Analysis of Final Flight Times, Distances, and Altitudes of Clipped Parallelogram, Clipped Delta, and Elliptical Fins on Structurally Sound Fuselages

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Introduction

Purpose

The purpose of this investigation is to evaluate which type of rocket fin will increase a rocket's height, distance, and speed the best. This analysis will examine the beneficial properties of three rocket fins: a "Clipped Delta" fin, an "Elliptical" fin, and a "Clipped Parallelogram" fin. All other variables, such as the fuselages and material, will be kept constant throughout the experiment to ensure fair results.
Since their creation as solid-propellent arrows used in war for short-range by the Chinese, rockets have been used for multiple purposes, especially during the intense space exploration race that began during the Cold War. Ever since, rockets have been used for multiple purposes, ranging from war (missiles) to entertainment (model rocketeers) to space exploration. Now, multiple Apollo missions have occurred, and there have been missions involving rockets, such as traveling to nearby satellites and the Moon. This project analyzes the best method that rockets in the real world can improve in terms of fin design whether they are model or full-scale rockets. Rocket fins are utilized to improve the aerodynamics of a rocket. Fins specialize in maintaining the direction and stability of a rocket. This is why rocket fins are crucial when it comes to improving the height, distance, and flight time. Discovering the most efficient type of rocket fin will enhance these three variables the greatest, and will improve the performance of a rocket. This evaluation will help scientists develop numerous advancements towards rockets, and will develop the study that is rocketry. Or, it can simply help rocketeers who love model rockets enjoy the thrill of seeing rockets fly exceptionally high and glide for miles.
This investigation was prompted by previous engineering and science lessons taught at the Engineering and Science University Magnet School (ESUMS) located in West Haven, Connecticut. These lessons helped influence this inquiry of rocket fins because it brought up many questions about rocketry, specifically the best type of fin shape that could be utilized to better rockets.
With this in mind, the question remains: Which rocket fin will increase a rocket's height, distance, and time the greatest?

Hypothesis

If conditions are favorable, then a clipped parallelogram fin will increase the distance, height, and time of the rocket the greatest because the shape of the clipped parallelogram fin will produce the least amount of drag. This is due to the shape of the fin allowing less lift near the top, decreasing the amount of pressure compared to the top of the fin. This airflow would allow for less air to roam around the top, decreasing drag. Less drag will ensure that the rockets fly higher, farther, and longer.

Variables

The independent variable of this experiment is the type of fin per rocket. All of the variables except the type of fin will be kept constant (control variables) throughout the experiment to ensure fairness. The dependent variables are the final height, final distance, and final flight time that each rocket achieves. However, when comparing the results of the

Materials

This experiment consists of multiple parts that will each play a role in making this evaluation possible. These major components include the built clipped delta fin rocket, the built clipped parallelogram fin rocket, the built elliptical fin rocket, a launching pad, four engines, and the materials needed for launching the rocket. Each specific detail for every part can be found below.

Clipped Delta Fin Rocket

- Fuselage (Made out of cardboard)
- Three 3D Printed Clipped Delta Fins (Made out of plastic)
- 3D Printed Nose (Made out of plastic)
- B6-4 Engine (Estes)
- Rocket Plug (Goes at the bottom of the engine)
- String (Connected from the nose to the fuselage)
- Small Piece of Wood (Located inside fuselage, between nose and engine)
- Recovery Wadding

Clipped Parallelogram Fin Rocket

- Fuselage (Made out of cardboard)
- Three 3D Printed Clipped Parallelogram Fins (Made out of plastic)
- 3D Printed Nose (Made out of plastic)
- B6-4 Engine (Estes Engine)
- Rocket Plug (Goes at the bottom of the engine)
- String (Connected from the nose to the fuselage)
- Small Piece of Wood (Located inside fuselage, between nose and engine)
- Recovery Wadding

Elliptical Fin Rocket

- Fuselage (Made out of cardboard)
- Three 3D Printed Elliptical Fins (Made out of plastic)
- 3D Printed Nose (Made out of plastic)
- B6-4 Engine (Estes Engine)
- Rocket Plug (Goes at the bottom of the engine)
- String (Connected from the nose to the fuselage)
- Small Piece of Wood (Located inside fuselage, between nose and engine)
- Recovery Wadding

Other Materials

- Launching Pad
- Launch Controller
- Metal Wire
- Pliers

Procedure

1. Obtaining Fuselages

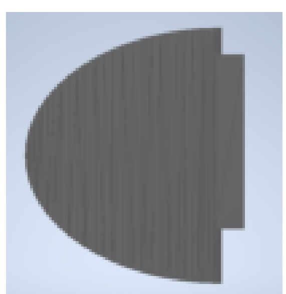
In order to construct the rocket fins properly, the fuselages had to be acquired. Receiving the fuselages would allow for the fin designs to be made appropriately for the fuselage. The fuselages that were going to be used were in an engineering teacher's possession. Once they were requested, the fuselages arrived a week later. This marked the completion of step one.

