SASTA OLIPHANT SCIENCE AWARDS

SOUTH AUSTRALIAN SCIENCE TEACHERS ASSOCIATION

Prize Winner

Science Investigation

Year 5 - 6

Amir Chaloob

Pulteney Grammar School

Rowe Scientific Pty. Ltd. www.rowe.com.au

Government of South Australia
Department for Education

SASTA South Australian Science Teachers Association

Amir Chaloob ID: 0529-016
Scientific Inquiry Report
Optimising Water Rocket Efficiency
Oliphant Science Awards 2026

Optimising Water Rocket Efficency

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Category: Science Investigation Report
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Optimising Water Rocket Efficiency

Introduction

Water rockets work on the same physics as spacecraft. The water rocket is partially filled with water, then the air is forced into the water rocket via an air pump, the compressed air forces the dense water out the lower nozzle of the rocket, creating a high-speed thrust that drives the rocket upward and the water out of the rocket. This process is based on four principles of motion- Newton's second and third laws of motion, conservation of momentum, aerodynamics and stability.

Aim

To investigate how varying fin number, nose cone weight, nose shape, water volume and launch pressure affects the flight altitude and stability of a water rocket, determining the optimal combination for maximum performance and efficiency.

Hypothesis

The design of the rocket will affect performance and efficiency. The more aerodynamic rocket with a weighted nose cone and streamlined body, 30% water to air ratio and higher compressed air pressure to launch will be the most stable, efficient and reach the highest altitude.

Materials

Table 1: Materials

3x 1.2L plastic bottles	Scissors	Sandpaper
Hot water	PVC primer	PVC cement
20g and 50g metal washer	Super glue	Permanent marker
Laminated paper A3	Electrical tape	Thick cardboard A3
10x2cm pine 1m	Drill bit and drill	¾ inch PVC pipe cap
Bike tyre valve	Sealant	PVC ¾ inch cap
2x 30cm ¾ inch PVC pipe	¾-1 inch PVC elbow	2x U bolts
Bike pump psi 40	Air compressor psi 100	Water
Paper	Pen	

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Method

Rocket construction

1. Rocket construction
   a. Rocket shaft
      i. Take three 1.2L plastic bottles.
      ii. Cut out base of bottle 1 (top) and 3 (base) and both ends off bottle 2 (middle)
      iii. Sand inside bottle 1 and 3 and outside bottle 2.
      iv. Dip the ends of bottle 2 into hot water to reduce its diameter to fit inside bottle 1 and 3.
      v. Use PVC primer then PVC cement to glue bottle 2, 2cm inside the base of bottle 1 and top of bottle 3.
      vi. Mark 10% volume intervals along bottle shaft.
   b. Nose
      i. Add different weighted metal washers to bottle top of bottle 3, secure with glue (nose weight). Use 20g and 50g weights in experiment **part A**.
      ii. For experiment **part B**, form a cone with laminated paper, secure to bottle 1 with electrical tape, making the join smooth.
   c. Fins
      i. Cut 4 slightly curved fins from thick cardboard equal size.
      ii. Secure fins, evenly spaced to the base of bottle 1. Later change this to 3 fins (experiment **part C**).
2. Base construction
   a. Cut 3x 40cm pine wood 10x2cm planks, secure in an ‘I’ shape and drill in place.
   b. Drill a hole in a ¾ inch PVC pipe cap, the same size as a bike tyre valve, insert the bike tyre valve and secure with sealant.
   c. Connect cap to 30cm ¾ inch PVC pipe (A), connect pipe to ¾-1 inch PVC elbow, connect elbow to 30cm PVC pipe (B), position at 90 degrees to ground, securing all joins with PVC primer and cement.
   d. Secure PVC pipe to wooden board with 2x U bolts.
   e. Connect bike pump/air compressor to bike valve.
3. To launch rocket
   a. Fill the rocket with the specific amount of water based on the volume markers.
   b. Load the rocket onto the PVC pipe B (have base upside down), then flip the base onto ground with rocket facing upwards.
   c. Connect air pump (bike pump/air compressor) nozzle to bike valve in the PVC pipe A cap.

d. Pump air into rocket and release once pressure achieved.

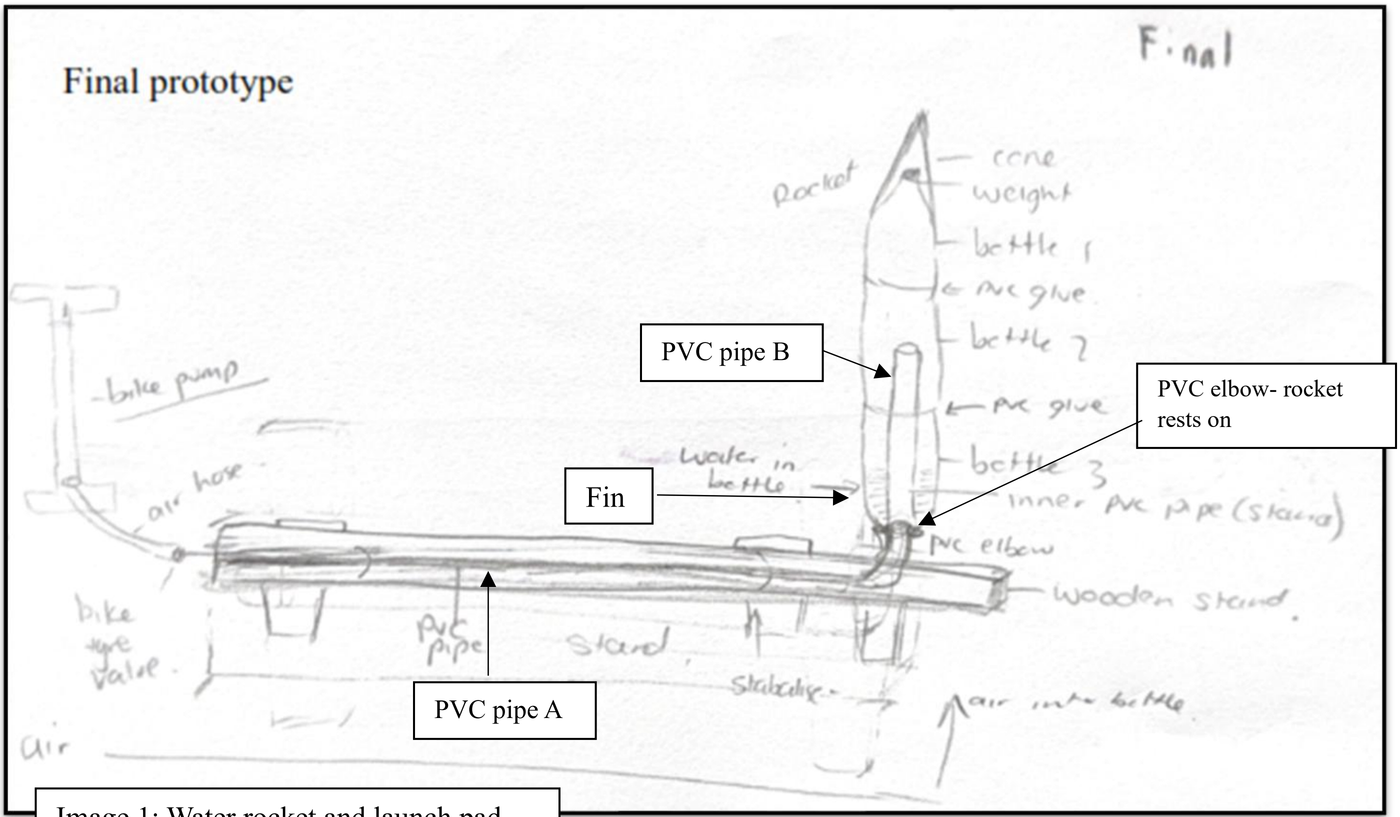

Image 1: Water rocket and launch pad.

Method

Experiment Part A: Weighted vs non weighted nose.

1. Constants- no nose cone, 4 fins, 30% water volume, low pressure bike pump psi 40.
2. Use no nose weight.
3. Launch rocket.
4. Record rocket altitude and stability. Repeat once.
5. Use 20g nose weight- repeat steps 3-4.
6. Use 50g nose weight- repeat steps 3-4.

Experiment Part B: Comparison of aerodynamics and stability blunt versus cone nose.

1. Constants- 4 fins, 20g weighted nose, low air pressure 40 psi
2. With no nose cone- launch rocket
3. Record rocket altitude and stability.
4. Repeat once.
5. With nose cone attached- launch rocket.
6. Repeat steps 3-4.

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Experiment Part C: Comparison of aerodynamics and stability 3 versus 4 fins.

1. Use constants- 20g weighted cone nose, low air pressure 40 psi
2. With 4 fins, launch the rocket with 20% then 30% then 40% then 50% then 60% then 70% water volume, recording rocket altitude, time in the air and stability. Repeat for each water volume.
3. Repeat step 2 with 3 fins.

Experiment Part D: Comparison of low versus high air pressure.

1. Use constants- 3 fins, 20g weight nose cone.
2. With low pressure air 40psi (bike pump), launch the rocket with 20% then 30% then 40% then 50% then 60% then 70% water volume, recording rocket altitude, time in the air and stability. Repeat for each water volume.
3. Repeat step 2 with high pressure air 100psi (air compressor).

Results

Table 2
Experiment Part A: Comparison of no weight versus weighted blunt nose.
4 fins, 30% water, low pressure pump psi 40

Weight	Stability	Height
No weight attempt 1	Unstable	0.8 m
No weight attempt 2	Unstable	0.7 m
20g weight attempt 1	Straighter, more stable	1m
20g weight attempt 2	Straighter, more stable	1m
50g weight attempt 1	Straighter, most stable	0.9m
50g weight attempt 2	Straighter, most stable	0.9m

Table 3
Experiment Part B:- Comparison of aerodynamics and stability blunt versus cone nose.
4 fins, 20g weighted, 30% water volume, low air pressure psi 40

Nose type	Stability	Height
Blunt nose attempt 1	Stable	1m
Blunt nose attempt 2	Stable	1m
Cone nose attempt 1	Straighter, more stable	1.1m
Cone nose attempt 2	Straighter, more stable	1.2m

Table 4

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Experiment Part C- Comparison of aerodynamics and stability 3 versus 4 fins.
20g weighted nose cone, low air pressure psi 40

Fins (number)	**Water %**	**Time in air (sec)**	**Height**	**Stability** **1: Stable** **2. Slight wobble** **3: uncontrolled**
3	20%	3	15m	2
4	20%	1.5	12m	2
3	30%	4	30m	2
4	30%	3.5	25m	2
3	40%	3.5	25m	2
4	40%	2	15m	2
3	50%	<1	4m	1
4	50%	<1	8m	1
3	60%	<1	2m	1
4	60%	<1	2m	1
3	70%	<1	0.8m	1
4	70%	<1	0.8m	1

Table 5
Experiment Part D: Comparison of low pressure 40 psi versus high pressure 100 psi .
3 fins, 20g weighted nose cone

Water %	**Pressure** **Low- bike pump 40psi** **High- air compressor 100psi**	**Time in air (sec)**	**Height**	**Stability** **1: Stable** **2. Slight wobble** **3: uncontrolled**
20%	Low	3	15m	2
20%	High	4.5	100m	2
30%	Low	4	30m	2
30%	High	6	120m	2
40%	Low	3.5	25m	2
40%	High	7	150m	2
50%	Low	<1	4m	1
50%	High	4	90m	1
60%	Low	<1	2m	1
60%	High	<1	80m	1
70%	Low	<1	0.8m	1
70%	High	<1	50m	1

Table 6
Volume and water percentage, total volume 2.8L.

