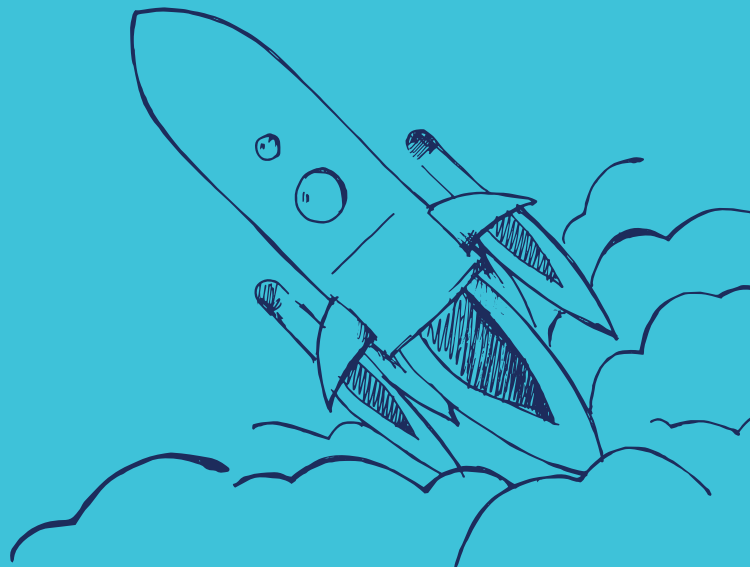
Wonder Project

Rocket Challenge

Challenge Guide



engineering new zealand
te ao rangahau

Contents

Using the challenge guide

The challenge guide provides all the information you need to run the challenge successfully. Use it alongside the online modules in the student Learning Hub.

It's not important that you pānui this entire document – we know it's pretty huge! We recommend you understand the challenge overview, but otherwise please feel free to simply focus on the parts that are helpful to you. Karawhiua!

STEM skills

Some of the STEM skills ākonga will use throughout the challenge are:

STEM skill	Description
Teamwork	Working together with others to achieve an end goal – recognising each other's expertise and strengths, being flexible, and making sure each rōpū member has a job.
Communication	Passing on information effectively, whakarongo when others are sharing ideas, understanding instructions, and asking pātai. Bringing different knowledge and experience to the table to improve results.
Open mindedness	Being willing to whakarongo, considering and accepting different ideas, and being open to new experiences and learning about the world around you.
Creativity	Taking risks, ignoring doubt and facing fears – using inventiveness and outside the box thinking to bring new ideas to life.
Problem solving	Thinking innovatively, being resilient, never giving up and trying lots of ideas to find the best solution.
Analysis	Being observant, collecting and interpreting data, detecting patterns, brainstorming ideas, and making decisions based on the results.

Kupu Māori glossary

We use kupu Māori throughout this document because it's a small but important way of encouraging others to do the same, to help keep the language alive.

Ākonga	**Student**	**Mahi**	**Work**
Karawhiua	**Give it heaps!**	**Pānui**	**Read**
Kaiako	**Teacher**	**Pātai**	**Question**
Kōrero	**Speak**	**Rōpū**	**Team**
Kupu	**Word**	**Whakarongo**	**Listen**

Challenge overview

Module	Activity sequence				
Module 1: Mission Command **45 minutes** **Purpose:** Understand the challenge, the pātai (question) you'll be solving and the process you'll use to solve it – engineering design process.	**Your mission** • Watch: Rocket Challenge welcome video • Understand the challenge pātai (question) ākonga will solve – I wonder how rockets fly?	**Get your crew together** • Listen to the Ambassador's career story • Complete "Mission Brief 1: STEM roles quiz" and learn more about STEM careers • Form a crew and assign crew roles	**Space journey prep** • Unpack your rocket kit • Start sourcing challenge materials	**What's an engineer?** • Watch: How to think like an engineer video • Display the engineering design process poster • Unpack the first step of the engineering design process – ask • Complete "Mission Brief 2: Ask" and set challenge goals	
Module 2: Fly **90 minutes** **Purpose:** Learn the basics of how to launch a rocket and determine the optimum water level for flight.	**Why rockets?** • Discuss the benefits of space exploration • Watch: Rocket Lab epic and recognise Aotearoa New Zealand's contribution to the space industry	**How do we launch a rocket?** • Watch: Four things to launch a rocket video	**Safety first** • Display the health and safety poster • Discuss the challenge's health and safety rules • Complete "Mission Brief 3: Launch hazards" and establish mitigations to potential risks • Complete optional activity: Health and safety relay	**Prepare for launch** • Learn about force and variables • Watch: Launching your rocket video	**First test flights** • Complete "Mission Brief 4: First test flights" and launch plain bottles, observing the effect of changing the water level variable • Analyse flight data to determine the best water level
Module 3: Force **75 minutes** **Purpose:** Build on rocket launch knowledge by exploring Newton's first law of motion and imagine a rocket design that will improve its flight.	**Newton's laws** • Discover Newton's three laws of motion and display poster • Watch: Newton's first law video • Learn the forces a rocket experiences during flight • Complete "Mission Brief 5: Forces of flight" and cement learning on forces	**Engineering design process** • Continue the engineering design process with step 2 – imagine • Complete "Mission Brief 6: Imagine" and imagine design features for the rocket • Plan the materials needed to create the rocket's design features			