2. Designing and Acquiring Rocket Fins

When this investigation began, designs and ideas for possible fins were researched. The designs that ended up being selected included an elliptical fin design, a clipped delta fin design, and a clipped parallelogram fin design. After further research on each design, they were reproduced and designed into the Autodesk and Tinkercad programs and were manipulated to fit the fuselages. Rounding the fins to an airfoil was another challenge as a concept. Furthermore, learning how to use the Autodesk Inventor software was a major challenge, as it was never used before in past projects. Learning how to use this software with first-hand teacher guidance and tutorials was a major breakthrough solution. After a month of tinkering with Autodesk and perfecting the fins by fileting, chamfering, and "airfoiling", they were set to be 3D printed. Soon after they were printed, they were ready to be attached to the fuselages. This marked the completion of step two.

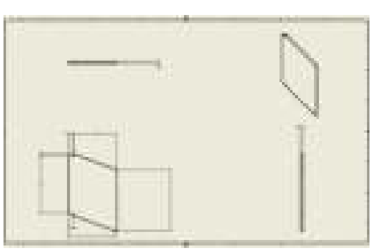
Note: A previous design of equipping a parachute inside the nose failed and was scrapped due to a lack of space and size. The design for the nose was replaced with an old student's design. (Picture on the very top-left displays the scrapped idea. Picture to the left of the first picture shows the new design.)

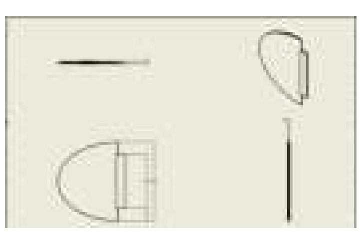
← Clipped Parallelogram Fin

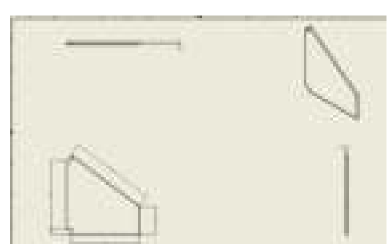


← Elliptical Fin

← Clipped Delta Fin

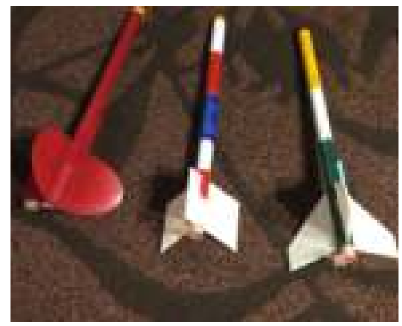






3. Assembling Rockets

Many precautions needed to be taken in order to ensure that each fuselage had the necessary components of a model rocket. These components included the nose, the fins, the B6-4 engine, the recovery wadding, and the string attaching the nose to the fuselage. The process took two weeks due to the complicity and changes that the fins had to go through. Multiple machines were used, such as complex bandsaws and pliers. Sandpaper and superglue were utilized to perfect each component. Bandsaws were used to level each fuselage to the same size, as multiple were unevenly sized. The noses were sanded to the level for which each lip was carefully placed into the fuselages. Three fins were made per rocket, and were glued at a 120° angle to evenly space out each fin. After gluing each fin to its corresponding rocket and making the necessary adjustments, they were ready for launch. This marked the completion of step three.



4. Collecting Launching And Testing Materials

This step required obtaining the necessary materials for launching, which were all accessible in multiple stores. The materials needed to launch the rocket were the following: Four B6-4 Engines, Four Engine Plugs, 12 pieces of Recovery Wadding, a Remote Control, and a Launching Pad. The woodshop teacher of ESUMS had lended basic materials necessary for launching each rocket, and the materials necessary for testing each rocket's height, distance, and time, which were an inclinometer, measuring tape, and a stopwatch. This marked the completion of step four.

5. Testing Rockets and Recording Data

The testing took two days in total. The first day consisted of only one test due to intensely frigid weather. That day, the test of the clipped delta fin was accomplished. The launching materials were utilized to help prepare the rocket for ignition. A piece of aluminum foil had to be added onto the launching pad pole due to inconsistent positioning. A video was also recorded for each launch to record the findings and observations necessary. Each rocket was tested at Seth G. Haley Elementary School, located in West Haven, Connecticut. A stopwatch was used to measure the final flight time of each rocket. A measuring tape of 25 feet was utilized to measure the final distance of each rocket. This was done by moving the measuring tape back and forth, in a "leapfrog" manner. This would repeat until the final distance from the launching pad to the rocket was achieved. The height of each rocket was measured with an Altitude Finder. This was done by standing 75 feet away from the launching site, and pulling and holding the trigger of the Altitude Finder to follow the highest point that the rocket reached. This would generate the height that the rocket achieved. By using these methods, the distance, time, and height for each rocket were successfully recorded, along with the wind speeds for each launch. All of the rockets were recovered after launch except the elliptical fin rocket. However, the data was successfully recorded, and the answer to the investigation presented had been solved. This marked the completion of the experimentation.

