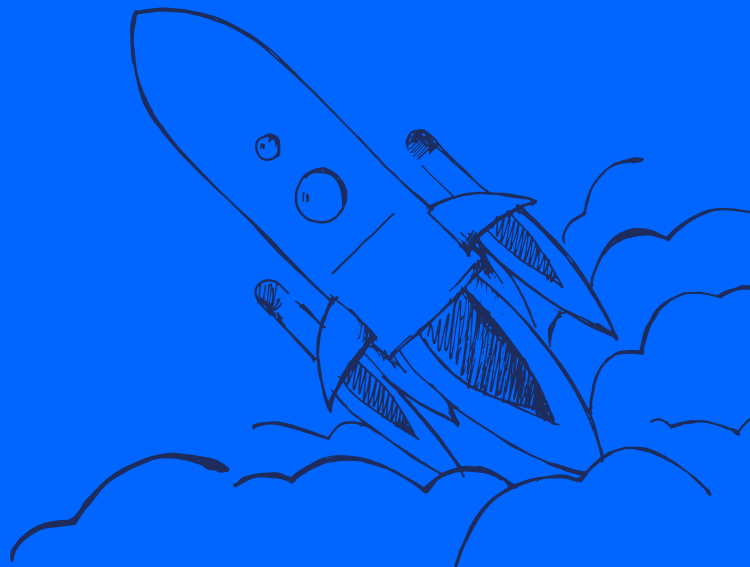
Wonder Project

Rocket Challenge

Key concepts



engineering new zealand
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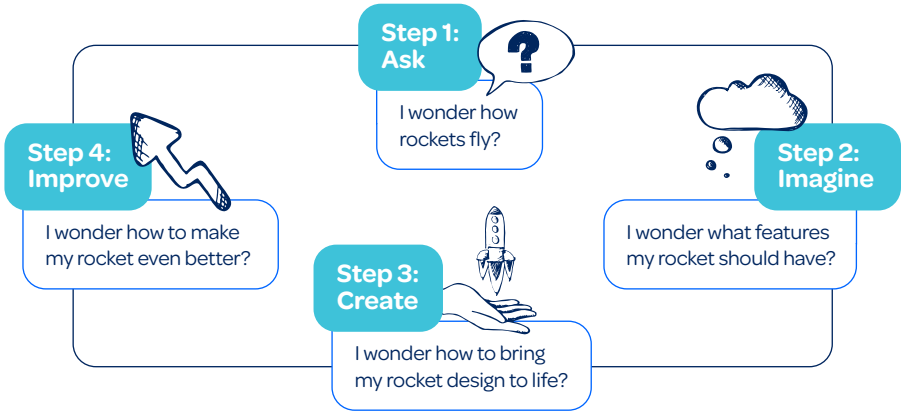
Engineering design process

The engineering design process is a series of simple steps that STEM superstars use to solve problems and make ideas work.

Engineers go back and forth between the steps until they find the best solution. This is called iterative thinking.



Step 1: Ask	Engineers ask pātai (questions) to help them understand the problem they're trying to solve.
Step 2: Imagine	Engineers imagine some possible solutions to the problem they defined in the 'ask' step.
Step 3: Create	Engineers choose the best of their solutions from the 'imagine' step and bring it to life.
Step 4: Improve	Engineers use all the knowledge gained throughout the engineering design process to improve their mahi.

Variables

Variables are things that change or can be changed.

- They are an important tool in STEM jobs to test the best way to achieve a goal.
- For example, in module 2, ākonga will test the effect of changing the rocket's water level (the variable) on how it flies. This will help them determine the best water level for flight.
- To accurately measure the effect a variable has on something, you must keep everything else constant and only change the variable.

Force

Force is a power that causes an object to move or changes an object's movement.

How does force relate to water rockets?

- To get the rockets into the air, we need force. To create force, ākonga will add water into their bottle and then pump air into it.
- When you pump air into the bottle, it bubbles up through the water and pressurises the empty space above.
- When the bottle is released, the pressurised air forces the water out of the bottle sending it up into the air.
- Once the water is gone, the bottle will stop accelerating upwards and eventually fall back to the ground, because the force of gravity is stronger.

Testing force:

- While standing, ākonga can turn to a partner, and lean/balance against each other's hands without making the other fall.
- Ask ākonga if they are feeling a push. Explain that this 'push' is a force.

