Fly Rocket Fly

The Flying Lady

Maximum Launch Distance:
290 yards

Date: December 22, 2016

Question:

For this project you must create a rocket out of a 2-liter soda bottle and see how far you can launch it. You may use almost any design you can come up with as long as it does not have any sharp or metal object inside of it. Functionality is not the only thing that counts in this project. You must also create a rocket that looks cool in the process.

Literature Review:

Mass- From most of our research we conducted we found that most groups typically had a mass of 350 to 400 grams. We however started testing different masses and this area included a big part of our design and research through this project. This we found to be off and that this was much too heavy if you include the amount of water also being put into the rockets. We found that the best weight would be around 175 grams with a distribution ratio of 3:4 in terms of body to nose cone. This allowed the nose cone to have more of a significance in the rocket's direction without adding too much more mass which would take away from the rockets overall distance. This also decreased the amount of a dive the rocket would want to take with it being more balanced overall.

Aerodynamics- Aerodynamics is probably the next most important section in this project. We found that even with just slight changes it makes a large difference in your rockets overall performance. You want to stay as symmetrical as possible when it comes to fins and nose cone pieces because thi9s will throw everything off and weaken your rocket. With pieces in off center positions it can result in the rocket diving, wobbling, or veering off in another direction. Anything that is different from another part will create drag and result in the rocket moving way off course from where you are aiming it. Another discovery we made is that pointed nose cones are not always best. These are easily damaged and if they are built just a little off center it will make your rocket go off course. Typically parabolic nose cone designs work better for making your rockets durable and better in flight.

Fins- Fins are an essential part of your rocket and need to be built very sturdy. Fins when they hit the ground can easily break and be damaged or even damage the body of your rocket. This can result in a unfixable rocket or a lot of time you will have to put in time to repair your rocket's fins. The best fin placement we found was just above the bottom curve of the rocket by no more than a half an inch. This helps control the rocket better in flight. Also make sure your fins are equidistant from each other and are lined up front to back on the rocket equally as well or else it will create an uneven balancing of the rocket and cause it to wobble or completely veer off course.

Nose Cone- The nose cone design is essential for a good rocket. The nose cone must be the most durable and typically heaviest part of your rocket. Your nose cone must be durable because when the rocket lands it will put all its power into the nose cone so it must be very durable to withstand multiple landings and launches. The nose cone must also be perfectly symmetrical so the rocket will fly straight through the air and now veer off course. Materials that work well to build the rockets would be dense and hard materials such as silicone window sealant or hot glue. Hot glue works well but can deform your nose cone due to the heat. Expanding foam can be used as a filler in the nose cone to make it stronger but not add a lot more weight. We for the front of the nose cone used a golf ball which stuck out of the front in the center to provide a spot for the rocket to land on which would not break easily.

Securing Pieces- Securing pieces of your rocket together with strong seals is necessary due to the amount of force that is exerted on it during a launch. We started off using duct tape which works fairly well however we found that fiberglass tape worked the best out of all of the tapes we tried due to how light but strong it is. Try to avoid using hot glue because it will warp the body of your rocket due to the heat. We used normal glue to attach the fins to our rocket and strips of tape that then went over the fins to keep them more secure during launch.

Mission 5: 2016-September 30

Launch Day 1

Results

Launch #	Water Amount (L)	PSI	Distance (yards)
1	⅔ L	108	215
2	⅔ L	108	30

Figure 1: Results 1

Our design consists of a screw-on nose cone that did not fit on the launcher due to its diameter. We must rebuild it with a slimmer design. Otherwise the launches went fairly well today our first launch went very far and flew very straight. On landing however one of the fins had become loose and had fallen completely off the body after the second launch. We must rebuild all the fins and find a different type of adhesive to put them on with. Hot glue did not work well.

Nozzle Design problems- The nozzle was much too bulky with the tape and glue both holding the plastic caps together which made this design much too large to fit into the launcher. It was both too long and too wide in diameter. We need to find a different method of attaching the two caps together.

Nozzle Design Sketches:

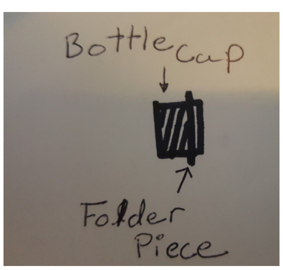

Figure 2: Nozzle Sketch Side View

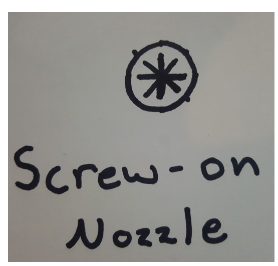

Figure 3: Nozzle Sketch Top View

The nozzle worked using a piece of a plastic folder and two bottle caps that were glued together one being cut very thin to use as a ring to hold the folder on. The folder piece was cut round and slits were put into it to focus the outgoing water into a narrower channel, therefore increasing the pressure and having the water escape at a lower rate.