Observations

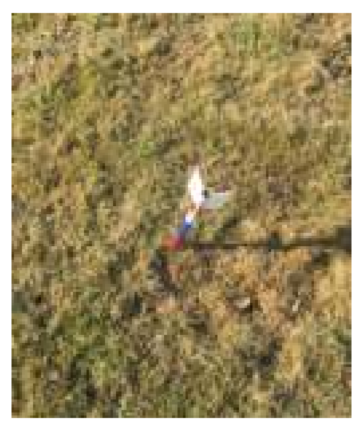
During the testing, each rocket's trajectory differed. Each launch was different due to the amount of height, distance, and time each rocket achieved. The observations and results for each fin and its corresponding rocket are listed below, along with graphs and data tables to fully represent each launch.

Clipped Delta Fin

The first design that was tested was the clipped delta fin. On the day that the design was tested, the wind was 8 mph. There was a clear sky, which allowed for the rocket to remain visible when launched. As it was the first fin tested, the first rocket, therefore, tested the procedure to launch the rocket took longer than expected. However, the first launch went very well, shockingly. When it was launched, it immediately went up. It was heading northeast away from the launching pad. While flying towards the sky, the engine exploded, causing permanent damage to the rocket. From that point, the rocket started making its descent towards the ground. It had achieved a height of 143.5 meters. Between the landing point and zenith, the angle was around 60-62 degrees. Once it started its descent, however, it quickly fell to the ground. When the rocket hit the ground, the stopwatch ended, and it recorded the flight time of the rocket, 10.51 seconds. The rocket also achieved a distance of 118.4402 meters from the launching pad. The rocket did not show any signs of instability during its flight. Most of the entire flight showed the rocket flying in a curved direction, almost like a parabola, as it had a steady flight. It did not fly awkwardly. During the experimentation of the Clipped Delta Fin rocket, the wind speed was 8 mph.

Clipped Parallelogram Fin

The second design that was tested was the clipped parallelogram fin. The clipped parallelogram fin was tested on a separate day from the clipped delta fin due to the low temperatures that day. However, that was one of the only days with a low wind temperature. Because of this, the remaining tests were forced to occur on a day with high wind speeds, around 19 mph. This means that if the clipped parallelogram fin does worse than another fin based on numbers, then the wind would be taken into account when determining the final answer to the experiment.



When the rocket was launched, it had a similar start to the rocket with the clipped delta fins. However, it did not fly as high as the previous rocket. The rocket managed to achieve a height of 137.5 meters, and the angle that it was launched from was 60 degrees. Once the rocket received a height of around 137.5 meters, the engine burst, and the rocket immediately began its descent. The rocket traveled northeast from the launching pad, and it achieved a distance of 96.7486 meters before coming into contact with the ground. Its total flight time was 12.5 seconds. Fortunately, the rocket was not damaged unlike the rocket with the clipped delta fin. The rocket was firm as it zoomed downwards, planting itself into the ground.

Elliptical Fin

The third and final design that was tested for this investigation was the elliptical fin. The elliptical fin was tested on the same day as the clipped parallelogram fin because weather conditions weren't as extreme. This means that all of the weather conditions described for the clipped parallelogram fin will therefore be applied to the elliptical fin as well.

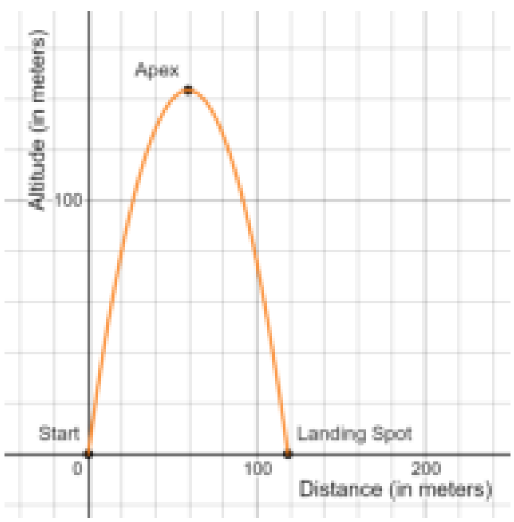
The overall performance of the elliptical fin was quite shocking. The launch did not go as smoothly as the others. Instead, it went northwest of the launching pad and landed on top of the school nearby. No damage was done to the school, or to any other objects nearby. However, due to its position after its flight, the rocket wasn't able to be recovered. The rocket immediately turned west when launched, only achieving a height of roughly 34 meters at an angle of 25 degrees. Once it turned west, it started heading north, and eventually landed on top of a school nearby. The time estimated for this launch was 7 seconds, and the distance estimated for this launch was 113.7158 meters. The rocket did not fly as high or as long as the previous two, and the launch evidently went haywire. Because the rocket was unrecoverable, the distance was roughly estimated based on an idea of where it landed on the school roof. Thus, this launch was inferior to the previous two launches.