Module	Activity sequence			
Module 4: Aerodynamics **85 minutes** **Purpose:** Learn how Newton's second law of motion and aerodynamics applies to rocket flight. Then apply this knowledge by creating a prototype rocket.	**Newton's second law** • Watch: Newton's second law video	**Aerodynamics** • Learn the features of an aerodynamic rocket • Optional: test aerodynamics by creating and flying paper planes	**Engineering design process** • Continue the engineering design process with step 3 – create • Watch: Modifying your rocket video • Complete "Mission Brief 7: Create" and add design features to the rockets	**Rocket weight distribution** • Complete "Mission Brief 8: Rocket weight distribution" and perform two weight distribution tests on the rocket • Analyse test data to determine how to improve the rocket's weight distribution
Module 5: Thrust **80 minutes** **Purpose:** Learn how Newton's third law and thrust apply to rocket flight. Then launch prototype rockets to determine how their fins affect their flight.	**Newton's third law** • Watch: Newton's third law video • Optional: test the law by blowing up and releasing balloons • Learn more about the thrust force • Complete "Mission Brief 9: Fact card frenzy" and reflect on challenge learning	**Prepare for launch** • Recap the key factors of aerodynamic rocket fins	**Prototype test flights** • Complete "Mission Brief 10: Prototype test flights" and launch prototype rockets, observing how each rocket's fins affect their flight • Complete optional activity: Measuring trajectory	
Module 6: Blast off! **120 minutes** **Purpose:** Improve rockets using challenge knowledge before launching them for the last time, collecting performance data. Use this data to answer the challenge pātai.	**Engineering design process** • Continue the engineering design process with step 4 – improve • Complete "Mission Brief 11: Improve" and summarise challenge learnings to determine final improvements to rockets	**Final flight** • Complete "Mission Brief 12: Final flights" and launch rockets for the last time, collecting data on their performance • Complete optional activity: Measuring trajectory • Analyse flight data to determine the best performing rocket, and why • Form conclusion to the challenge pātai – I wonder how rockets fly? • Celebrate and reflect on learning		

Curriculum links

Achievement objectives

Kaiako can also make wider curriculum links to other achievement objectives depending on ākonga level and individual learning programmes.

Strand	Ākonga will	Curriculum level/phase
Science: Physical world	**Physical inquiry and physics concepts** Identify and describe how movement and forces affect the motion of rockets.	Level 3
Technology: Technological knowledge	**Technological modelling** Undertake functional modelling of rocket prototypes to inform decision making. Evaluate rocket prototype fitness of purpose to refine further developments.	Level 3
Mathematics and statistics: Geometry and measurement; Statistics	**Measurement** Use metric units to find length, volume, weight (mass) of the rockets, the angle of rocket launch and distance of flight. **Statistics** Investigate what influences a rocket's flight (eg force, aerodynamics, Newtons laws of motion).	Phase 2 (refreshed curriculum)

Your resources

To complete the Rocket Challenge, you'll be using the items in your rocket kit, alongside some items you'll need to source as a school.

Wonder Project kits are designed to be reused. Please keep it on hand for next year, or to pass on to another kaiako so we can reach as many schools as possible.

Rocket kit items

Items

- Rocket launcher
  play video: assembling your launcher
- 3 x Safety vests
- 4 x Safety goggles
- Example parachute
- Clipboard
- Progress stickers

Schools to supply

Required:

Ambassador career story

- Technology
  to display a PowerPoint presentation

Rocket creation

- 2 x 1.5 litre PET soda bottles per crew
  1 for base rocket, 1 for nosecone
- Materials to modify rocket prototypes
  refer to page 28 for suggestions
- Hot glue guns
  or other adhesives
- Classroom resources
  including pens, decorations, and scissors

Rocket launch

- Bike pump
  foot pump is best
- Bucket of water
- Measuring cups
- Stopwatch/timer
- Protractor
- Rolling distance counter, measuring tape or long rulers
- Phone or tablet
  to record flights

Rocket testing

- Ruler
- String

Need help sourcing something? We're here to help with a library of resources you can borrow. Get in touch with what you need at **hello@wonderproject.nz**

Optional:

Health and safety relay activity

- 3 x hard hats
  ask ambassador to supply

Measuring trajectory activity

- Projector, whiteboard + whiteboard pen *OR,* tracing paper, pencil + laptop/tablet

Mission Brief 11: Improve

- Resources to make a parachute
  string, tape and recycled plastic bags or fabric

Lesson plans

Module 1:
Mission Command

45 minutes (approximate)

Purpose

Ākonga will understand the challenge, the pātai (question) they'll be solving and the process they'll use to solve it – engineering design process.