Water percentage	Calculations	Water volume
20%	2.8L ÷ 100 x20	0.56L
30%	2.8L ÷ 100 x30	0.84L
40%	2.8L ÷ 100 x40	1.12L
50%	2.8L ÷ 100 x50	1.4L
60%	2.8L ÷ 100 x60	1.68L
70%	2.8L ÷ 100 x70	1.96L

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Table 7
Efficiency of height per unit of water- low pressure psi 40.
Volume 2.8L (height ÷ water volume)

Water percentage	Water volume (L)	Height reached (m)	Efficiency (height ÷ water volume) m/L
20%	0.56L	15	26.79
30%	0.84L	30	35.71
40%	1.12L	25	22.32
50%	1.4L	4	2.86
60%	1.68L	2	1.19
70%	1.96L	0.8	0.40

Table 8
Efficiency of height per unit of water- high pressure psi 100.
Volume 2.8L

Water percentage	Water volume (L)	Height reached (m)	Efficiency (height ÷ water volume) m/L
20%	0.56L	100	178.57
30%	0.84L	120	142.86
40%	1.12L	150	133.93
50%	1.4L	90	64.29
60%	1.68L	80	47.62
70%	1.96L	50	25.51

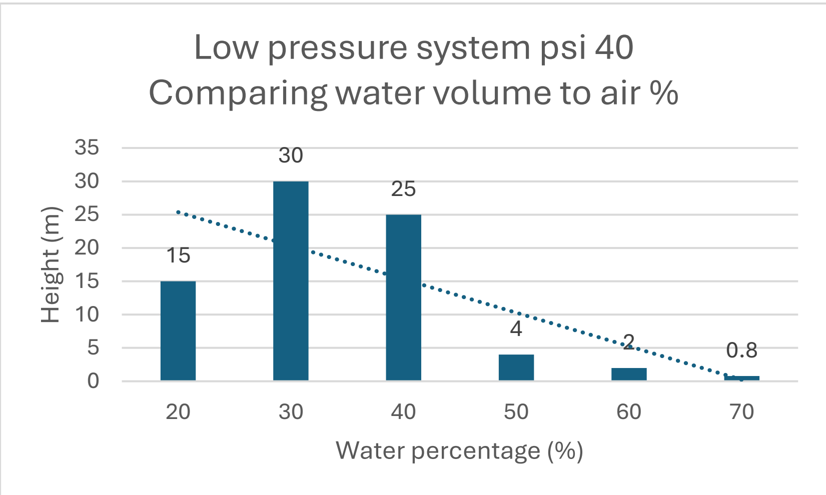

Image 2: Comparison of water to low air pressure

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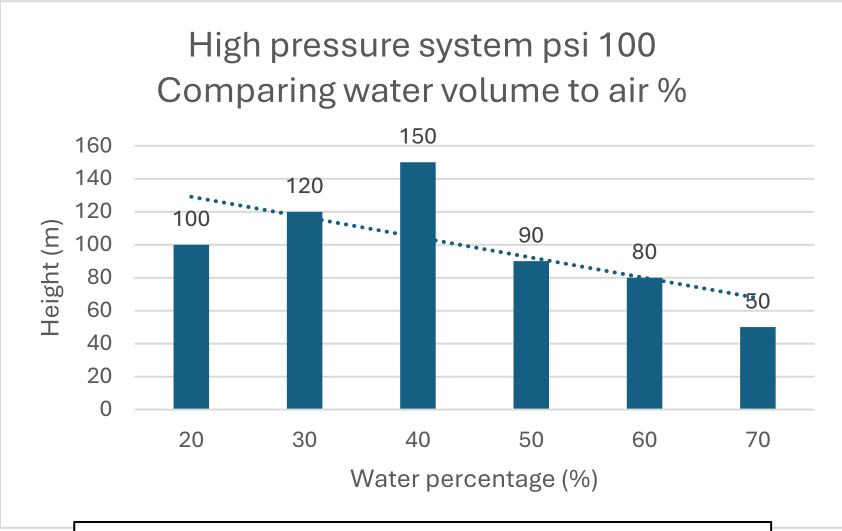

Image 3: Comparison of water to high air pressure

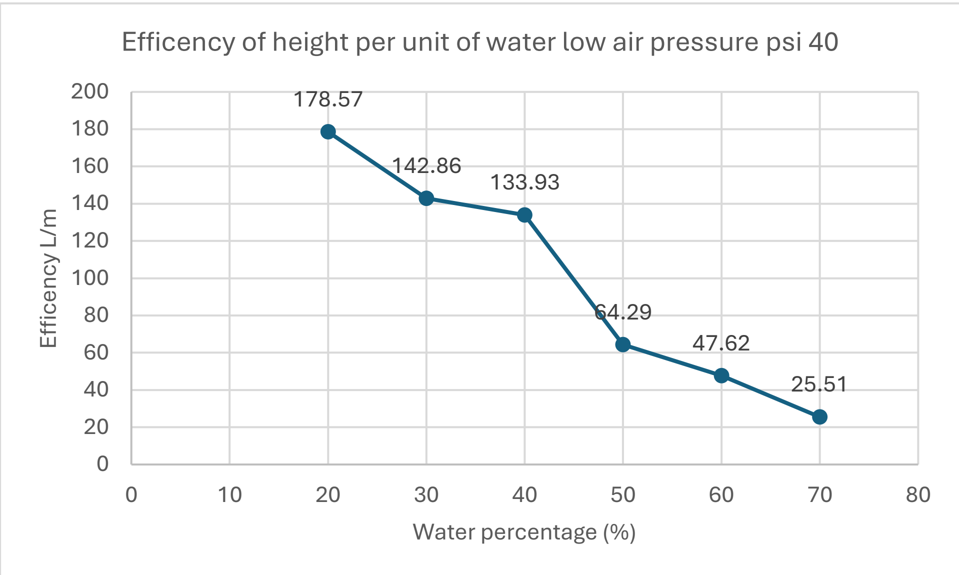

Image 4: Efficiency in low air pressure

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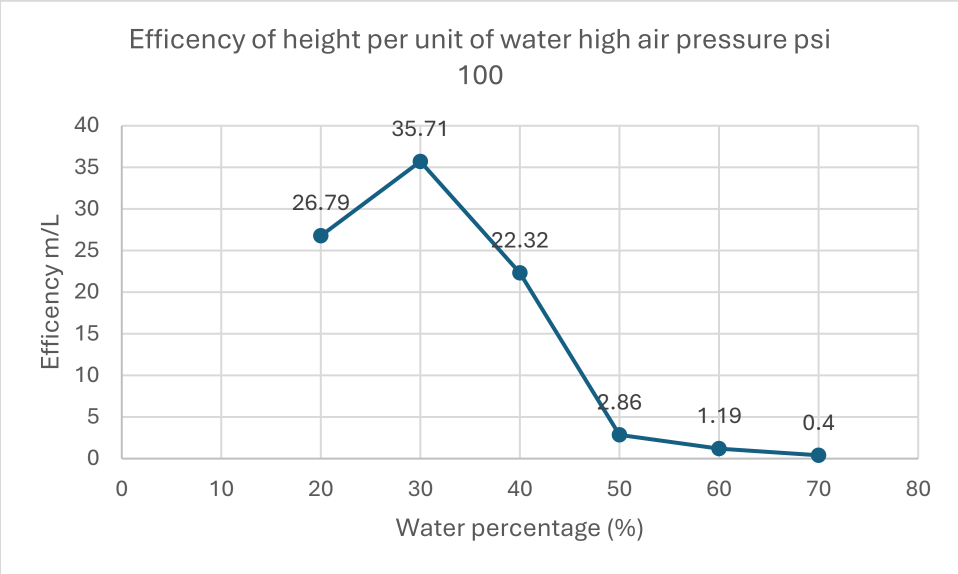

Image 5: Efficiency in high air pressure

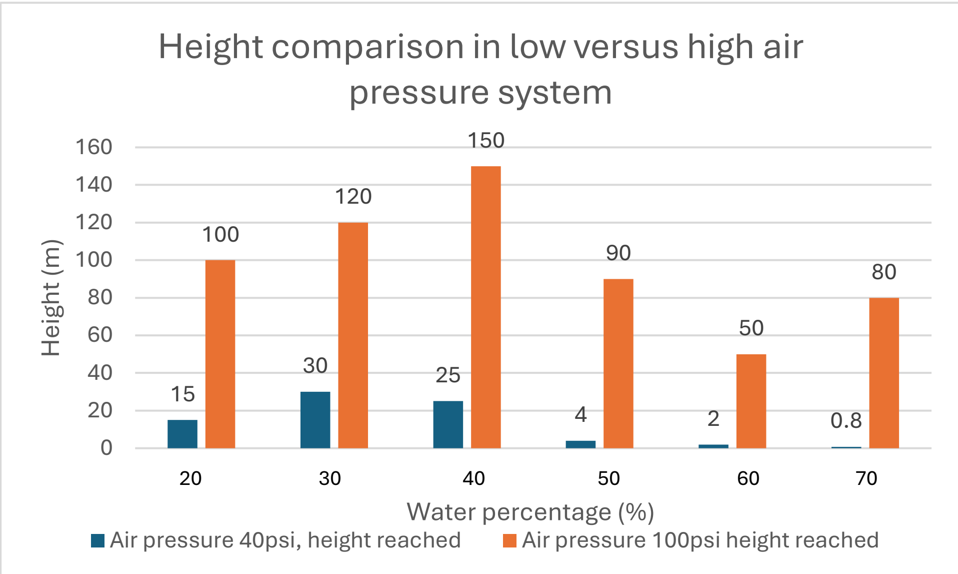

Image 6: Comparison of performance of low versus high air pressure

Conclusion

The rocket design with 20g weighted nose cone, 30-40% water to air ratio, high pressure 100psi launch reached the highest altitude whilst maintaining stability and is the most efficient water to air ratio in a low-pressure system. However, the water ratio of 20% with the same parameters is the most efficient in water air pressure ratio in a high-pressure system.

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Discussion

Water rockets work on the principle of Newtons third law of motion, where the compressed air forces the dense water downward out of the rocket nozzle (action) and the rocket experiences an equal and opposite upward force shooting it into the sky (reaction). This allows the rocket to launch. Newton's second law (force= mass x acceleration) explains why 30-40% water was the optimal amount for maximum altitude. With lower volumes there is not enough water mass for maximum propulsion thrust as the water is expelled and then the thrust force is finished too quickly. At 50% or more water, there is not enough compressed air to produce enough force to launch the heavy water rocket.

Rocket momentum upwards is maintained if the propulsive forces continue but is affected by external forces. Air resistance and stability was improved with a weighted cone shaped nose. More than a 20g weight created more drag which affected altitude. Whilst the nose cone assisted with moving the centre of gravity forward, the nose weight was superior to no weight. Fins placed low on the rocket moved the centre of pressure behind the centre of gravity (rocket nose) improving stability. 4 fins were slightly more stable than 3 fins but increased air resistance and reduced altitude. Evaluating three compared to four fins at a higher pressure may have shown a greater difference in stability. Once the water and air was expelled, air resistance and gravity caused the rocket to descend.

Higher air pressure had better efficiency for water to height ratio. Higher air pressure fills the rocket more rapidly, increasing velocity by expelling water faster. However, the rocket landed further away which indicates some instability with higher pressures.

The experiment accuracy for height could be improved with measuring using trigonometry, but this would require a large area and additional people as the angle needs to be measured from a significant distance. The experiment could be repeated at different launch angles.

