What is the Ideal Number of Fins for a Model Rocket?

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Thanks to my parents for supporting this project and

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1. Purpose

The purpose of this paper is to find the number of fins to lift a model rocket to maximum height. Different numbers of fins have different impacts on the rocket's aerodynamics. I will test zero to four fins on model rockets to determine which gets the highest flight. Also, I hope this experiment will inspire other people to begin model rocketry.

2. Hypothesis

I think that the best fin design for this project will be four fins. It will be the best because it will have the most aerodynamic stability. Also, I think three fins would work well on the rocket because it will also have large amounts of stability. I estimate that the best design will go a least 30-60m above second place. I think that the classic design of four fins at the bottom will be slightly better than average. The other fins (zero, one, and two) I think will do okay. One will not do so well because it would be off balance and zero would do okay because if there is no wind it would do well. Two fins should flip over because of balance but it could still do good

3. Background Research

According to the website Rockeeters.in the history of model rocketry started after World War II when V2s (WW2 missile) and other rockets were all the craze. Many professionals were making their own fuel and rockets while others did not have the money or experience. One of those professionals wanted to make rockets available to the general public though. He was the founder of Estes, the largest model rocket supplier today. He started it in his basement making rocket fuel and wood bodies and now has a massive company. Now many people can use rockets, even people with no experience. (The Rise and Rise on Model Rockets, 2018).

The Nasa.gov website discusses the history of rockets. The first rockets were used in the early 12th century. They were basically long poles with fireworks on top of them. They were used to launch at enemies as early missiles. Eventually people wanted them to be smaller so they shortened the stick and added fins. Throughout the 13th to 15th centuries rockets were upgraded and made at a higher quality. In the late 17th century rockets were made into the science of aerodynamics and fuels. People began working with very powerful rockets to go high up. Eventually in the Revolutionary War powerful rockets were used to bombard US ships. Rockets were very successful in war, and in peace until Prussia invented artillery. After that, rockets slightly fell into disuse and were only used for fireworks. Later in 1898 a teacher suggested that rockets could be used for space exploration and proposed the first liquid rocket fuels. Then later in 1910-20 a man named Robert Goddard wrote a book proposing the first sounding rockets, they are small rockets that go a small distance into the air. He has been called the father of modern rockets. Many rocket societies had come up across the globe and many governments were testing small rockets. In WW2 german scientists had created the V2 which was a missile/ rocket. Later, the first artificial satellite was placed in orbit by the USSR and that began the space race. Rockets were very popular and new and more rockets were created as time went on. Now many agencies and governments are looking forward towards a future where humanity is a spacefaring civilization. (Brief History of Rockets, n.d.).

The Science Learning Hub website discusses rocket aerodynamics. Their (“Rocket Aerodynamics,” 2011) article says, “The stability of a rocket is its ability to keep flying through the air pointing in the right direction without wobbling or tumbling. Fins are used on smaller rockets to provide this stability and control direction. It works in the same way as placing feathers at the tail of an arrow."

The website discusses additional aerodynamics related to fins. The greater drag on the fins keeps the tail of the dart at the back so that the point of the dart travels straight and does not go off course. Fins are used on most rockets to provide stability and control the angle of the rocket. They are essential for traveling straight through the atmosphere. Aerodynamics of a rocket depend on the center of mass and the shape of the fins. The center of mass depends on the weight of the rocket and it can turn the rocket different ways in the air. Having a low center of mass is important because it will keep the rocket stable and pull the bottom down to prevent the rocket from flipping. If there is a high center of mass the rocket can flip and go upside down. (Rocket Aerodynamics, 2011).