Note:
This picture illustrates the rocket with the clipped parallelogram fins (left) and the rocket with the clipped delta fins (right). The rocket holding the elliptical fin isn't shown because it wasn't able to be located and retrieved. The clipped parallelogram fin rocket wasn't as badly damaged as the clipped delta fin rocket. The clipped parallelogram fin rocket obtained no severe damage, but the nose got stuck into the fuselage. Other than that, no harm came upon the rocket.
The clipped delta fin rocket underwent more severe damage compared to the clipped parallelogram fin rocket. The top half suffered greatly compared to the bottom half. One part of the fuselage had cracks while another part tore open, and was bent, revealing the nose and the string attaching it to the fuselage. The rocket evidently had a rougher landing.

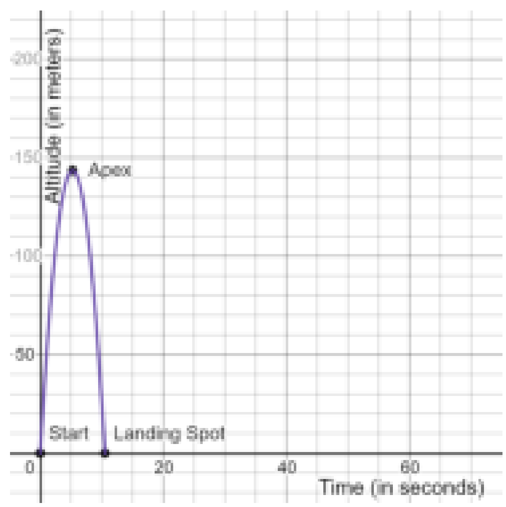
Results

Below are the graphs for each type of fin. These graphs take three variables into account. These variables are altitude (in meters), vertical distance (in meters), and time (in seconds). Each fin has three graphs illustrating the launch of its corresponding rocket.

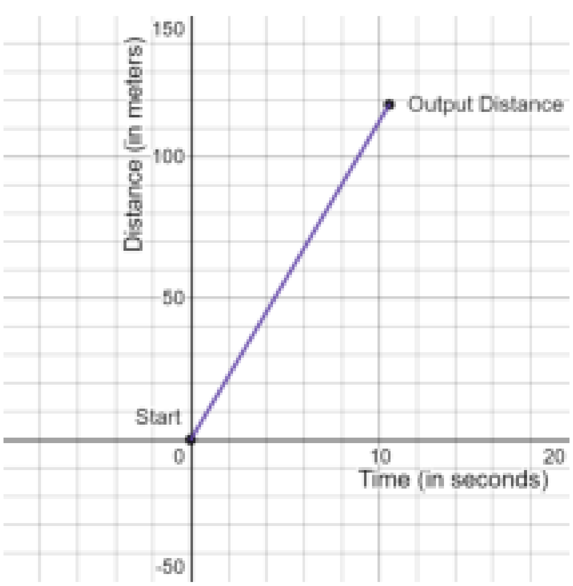
Clipped Delta Fin



Clipped Delta Fin: Altitude vs Distance
This graph represents the altitude of the clipped delta fin compared to the horizontal distance from the launching pad to where the rocket landed.
Equation: f(x) = -1/24.439165 (x-59.2201)^2

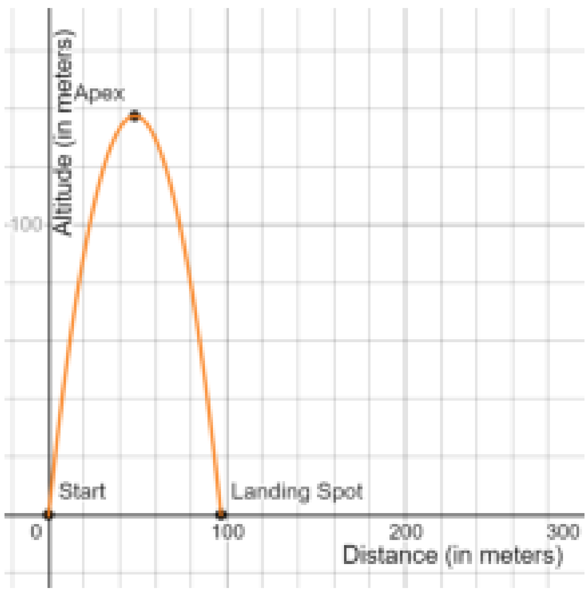


Clipped Delta Fin: Altitude vs Time
This graph represents the altitude of the clipped delta fin compared to the final flight time of the rocket from take-off to landing.
Equation: f(x) = -5.196447 (x - 5.255)^2 + 14