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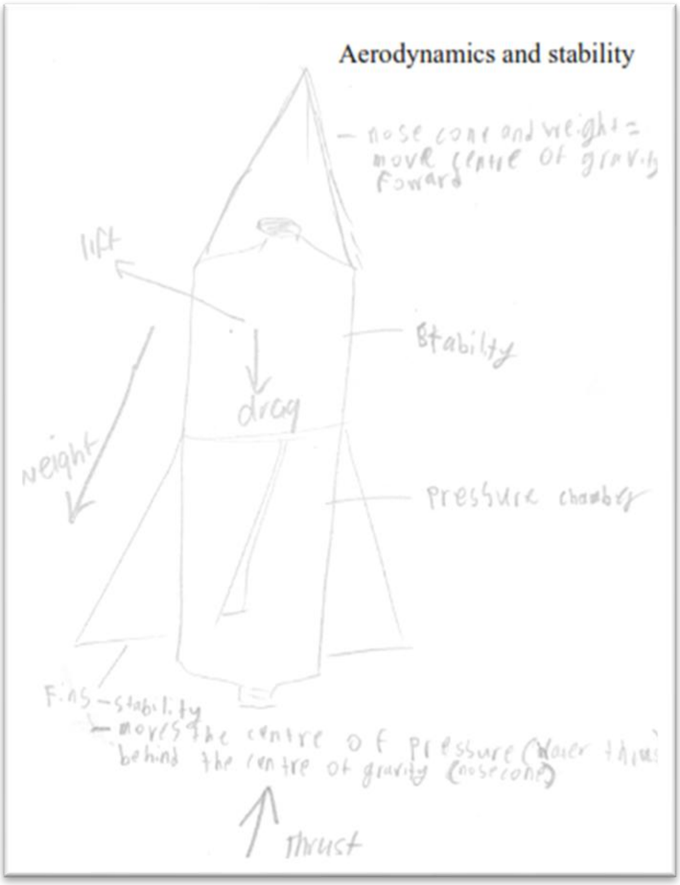

Image 7: Aerodynamic and stability principles

Word count 1096

Bibliography

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2. USWaterRockets (2015). *How to make a Gardena Water Rocket Launcher*. [online] YouTube. Available at: https://www.youtube.com/watch?v=hJf7DHApz2Y
3. Wikipedia Contributors (2019). *Water rocket*. [online] Wikipedia. Available at: https://en.wikipedia.org/wiki/Water_rocket.
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8. *National Physics Laboratory (2007). A guide to building and understanding the physics of. [online] Available at: https://www.npl.co.uk/getattachment/1c1d9302-7838-46b2-86c9-d6a712aab120/wr_booklet_print.pdf.*
9. USWaterRockets (2024). *Flight Testing Dual Parachute Single Servo Mechanism*. [online] YouTube. Available at: https://www.youtube.com/watch?v=xwujou_V0L0.
10. USWaterRockets (2016). *Competition Water Rocket Design Tutorial*. *YouTube*. Available at: https://www.youtube.com/watch?v=hTmL1exWt8s

Acknowledgements

I used a website called My bibliography to help with reference list. I read about the science and design process of my rocket for many weeks, then I talked about these with my parents each night, teaching them. This helped me make sure I understood the science and then made it easier to type my work. I also used some voice to text typing and then edited my work as there was a lot of typing. My parents encouraged me to use more scientific language, so I used an online thesaurus to make my work more scientific. I used grammar and spell check in Word. My Dad and Mum supervised my building and helped me get the materials. My brother was helpful in launching the rocket as I needed more than one set of hands including one to pump the air compressor or bike pump, one to hold the rocket and I needed two people when I was trying to measure the angles from a distance. I used a scrap book to keep my results and mock up graphs, then mum showed me how to use excel and I spent lots of time having fun with excel graphs!

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Optimising Water Rocket Efficiency
Workbook
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Optimising Water Rocket Efficency

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Optimising Water Rocket Efficiency
Oliphant Science Awards 2026
Logbook

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Logbook

<u>**1/5/2026**</u>

I am using the Oliphant Science Investigation planning information and will make sure I answer all these questions.

Questions (from Oliphant website):

1. **Questioning and predicting:**
    a. What is the question that you are investigating?
    b. What do you predict will happen?
2. **Planning and conducting:**
    a. Explain why you chose the particular method for your investigation.
    b. What are the possible variables in your investigation?
    c. Which variable will you change?
    d. Which variable will you measure?
    e. Is your investigation a 'fair test'?
    f. Describe all the steps of your investigation so that someone else could do it again exactly as you did it.
3. **Equipment and materials:**
    a. List all the equipment and materials that you used in your investigation.
    b. List any possible risks that may result from the investigation and describe how they were controlled.
4. **Processing and analysing data and information:**
    a. Present the measurements or observations from your investigation in suitable ways. Depending on the year level, these may include tables, graphs and photographs or sketches.
5. **Analyse your results.**
    a. What patterns and relationships can be seen in the data?
    b. What conclusions can be made?
    c. Do your results support your predictions?
6. **Evaluating**:
    a. How could your investigation be improved?
    b. How could your findings be useful to others?
    c. What other related questions could be further investigated?
7. **Communicating**:
    a. Present your science investigation using scientific terms where this is appropriate.
    b. Represent your findings in a number of ways. These may include various texts, charts, graphs, tables, and may include the use of digital technologies.
    c. Relate your investigation to any research that you have done from other sources.
    d. Your report must include a References section containing all the sources of information you researched (all the books, websites, magazines and any people you have talked to). If you quote directly from a source, you must use quotation marks and include a reference to the source of the quote.
8. **Acknowledgement** of any AI tools used in preparing your entry, in line with the Oliphant Science Awards AI Policy

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Logbook

9. **Wordcount**: 1000 words (10% tolerance)
10. **Submit**
    a. Cover sheet (from coordinator)
    b. Risk assessment
    c. Science logbook
    d. Science report
11. Due date: 5-28th June 2026 online

2/5/2026

What will I do my investigation on?

I've been thinking about the Oliphant Science Awards since last year and I have lots of ideas:

- I like food chemistry:
    - How to make bread last longer? What natural products prevent mould growth?
    - Optimal growing conditions for tomatoes?
- How does sugar affect my body?
- Rocket science

Why did I choose to investigate rockets?

On the 1st of April 2026 the Artemis II mission launched from NASA's Kennedy Space Centre in Florida, crewed by 4 people, with the aim to flyby the moon. This was the:

- first crewed flight beyond low Earth Orbit since Apollo 17 in 1972 (literally my Dad's lifetime!!)
- the first crewed flight of the NASA-led Artemis program
- the first crewed flight of the Space Launch System (SLS)
- the first crewed flight of the Orion spacecraft

I am fascinated by space and think rocket are cool so I also want to build my own rocket. This led me on my own adventure of researching rockets. I know there is extensive testing that goes into a rocket launch, so I am going to research what's important in making a rocket to improve take off, height, distance and so on.

How will I record my bibliography?

I will be using My bibliography to help with reference list- https://www.mybib.com/#/projects/8dLNdm/citations.

- Wikipedia Contributors (2024). *Artemis II*. [online] Wikipedia. Available at: https://en.wikipedia.org/wiki/Artemis_II.
- USWaterRockets (2015). *How to make a Gardena Water Rocket Launcher*. [online] YouTube. Available at: https://www.youtube.com/watch?v=hJf7DHApz2Y [Accessed 2 Feb. 2025].

https://www.youtube.com/watch?v=tGxOnuNxDoQ

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Can I build a rocket?

- Yes

Are there different ways to build rockets?

- Yes

What kind or model rockets can I build?

- Fluid and pressure rockets
    - Water rockets
    - Alka-Seltzer Rockets (like coke in mentos)
    - Vinegar and baking soda rockets
- Model rockets
- Mechanical rockets
    - Air or stomp rockets

What rocket will I build?

- After lots of research I will build a water rocket. This is because I like science, engineering and building. I also think this design will be able to be controlled the most in terms of experiments with the ability to control variables and controls.

What do I want my rocket to do? How do I measure success of my model rocket? What can I measure?

- I want the rocket to fly, to go high and straight!
- Based on my research this can be achieved with a water rocket as I can change the water and air pressure. I will also spend time to make the most successful rocket.

4—9/5/2026

What is the science behind water rockets?

- Water rockets work on the same physics as a real NASA spacecraft.
- The water rocket is filled partially with water, then the air is forced into the water rocket, the compressed air forces the water out of the lower nozzle of the rocket, creating a high-speed thrust that drives the rocket upward and the water out of the rocket. This process is based on 4 principles of the physics of motion- Newton's laws of motion, pressure differentials, and aerodynamics
    - **Newton’s Third Law (Action & Reaction):** when compressed air forces the water downward out of the Rockets nozzle (action) the rocket experiences an equal and opposite upward force shooting it into the sky (reaction). This is the propulsion mechanism.

    - Wikipedia Contributors (2019). *Water rocket*. [online] Wikipedia. Available at: https://en.wikipedia.org/wiki/Water_rocket.

- **Newton's Second Law (F=ma):** force= mass x acceleration. The water is 800 times more dense than air, so when the pressurised air forces the water out of the water rocket, the force is much greater because of the more dense and high mass water.
    - This is why the rocket watch with 30-40% water created a higher altitude than the 10 and 20% water trials.
    - But why then did my 70% water rocket not fly higher???
        - Science Mill. (2023). *The basics of rocket science*. [online] Available at: https://www.sciencemill.org/blog/2023/4/29/the-basics-of-rocket-science.

- **Conservation of Momentum:** Conservation of Momentum: The momentum of the expelled water and air downwards is perfectly balanced by the momentum of the rocket moving upwards. The rocket shoots upwards as the water (mass) is being ejected down, the rocket rapidly accelerates (Newton's second law) keeping the momentum of the rocket.
    - *www.youtube.com. (n.d.). Water Rocket #physics #science #facts. [online] Available at: https://www.youtube.com/shorts/mVP0RSyjxuw [Accessed 20 Jun. 2026].*

- **Aerodynamic and stability:** gravity, air resistance and drag (air resistance of the air moving over the rocket and fins). The fins shift the centre of pressure behind the centre of gravity pointing the rocket straight up which creates stability.
    - **Centre of pressure** is the geometric balance point of all aerodynamic forces acting on the rocket.
        - Bottle centre of pressure is the middle
        - Fins alter the bottle shape
        - No longer does the wind blow evenly over the rocket
        - The fins increase the surface area of the rocket base
        - When the rocket moves through the air, the wind catches the fins more than it catches the smooth nose cone. So now the average point of wind resistance is now at the base of the rocket.
        - For a rocket to fly straight, the Centre of Mass (CM) must be in front of the Centre of Pressure (CP)

NSS, N.D.S.S. (2024). *Rocket Design — Explained Like I'm Five*. [online] Medium. Available at: https://medium.com/@nssnewdelhispacesociety/rocket-design-explained-like-im-five-391dda32d069.

