch team was to set up the Sherman Launcher and take it down before and after each day of testing. Also my main job was to pull the pin and how you do that place the rocket on the launcher until you feel a slight click over the O-ring. Once the rocket is placed on the launcher you put the pin in between the slits in the pin holder so it is on top of the lip of the bottle. When the bottle is properly set up the you step back so the rope is straightened but not too tight because then the pin will fall out. When the pin man is all set you say squeeze-squeeze which tells the person to pressurise the rocket. Then whoever is in charge of communicating with the people in the field will make sure everything is clear with them. Once the bottle is pressurized and whomever communicating with the team in the field yells all clear, the vuvuzela is blown to warn everyone, you pull the pin. When pulling the pin you must pull with your shoulder, back facing away from the field then. Pin man must keep arm straight because otherwise the pin won't come out on the first try and it causes shoulder pain.