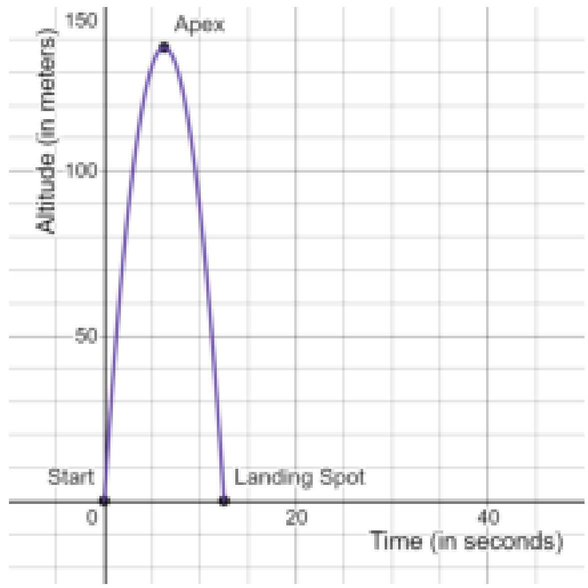
Clipped Delta Fin: Distance vs Time
This graph represents the horizontal distance of the rocket to the launching pad and it is compared to the final flight time of the rocket from take-off to landing.
Equation: f(x) = 11.266x

<u>Clipped Parallelogram Fin</u>



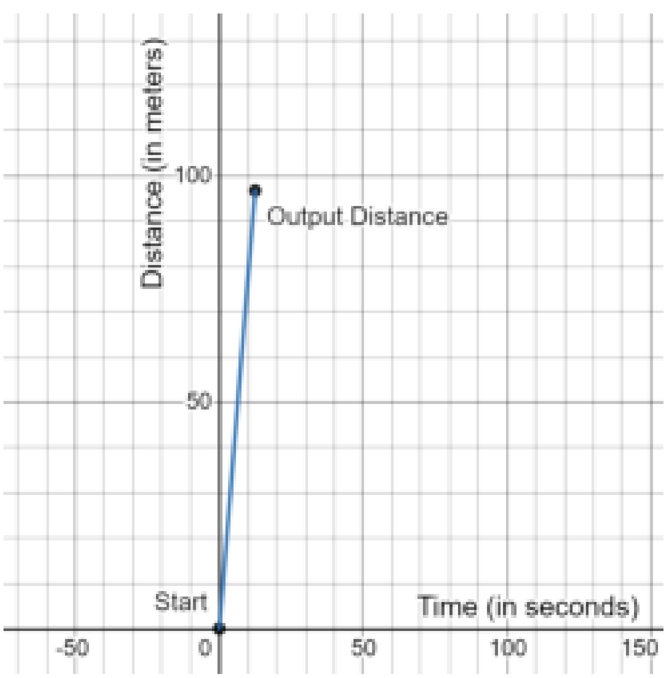
Clipped Parallelogram Fin: Altitude vs Distance
This graph represents the altitude of the clipped parallelogram fin compared to the horizontal distance from the launching pad to where the rocket landed.

Equation: f(x) = -1/17 (x-48.4)^2 + 137.5



Clipped Parallelogram Fin: Altitude vs Time
This graph represents the altitude of the clipped parallelogram fin compared to the final flight time of the rocket from takeoff to landing.

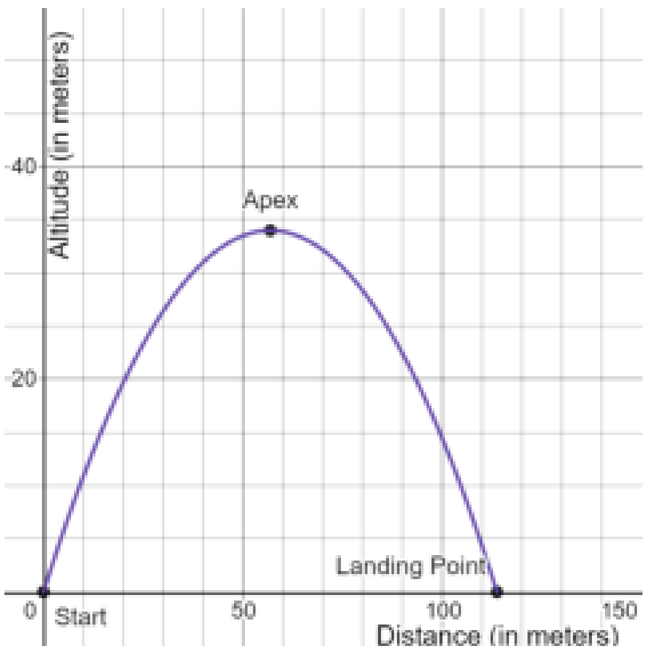
Equation: f(x) = -3.52(x-6.25)^2 + 137.5



Clipped Parallelogram Fin: Distance vs Time
This graph represents the horizontal distance of the rocket and it is compared to the final flight time of the rocket from take off to landing.