Centre of mass

- the exact balance point of an object where its entire weight is evenly distributed in all directions

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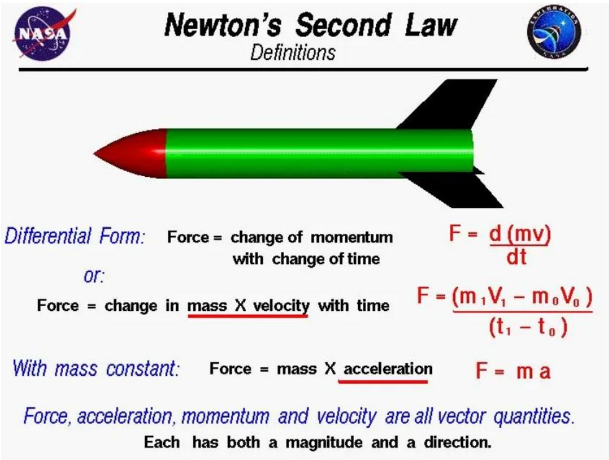

Rocket Dynamics. Source: NASA Glenn Research Center

NSS, N.D.S.S. (2024). *Rocket Design — Explained Like I'm Five*. [online] Medium. Available at: https://medium.com/@nssnewdelhispacesociety/rocket-design-explained-like-im-five-391dda32d069.

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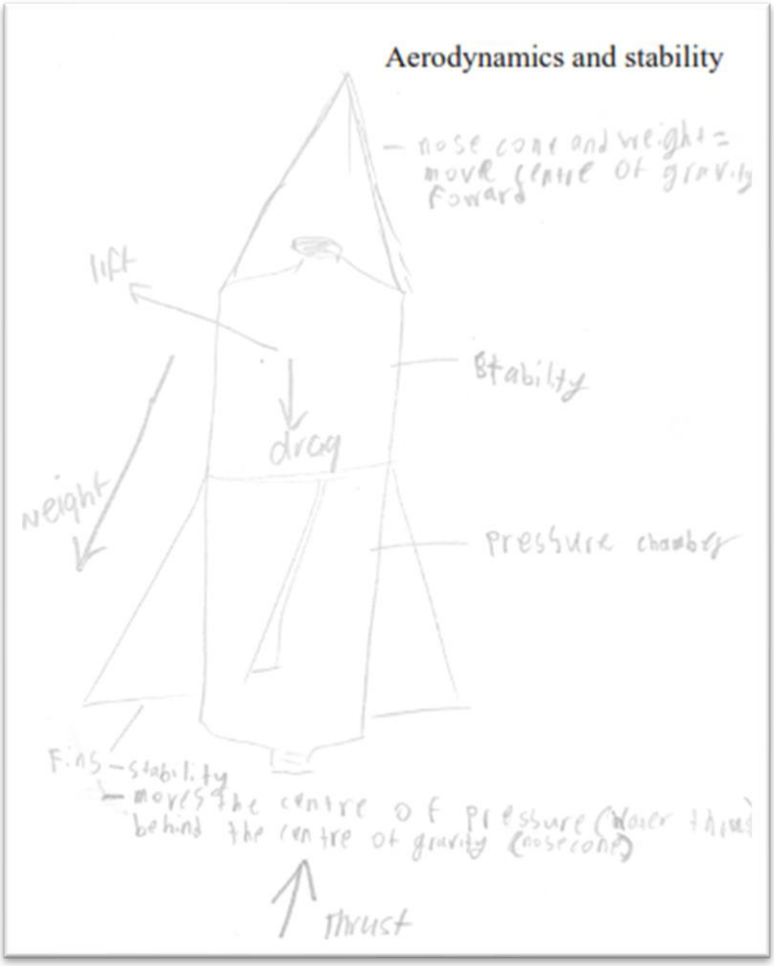

My rocket design with aerodynamics and stability

Stages of a Launch

1. **Pressurisation:** potential energy is created when air is pumped into the partially filled water rocket, compressing the air.
2. **Propulsion**: when the rocket is released the compressed air pushes the water down and out of the rocket nozzle, creating a high-speed thrust that drives the rocket upward, accelerating rapidly as the rocket looses water mass.
3. **Coasting:** once all the water is ejected from the rocket, the remaining final compressed air is ejected for the final thrust, as per Newton's first law, if an object is in motion it must stay in motion unless someone or something stops it, in this case gravity and air resistance (drag) slow it to a stop and then rocket falls to the ground.

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What affects the altitude the water rocket will reach? Rocket design

- **Aerodynamics**
  - Air resistance
    - Need to reduce air resistance
    - Smooth cone shaped nose reduces air resistance
    - Smooth streamline rocket body with minimal air friction
    - 3 versus 4 fins (will be investigated in pre-flight experiments as 4 finds may be more stable but will create more air resistance and drag.
- **Stability**
  - The fins placed at the bottom of the rocket keep the rocket flying upwards and move the centre of pressure behind the centre of gravity.
  - 2 fins during my experiment caused a flipping motion of my rocket doing 360 degree tumbles which created significant air resistance, instability and reduced the altitude.
  - Fins slightly angled create spin stabilisation (angle 1-2 degrees)
  - Spin stabilisation assists with aerodynamic stability
- **Water Mass- to- air ratio:**
  - Water mass creates a heavier rocket and the need for increased pressure to launch.
  - The water pushed out from the water rocket is what creates most of the thrust force as the compressed air forces out the water.
  - There needs to be a balance between enough air versus enough water for thrust, and this is the basis of my investigation.
- **Weight**
  - I will use light weight water bottles that will minimise weight but can withstand high air pressures.
- **Compressed air pressure**
  - the higher the air pressure, means I can get lots of air into the rocket which would overcome any leaks that a lower psi pressure may not.
- **Number of rocket chambers**
  - The lower bottle acts as a pressure chamber and the high bottles work for stability.
  - The number of bottles determine the volume, weight and aerodynamics.
  - More bottles lead to increased water and air for propulsion but this needs to be balanced with weight and aerodynamics. Studies recommend 2-4 bottles.
- **Centre of mass**
  - Pre-experiments
    - Will adding weight to the nose affect stability? I will experiment
    - Why? It moves the centre of gravity to keep the rocket straight.
    - How much to use? I will experiment

National Physics Laboratory (2007). A guide to building and understanding the physics of. [online] Available at: https://www.npl.co.uk/getattachment/1c1d9302-7838-46b2-86c9-d6a712aab120/wr_booklet_print.pdf.

What have I learnt about water rockets?

- the amount of water affects the height (altitude) reached
- the amount of air pressure affects the height (altitude) reached

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- the design affects stability, air resistance and drag
- and all the above!

10/5/2026

My experiment planning:

- I will build a water rocket with pre-experiments to work out:
  - Blunt nose versus a cone nose
    - I think the cone nose will win as this is more aerodynamic
  - the number of fins to maximise stability and reduce air resistance
  - test the most ideal weight in the nose of the rocket for stability.
    - A weight and cone nose will shift the rockets centre of gravity (upward/front of rocket) keeping it moving upwards in propulsion.
  - These experiments will allow me to have a rocket with design as a non-variable.
    - Fins, weight, nose cone
- Then for my experiment I want to test:
  - what combination of water volume and air pressure produces the highest altitude
  - does the water volume or air pressure affect stability
  - does a lower pressure versus a higher pressure affect altitude.
    - Technically the pump should not affect the launch altitude but the maximum pressure (psi) that can be delivered with a bike pump is much less than an air compressor.
      - Bike pump
        - Max pressure is usually 50-80psi (I found mine to be 40psi), physical ability and fatigue limit the pressure produced with the bike pump.
      - Air compressor
        - Reach 90-120 psi (100psi in my experiment), with a higher pressure, the water is expelled at a higher velocity.

USWaterRockets (2024). *Flight Testing Dual Parachute Single Servo Mechanism*. [online] YouTube. Available at: https://www.youtube.com/watch?v=xwujou_V0L0 [Accessed 7 Jun. 2026].

USWaterRockets (2016). *Competition Water Rocket Design Tutorial*. *YouTube*. Available at: https://www.youtube.com/watch?v=hTmL1exWt8s [Accessed 3 Dec. 2019].

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<u>11-17/5/2026</u>

Experiment design and rocket building

- After all my research, I've built my rocket, now time for testing!!
- **Type of rocket**
    - I built a water rocket
    - Design features based on research
        - I started with 2 bottles, this created:
            - a longer rocket body making it more stable and increased volume
            - increases the air and water volume in the rocket as it's a larger volume which should create a greater thrust duration.
        - Aerodynamic nose cone
            - I've made the nose of the rocket ship with laminated cardboard to make it more aerodynamic and secured it with tape making the connection to the bottle smooth. Making it this way reduces air resistance and improves aerodynamics which should make the air resistance on the rocket less.
        - 3 fins versus 4 fins
            - I will investigate this in my experiment- 4 versus 3 fins.
            - Based on research 3 fins should create stability but less air resistance and drag compared to 4 fins.
        - Weighted nose for improved stability
            - I will experiment a weight versus non weight nose for stability.
- **What am I going to test?**
    - Height achieved (altitude)
    - Stability
    - How efficient is it? How much air pressure was required to reach the height? Height per unit of pressure
    - How efficient is it? How much water was required to reach the height? Height per unit of pressure
    - Stability (is it straight or does it wobble)

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16/5/2026 building- Rocket Launch Pad




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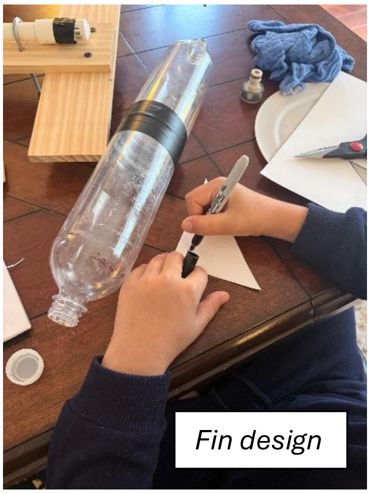
17/5/2026 building- Rocket


Fin design


Sanding for fit


Priming


Fin design

Nose cone design trials

Water Rocket Progression

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21/5/2026

Pre-experiment consideration- height measuring.

Measuring height

- Ideas and reasoning
  - Estimate based on sight
    - Easy and fast
    - Not accurate
  - Estimate based on the height of a tree I will launch near
    - Easy and fast
    - I can measure the tree height with my drone before
    - It is very accurate
    - The rocket might get stuck in the tree
  - Use a measuring tape next to the launch pad
    - This is good and worked well for the low pressure launches
    - The rocket did sometimes crash into the bin on descent
    - This did not work for the high pressure launches as they were more than 2 metres
  - Use a drone to capture the height
    - Great idea but I do not want my drone to be wiped out by my rocket!
- I googled ideas to measure height and came across trigonometry.
  - You can use the formula **Height= distance x tan(angle)**
  - I will stand 15m from the launch pad and used a protractor to measure the angle of the rocket at its maximum height
  - as I had to be very quick to record the angle at maximum height.
  - I will use a scientific calculator

30-31/5/2026 Testing

Pre testing

Weighted nose- stability and height, (4 fins and 30% water, low pressure pump)

Weight	Stability	Height
No weight attempt 1	Unstable	0.8 m
No weight attempt 2	Unstable	0.7 m
20g weight attempt 1	Straighter, more stable	1m
20g weight attempt 2	Straighter, more stable	1m
50g weight attempt 1	Straighter, most stable	0.9m
50g weight attempt 2	Straighter, most stable	0.9m

Comparison of cone versus blunt nose 20g weighted, 30% water volume, low air pressure psi 40		
	Stability	Height
Blunt nose attempt 1	Stable	1m
Blunt nose attempt 2	Stable	1m
Cone nose attempt 1	Straighter, more stable	1.1m
Cone nose attempt 2	Straighter, more stable	1.2m

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3 fins vs 4 fins with nose cone weight and 30% water volume and low pressure pump 40psi

Fins	Stability	Height
3 fins attempt 1	Minimal wobble	1.5m
3 fins attempt 2	Minimal wobble	1.5m
4 fins attempt 1	Slightly better, minimal wobble	1m
4 fins attempt 2	Slightly better, minimal wobble	1m

Interpretation

- The weighted nose made the centre of gravity at the front of the rocket which made it more stable as the thrust was behind the centre of gravity.
- Based on these results I will use 20g weight for my experiment as this created increased stability but did not reduce altitude.
- Based on these results I will use 3 fins for my experiment as the stability was not very different between 3 and 4 fins but 4 fins reduced altitude.

