BLACK HAWK

DESIGN REPORT

The purpose of this project is to have kids experiment with properties of physics such as aerodynamacy and trajectory. The goal is to create a rocket, optimize it through multiple rounds of testing and modification, and finally to compete against other rockets on Rocket Day.

LIT REVIEW

Nose Cone: In researching the nose cones, we found that there is a shape of nose call a "Von Karman Ogive" that is generally regarded as being the most aerodynamic shape a nose cone can have. While initially we considered trying to replicate one of these proven nose shapes, it became clear that not only would achieving a nose cone of one of these shapes on a bottle rocket be extremely technical and time consuming, but that it also would have a negligible effect on the scale we intend to use it. For this project, I recommend that a round nose cone be implemented, and that the nose be smooth and have no holes or pockets that would catch the air as this could cause slowing or spinning of the rocket. However, beyond that, shooting for a "Von Karman Ogive" or something similar would be a completely unnecessary waste of time.

Mass: The mass and distribution of mass throughout the rocket are important factors. A good fraction of the rocket's weight should be in the nose cone. The ratio of weight between the bottom and tip of the rocket will determine how straight and stably it flies. We suggest a rocket of about 300-400 grams in mass. Good things to use for adding mass are clay and bouncy balls.

Fins: Fin size is extremely important. If your fins are too small, they will not provide your rocket with adequate stability. Your rocket is likely to spiral out of control, but even the slightest revolution is wasted energy that will shorten the distance your rocket travels. Fin size is definitely something to experiment with. As far as shape, I recommend either a 4 sided irregular shape, surface area is probably the most important thing. Also, fins should be made of relatively light material. Balsa wood, cardboard, and thin house siding are all good options.

Adhesives: PL Premium glue by loc-tite is a fantastic adhesive for plastic bottle rockets. The glue works very well with PET (the plastic the bottles are made of) and when it dries, it is extremely strong. A large tube can be bought for under 10 dollars at a hardware store. Whatever you buy or use, you might want to read the bottle to see how compatible it is with PET. If you are splicing bottles; using sealant alone is a bad idea. Sealant is not as strong as glue and will likely burst under high pressure.

Splicing bottles: To splice bottles, we first cut up two 2-liter bottles. Then, we heated a pool of water in a pan about 1 cm deep to near boiling temperature. It's important to push the edges of the bottle to the bottom of the pan to shrink the bottle and curl the edge evenly. Only one bottle gets shrunk. Sand the outside of the edge of that bottle, and the inside of the other, about 2 cm up on both surfaces. Use a strong glue, possible mixed with a sealant, to bind the bottles. See the adhesive section for more information.

Testing and Development

Mission #1: 2016- September, 30.

Preparation:

For the first launch, we decided launched a control rocket. As with all scientific experiments, we thought it was important to run a control to fully observe the effectiveness of our bottle modifications. For this, there was no real preparation needed.

Results:

The control rocket, as expected, did not fare very well. It flew erratically across a short distance of 22 yards.

Recommendations:

The blank rocket flew horribly, to no surprise. For the experiment to go as expected, when we launch the Black Hawk next time, it should perform significantly better than the blank bottle.

Mission #2: 2016- October, 4.

Preparation:

A lot of work went into creating the Black Hawk before it was finally ready to launch. First, the bottles were cut and the edge of one bottle was shrunk and curled in boiling water. Then the outer edge of the shrunk bottle and the inner edge of the other bottle were sanded to provide texture for the glue to bind to. Then the bottles were glued together using Loctite PL Premium glue, and a sleeve made out of 2 other bottles with the bottoms and caps cut off were fit over the main bottle. They dried for a period of several days. Then, the bottle was reinforced with a liberal amount of glass strapping tape. The strong glue and tape reinforcement keep the bottle from bursting under high pressure. Because our would be much more strong than the average rocket, have the strong glue and tape reinforcement, we planned to launch at a psi higher than those of the other students. Next, the fins were made out of cedar wedges. A template for the wings was created on paper, then the template was cut out. Then the template was traced onto the cedar wedges, which were then cut with a bandsaw to follow the curves of the fin smoothly. This method worked very well. The fins were glued on with PL Premium and GE Plastic Adhesive. It was tricky to keep the fins in place while the glue dried, but they turned out all right. After the fins finished drying, a nose cone was made by cutting off the top of a bottle, cutting off its cap, replacing that with a bouncy ball, then packing in clay around it. After being painted black and white, the bottle was complete and ready for its first launch.

Results:

The rocket launched upward with a seemingly large amount of force, however it then seemed to fly in an exaggerated spiral before falling to the ground.

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

Recommendations :

Clearly the spiral was caused by the fins being either too small or misaligned. As the spiral resulted in a large loss of forward-moving energy, and subsequently an undesirable launch distance, the fins would have to be redone. The new fins would have more surface area, and be made of a sturdier material, as the old fins broke upon hitting the ground as well.