Equation: f(x) = 7.7399x

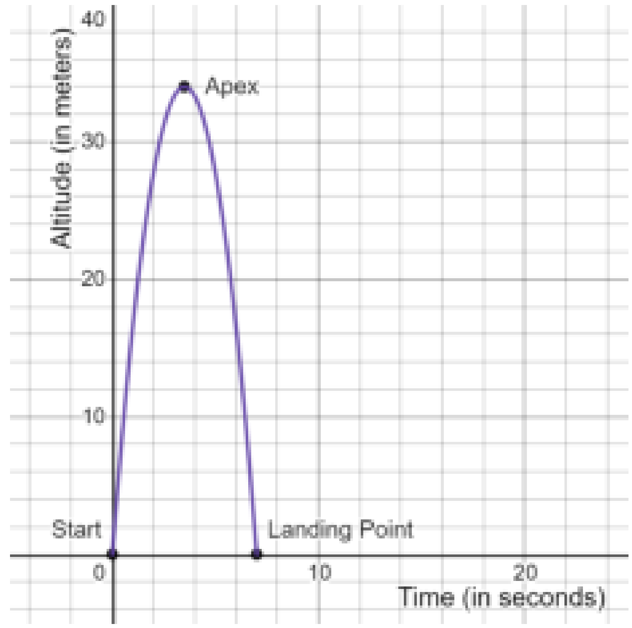
Elliptical Fin



Elliptical Fin: Altitude vs Distance

This graph represents the altitude of the elliptical fin compared to the horizontal distance from the launching pad to where the rocket landed.

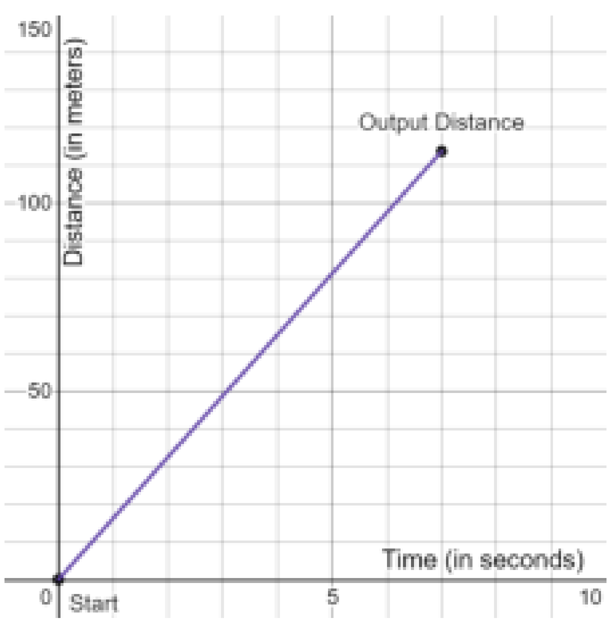
Equation: f(x) = -1/95.082964 (x - 56.8579)^2 + 34



Elliptical Fin: Altitude vs Time

This graph represents the altitude of the clipped compared to the final flight time of the rocket from takeoff to landing.

Equation: f(x) = -2.77551 (x-3.5)^2 + 34



Elliptical Fin: Distance vs Time

This graph represents the horizontal distance from the launching pad to where the rocket landed and it is compared to the final flight time of the rocket from takeoff to landing.

Equation: f(x) = 16.245x

Final Results

Type of Fin	Final Height (in meters)	Final Distance (in meters)	Flight Time (in seconds)	Wind (in mph)
Elliptical Fin	34 meters (25 deg)	113.7158 meters	7 seconds	19 mph
Clipped Delta Fin	143.5 meters (60 - 62 deg)	118.4402 meters	10.51 seconds	8 mph
Clipped Parallelogram Fin	137.5 meters (60 degrees)	96.7486 meters	12.5 seconds	19 mph

Clipped Delta Fins

Clipped Parallelogram Fins

Elliptical Fins

Discussion

Data Analysis and Interpretation

The main purpose of this investigation was to research which type of rocket fin would perform the best, an elliptical fin, a clipped delta fin, or a clipped parallelogram fin. By acknowledging each result for each category for each rocket, and taking into account wind conditions and weather conditions, it can be concluded that the best type of rocket fin is the clipped parallelogram fin. Followed by the clipped parallelogram fin is the clipped delta fin, and the elliptical fin did the worst out of the three, earning its spot as last place.

However, uncontrolled variables may have taken place. This includes the direction of wind speeds that took place during the experiment. During each launch, the wind could've played a role in determining the height and distance of each rocket. For example, when launching the clipped delta fin rocket, the wind speeds were low. Whether they were blowing towards the direction of the rocket or away towards the direction of the rocket is a mystery. Furthermore, the difference in wind speed and direction for the clipped parallelogram fin and the elliptical fin may have made a difference in the total flight time, distance, and height. Certain fins may behave differently according to different wind speeds. This applies mainly to the elliptical fin rocket. When launched, the rocket went into disarray and ended up being non-retrievable. Perhaps it wasn't caused by the design of the fin, but by a sudden gust of wind, or any unknown weather conditions taking place that would have affected the launch.