This was a massive day and I had to redesign my rocket and make a few modifications. Some of the issues I had and how I fixed them included:

- Design 1: Hose connection rocket to launch pad
  - When I connected my rocket to the launch pad all the water ran out of the bottle into my launch pad PVC piping! This is because there was no valve in the hose connections.
- Design 2: Cork and bike pump needle
  - I had to make a new launch design on what I could find on the farm!
  - I did some research and found I could use a cork in the bottom of the bottle with a bike pump needle. Only problem was we have no wine bottle corks and I'd already glued the garden hose connection into the rocket and couldn't extend it!
  - I cut the base off my rocket and extended my rocket with a 3rd water bottle so I could use the top to insert the bike pump needle.
  - An extra bottle had the advantage of providing extra length which will maximise air capacity and improve stability.
  - I drilled a hole into the water bottle lid and snuggly fit the bike needle.
  - Testing: the water still leaked slowly BUT I realised I need a long pipe in the middle of the water rocket to allow me to use different amounts of water without it leaking back up the launch pad PVC!
- Design 3: long PVC piping.
  - I extended PVC pipe on the rocket launch pad, this went most of the way up the rocket and allowed 0—90% water addition to the rocket for testing.
  - There was a little leak when I placed the rocket upside down on the launch pad as it wasn't a perfect seal. I had to use the PVC pipe I could find on the farm which was a little bit smaller than the launch pad PVC piping. I put PVC pipe tape around the connection which reduced the leak but also provided more stability for the rocket to sit on for launch.

    - This was working great for the lower pressure bike pump part of the experiment but when after 3 test runs of the high pressure air I went from very high altitude to minimal altitude from my rocket despite using the same water percentage.
    - Trouble shooting
        - I checked all the launch pad connections- they were solid and no leak
        - I rebuild the rocket nose as I thought this may be really affecting the aerodynamics with damage from previous launches.
        - I checked the nose weight was still in place
        - I reinforced all the rocket connections with electrical tape
            - The rocket launched to a high altitude like before BUT I noticed I had water leaking from between my first and second bottle connection- the one I made today but had not glued with PVC primer and cement.
            - I launched the rocket again with minimal altitude, so I took apart my rocket, dried between water bottle 1 and 2, glued them back together with PCV primer and cement and will wait for them to dry over the week.
- Measuring height with trigonometry
    - Trigonometry: highest= distance x tan(angle)
    - Protractor: the ground was 0 degrees,
        - Manuel: using a ruler, based at the centre based on the protractor, I lifted the end of the ruler to line up with the height on the rocket at its peak height, recording the angle.
        - Digital protractor
    - I wanted to do this using trigonometry but there were lots of issues with measuring the angle
        - The rocket was too high and too fast to be able to measure the angle accurately, I could not get far enough away from the base on the rocket base and the rocket shot up too fast to measure.
        - It was too hard to track the rocket and measure the angle all within a few seconds.
        - I could never launch my rocket as I had to be far away to measure the angle.
        - I am disappointed I couldn't use trigonometry but I decided to revert to estimation based on
            - Measuring tape next to trees for lower heights (was a problem as my rocket got stuck in a tree)
            - Using my drone to check the height reached (but this required an extra person to fly the drone)
            - So I used the drone to measure the heights on multiple landmarks, then I could make a more accurate estimate of height. I also noted the level of landmark each launch reached so as I could see if a launch was higher or lower than previous launches.

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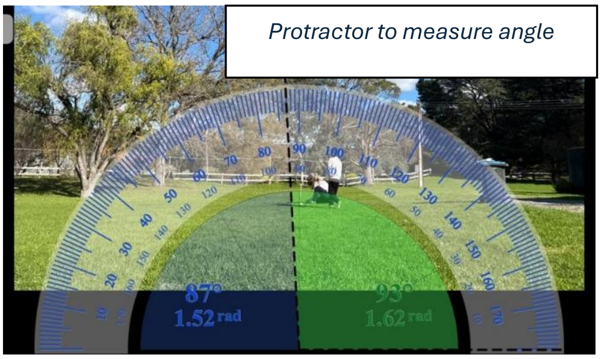
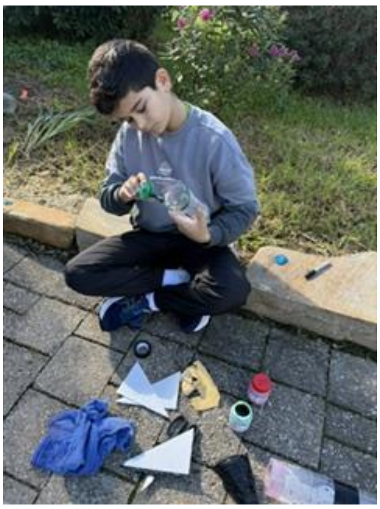
Measuring tape

Protractor to measure angle



Measuring and marking water percentage

Filling up my rocket with water



PVC primer and cement

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Testing phase and problem solving

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High pressure, 30% water launch

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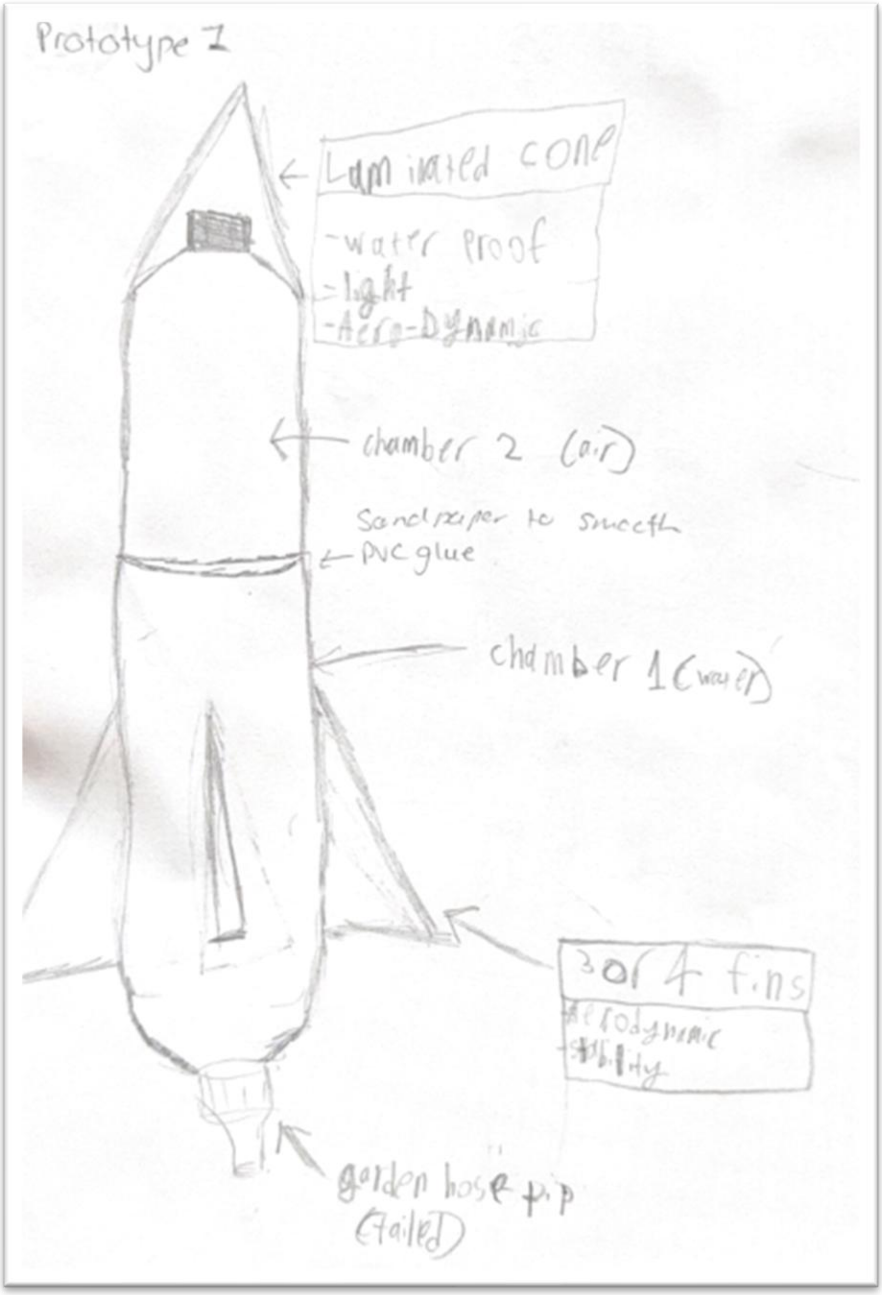
1/6/2026

Design prototypes

I’ve scanned in my prototype designs.



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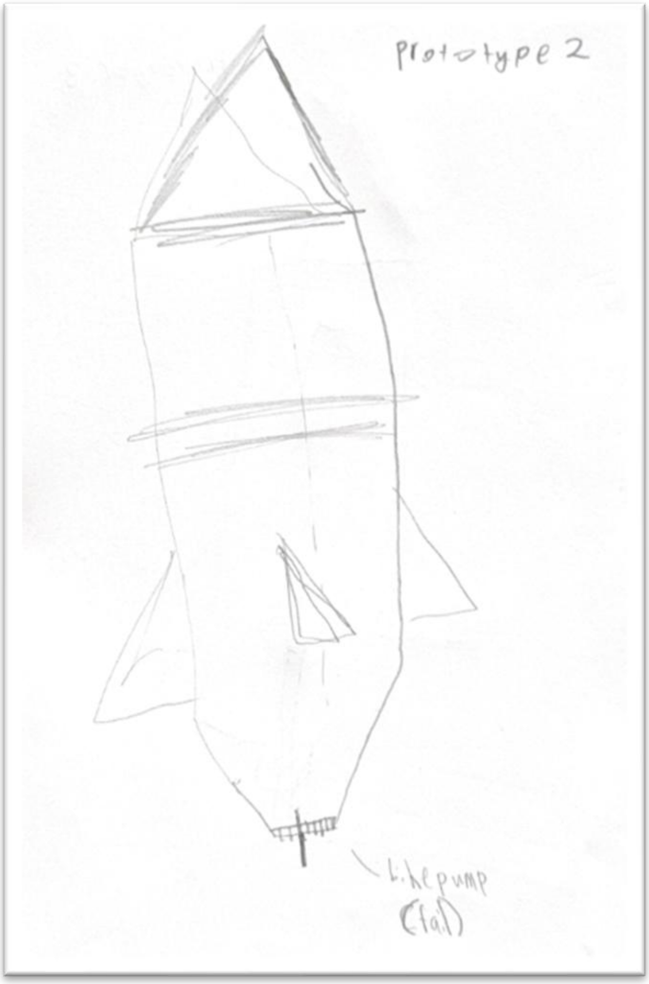