Mission #3: 2016- October, 6.

Preparation:

The Black Hawk was equipped with new fins, this time larger and made of plastic siding. The fins were cut with a pair of wire cutters.

Results:

The Black Hawk launched much better this time, however, it still did not fly very straight. It launched almost 3 times as far as it had last launch. The new fins were clearly a large improvement.

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.

Recommendations:

The performance of the Black Hawk improved greatly. However, though the fins worked much better, something about their calibrations was still off. The rocket should have flown straight. The angle at which the fins were place, and whether or not the fins stand perpendicular to their respective diameters of the bottle, should be reexamined.

Mission #4 : 2016- October, 13.

Preparation:

The fins were removed, repositioned so that they were perfectly 120 degrees apart, and bent to the best of our ability to ensure that they were perpendicular to the diameter of the bottle. The nose cone was also fixed and more clay was added, bringing the rocket's mass from 351 grams to 374 grams.

Results:

The Black Hawk saw some improvement. Another 10 yards of distance. Most likely this was a result of the fin adjustments.

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

Recommendations:

The nose cone was practically destroyed on impact. We will have to make a new one. This will probably happen repeatedly throughout the testing process. However the nose cones are very easy to replace, and can be repaired on site well enough to do multiple launches in a day. For this reason we will probably just continue to replace the nose cone each launch day. For the record, the group rejected the idea of spreading epoxy or a similar substance on the interior of the nose cone to give it structural integrity. If enough epoxy was used it could have replaced the clay as weight as well.

Mission #5 : 2016- October, 19.

Preparation:

The new nose cone has been added, it is identical to the last one. No other changes were made to the rocket itself. For launch 5, we wanted to test how the rocket would perform will a larger amount of water in the tank.

Results:

The first launched showed that 2 liters was too much water, it weighed the rocket down too much, cutting the launch short at 202 yards. The rocket sustained heavy damage to the nose cone, the distortion of which caused air to drag the rocket out of its flight path. The 2nd launch achieved a menial distance that was not recorded.

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

Recommendations:

2 liters was definitely too much water. Next time we should try around 1.6L. Also we will once again have to replace the nose cone. Next time we'll try to secure the bouncy ball more so that it will stay in place and not create a pocket for air enter and cause drag.

Mission #6 : 2016- October, 25.

Preparation:

The nose cone was replaced once again, decreasing the rocket's mass to 365 grams.

Results:

Another 10 yard increase in launch distance can be seen in the table below. The water level of 1.6 liters seems to be in the ideal range.

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

Recommendations:

The Black Hawk had a very successful launch. This is mostly likely due to the adjustment of the water level used as fuel. 1.6L seems to be about the sweet spot. The change in rocket mass may have had an effect as well, but it is likely minimal.

Mission #7 : 2016- October, 27.

Preparation:

We made two new nose cones for the Black Hawk in anticipation of future nose cone failure. We did not launch the Black Hawk this day as it was not yet repaired. Instead the Velocity 9 was launched. The Velocity 9 was our second rocket, an experimental two tanked rocket. I chose not to include it in my report because it proved to be inferior to the Black Hawk, which was always the main focus of our project.

Mission #8 : 2016- October, 31.

Preparation:

The nose cone of the Black Hawk once again was in need of replacement. Other than this, no real changes were made to the rocket. It seems to be near its final form, we just want to see if it can consistently perform on the level we need it to for rocket day.

Results:

The Black Hawk had two unimpressive launches. They were all right, nothing major went awry, however the rocket did not seem to be performing on the level we had seen it perform previously.

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

Recommendations:

As no real changes had been made to the rocket or the launch process since it had achieved a 257 yard launch, it was difficult to pinpoint why the rocket was performing significantly poorer today than it had in the past. Perhaps it was due to inconsistencies with either the weather or the process by which our classmates measured the rockets’ distances.

Mission #9 : 2016- November, 2.

Preparation:

A new nose cone was created, which was about 30 grams lighter than the previous one(s). This will test to see if perhaps the total weight or nose cone mass of our rocket needs to be adjusted.

Results:

The launch distances are roughly the same as they were last launch day.

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

Recommendations:

Seeing as the modifications had little to no effect on our launch distances, coupled with the fact that the previous rig had performed quite inconsistently, it is hard to draw conclusions as to what is going to help our rocket improve. Again, weather and the distance measuring techniques may be key factors in determining the distances recorded for our rockets. The data we currently have in inconclusive. Also, a new nose cone must be created for Black Hawk.

BROKEN RECORD

Mission #10 : 2016- November, 4.

Preparation:

This launch is to ensure that the rocket is in working condition for rocket day.

Results:

Another unsatisfactory launch.

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

Recommendations:

The rocket will launch for Rocket Day, however it may not fare too competitively.

Rocket Day Conclusion

The rocket did not perform very well on rocket day. We came nowhere near our previous successes.