Theoretically, an elliptical fin is supposed to perform the best. According to Apogee Rockets, a website that sells rocket materials and makes tutorials on how to use them, elliptical fins produce the least amount of drag. The elliptical-like shape of the fin allows the lift to be sent closer to the fuselage. It also allows incoming air to roll off the faces and edges, causing the airflow to steady, sending lift closer to the fuselage because the fin is longer near the fuselage, thus resulting in less drag. This means that there is less lift at the top of the fin, which proves why elliptical fins are theoretically superior to any other model rocket fin.

However, the results produced from this investigation beg to differ. The experiment investigating the same question that Apogee Rockets answered concluded in the elliptical fin producing the worst result. This is shocking as most people believe that elliptical fins produce excellent results. Two occurrences that may have influenced the test include the design of the elliptical fin being flawed, or the wind conditions at that moment disrupting the launch. Similar events regarding model rockets show that the clipped delta fin outputted remarkable results for rockets of greater sizes and greater engines. Most model rockets that have been launched have either clipped delta or clipped parallelogram fins. The results in the investigation show that these two fins produce around the same results, with the clipped parallelogram fin taking the crown for the best type of rocket model fin out of the three. This means that although elliptical fins may theoretically be the best type of fin, they are not used as much as clipped delta fins or clipped parallelogram fins. This may also mean that clipped delta fins and clipped parallelogram fins are more flexible.

If this experiment were to be repeated, the weather conditions would be taken into account, and the launch would be done in a wider field. The launch process would've repeated itself, but the time that the launch would occur would differ based on the weather condition for each hour.

Reliability Analysis

The method that was used to launch and test each type of rocket is the typical way for model rockets of all kinds of shapes and sizes to launch into the sky. Launching pads have multiple components that make rockets launch into the sky, and the launching pad purchased for this experiment was no different. However, the method used to launch and test each rocket isn't the most reliable one because weather conditions can affect the launch, either in a good way or a bad way. Even though the method used wasn't as reliable, it was still efficient because it helped discover the answer to the investigation. By utilizing the method of inserting a B6-4 engine into each rocket, inserting a spark plug into each engine, connecting it to a launch controller, and putting the rocket on the launchpad, a rocket can constantly achieve around the same result. This is because the method will never change, regardless of the type of rocket that is being used, or the type of fin that is being used. The only times when results may appear different are when wind speeds are high.

To conclude, the method used to test and launch each rocket wasn't 100% accurate, but it was efficient to the point where each rocket was tested and analyzed successfully. Possible conditions that could have made the launch not 100% accurate include wind speeds, the direction of those wind speeds, and any other unknown factors that could've influenced the launch.

Validity Analysis

The sequence of creating a rocket and preparing it for flight is a long one, but if the steps are followed accurately, then the necessary requirements will be met for each rocket when launched. The procedure that was utilized to launch each rocket was successful every time because the distance of each rocket, the height of each rocket, and the flight time of each rocket were successfully recorded. Unless weather conditions are extreme, the technique used to launch the rocket shouldn't fail to supply the rocket with distance, height, and flight time. This makes the procedure used to launch the rockets nearly accurate.to measure what it is intended to measure.

Multiple sources can also be used to prove that the technique used to launch each rocket was valid. Multiple videos show clipped parallelogram fins and clipped delta fins achieving similar results to the fin designs used in this investigation. The only fin that produced different results was the elliptical fin, but this may have been due to the design of the fuselage or the fin itself. By using this knowledge, a conclusion can be made that the results achieved in this experiment weren't by chance, but rather by the design of each fin and fuselage. The designs that were utilized allowed the clipped parallelogram and clipped delta fins to achieve around the same results that other people achieved using those exact same fins.

The mean for the height was 105 meters. The mean for the distance was 109.634 meters. The mean for the flight time was 10.003 seconds. Apogee Rockets, Estes Rockets, and Simple Rocketry explain that the average height a rocket achieves with a B6-4 engine is between 100 and 2500 feet. The average distance that a model rocket achieves with a B6-4 engine is between 0 feet and 400 ft. The average flight time for a model rocket with a B6-4 engine is between 0 to 20 seconds. This correlates with the data obtained from this experiment and proves that the results achieved from this investigation are not random, and are to be expected from any model rocket. This also validates the data points achieved from each rocket.

Conclusion

The purpose of this experiment was to investigate the type of rocket fin that could best increase the height, distance, and flight time of a rocket. The three types of rocket fins that were used in this experiment were an elliptical fin, a clipped delta fin, and a clipped parallelogram fin. In order to achieve the experiment, the fins had to be designed on Autodesk, and then 3D printed and glued onto a fuselage.