Resources

From your rocket kit:

Full rocket kit
with launcher pre-assembled

School to supply:

Technology
for the ambassador's PowerPoint presentation

Print or share online:

- Mission Brief 1: STEM roles quiz (1 per ākonga)
- Mission Brief 2: Ask (1 per crew)
- Sticker chart (1 per ākonga)
- Poster: Engineering design process (1 per class)

Module outcomes

- Learn the challenge pātai/question they'll be solving – I wonder how rockets fly?
- Understand the role of STEM in rocketry
- Form a crew and assign challenge roles
- Learn the process they'll use to complete the challenge – engineering design process
- Explore the first stage of the engineering design process – ask

Preparation

Pre-module checklist

Kaiako

- ◯ Completed teacher training
- ◯ Pānui Module 1 of the Student Hub
- ◯ Checked your rocket kit is ready for blast off
- ◯ Ensured the rocket launcher is assembled (play video)
- ◯ Pānui the health and safety guidance
- ◯ Completed the teacher pre challenge survey
- ◯ Asked ākonga to complete the student pre challenge survey
- ◯ Asked ākonga to take home the caregiver information sheet
- ◯ Joined Wonder Project Facebook group

Ambassadors

- ◯ Completed ambassador training
- ◯ Pānui Module 1 of the Student Hub
- ◯ Ordered free Wonder Project t-shirt to wear on visits
- ◯ Ensured the rocket launcher is assembled (play video)
- ◯ Pānui the health and safety guidance
- ◯ Prepared your career presentation
- ◯ Joined Wonder Project Facebook group

Module 1 lesson plan

Use this plan to support you as you work through Module 1 of the student online Learning Hub.

Key:	Refers to key concept	More information in the activity notes	Ambassador role can be done online
Explicit teaching:	Teaching and modelling	Development of skills (guided practise)	Application of skills

Timing	Activity	Teaching sequence	Ambassador role
	Pre challenge surveys		
	Student and teacher pre challenge surveys	All kaiako and ākonga should complete their pre challenge survey before the challenge. They are an important tool for us to improve the programme each year and continue our funding to keep the Wonder Project free for schools.	
Block A 25 minutes	**Your mission**		
	Video: Welcome to the Rocket Challenge	Watch video that introduces the Rocket Challenge – to design, build and launch water rockets. Understand the challenge pātai (question) ākonga will solve – I wonder how rockets fly?	Support ākonga to understand how STEM relates to rockets and how exciting it can be. **Ask pātai:** *What do you already know about rockets?*
	Get your crew together		
	Meet your Mission Command	Establish the kaiako and ambassador as Mission Command. Then, the ambassador will share their career story. If you don't have an ambassador, watch Haritina Mogoșanu's career story video, our Wonder Project virtual Ambassador.	Introduce yourself to the class and share your career story presentation (5 mins). Use the tips provided in the video telling your story.
	Mission Brief 1: STEM roles quiz	Complete activity that supports ākonga to understand which area of STEM might suit them best. Then, get ākonga into a crew of 3–6 classmates and use their quiz results to choose their role for the Rocket Challenge.	After the quiz, facilitate a wrap-up kōrero on the class's results. Share your knowledge on different STEM roles – including cool STEM projects you're aware of or have been involved with.
	Space journey prep		
	Unpack your rocket kit	Ensure the launcher is assembled before you start the challenge. Get ākonga to help unpack the kit. Print one sticker chart per ākonga and distribute so they can start to track their progress.	Explain how each kit item might be used.

Timing	Activity	Teaching sequence	Ambassador role
Block A 25 minutes	**Space journey prep (cont)**		
	Smile for the camera	Start to think about what parts of the challenge ākonga would like to capture for their blast off competition entry (see Mission Brief 13). **Pātai to consider:** *What story do you want to tell? How? What messages do you want to include?*	
Block B 20 minutes	**What's an engineer?**		
	Video: How to think like an engineer	Watch video that introduces the engineering design process that ākonga will follow to imagine, create and improve their rockets. Put the engineering design process poster on the classroom wall.	Before the video, **ask pātai:** *What do you think an engineer does?* After the video, **ask pātai:** *What is important about the ask/imagine/create/improve stage? Why might it be helpful to go back and forth between each stage?*
	Engineering design process – ask	Explore the first step of the engineering design process 'ask'. Understand that engineers start projects by asking pātai to help them define the problem they're trying to solve. **Discuss the challenge pātai:** *I wonder how rockets fly?*	Support ākonga to understand how asking pātai at the start of a project can help with the problem-solving process. Give examples of when you might have done this at mahi.
	Mission Brief 2: Ask	Complete activity that encourages ākonga to think about their goals for the challenge, pātai they need answered to help achieve their goals, and potential problems they might need to overcome.	Discuss why goal setting is an important part of STEM roles. After the activity, ask each crew to share one of their pātai and why they chose it.
Remember: Ask ākonga to start collecting recyclable materials for their rockets!			