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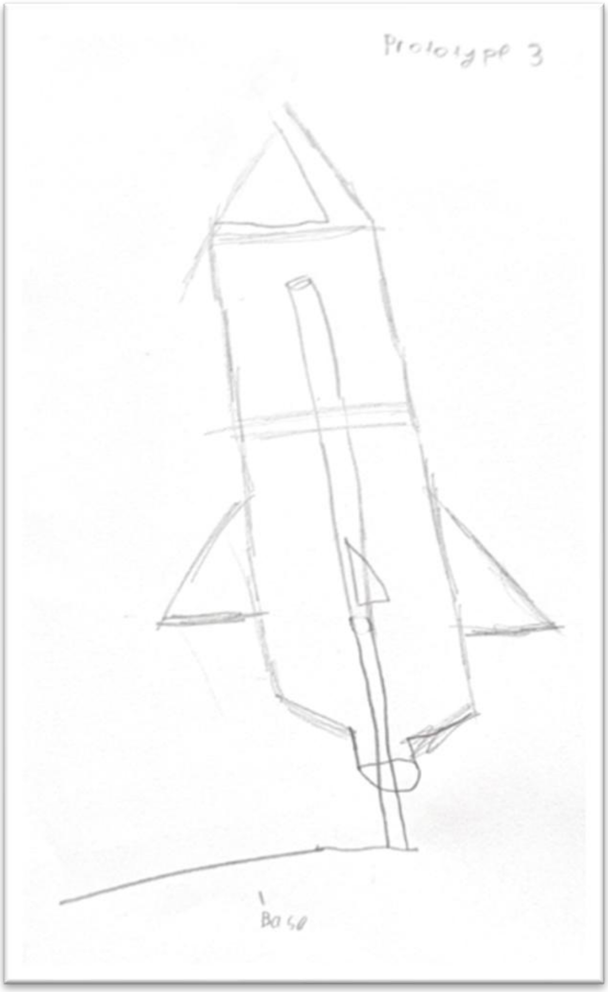

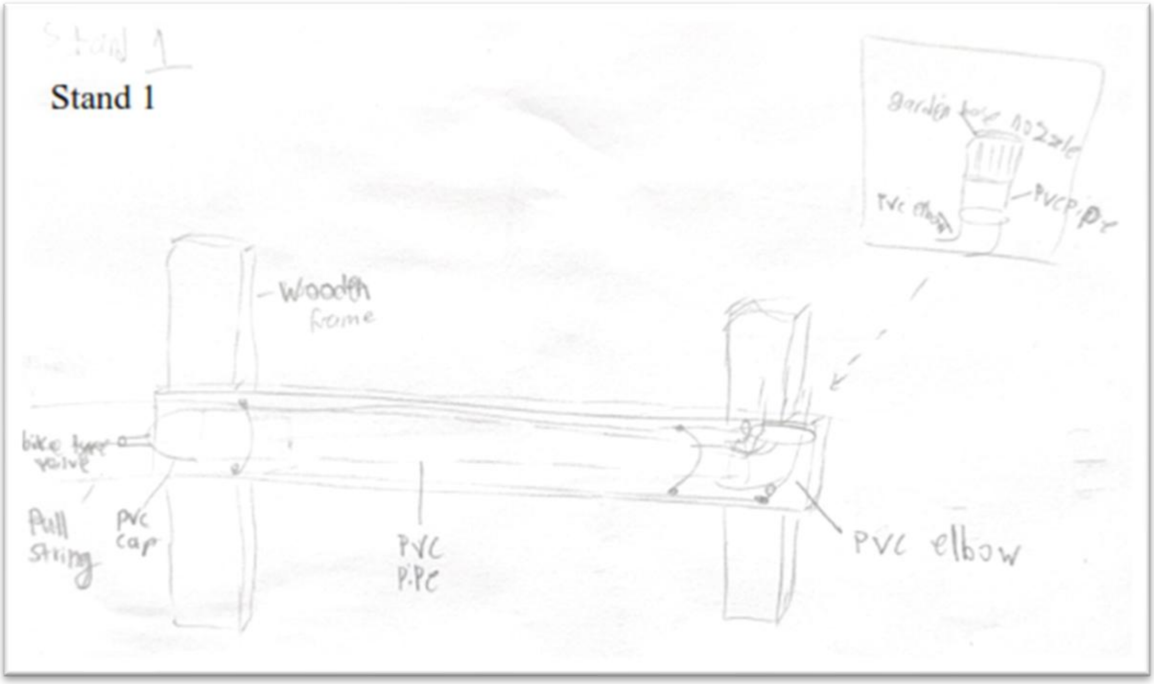
Stand 1
Stand 1
garden hose nozzle
PVC pipe
PVC elbow
bike tyre valve
Pull string
PVC cap
PVC pipe
PVC elbow


Stand 2
extended PVC pipe to go above water

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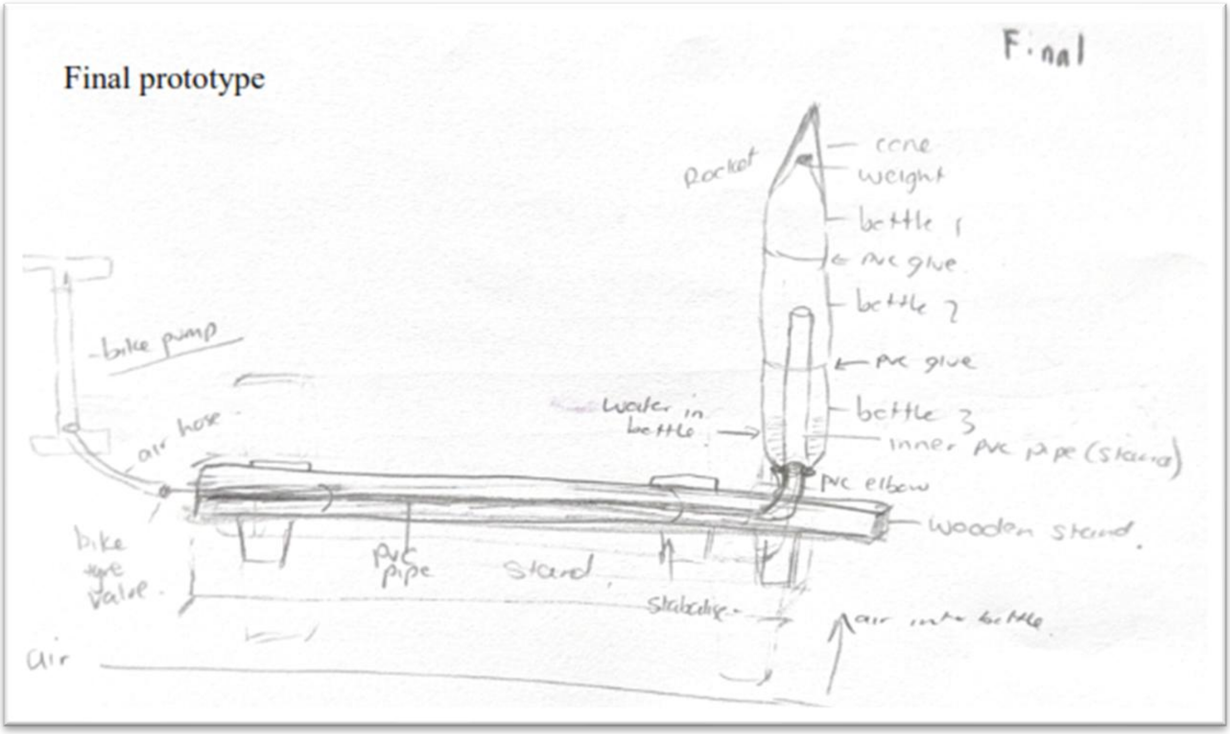

3-4/6/2026

- I planned my method and wrote up how I built my rocket and stand.
- I am going to use this straight into my report because I had to keep re writing it.

Rocket construction

1. Rocket construction
   a. Rocket shaft
      i. Take 3 x1.2L bottles
      ii. Cut out base of bottle 1 (top) and 3 (base) and both ends off bottle 2 (middle)
      iii. Sand inside bottle 1 and 3 and outside bottle 2.
      iv. Dip the ends of bottle 2 into hot water to reduce its diameter to fit inside bottle 1 and 3.
      v. Use PVC primer then PVC cement to glue bottle 2, 2cm inside the base of bottle 1 and top of bottle 3.
      vi. Add 20g metal washer to bottle top of bottle 3, secure with glue (nose weight).
      vii. Make 10% volume intervals along bottle shaft.
   b. Nose
      i. Form a cone with laminated paper, secure to bottle 1 with electrical tape. making the join smooth.
   c. Fins
      i. Cut 4 slightly curved fins from thick cardboard equal size.
      ii. Secure fins, evenly spaced to the base of bottle 1. Later change this to 3 fins.

2. Base construction
   a. Cut 3x 40cm pine wood 10x2cm planks, secure in an ‘I’ shape and drill in place.
   b. Drill a hole in a ¾ inch PVC pipe cap, the same size as a bike tyre valve, insert the bike tyre valve and secure with sealant.
   c. Connect cap to 30cm ¾ inch PVC pipe (A), connect pipe to ¾-1 inch PVC elbow, connect elbow to another 30cm PVC pipe (B), securing all joins with PVC primer and cement.
   d. Secure PVC pipe to wooden board with 2x U bolts.
   e. Connect bike pump/air compressor to bike valve.
3. To launch rocket
   a. Fill the rocket with the specific amount of water based on the volume markers.
   b. Load the rocket onto the PVC pipe B (have base upside down), then flip the base onto ground with rocket facing upwards.
   c. Connect air pump (bike pump/air compressor) nozzle to bike valve in the PVC pipe A cap.
   d. Pump air into rocket and release once pressure achieved.

Method

Experiment 1 Weight vs non weight nose

1. Use constants- no nose cone, 4 fins, 30% water volume, low pressure bike pump psi 40.
2. Use no nose weight
3. Launch rocket
4. Record rocket altitude and stability.
5. Repeat once
6. Use 20g nose weight- repeat steps 3—5
7. Use 50g nose weight- repeat steps 3—5

Experiment 2 Comparison of aerodynamics and stability blunt versus cone nose

1. Use constants- 4 fins, 20g weight nose, low air pressure 40 psi
2. With no nose cone- launch rocket
3. Record rocket altitude and stability.
4. Repeat once
5. With nose cone attached- launch rocket.
6. Repeat steps 3-4.

Experiment 3 Comparison of aerodynamics and stability 3 versus 4 fins

1. Use constants- 20g weighted cone nose, low air pressure 40 psi
2. With 4 fins, launch the rocket with 20% then 30% then 40% then 50% then 60% then 70% water volume, recording rocket altitude, time in the air and stability. Repeat for each water volume.
3. Repeat step 2 with 3 fins.

Experiment 4

1. Use constants- 3 fins, 20g weight nose cone
2. With low pressure air 40psi (bike pump), launch the rocket with 20% then 30% then 40% then 50% then 60% then 70% water volume, recording rocket altitude, time in the air and stability. Repeat for each water volume.
3. Repeat step 2 with high pressure air 100psi (air compressor)

6/6/2026 Experiment

- Round 2 testing- after 1 week of letting the rocket bottle join dry after I glued them back together with PCV primer and cement.
- The results were significantly different, and I believe this is because I must have been losing pressure in my last round of testing with an air leak between the rocket body bottles which was now fixed with PVC primer and cement.
    - **Constants**
        - Same rocket
        - Same weighted nose
        - Same 3 and 4 fins
        - Same launch angle of 90 degrees
        - Same day and weather conditions
    - **What I will test (variables)**
        - Different water percentages
        - Different air pressure systems
    - **What will the outcome**
        - Stability (straight vs wobble)
        - Height (performance)
        - Efficiency
            - Height per unit of water
            - Height per unit of pressure

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Results

20g weighted nose3 fins vs 4 fins, low pressure psi 40

Fins (number)	Water %	Time in air (sec)	Height	Stability 1: Stable 2. Slight wobble 3: uncontrolled
3	20%	3	15m	2
4	20%	1.5	12m	2
3	30%	4	30m	2
4	30%	3.5	25m	2
3	40%	3.5	25m	2
4	40%	2	15m	2
3	50%	<1	4m	1
4	50%	<1	8m	1
3	60%	<1	2m	1
4	60%	<1	2m	1
3	70%	<1	0.8m	1
4	70%	<1	0.8m	1

- The higher the rocket reached the more likely it was to wobble
- There was not a significant difference in 3 versus 4 fins in stability but it did significantly affect the height reached and this is because 4 fins increase the weight and increased air resistance, causing a lower altitude peak for the 4 fin rockets.

