

Designing and refining water rockets

The NPL Water Rocket Challenge is to land a rocket at a range of $70\text{ m} \pm 5\text{ m}$



This poster explains

- How different aspects of rocket design and launch affect performance
- How to find the best parameters for a rocket to succeed

Shape

A streamlined design helps air flow smoothly round the rocket, reducing the effect of air resistance. Good rotational symmetry reduces spin.

Mass and its distribution

Keeping the front heavier and the back lighter makes the rocket's trajectory more predictable.

Fins

use drag to reduce spin about all axes. Fins add mass to the rear of the rocket, so should be kept as light as possible.

Nozzle diameter

Wider nozzles with a smooth neck profile allow water and air to leave the bottle more quickly, thus increasing thrust.

Launch angle

affects time of flight and range.

Steeper angles increase flight time, though energy used lifting against gravity cannot be used to move the rocket forwards.

Air pressure

relates to how much potential energy the rocket stores – too little and the rocket will fall short, too much and it may overshoot.

Water fraction

Thrust derives from water and air leaving the rocket, but because water is almost 1,000 times denser than air, a given volume of water provides much more thrust than air. However, stored energy depends on the volume of compressed air. If the rocket is over-filled with water, then the stored energy may not be sufficient to push it all out.

All these factors affect rocket performance, so you need a...

Science investigation to refine the design and technology of a rocket, and its launch.

1. Determine project aim (land 70 m away every time)
2. Research and gather information (see what others did)
3. Design and build rocket and launcher, choose launch parameters
4. Run launch tests
5. Pool results with other teams
6. Analyse results and evolve your design/launch:
 - What worked well?
 - What would you change?
 - How might you do it differently?
7. Re-test

Test launch results

(all angle 60° and water 10%)

Launch	Pressure	Range
1	1.5 bar	30 m
2	2.5 bar	47 m
3	3.5 bar	55 m

Plot a graph and try predicting what pressure will reach the target zone. Do you need to change launch angle or water fraction?

Did you know?

On leaving the rocket, the air expands and its heat is shared over a larger volume so it cools down, briefly, to -75°C . (Yes – we checked this!) Typical rocket launch energy, just over 100 joules, creates a g -force of almost 30 g over a very short time (0.06 second). Mean launch power is about 2 kW. Check it out at npl.co.uk/wrc



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