Module 2:
Fly

90 minutes (approximate)

Purpose

Ākonga will learn the basics of how to launch a rocket and determine the optimum water level for flight.

Resources

From your rocket kit:

- Safety goggles
- Safety vests
- Assembled rocket launcher
- Clipboard
- Wonder Project stickers

School to supply:

- 1.5 PET litre soda bottles
  1 per crew
- Bike pump
  Foot pump is best – ask us about borrowing one
- Bucket of water
- Measuring cups
- Phone or tablet
  to record flights

Ambassador to supply:

- 3 x hard hats from mahi (Optional health and safety relay activity)

Print or share online:

- Optional health and safety relay activity (1 per crew)
- Mission Brief 3: Launch hazards (1 per crew)
- Mission Brief 4: First test flights (1 per crew)
- Poster: Health and safety (1 per class)

Module outcomes

- Understand the benefits of rockets and space exploration
- Learn the basics of how to launch a rocket
- Understand the health and safety rules and plan risk mitigations
- Learn the concepts of force and variables
- Set and reflect on a conjecture on how water level impacts the rocket's flight
- Perform the first test launch to explore the outcome of changing the water level variable
- Analyse flight data to find the optimum water level for flight

Preparation

Pre-module checklist

- ◯ Familiarised yourself with the launcher (play video)
- ◯ Collected your resources
- ◯ Pānui through Module 2 of the Student Hub

Module 2 lesson plan

Use this plan to support you as you work through Module 2 of the student online Learning Hub.

Key:	Refers to key concept	More information in the activity notes	Ambassador role can be done online
Explicit teaching:	Teaching and modelling	Development of skills (guided practise)	Application of skills

Timing	Activity	Teaching sequence	Ambassador role
Block A 45 minutes	**Why rockets?**	Give context to the challenge by discussing why rockets are an innovative STEM invention and how they benefit society. **Pātai to consider:** *What do you think we use rockets for? How do you think they benefit us?*	Support kōrero by discussing Rocket Lab or the NZ space agency.
	Video: Rocket Lab epic	Watch video and get inspired by Kiwi STEM superstars working in rocketry.	
	How do we launch a rocket?		
	Video: 4 things to launch a rocket	Watch video that introduces the four basic things required to launch a rocket. **Pātai to consider:** *Why do you think it's important to have a good crew? What does good teamwork look like?*	Provide an example of a time you worked in a rōpū to get a job done. Why was it helpful to work as a rōpū?
	Safety first		
	Safety first	Put up the Health and Safety poster and discuss the 10 health and safety rules ākonga should follow throughout the challenge. **Pātai to consider:** *Why is it important to follow health and safety rules?*	Review the role of the Health and Safety Officer in Mission Brief 1 with the class. Ask the Health and Safety Officer from each crew to pānui one of the rules to the class.
	Optional health and safety relay activity	Complete this optional activity to reinforce the health and safety rules.	Supply 3 x hard hats from work, if possible. Before the relay, discuss how you follow health and safety rules at mahi and why it's important.
	Mission Brief 3: Launch hazards	Complete this activity to establish mitigations to potential launch risks and hazards. Ākonga should share their answers with the class.	When ākonga share their answer with the class, write them up on the whiteboard.

Timing	Activity	Teaching sequence	Ambassador role
Block A 45 minutes	**Prepare for launch**		
	I wonder how to launch our water rocket? 	Introduce the concept of force, a power that causes an object to move or changes an object's movement, and how ākonga will create force to launch their water rockets.	Lead kōrero on force. 
	Testing variables 	Introduce the concept of variables and the variable ākonga will measure for their first test flights – water level.	Lead kōrero on variables and why they're an important tool when testing rockets, and in STEM broadly. 
	Video: [Launching your rocket] 	Watch video that describes how to set up the launcher and rocket for the test launch and covers important health and safety information. After the video, review the health and safety rules poster, revise each crew role and hand out health and safety gear. Assign ākonga to video the test flights and give each crew a printed copy of Mission Brief 4 to bring to the launch zone. As a health and safety measure, **air pressure must not go over 60 psi.**	While the video is playing, get the assembled launcher ready and secured to the ground in the designated launch zone. *Use the instructions in the launching your rocket video as a reminder.*
Block B 45 minutes	**First test flights**		
	Mission Brief 4: First test flights 	Set a conjecture on how water level will impact the rocket's flight. Then complete a series of test flights using a plain **new** 1.5 litre **carbonated** drink bottle, observing the effect of different water levels. Mission Command should set up and manage the rocket launches. Make sure some of the test flights are filmed.	Set up the basic water rockets – these should not have added fins at this stage. Launch each test flight. Take note of which water level resulted in the best performance to support analysis.
	Understanding your data 	Analyse the data collected from Mission Brief 4 to figure out the optimum water levels for flight. Compare these results to the conjecture.	Support ākonga to understand how air pressure and water levels relate to force and how this information could help with their analysis. 