Mission 6: 2016-October 4

Launch Day 2

Results

Launch #	Water Amount (L)	PSI	Distance (yards)
1	⅔	110	200
2	1	125	235

Figure 4: Results 2

Today went fairly well. Our rocket had good launches both times. The rocket was wobbling a bit through the air so we need to make sure the fins are perfectly straight and are evenly spaced out. The nosecone became dented today on our first launch but fixed itself when it was pressurized due to the nose cone being solid and the inner tank chamber pushing it back out. Creating a nose cone with solid materials that back up right against the inner chamber creates a rocket that will immediately fix itself when pressurized on the launcher. This will also make the nose cone much more durable and and be used for more launches without needing to be rebuilt.

The nozzle was again too big today by a small amount due to the small area in which it has to fit inside of on the cuff of the launcher. The nozzle must be rebuilt again to an even smaller size to be able to be used.

Mission 7: 2016-October 13

Launch Day 3

Results

Launch #	Water Amount (L)	PSI	Launch Angle	Distance (yards)
1	1	130	32	246
2	1	130	41	250

Figure 5: Results 3

Our first launch wobbled a lot coming off of the launcher but kept in a straight line. The slits in the nozzle had broken off when putting our rocket on the launcher due to the slits not being large enough to fit over the launch tube.

Our second launch was relatively straight but veered off course slightly and headed into the woods therefore our distance reading may be off by a couple of yards. The launcher needs to be angled more into the field because multiple groups are launching in that direction. Also the rocket had a circular pattern during flight and had gone up and down while rotating cause the rocket to do loops through the air. Our fins must be realigned due to this.

Today we also tried changing the angle on the launcher to try to find the best angle to launch at. Between our two launches we tried 32 degrees and 41 degrees in which we found almost no difference between the two launches. This we will further test when the fins are realigned to get more consistent results when using launch angle as a variable.

Mission 8: 2016-October 19

Launch Day 4

Results

Launch #	Water Amount(L)	PSI	Launch Angle	Distance (yards)
1	1	130	45	248
2	1	135	45	221
3	1	135	45	175

Figure 6: Results 4

The first two launches went well however the second launch the rocket started wobbling a lot midflight. The third launch the rocket wobbled a lot right off the launcher cutting down on our distance. The fins need to be reinforced more so they are stable through the beginning of the launch. The glue does not stabilize them enough by itself to hold the wings straight through the beginning part of the launch. To do this we used a strip of tape that went up one side of the fin and down onto the rocket body to hold the fin in place better.

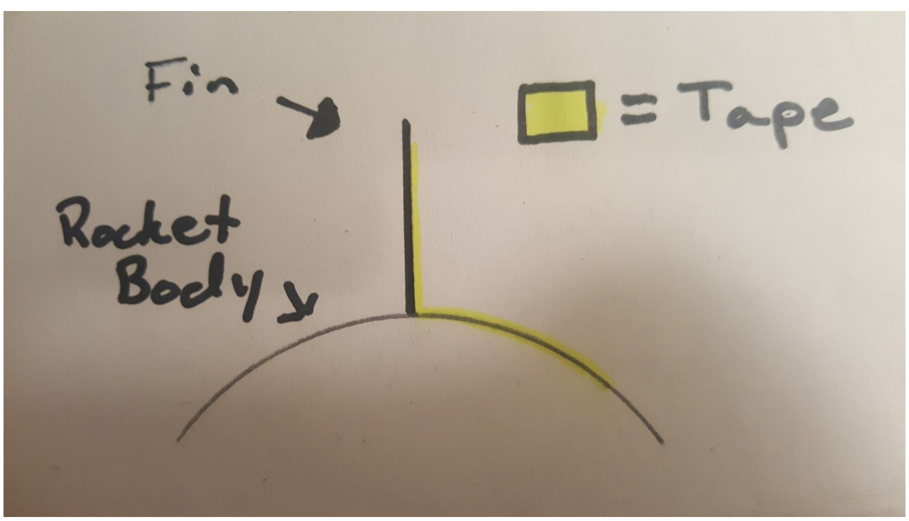

Figure 7: Fin Reinforcement 1

Using this type of design to stabilize the fin seemed to work very well with how strong it was and the aerodynamics that is had presented due to it being such a small piece it had no effect on the rocket's flight path.

