ABSTRACT

This Independent research project investigates how much water is needed in a water rocket for it to have the longest flight time. The rocket flights took place at the local oval, all flights were timed and video recorded. The air was pumped into the bottle using a pump with a pressure gauge, up to 50 psi. The rocket was then released and the timer started. The hypothesis was that a rocket with 30% water in it would stay in the air for the longest. This was proved wrong and the rocket with 40% water had the longest flight time with an average of 5.3 seconds in the air. The rocket with 30% water had an average flight time of 5.22, very close to the rocket with the longest flight duration. The rocket with 90% water didn't fly for very long as it was too heavy and didn't have enough space for enough thrust to fly for very long.

AIM

To see how much water is needed in a water rocket for it to be propelled into the air for the longest flight time.

• Independent variable: Amount of water in the rocket
• Dependent variable: Flight time

RESULTS

<table>
<thead>
<tr>
<th>Water Fill Level (%)</th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3</th>
<th>Test 4</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3.2</td>
<td>2.31</td>
<td>2.76</td>
<td>3.01</td>
<td>2.82</td>
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<tr>
<td>10</td>
<td>4.2</td>
<td>3.44</td>
<td>4.61</td>
<td>4.3</td>
<td>4.14</td>
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<tr>
<td>20</td>
<td>4.96</td>
<td>4.5</td>
<td>4.84</td>
<td>4.95</td>
<td>4.81</td>
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<tr>
<td>30</td>
<td>5.36</td>
<td>4.99</td>
<td>5.26</td>
<td>5.28</td>
<td>5.22</td>
</tr>
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<td>40</td>
<td>5.55</td>
<td>4.89</td>
<td>5.41</td>
<td>5.37</td>
<td>5.3</td>
</tr>
<tr>
<td>50</td>
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<td>5.2</td>
<td>4.92</td>
<td>5.2</td>
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<tr>
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<td>4.32</td>
<td>3.78</td>
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<td>2.73</td>
<td>2.65</td>
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<td>2.69</td>
<td>2.72</td>
</tr>
<tr>
<td>90</td>
<td>1.37</td>
<td>1.28</td>
<td>1.4</td>
<td>1.36</td>
<td>1.35</td>
</tr>
</tbody>
</table>

DISCUSSION

• The purpose of this investigation was to investigate how much water is needed in a water rocket for it to have the longest flight time. The hypothesis was that the rocket with 30% water would have the longest flight duration. The results from the experiment show that the rocket with 40% water actually had the longest flight time.
• The accuracy of the experiment can be improved in a number of ways. The amount of water in the rocket was never exact as there were some leaks when plugging it onto the launch pad. The weight of the rocket also sometimes changed due to water leaking into the foam nose. The experiment did have the same materials used throughout the whole experiment. The stopwatch that was used had millisecond to get more accurate results for the flight time.
• The experiment was reliable because someone else could do the same thing and get similar results. The experiment was repeated four times to get enough results to draw a conclusion. They were also close to each other and there were no strange results gathered.
• The investigation was valid as it tested the aim. The same air pressure was used through the whole experiment and only the amount of water was changed. All the other factors in the experiment were kept the same.
• The results collected followed a trend with the flight time increasing and then at 40% water it decreases because of the weight and there not being enough air. The test with 60% water was lower then expected but this could be because the rocket was getting heavier.
• Difficulties that were faced through the experiment was the rocket breaking and being unstable. After the first rocket broke the design was modified to have more stability to get more accurate results. After the new rocket was constructed all results had to be redone. This took more time but was beneficial in the end as the second rocket was stable, never broke and consistent results were collected.

CONCLUSIONS

• The rocket with 40% water in it was in the air for the longest. The rockets with little water in them didn’t have enough water to push it high in the air and the rockets with lots of water didn’t have enough air pressure to push the water out.

AIM

To see how much water is needed in a water rocket for it to be propelled into the air for the longest flight time.

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METHOD

1. Fill the bottle with 10% water
2. Tip the bottle upside down and connect it to the release mechanism at the end of the hose making sure not to spill the water out of the bottle.
3. Pump the air into the bottle with the bike pump to 50 psi as measured using the pressure gauge
4. Activate the release mechanism from the bottle by pulling the string attached and start the timer.
5. When the rockets hits the ground stop the timer.
6. Record the time the rocket was in the air into a table
7. Repeat the experiment with the amount of water 4 times
8. Do the same with 0%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, and 90% water and record results
9. Calculate the averages

EVALUATION

In my experiment I kept the air pressure the same at 50 psi. I measured this using the pressure gauge on a bike pump. After testing different rockets the rocket that I ended up using was strong and held together well and the design with a foam nose was good because it made the landing softer. The same size and brand of bottle was used through the whole experiment. The variables were controlled and I would say that the experiment was valid. I repeated the experiment and got similar results each time.