Remember: Ask ākonga to start collecting the materials they will use in future modules! You might also like to source some bouncy balls to demonstrate Newton's first law.

Module 3:
Force

75 minutes (approximate)

Purpose

Ākonga will build on rocket launch knowledge by exploring Newton's first law of motion and imagine a rocket design that will improve its flight.

Resources

From your rocket kit:

- Wonder Project stickers

School to supply:

- Ball
  to demonstrate Newton's first law
- Decorations and colourful pens/pencils

Print or share online:

- Mission Brief 5: Forces of flight (1 per crew)
- Mission Brief 6: Imagine (1 per crew)
- Poster: Newton's laws (1 per class)

Module outcomes

- Learn about Newton's laws of motion how they relate to rocket flight
- Learn Newton's first law
- Learn the forces rockets experience during flight and their impact
- Explore the second stage of the engineering design process – imagine
- Imagine and draw some rocket designs that will improve its flight

Preparation

Pre-module checklist

- ◯ Collected your resources
- ◯ Pānui Module 3 of the Student Hub

Module 3 lesson plan

Use this plan to support you as you work through Module 3 of the student online Learning Hub.

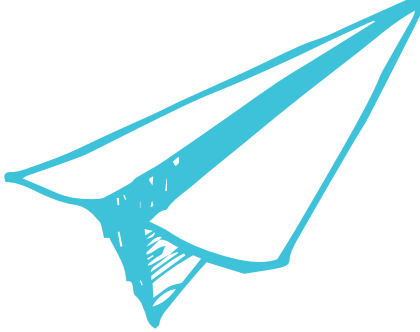
Key:	Refers to key concept	More information in the activity notes	Ambassador role can be done online
Explicit teaching:	Teaching and modelling	Development of skills (guided practise)	Application of skills

Timing	Activity	Teaching sequence	Ambassador role
Block A 30 minutes	**Newton's laws**		
	Video: **Newton's first law**	Watch video that introduces ākonga to Newton's laws in relation to rocket flight and details Newton's first law. After the video, put up the Newton's laws poster and participate in a Q&A session to understand the effect force has on the motion of objects. Model Newton's first law outside by kicking and stopping some bouncy balls in crews.	After the video, lead a Q&A session on force and Newton's first law. Give applied examples of force. Eg when you push a window open on a sunny day, you are using force to open it.
	Mission Brief 5: **Forces of flight**	Complete activity that introduces the forces that each crew's water rocket will experience during flight: thrust, drag, weight and lift.	Help explain each force of flight by demonstrating using a plastic bottle.
Block B 45 minutes	**Engineering design process**		
	Imagine	Explore the second step of the engineering design process 'imagine'. Understand that after defining the problem they are trying to solve, engineers imagine some solutions to the problem. **Pātai to consider:** *How could we make our basic rockets fly better?*	Discuss how you have imagined some solutions to a project in your job.
	Mission Brief 6: **Imagine**	Reflect on test flight one results and knowledge on forces of flight. Then, complete activity by imagining some design features that will improve the water rockets. Get crews to share the reasoning behind their ideas with the class.	As ākonga complete the activity, **ask pātai:** *Why have you chosen to add this feature to your rocket? How will this feature help your rocket travel higher and a longer distance?*
	It's planning time	Decide what recyclable materials are required to construct rocket design features and write a list. Then, decide who's responsible for bringing in what.	Support the class by discussing the properties and benefits of different materials

Remember: Bring in materials to construct your rocket prototypes in Module 4. You'll also need some string, a ruler and some paper.

Module 4:
Aerodynamics

85 minutes (approximate)



Purpose

Ākonga will learn how Newton's second law of motion and aerodynamics applies to rocket flight. Then, they'll apply this knowledge by creating a prototype rocket.