Mission 9: 2016-October 25

Launch Day 5

Results

Launch #	Water Amount (L)	PSI	Launch Angle	Distance (yards)
1	1	130	41	198
2	1	130	75	168
3	2/3	135	42	106

Figure 8: Results 5

During the first launch when our rocket landed the nose cone detached from the rocket body. The rocket needs to be rebuilt completely. Therefore on the second launch we went out to set a hang time record. This we ended up setting at roughly 7.5 seconds. For the third launch we went to see how well the rocket would fly with the nose cone slightly detached and it went straight into the ground about 100 yards away and completely broke off. The entire nose cone needs to be rebuilt and nose cone design will be changed to make the rocket stronger so it does not break as easily. More tape must be used as well to secure the nose cone better because the entire nose cone split from the rocket body at the seam although both parts were still intact besides separation. The golf ball in the nose cone is the only thing we had kept the same in the overall rebuild of the piece. The fiberglass tape is used to help support the golf ball and the silicon sealant is used for mass while the expanding foam is used as a cushion between the rocket body and the rest of the nose cone.

New nose cone design:

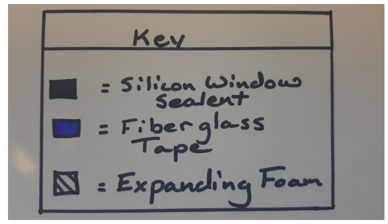

Figure 9: Nose Cone Design **Figure 10: Nose Cone Design Key**

Mission 10: 2016-October 27

Launch Day 6

Results

★= New Record

Launch #	Water Amount (L)	PSI	Launch Angle	Distance (yards)
1	1	135	40	★275
2	1	131	40	259
3	1	132	40	268

Figure 11: Results 6

Today's launches went very well with our first launch putting up an all time record. Now we will start tampering more precisely with launch angles and water amounts to find the best combination for maximum distance. Maximum PSI seems to work best for our rocket but it can cause a lot of force on the fins which can cause them to break off due to the high rate of acceleration coming off of the launcher.

The new rocket with all the new implemented designs and ideas worked very well. The rocket had flown very straight and showed no signs of wobbling or weakness in any part of the rocket.

Mission 11: 2016-October 31

Launch Day 7

*Snowing with strong head wind

Launch #	Water Amount (L)	PSI	Launch Angle	Distance (yards)
1	1	135	40	196
2	1	135	40	176
3	1	135	40	196

Figure 12: Results 7

Due to the cold and snow many rockets seemed to not do well and with the addition of a strong headwind all rockets were underperforming today. With launches being considered inconclusive no variables were tested today and we just launched repeatedly with the same settings.

The tape holding our fins did come detached due to the cold and dampness so they must be repaired.

Mission 12: 2016-November 2

Launch Day 8

Results

Launch #	Water Amount (L)	PSI	Launch Angle	Distance (yards)
1	1 1/4	135	45	227
2	1 1/4	125	45	264
3	1 1/4	135	55	242
4	1 1/4	135	47	189

Figure 13: Results 8

Rocket is flying with staggered results and possibly needs to be rebuilt.

One and one quarter liters of water seems to give us our best results compared to other launch when it comes to height. The launch angle needs to be adjusted to compensate this extra weight pulling the rocket to a more vertical angle as it comes off of the launcher.

Distances were very inconsistent compared to our previous day's launches on Day 6. Rocket may need to be retaped to make sure everything is holding after the snow again. Although angles were tampered with slightly these numbers are still coming out to be much lower than they should be considering past performance of this specific rocket.

Mission 13: 2016-November 4

Launch Day 9

Results

Launch #	Water Amount (L)	PSI	Launch Angle	Distance (yards)
1	1 1/4	135	45	185
2	1 1/4	135	45	254
3	1 1/4	135	45	245

Figure 14: Results 9

Launches are still lower in distance than they should be. Launch variables were all kept the same to see if problems would arise with the rocket showing any weaknesses. Fluctuating results indicate that the rocket is not stable during flight which it was not, the rocket had a constant wobble which in the second and third launches straightened out fairly quickly after initial launch. However in the first launch it had a constant wobble lowering the overall distance by more than 50 yards from our rockets average.

Rocket must be rebuilt. Dents in the body indicate that the rocket's body has become less aerodynamic causing it to wobble during flight resulting in loss of distance. The same design will be used for the next rocket.