3 fins, 20g weighted nose cone, low 40psi vs high 100 psi

Water %	Pressure Low- bike pump 40psi High- air compressor 100psi	Time in air (sec)	Height	Stability 1: Stable 2. Slight wobble 3: uncontrolled
20%	Low	3	15m	2
	High	4.5	100m	2
30%	Low	4	30m	2
	High	6	120m	2
40%	Low	3.5	25m	2
	High	7	150m	2
50%	Low	<1	4m	1
	High	4	90m	1
60%	Low	<1	2m	1
	High	<1	80m	1
70%	Low	<1	0.8m	1
	High	<1	50m	1

As the rocket reached a higher altitude the rocket began to slightly wobble but remained close to 90 degrees. The only time the rocket did 360 degree flips was when one of the fins came off which highlighted the need for at least 3 fins for stability.

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Calculations

Volume and water percentage, total volume 2.8L		
Water percentage	Calculations	Water volume
20%	2.8L ÷ 100 x20	0.56L
30%	2.8L ÷ 100 x30	0.84L
40%	2.8L ÷ 100 x40	1.12L
50%	2.8L ÷ 100 x50	1.4L
60%	2.8L ÷ 100 x60	1.68L
70%	2.8L ÷ 100 x70	1.96L

Efficiency of height per unit of water- low pressure psi 40, volume 2.8L (height ÷ water volume)			
Water percentage	Water volume (L)	Height reached (m)	Efficiency **(height** ÷ water volume) m/L
20%	0.56L	15	26.79
30%	0.84L	30	35.71
40%	1.12L	25	22.32
50%	1.4L	4	2.86
60%	1.68L	2	1.19
70%	1.96L	0.8	0.40

Efficiency of height per unit of water- high pressure psi 100			
Water percentage	Water volume (L)	Height reached (m)	Efficiency **(height** ÷ water volume) m/L
20%	0.56L	100	178.57
30%	0.84L	120	142.86
40%	1.12L	150	133.93
50%	1.4L	90	64.29
60%	1.68L	80	47.62
70%	1.96L	50	25.51

In the lower air pressure system, the most efficient ratio of air to water was 30% water then 20% water then 40% water, before a significant decline in efficiency beyond 40%. In the higher air pressure system the most efficient ratio of air to water was 20% followed by 30% then 40% water with again a significant decline beyond 40% water. This is likely due to the weight of the increased water mass and limited amount of air capacity left in the bottle in the higher water ratio's leaving not enough air to force the heavy weight of the rocket.

The higher air pressure had better efficiency for water to height ratio. This is because the air compressor allowed more air to rapidly fill the rocket which would overcome any small air leaks in the rocket as well as fill the rocket more quickly, providing more compressed air into the rocket.

In a high pressure system, a 5L capacity water rocket, filled to 20%, would reach 178.57 metres based on my results!!

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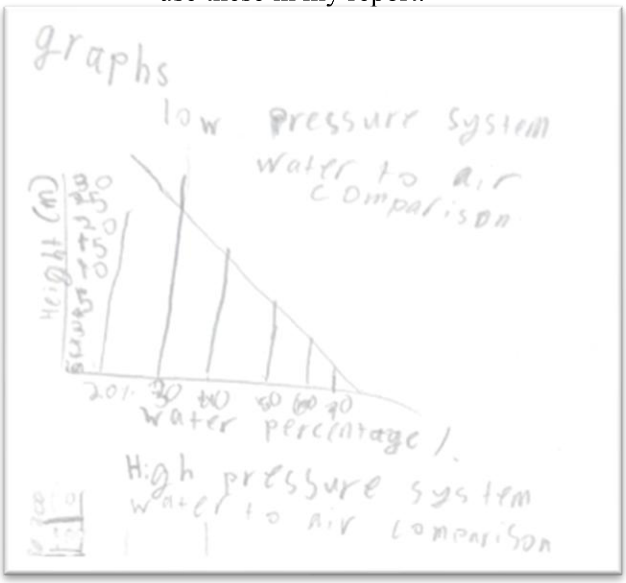
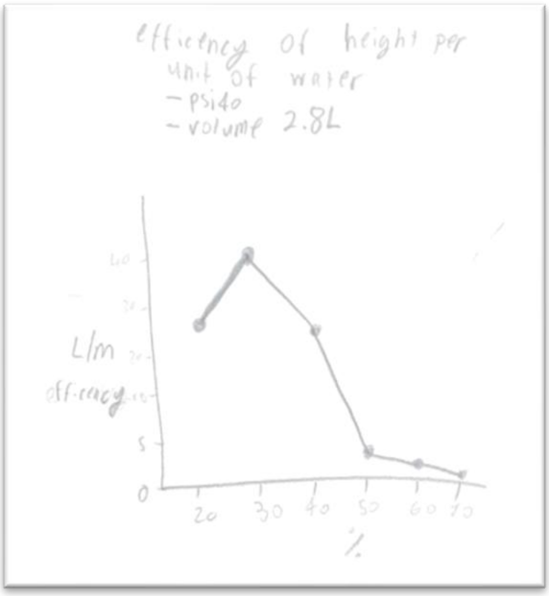
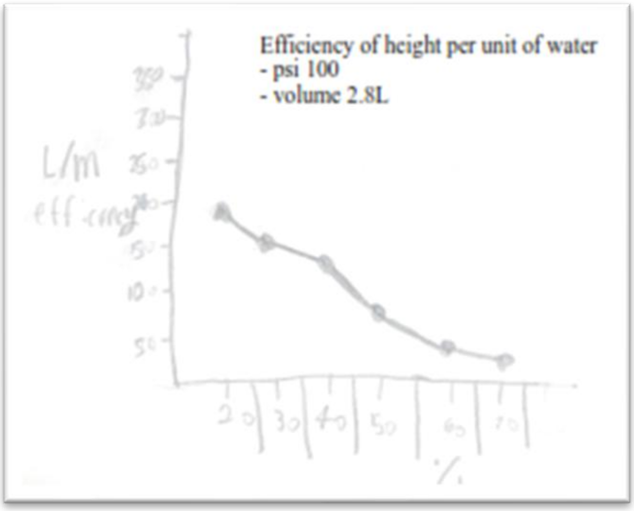
3 fins, 20g weighted nose cone, low 40psi vs high 100 psi

7—12/6/2026 results and interpretation

- I made my results into rough sketch up graphs
- Then to make it more profession I used excel to create graphs to represent my results as I will use these in my report.







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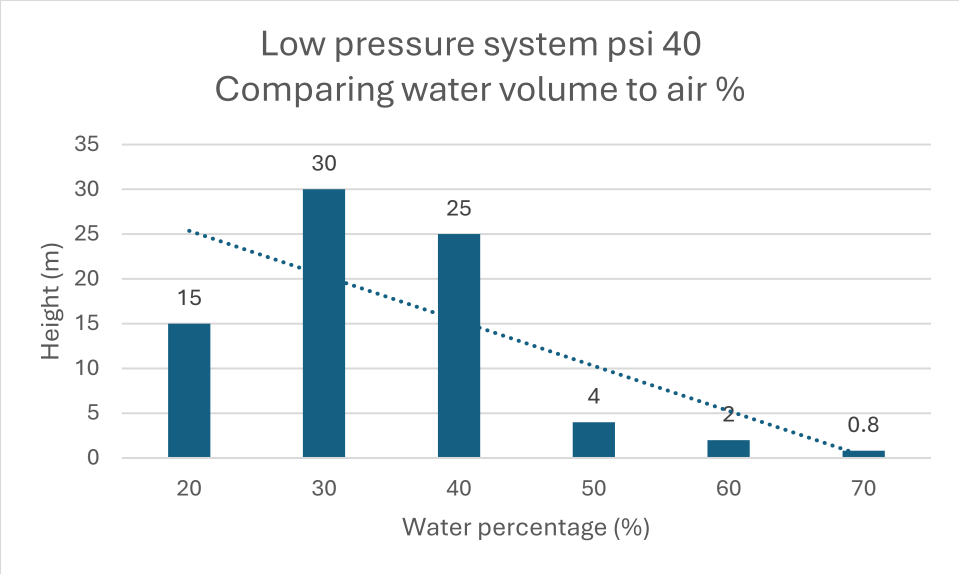

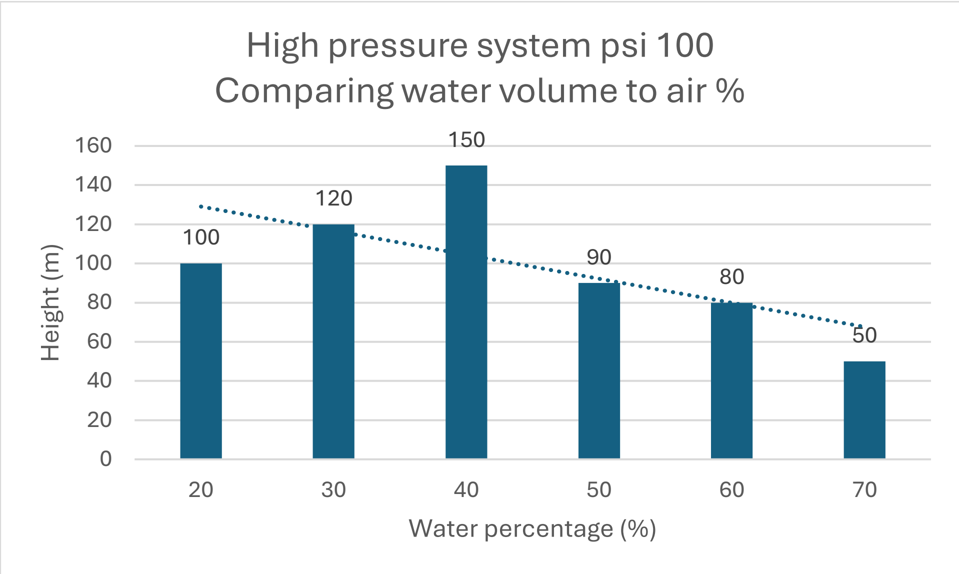

I used a column graph to show the different height and water percentage and added a trend line to show the trend of water percentage efficiency.