Resources

From your rocket kit:

- Wonder Project stickers

School to supply:

- Paper
  to make paper planes
- 1.5 litre PET soda bottles
  2 per crew – 1 for base rocket, 1 for nosecone
- Materials
  to modify rocket prototypes
- Hot glue guns
  or other adhesives
- Decorations
- Classroom resources
  including scissors, rulers and string
- Ruler
- String

Print or share online:

- Mission Brief 7: Create (1 per crew)
- Mission Brief 8: Rocket weight distribution (1 per crew)

Module outcomes

- Learn Newton's second law
- Learn about aerodynamics and how it impacts rocket flight
- Learn the features of an aerodynamic rocket
- Explore the second stage of the engineering design process – create
- Create a rocket prototype, using challenge knowledge to inform design
- Evaluate and test prototype rocket weight distribution
- Understand the importance of testing and improving

Preparation

Pre-module checklist

- ◯ Collected your resources
- ◯ Pānui Module 4 of the Student Hub

Module 4 lesson plan

Use this plan to support you as you work through Module 4 of the student online Learning Hub.

Key:	Refers to key concept	More information in the activity notes	Ambassador role can be done online
Explicit teaching:	Teaching and modelling	Development of skills (guided practise)	Application of skills

Timing	Activity	Teaching sequence	Ambassador role
Block A 40 minutes	**Newton's second law**		
	Video: **Newton's second law**	Watch video that details Newton's second law and how it applies to the forces of flight: Force = mass x acceleration Model Newton's second law in action by pushing different weighted objects along a table.	Lead a Q&A session on Newton's second law. Give applied examples of the law. Eg outline the difference between dropping a feather and a bouncy ball. Describe the forces acting on each object as they fall.
	Aerodynamics		
	Features of an aerodynamic rocket	Explore aerodynamics, the study of how air moves around an object, and how it affects a rocket's forces of flight. Test aerodynamics by making some paper planes and observing which design flies the best. Then, discuss which features enabled this success and how it could be applied to rocket designs.	Help ākonga create some paper planes. Ask them to predict how different designs will change the planes' flight (eg a balanced shape helps with stability and reduces drag). After the flights, **ask pātai:** *What features do you think made this paper plane fly better? Do you know which features on a rocket help with its flight?*
Block B 45 minutes	**Engineering design process**		
	Create	Explore the third step of the engineering design process 'create'. Understand that after engineers have imagined some solutions to their problem, they create a prototype or model that helps them test their ideas.	**Ask pātai:** *Why do you think it's helpful to test ideas with a prototype?*
	Video: **Modifying your rocket**	Watch instructional video on the modifications ākonga can make to their basic rocket to improve its flight. **Pātai to consider:** *How many fins do you think a rocket should have? What size should the fins be? What materials should you use and why?*	
	Mission Brief 7: **Create**	Complete this activity to cement learning on the aerodynamic design features of a rocket and create an improved fin template. Then, create a rocket prototype using this template. Refer to safety tip on page 28 if using hot glue.	Discuss how geometry and measurement can help construction and improve aerodynamics.

Timing	Activity	Teaching sequence	Ambassador role
Block B 45 minutes	**Rocket weight distribution check**		
	Mission Brief 8: Rocket weight distribution 	Complete this activity to check whether rocket prototypes have an aerodynamic weight distribution – amending as required.	Discuss the relationship between materials used in prototyping and their performance properties. 

Remember: Ensure you have the resources for the second test flights in Module 5. You might also like to bring some balloons to demonstrate Newton's third law.

Module 5:
Thrust

80 minutes (approximate)

Purpose

Ākonga will learn how Newton's third law and thrust apply to rocket flight. Then, they'll launch prototype rockets to determine how their fins affect their flight.

Resources

From your rocket kit:

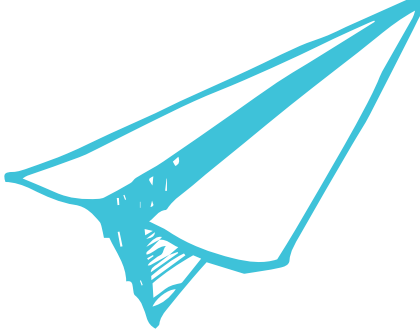
- Assembled rocket launcher
- Safety goggles
- Safety vests
- Clipboard
- Wonder Project stickers

Print or share online:

- Mission Brief 9: Fact card frenzy (1 per crew)
- Mission Brief 10: Prototype test flights (1 per crew)
- Optional measuring trajectory activity

School to supply:

- Balloons
  to demonstrate Newton's third law
- Prototype rockets
  1 per crew
- Bike pump
  Foot pump version is best
- Bucket of water
- Measuring cups
- Stopwatch/timer
- Phone or tablet
  to record flights
- Projector, whiteboard + whiteboard pen *OR,* tracing paper, pencil + laptop/tablet



Module outcomes

- Learn Newton's third law
- Learn more about the thrust force and how it impacts rocket flight
- Set and reflect on a conjecture on how rocket fins impact their flight
- Launch rocket prototypes and collect observational data on rocket fin performance
- Analyse flight data to gain insights into how to improve rocket fin designs

Preparation

Pre-module checklist

- ◯ Re-familiarised yourself with the launcher (play video)
- ◯ Collected your resources
- ◯ Pānui Module 5 of the Student Hub

Module 5 lesson plan

Use this plan to support you as you work through Module 5 of the student online Learning Hub.