Mission 14: 2016-

Launch Day 10

Results

Launch #	Water Amount (L)	PSI	Launch Angle	Distance (yards)
1	1 1/4	135	45	157
2	1 1/4	135	45	138
3	1 1/4	135	45	158

Figure 15: Results 10

The wings on the rocket seem to be unstable due to a deformity in the rocket body causing the fins to dent into the rocket body very easily. This in turn is causing extreme amounts of wobbling and much shorter distances than presumed. The rocket must be rebuilt for Rocket Day.

The rocket tended to veer off course in every launch causing distances to drop as a result as well.

The same design will be used for the next rocket build.

Conclusion

Rocket Day Results:

The rocket veered off course and into the trees on the first launch with no harm done to the rocket itself. The distance was not measurable due to the location of the rocket's landing.

The second launch however went very well with a new record of 290 yards.

Final Rocket Design

For our final design we used a total of two 2 liter soda bottles. One for the body which was left alone besides the stickers, which were taken off of both bottles, and the other one of which we had cut to make the nose cone. The blue line in the figure below representing where we had cut the bottle.

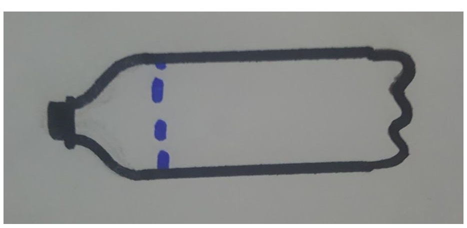

Figure 16: Bottle Cut

We then proceeded to cut the top of the bottle again to make a whole in which a golf ball could partly protrude out of. Again the blue dashed line representing where it was cut. The ball was then placed into the top through the inside sit it can rest without falling through as shown in Figure 18.

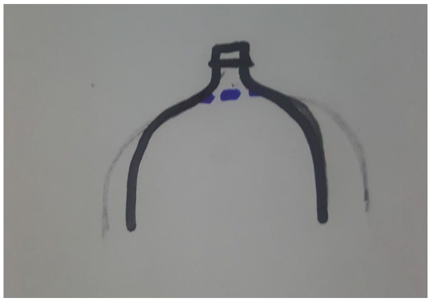

Figure 17: Bottle Cut 2 **Figure 18: Golf Ball**

The layers were then added into the cone as shown in Figure 19. The layers were packed in so there were no air gaps to provide the most durable and sturdy nose cone possible. With the sealant acting as weight and the expanding foam acting as a cushion between the chamber/body of the rocket and the nose cone itself.

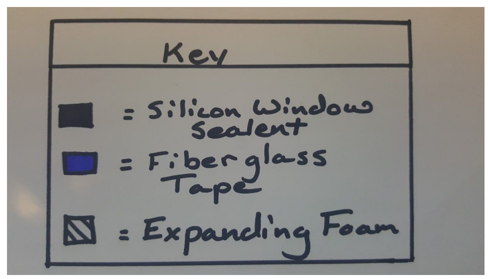

Figure 9: Nose Cone Design **Figure 10: Nose Cone Design Key**

The nose cone was then placed on the bottom of the other bottle to form the basic rocket body. They were attached using several wraps of fiberglass tape, which we found to be very strong yet light. The blue in Figure 19 representing the tape.

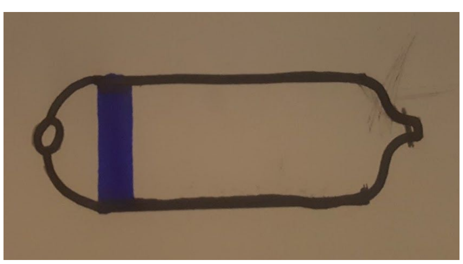

Figure 19: Tape Lines 1

The fins, which were made out of house siding, were then attached equidistant from each other using a strong adhesive glue(Figure 20). They were placed 1 centimeter from the bottom of the rocket body where the body goes back toward the nozzle(Figure 21). A piece of tape is then placed on one side of the fin itself to run down to the body as an extra stabilizer to keep the fin in place during launch in which the yellow is the tape(Figures 7).