The hypothesis formed for this experiment was that if conditions were favorable, then a clipped parallelogram-shaped fin would influence the distance, height, and time of the rocket the greatest. This hypothesis was supported due to the fact that the clipped parallelogram performed the best out of the three fins tested, despite weather conditions and wind speeds acting upon it.

The main idea that can be drawn from this experiment is that the best type of rocket fin that can be utilized to influence a rocket's height, distance, and flight time the most is the clipped parallelogram fin. This is due to the clipped parallelogram fin producing a low amount of drag during flight, and it performed the best due to it being flexible to weather conditions and having a design that could penetrate through extreme wind conditions.

This experiment could have been improved if each rocket was tested in the exact same weather conditions. These weather conditions would include a decent temperature, a clear sky, and a low wind speed. Also, if each rocket was tested on the same day, then that would provide more reliability for the results because each rocket would've been tested in the exact same environment. That way, the only variable that could've possibly changed would be the type of rocket fin.

This experiment could be taken further to examine the types of rocket fins that would increase specific variables in specific conditions. The information gathered from the investigation can help young rocketeers develop their rockets and maximize their full potential to make their rockets soar into the sky. Scientists can also develop the results achieved from this experiment, and help develop rocket fins on real rockets. The purpose that this investigation serves can be applied to model rockets, but it can also be researched deeply so as to truly find out the best type of rocket fin under various conditions, even conditions beyond Earth.

Furthermore, future research regarding rocket fins can also involve the best type of material, the best width and length for model rocket fins, and the best conditions for launching rockets. Findings recorded from these possible experiments combined with the findings achieved from the current investigation can help develop rocketry as a whole. Whether rocketeers use this for their own personal fun, or for their own personal research, the analysis regarding the best type of rocket fin in terms of height, distance, and flight time will help develop rocket science, and help rocketry thrive forevermore.

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- Alyssa Anderson - Teacher at ESUMS - Part of Science Club Staff: Provided a classroom and additional resources for the project. Signed permission slips to enact the investigation.
- Paula Matei-Grysiak - Teacher at ESUMS - Part of Science Club Staff: Provided a classroom and additional resources for the project. Signed permission slips to enact the investigation.
- Patricia Joseph - 12th Grade Student at ESUMS - Part of Science Club Staff: Provided additional resources and past knowledge and experiences for the project.
- Brian MacWilliam - Innovation Instructor - Runs the School Woodshop: Supplied materials needed to fully build each rocket, and allowed the rocket assembly to occur in the woodshop. Helped create the rockets, and gave valuable information and feedback necessary for the creation of each rocket.
- Hunter Smith - Teacher at ESUMS: Delivered the 3D printed fins to the woodshop and gave advice
- Naidhruv Ananth Iyer - 12th Grade Student at ESUMS - Part of Science Club Staff: Provided past knowledge and experiences with rocketry. Helped record flight time for the clipped delta fin rocket.
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- Sujit Gokhale - Parent of Parth Gokhale: Helped record flight time for the elliptical fin rocket and the clipped parallelogram fin rocket. Provided Financial Aid.

References

- *Estes Rockets*, 1 Feb. 2022, https://estesrockets.com/.

- Apogee Components, Inc©. "Model Rockets & How-to Rocketry Information. " Model Rockets & How-To Rocketry Information, https://www.apogeerockets.com/.

- Perfect, Dude. "Model Rocket Battle 2| Dude Perfect - Youtube." *Youtube*, https://www.youtube.com/watch?v=uPCi5Rs7EuA

- "Science Learning Hub. " *Science Learning Hub*, https://www.sciencelearn.org.nz/.

- *NASA*, NASA, https://www.nasa.gov/.

- "Home." *Calculator.net: Free Online Calculators - Math, Fitness, Finance, Science*, https://www.calculator.net/right-triangle-calculator.html

- "Graphing Calculator." *Desmos*, https://www.desmos.com/calculator

- Apogee Components - Tutorial Videos

- Thompson, Grant. "How to Build a Rocket (from Scratch) - Youtube. " *Youtube*, https:www.youtube.com/watch?v=r2lDXoW78u0

- "How To Measure Altitude of Your Rocket." *YouTube*, YouTube, https://www.youtube.com/watch?v=lrkyBcf7h58&t=105s

- *Autocad Basic Tutorial for Beginners - Part 1 of 3 - YouTube.* https:www.youtube.com/watch?v=cmR9cfWJRUU

- *Autocad Basic Tutorial for Beginners - Part 2 of 3 - YouTube.* https://www.youtube.com/watch?v=g_jKTv3pLp0

- *Autocad Basic Tutorial for Beginners - Part 3 of 3 - YouTube.* https://www.youtube.com/watch?v=37S-2wZ2r0Q