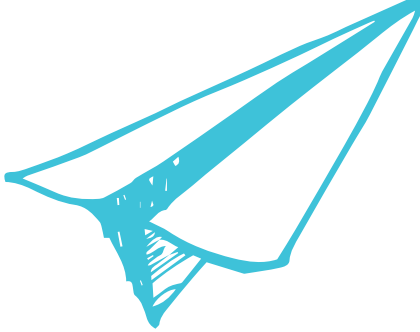
Key:	Refers to key concept	More information in the activity notes	Ambassador role can be done online
Explicit teaching:	Teaching and modelling	Development of skills (guided practise)	Application of skills

Timing	Activity	Teaching sequence	Ambassador role
Block A 30 minutes	**Newton's third law**		
	Video: **Newton's third law**	Watch video that details Newton's third law and how it applies to thrust: For every action there is an equal and opposite reaction. With the Newton's laws poster as a reference, participate in a Q&A session on Newton's third law. Blow up and release some balloons to test the law and as a simple analogy of how a rocket works.	Lead a Q&A session on Newton's second law. Give applied examples of the law. Eg outline the difference between dropping a feather and a bouncy ball. Describe the forces acting on each object as they fall.
	Thrust	Apply Newton's third law to the forces of flight by exploring thrust and how it helps launch rockets. **Pātai to consider:** *How do you think thrust relates to rocket launch? How is the thrust force created in your water rockets?*	Support kōrero on thrust and how it relates to other forces of flight eg thrust works in opposition to drag and weight.
	Mission Brief 9: Fact card frenzy!	Create fact cards ākonga can use to test each other's knowledge. When they're done, use their cards to test them. This activity can be used to assess knowledge and understanding on forces and Newton's laws.	Test ākonga knowledge of challenge material by testing them with their fact cards.
Block B 60 minutes	**Prepare for launch**		
	Rocket aerodynamic design variables	Recap the four factors of aerodynamic rocket fins to prepare for launch: • Shape • Size • Number • Materials	

Timing	Activity	Teaching sequence	Ambassador role
Block B 60 minutes	**Prototype test flights**		
	Mission Brief 10: Prototype test flights 	Set a conjecture on how fins will impact the rocket's flight. Then, test rocket prototypes to determine which fin designs work best and inform further improvements. After the launch, analyse data collected, compare results to the conjecture and make a list of improvements. Ensure health and safety protocols are followed and that ākonga don't pump to over 60 psi.	Allow ākonga to set up the launcher under your supervision. Supervise each launch, ensuring they don't pump to over 60 psi. Ensure ākonga are keeping the water level and air pressure constant so they can accurately observe how different fin designs impact flight. Take note of which fins performed best to support analysis.
	Optional measuring trajectory activity 	Plot the trajectory of rocket prototypes using test flight videos. Think about what the trajectory means and how it can be used to inform rocket design changes.	**Ask pātai:** *What do you think this trajectory means? What trajectory would be better? How do you think we could achieve that?*
Remember: Ensure you have the resources for the final test flights in Module 6. You might also like to bring some resources to make parachutes and improve prototype designs.			

Module 6:
Blast off!

2 hours (approximate)



Purpose

Ākonga will use challenge knowledge and data to make final improvements to their rockets before launching them for the last time, collecting data on their performance. They'll use this launch data to form a conclusion to the challenge pātai.

Resources

From your rocket kit:

- Assembled rocket launcher
- Safety goggles
- Safety vests
- Clipboard
- Example parachute
- Wonder Project stickers

School to supply:

- Prototype rockets *1 per crew*
- Materials *to improve rocket prototypes*
- Hot glue guns *or other adhesives*
- Decorations
- Classroom resources *including scissors and pens*
- Final rockets *1 per crew*
- Bike pump *Foot pump version is best*
- Bucket of water
- Measuring cups
- Stopwatch/timer
- Protractor *to set launch angle*
- Rolling distance counter, measuring tape or long rulers
- Phone or tablet *to record flights*

Print or share online:

- Mission Brief 11: Improve (1 per crew)
- Mission Brief 12: Final flights (1 per crew)
- Mission Brief 13: Blast off competition (1 per crew)

Module outcomes

- Explore the fourth stage of the engineering design process – improve
- Make final improvements to rocket prototypes, using challenge learnings and data
- Set and reflect on a conjecture on how rocket improvements will impact its flight
- Launch final rockets, collecting data on performance
- Analyse flight data to gain insights into which crew created the best rocket, and why
- Form a conclusion on the challenge question/pātai