• Some areas that I could have improved would be the accuracy of the results I collected. There were inaccuracies of the amount of water in the rocket due to leakages when plugging the rocket onto the launch pad. Some improvements would be to read the water level after plugging in the rocket before the launch and add any lost water. The water level markings on the rocket also weren’t perfect as they were not fully straight. The weight of the rocket also changed somewhat through the experiment as water absorbed into the foam nose. I could have put a better barrier between the bottle and the foam so that if it cracked like it did the water wouldn’t go through. The timing of the rocket in the air wasn’t perfect. The stopwatch accuracy varied with my reaction time to press start at the correct time. I did have the same person press the timer each time. Next time I could design a way to have the timer start when the rocket is released without having a person press start. The videos were also used to time the flights and look at the lift off in slow motion.

• The火箭 with 40% water in it was in the air for the longest. The rockets with little water in them didn’t have enough water to push it high in the air and the rockets with lots of water didn’t have enough air pressure to push the water out.

• Diagram of the rough water rocket and launcher set up
• http://www.aircommandrockets.com/rocket_launcher.htm
There are many different types of water rockets out there and many different ways of making your own one. They have been used in schools to help teach kids about aeronautics. Water rockets are used by dragging a corner. It’s designed to be printed on a photo paper. It’s designed to be printed on a photo paper. Printing:


**BACKGROUND RESEARCH**

- **Water and air**
  - A water rocket is a type of rocket that uses water and pressurized air as the energy to propel it out the nozzle. The bottle is filled partially with water and then pressurized with air. Pushing the water out the nozzle at the back creates thrust and causes the rocket to move in the other direction.
  - For the rocket to be in flight for the longest time you have to find the best ratio of water to air. If the rocket has too much water and not enough air then it will be heavy and won’t accelerate fast. It also won’t have enough air to thrust out all the water. When there is a lot of water in the bottle the air in the bottle needs to expand many times its original volume in order to push out all the water. As the air expands the pressure drops, when the pressure inside reaches the same pressure as outside no more water comes out. If the expansion of the air stops before all the water is pushed out then the remaining water is extra weight which reduces the acceleration of the rocket.
  - If the rocket only has a small amount of water in it then it accelerates rapidly but for only a short time. There is air pressure remaining in the bottle after the water has come out which can’t be used to accelerate the rocket.
  - The best ratio of water and air is a compromise between the acceleration and the length of time that the acceleration occurs over.

- **Stability**
  - For the rocket to go up in a straight line, the centre of pressure needs to be behind the centre of gravity. As the rocket flies through the air, aerodynamic forces act on all parts of the rocket. The aerodynamic forces act through a single point called the centre of pressure. The centre of pressure can be calculated by working out the projected area of each part and how far it is from a reference location. A simplified formula was found on the NASA website and used to calculate the center of pressure for the rockets. As the rocket flies through the air it rotates. The rotation occurs around the point called the center of gravity. A formula was also found on the NASA website. The centre of gravity moves as the amount of water changes. As the amount of water is reduced the centre of gravity moves further towards the back. To keep the centre of gravity in front of the center of pressure fins are required. The fin area and location was calculated so that the rocket would be stable no matter how much water there was. The diagram shows when the cp is behind the cg the lift from the rocket pushes the rocket back on track if it is pushed off track. The chart shows the position of the centre of gravity and the centre of pressure vs the amount of water in the rocket.

- **Rocket simulation**
  - An excel spread sheet that calculates the acceleration, speed, height and duration of a water rocket was found on the university of Queensland site. The characteristics of the test rocket were put into the simulation and compared with the actual measurements. The results were relatively close to what was measured. The simulation crashed and burned if there wasn't enough air pressure to force all the water out of the bottle, in this case at 65%.

- **Bottle type**
  - For the body of the rocket there are many different styles of plastic water bottle that I could use. I have found that the Schweppes 1.25L soft drink bottle will be ideal for my experiment because of the shape that it has. The profile of the Schweppes plastic bottle is close to the same through the body of the bottle giving it optimal aerodynamics. It will glide better in the air while other bottles such as the Deep Spring’s bottles, are wider at the top and bottom and skinnier in the middle. Schweppes have reduced the weight of their plastic bottles which will make it go up higher. It also has the best lid to use as it is deeper than other 1.25L bottles. This makes it a lot easier when putting the sprinkler adaptor and washer through the lid as it then still has space to screw back on and create an adequate seal.

**ACKNOWLEDGEMENTS**

- Alan Hinds – for helping me design the rocket and do the experiment
- Robyn Hinds – for helping me carry out the experiment
- Miss Crain – guiding me in the correct direction and assisting when needed

**BIBLIOGRAPHY**