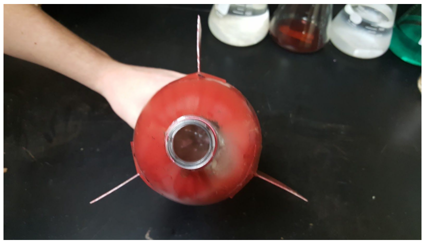

Figure 20: Fin Placement 1

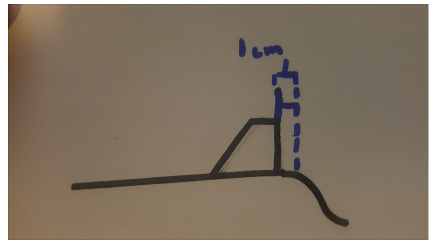

Figure 21: Fin Placement 2

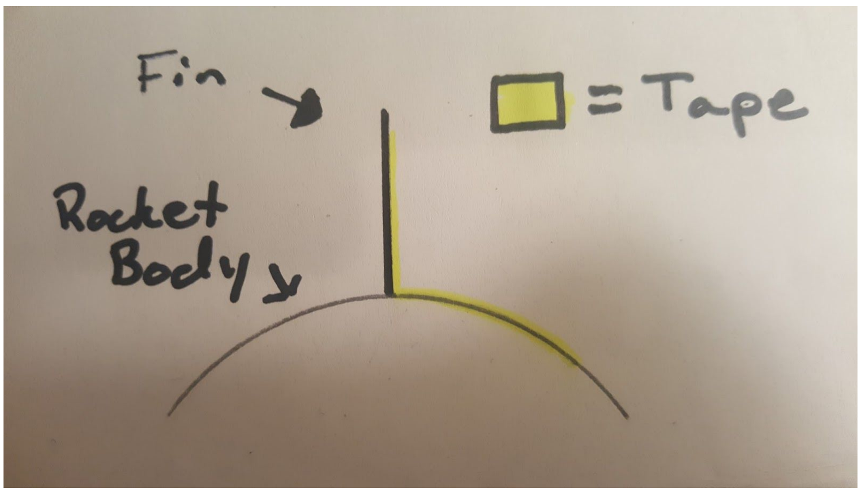

Figure 7: Fin Reinforcement 1

Then more fiberglass tape was used which runs down the body of the rocket from the nose cone and is split to go around the fin and run down both sides of the fin lengthwise. This would provide extra stability to the fins as shown in Figures 22 and 23 again with yellow representing the tape and blue representing the fin.

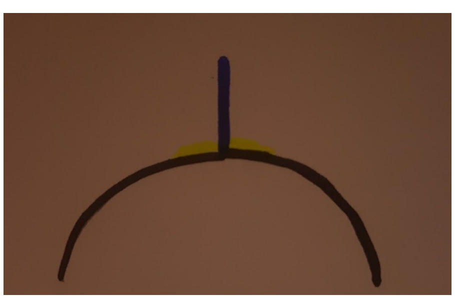

Figure 22: Fin Reinforcement 2

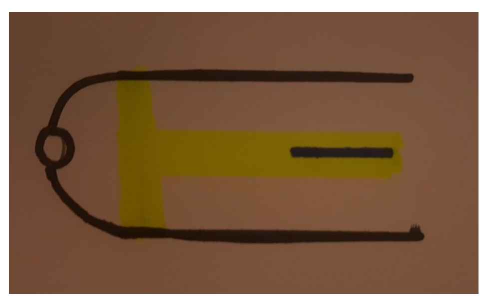

Figure 23: Fin Reinforcement 3

Some other useful notes to add to this would be that the mass of the entire rocket should be around 190 grams. We typically tried to stay just under 200 grams to keep the weight of the rocket down helping it fly better. Also we tried to get our rocket to a weight distribution ratio of about 4:5 in nose cone to rocket body which we came fairly close to with our overall mass being 188 grams and the nose cone having a mass of around 90 grams.

Some advice I would give on working on this project is to try new concept and ideas and to constantly try to evolve your rocket by using these new concepts and ideas to improve. Try different things do not go off of just what others are doing, try to do something different and see if it works.

Launch Team

On the launch team I had several jobs in which I had done throughout the course of this project. One job which I had done most frequently was loading rockets onto the launcher. I was in charge of this every launch day and this became my main role. I also however did many other things to help on the launch team. I typically was part of the preparation team that would set up the launcher and air compressor. I had hooked up hoses, staked in the launcher, and aligned the launcher with the area in which we were shooting toward. Another job which I had been in charge of was changing settings on the launcher if people wanted to test different launch angles. This included loosening the launchers bolts, setting the angle at which the person wanted to launch at, and tightening the launcher back down so it held in that position. Those were the jobs I would do on an everyday basis as part of the launch team but I sometimes would also do other jobs such as setting the pressure on the air compressor or pulling the launch cord to set off the rocket. Those jobs are what I had done as part of the launch team during our rocket days.