Forces of flight

There are four forces that water rockets will experience during flight:

Thrust	The force that makes your rocket move through the air.
Drag	The force on your rocket opposite to its movement through the air.
Weight	The force of gravity on your rocket.
Lift	The force that keeps your rocket stable.

These forces are all related to each other during flight – to get a rocket off the ground, you need to increase thrust to counter its weight and drag. Then, lift keeps the rocket stable during flight.

Newton's laws of motion

Newton's laws of motion are three laws that help us understand the relationship between the motion of objects, and the forces acting upon them.

Newton's first law

An object will remain at rest (not moving) or keep moving forever at the same speed and in a straight line unless there is another force acting on it.

Ākonga video: Newton's first law

How does this relate to rockets?

A rocket at the launchpad will remain stationary until the thrust from its engines creates a force greater than the force of gravity, allowing it to lift off.

In the Rocket Challenge, the water rocket will remain stationary until the built-up air and water is released from the bottle, pushing the rocket upwards.

Testing Newton's first law

Ākonga can kick and stop some bouncy balls in their crews to test the law in context:

- The ball will stay at rest until a crew member kicks it.
- It will then keep moving until another force acts on it – this could be the foot of another crew member, or simply the friction of the ground underneath it.

Newton's second law

Force = mass x acceleration

This law tells us that when an object has more mass (it's heavier), it needs more force to make it move.

Ākonga video: Newton's second law

How does this relate to rockets?

Rockets are heavy objects, so, they require strong forces to get them off the launch pad. If ākonga add too many unnecessary features to their rockets, or use heavy materials, they will need to adjust the air pressure and water level to achieve the same flight as a lighter rocket.

Testing Newton's second law

You can test this law by setting up balls with varying masses in a line on a table:

- Hit each ball with the same force using a ruler by pulling it back to a consistent distance before releasing it.
- Then, observe and measure the distance each ball travels after being hit.
- The force applied to the lighter balls should make them accelerate faster, as they have less mass. This means they will travel a longer distance.

Newton's third law

For every action there is an equal and opposite reaction

Ākonga video: Newton's third law

How does this relate to rockets?

This law relates to the 'thrust' force that rockets experience during flight. Thrust works in opposition to drag and weight to push the rocket into the air:

Action	Ākonga pump air into their water rocket which pushes water out of the bottom, creating thrust.
Equal and opposite reaction	Rocket flies upwards in the opposite direction of the water.

Testing Newton's third law

You can test Newton's third law with balloons as a simple analogy of how a rocket engine works.

In their crews, ākonga should blow up and release some balloons to see how far they travel – experimenting with different levels of air.

- The air trapped inside the balloon is pushed out the open end of the balloon.
- According to Newton's third law of motion, the expelled air exerts an equal force in the opposite direction of the motion of the air, causing the balloon to move forward.

Aerodynamics

Aerodynamics is the study of how air moves around an object.

A rocket's aerodynamics affects its forces of flight. So better aerodynamics = better flight.

For example, if a rocket is heavy, improving its aerodynamics and increasing force will help it lift-off.

Testing aerodynamics

Ākonga can test aerodynamics by crafting and flying a variety of paper planes. The better the aerodynamic design of the paper plane, the further and straighter it will fly.

Tip: Ask the ambassador to help create some alternative designs for comparison.

Features of an aerodynamic rocket

Ākonga will learn the features of a rocket that make it more aerodynamic – these features should be considered when creating rocket prototypes. They include:

Feature	Effect on aerodynamics
Streamlined rocket body	The rocket has a form that presents little resistance to the flow of air.
Nosecone	The conically shaped top section of a rocket, designed to cut through the air and reduce drag. It's also designed to withstand high temperatures which is helpful during re-entry into Earth's atmosphere.
Fins	Placed on the bottom of the rocket to provide stability and help control the direction the rocket travels. Ākonga should consider the following when it comes to fins: • **Shape:** Most fins are triangular, but ākonga should get creative and see which shapes are the most aerodynamic. • **Size:** Larger fins increase drag while smaller fins don't provide any stability. • **Number:** Ākonga can experiment with the number of fins. For the best flight, fins need to be evenly placed around the rocket to distribute the weight and drag evenly. • **Materials:** Heavier materials will weigh the rocket down, but lighter materials won't hold their form during launch.
Weight distribution	Rockets are more stable if there's more weight at the top, and more drag force at the base.