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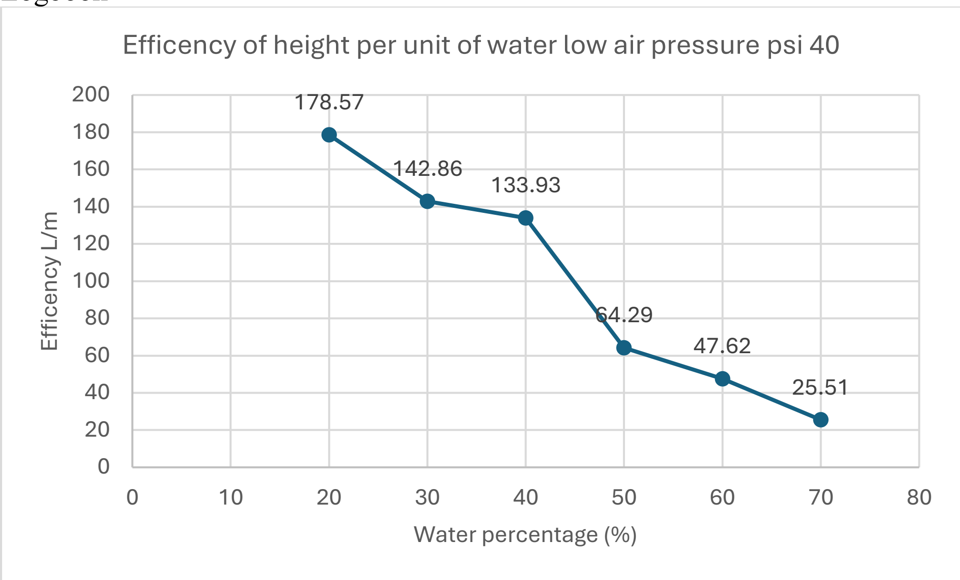

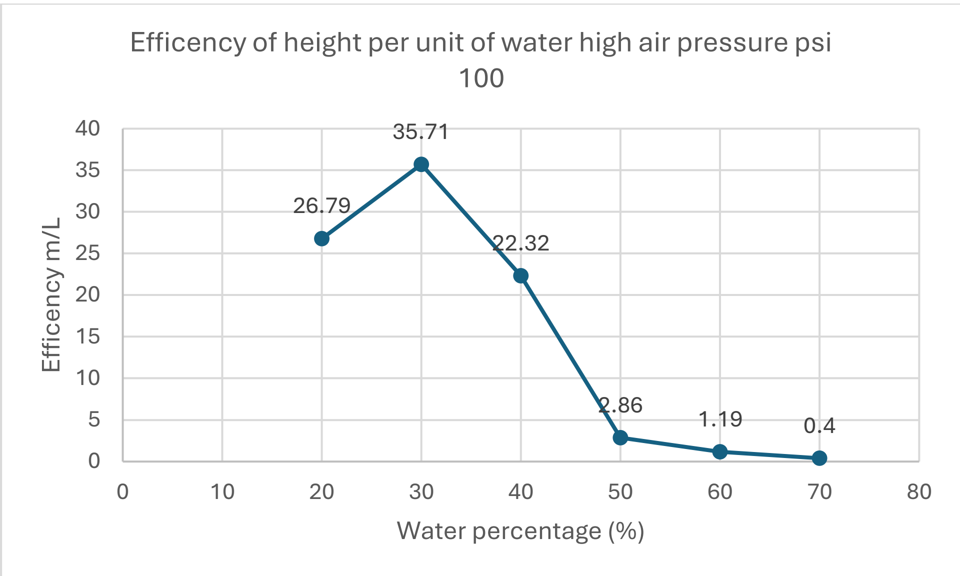

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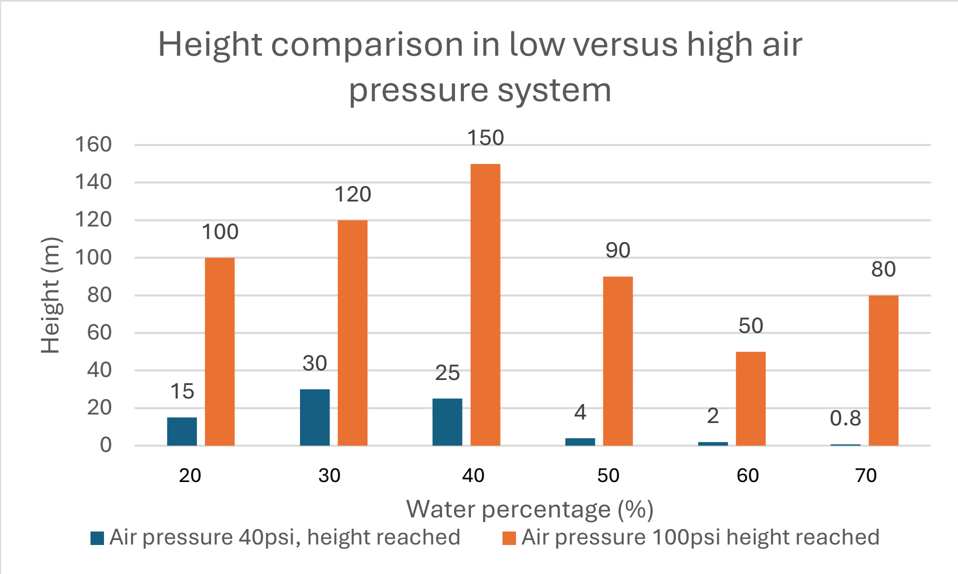



Bike pump psi 40 connected to launch

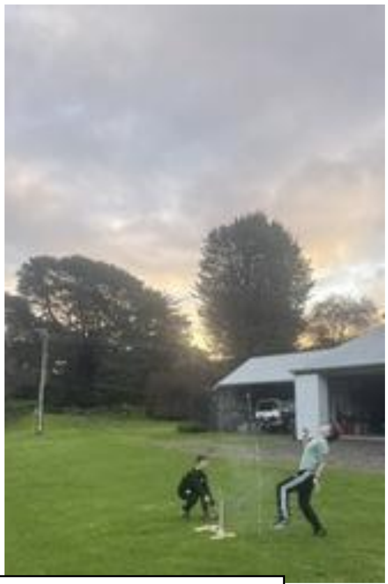

Air compressor psi 100 connected to launch pad




Loading the rocket to the launch pad

Amir Chaloob ID: 0529-016
Category: Scientific Inquiry
Optimising Water Rocket Efficiency
Oliphant Science Awards 2026
Logbook

Air is forced into the water filled rocket, builds pressure, then the rocket which is being held down is released, the air forces the water out the bottom of the rocket, propelling the rocket up, Newton's third and second law and momentum sending the rocket into the air



Newton's third law- see the water propulsion out, forced down by the compressed air and the rocket launches

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<u>13-15/6/2026</u>

Conclusion: 20g weight cone nose, 30-40% water to air ratio, high pressure launch reaches maximal altitude whilst maintaining stability and efficiency.

Discussion

- Water rockets work on the principle of Newtons third law of motion, where the compressed air forces the more dense water downward out of the rocket nozzle (action) and the rocket experiences an equal and opposite upward force shooting it into the sky (reaction). This allows the rocket to launch. Newton's second law (force= mass x acceleration) explains why 30-40% water was the optimal amount for maximum altitude. With lower volumes there is not enough water mass for maximum propulsion thrust as the water is expelled and then the thrust force is finished too quickly compared to the 30-40%. At 50% or more water to air ratio, there is not enough compressed air to produce enough force to lift the heavy water rocket.
- Momentum of the rocket propelling upwards is maintained as long as the propulsive forces (air and water) continue but will be affected by external forces. Air resistance and stability was improved with a weighted cone shaped nose. Fins placed low on the rocket moved the centre of pressure behind the centre of gravity (rocket nose). More weight created more drag which affected altitude. Whilst the nose cone assisted with moving the centre of gravity forward, the nose weight was superior to no nose weight. Once the water and final air is expelled, the air resistance and gravity will cause the rocket to descend.
- The fins moved the centre of pressure behind the centre of gravity (nose cone) which gave more stability as the water was ejected from the water rocket creating thrust.
- 4 fins was slightly more stable than 3 fins but increased air resistance and reduced altitude.
- The higher air pressure had better efficiency for water to height ratio. This is because the air compressor allowed more air to rapidly fill the rocket which would overcome any small air leaks in the rocket as well as fill the rocket more quickly, providing more compressed air into the rocket. The higher 100psi air compressor expelled the water more quickly than the lower pressure bike pump which increased the velocity of the rocket.

<u>20-26/6/2026</u>

- I completed my science report over the weekend.
- Kept rewriting my report, reducing the words, checking everything was correct, formatting.
- This was fun and really challenging, I am a bit exhausted.
- In the last few years I have done Oliphant Science Awards, I have found it easier to focus on different parts and complete different sections at a time. This gives me the different parts of the report already to go.

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Acknowledgements

- I used a website called Mybib.com to help with reference list
- I researched the science and design process of my rocket for many weeks, then I talked about these with my mum, teaching her. This helped me make sure I understood the science and then made it easier to type my work.
- I also used some voice to text typing and then edited my work as there was a lot of typing. I used an online thesaurus to make my work more scientific, and spell checked on the computer.
- My Dad and Mum supervised my building and helped me get the materials.
- My brother was helpful in launching the rocket as I needed more hands:
  - one to pump the air compressor or bike pump
  - one to hold the rocket
  - I needed two people when I was trying to measure the angles from a distance.
- I used a scrap book to keep my results and mock up graphs, then mum showed me how to use excel and I spent a lot of time having fun with excel graphs!

OSA RISK ASSESSMENT FORM

for all entries in (✓) ☐ Models & Inventions and ☑ Scientific Inquiry

This must be included with your report, logbook or entry. One form per entry.

STUDENT(S) NAME: Amir Chaloob ID: 0529-016

SCHOOL: Pulteney Grammar School

Activity: Give a brief outline of what you are planning to do.

I am planning to research, design and build a water rocket. The aim is to build the most efficient rocket to reach the highest altitude. Based on my current research the design of the rocket and ~~angle of launch will be a fixed variable but I am going to test different amounts of water and~~ air pressure.

Are there possible risks? Consider the following:

- Chemical risks: Are you using chemicals? If so, check with your teacher that any chemicals to be used are on the approved list for schools. Check the safety requirements for their use, such as eye protection and eyewash facilities, availability of running water, use of gloves, a well-ventilated area or fume cupboard.
- Thermal risks: Are you heating things? Could you be burnt?
- Biological risks: Are you working with micro-organisms such as mould and bacteria?
- Sharps risks: Are you cutting things, and is there a risk of injury from sharp objects?
- Electrical risks: Are you using mains (240 volt) electricity? How will you make sure that this is safe? Could you use a battery instead? **Only batteries can be used for Models & Inventions entries*
- Radiation risks: Does your entry use potentially harmful radiation such as UV or lasers?
- Other hazards.

Also, if you are using other people as subjects in an investigation you must get them to sign a note consenting to be part of your experiment.

Risks	How I will control / manage the risk
1. Sharps risk 2. Pressure risk 3. Chemical risk (glue)	1. The building will require use of scissors, angle grinders, drills, circular saw, hammers, nails, screws which require appropriate training and use of the tools (I have been trained), ensuring no loose clothing that can get caught, supervision of a trained adult (I have one), securing the items with appropriate use of the tools, safety goggles, secure gloves, face shields. 2. The rocket will launch with air pressure and the downward force of water, I have designed a launch pad to reduce risk of collision. I am also conducting the experiments in a paddock away from any buildings, people or animals. 3. I will use glue to secure the rocket water bottles. This will be done in a well ventilated open space. I also have goggles and gloves.

(Attach another sheet if needed.)

Risk Assessment indicates that this activity can be safely carried out

RISK ASSESSMENT COMPLETED BY (student name(s)): Amir Chaloob

SIGNATURE(S): Amir

☒ By ticking this box, I/we state that my/our project adheres to the listed criteria for this Category.

TEACHER'S NAME: Tom Mildren

SIGNATURE: [signature] DATE: 12/6/26