4. Materials

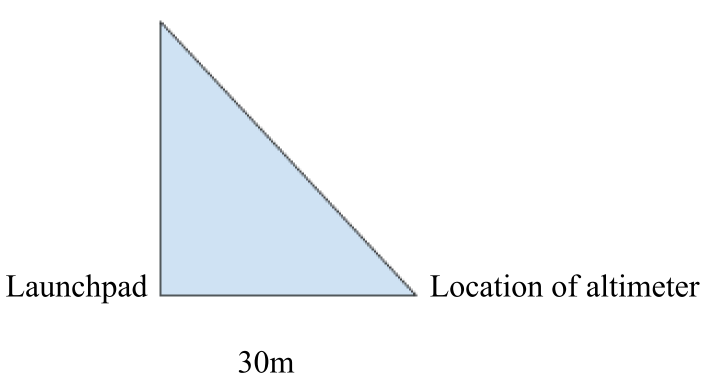
The materials in my experiment include: black powder rocket motors, waxed cardboard body tubes, estes small launchpad, balsa wood fins and an estes launch controller. The most common rocket motor on the market is the black powder motor. These motors have clay nozzles in a paper sleeve with rocket fuel inside which propels the rocket up into the sky. The body of the rocket model can be made out of many different things like cardboard or construction paper. It is possible to change the body by making it a different shape or material. The fins of the rocket are made of a very lightweight wood or plastic. It is possible to change the shape of those too. It is best to use a small launchpad with a metal rod to angle the rocket. Some homemade rockets can be a bit on the smaller side but they work just as well as bigger rockets. By using a rocket launch controller, a person can ignite the rocket from a distance with an igniter that send an electrical charge to the engine, firing it up. Can I insert a video of me explaining a rocket launch?

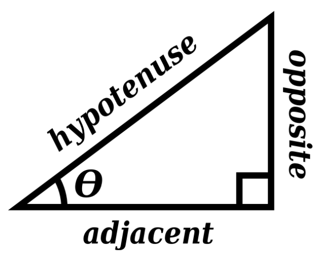
5. Procedure

The experiment for this project is what is the best number of fins on a model rocket and how do the fins impact aerodynamics. I am doing this by measuring the altitude of the rocket and other factors which make up this project. I will try to do 3 launches for each rocket in total keeping factors like wind speed constant. There will be 5 different variations of rockets. Also, there are many different parts of the rocket too which I will explain.

I am doing each launch by setting the engine into the rocket, then stuffing the parachute into the rocket with wadding. I set the rocket on the launch pad and connect the controller to the rocket. I then fire the engine and the rocket launches. Here is a video of me explaining the launch procedure: https://photos.app.goo.gl/pY5ikvH7HupUZXSt6.

The parachute deploys and we find the angle by going 30m away from the launch and use an altimeter to find the angle of the rocket. With that angle you do trigonometry to find the approximate height of the rocket. Here is the trigonometry:





$\text{Tan A} = \frac{opp}{adj}$ So, $\tan A = \frac{x}{30}$ (A = angle)

Using this ratio I plugged in the angle measures from the altimeter measurements I took during the trials. Then I solved to find the altitude of each launch.

6. Results

I did each launch in 9-10 mph winds, it was cold conditions and cloudy skies. Launch one was a rocket with zero fins; this rocket went mid height (average 32m) compared to others but eventually lost control. Launch two was a rocket with one fin and it went low height (average 12m) and lost control, spiraling end over end. Launch three was a rocket with two fins and it went very low (average 15m) and lost control early. Launch four was a rocket with three fins and it went very high (average 58m) and did not lose control. Launch five was a rocket with four fins and it went even higher (average 79m) and did not lose control.

Flight Data Table

Rocket No.	**Launch 1**	**Launch 2**	**Launch 3**
Prototype 1 Zero Fins	48 Degrees 33m	47 Degrees 32m	46 Degrees 31m
Prototype 2 1 Fin	21 Degrees 11m	22 Degrees 6m	30 Degrees 17m
Prototype 3 2 Fins	35 Degrees 21m	28 Degrees 16m	25 Degrees 9m
Prototype 4 3 Fins	64 Degrees 62m	66 Degrees 68m	61 Degrees 54m
Prototype 5 4 Fins	70 Degrees 83m	69 Degrees 79m	68 Degrees 75m

7. Conclusion

In conclusion, after 3 launches each of zero wings, one wing, two wings, three wings, and four wings, almost all the rockets performed as expected. Only the zero winged rocket did not but that rocket did better than expected. The four winged rocket did very well and flew high and the three wings just a little bit lower than the four winged rocket it went lower because it was more off balance because of less fins. Two wings because it had no balance on one side so it did normal but not as high as the three wing and the four winged rocket. One wing did ok, but it still flew very short. Zero wings did very well and shot straight up, still going under other rockets but much better than expected it was better balanced than others because of no small numbers of fins.

My hypothesis was correct and four wings did the best with three wings coming right under it. They both also went much higher than the others so when I estimated they would go far above the others I was correct. In conclusion, the rocket with better balance and better aerodynamics is the better rocket because equal fins create more balance and still produce minimal amounts of drag. This was a very fun project because I got to learn how aerodynamics affect rockets.

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