Preparation

Pre-module checklist

- ◯ Re-familiarised yourself with the launcher (play video)
- ◯ Collected your resources
- ◯ Pānui Module 6 of the Student Hub

Module 6 lesson plan

Use this plan to support you as you work through Module 6 of the student online Learning Hub

Key:	Refers to key concept	More information in the activity notes	Ambassador role can be done online
Explicit teaching:	Teaching and modelling	Development of skills (guided practise)	Application of skills

Timing	Activity	Teaching sequence	Ambassador role
Block A 60 minutes	**Engineering design process – improve**		
	Improve	Explore the fourth and final step of the engineering design process 'improve'. Understand that after engineers have created and tested their ideas, they use the data from their testing to make improvements.	Explain a time that you have improved on an idea at mahi. **Ask pātai:** *Why do you think it's helpful to test and improve your ideas? How will you improve your rockets?*
	A safe landing	Consider adding a parachute to the rocket's nosecone to improve its performance. This can be done as part of Mission Brief 11. Use the parachute supplied in the kit as a guide.	Create your own rocket design with a parachute to demonstrate to ākonga.
	Mission Brief 11: Improve	Complete this activity to reflect on learnings and data from the challenge, then consider and carry out improvements to rockets before their final flights.	Help ākonga understand their data. **Ask pātai:** *Why do you think your rocket flew this way? Can you find any patterns between flight performance and design features?*
Block B 60 minutes	**Final flight**		
	Mission Brief 12: Final flights	Set a conjecture on how design improvements will impact the rocket's flight before launching the final, improved rockets to see which crew's is the highest performing. Ensure health and safety protocols are followed, that ākonga don't pump to over 60 psi, and that the launcher angle is set to 45˚ so that crews can measure the launch distance. After the launch, review data collected, do a final analysis, and then, form a conclusion on the challenge pātai.	Allow ākonga to set up the launcher under your supervision. Supervise each launch, ensuring they don't pump to over 60 psi. Ensure ākonga are keeping the water level and air pressure constant and the launch angle is set to 45˚ so the only variable is each crew's rocket. Support ākonga to film their flights.
Optional	**Whānau showcase**	Invite whānau to visit the classroom so ākonga can show off their rockets and perform an example launch. You could also film the launch and share with whānau virtually.	Set up the launcher for an example launch. Supervise the launch, ensuring ākonga don't pump to over 60 psi.

Timing	Activity	Teaching sequence	Ambassador role
Optional	**I wonder how to tell our story?**		
	Mission Brief 13: Blast off competition	Plan and create a creative video or poster that captures the Rocket Challenge experience to be in to win a prize.	
	Post challenge surveys		
	Student, teacher and ambassador post challenge survey	All kaiako ākonga and ambassadors should complete their post challenge survey after they complete the challenge. They're an important tool for us to improve the programme each year and continue our funding to keep the Wonder Project free for schools. We supply kaiako with the survey data from their school to show the impact the Rocket Challenge has had on ākonga perceptions towards STEM, and how much they've learned.	

Activity notes

Here you'll find support notes and answers for relevant activities. If there's anything else you need help with, please get in touch at hello@wonderproject.nz

Mission Brief 3:
Launch hazards

Example answers:

Pre launch

Hazard	Risk	How to reduce risk
Launcher not assembled correctly.	Broken equipment, rocket won't fly properly.	Get the ambassador to check the launcher is assembled correctly before launch.
Rocket explodes due to too much air pressure, or wrong bottle used.	Injury to self or others.	Always use a new 1.5 litre carbonated drink bottle to ensure it's in the best condition. Never pump above 60 psi.

Post launch

Hazard	Risk	How to reduce risk
Rocket doesn't blast off and ākonga touch it.	Rocket may explode when touched and hurt someone.	If a rocket fails to launch, ākonga should stay at least 3 metres behind the launch site. Then, the ambassador or kaiako should pull the relief valve.
Rocket launched near people or buildings.	Rocket hits people or buildings.	The rocket should only be launched in a wide-open space, directed away from buildings. The Health and Safety Officer should ensure all spectators are at least 3 metres behind the launch site before launch.
Rocket lands on a high building or in the trees.	Lose rocket, block gutters.	The rocket should only be launched in a wide-open space, directed away from buildings and trees.

Launching your rocket

Mission Briefs
4, 10, 12.

Prepare for launch

Assemble your launcher

- Ensure your launcher is assembled at least 24 hours before use.
- Play video: assembling your launcher

Safety notes

- Due to their ability to stay together under high pressure, only use bottles in good condition, made from PET plastic, for carbonated drinks. You could use L&P, Coca Cola, Fanta or Sprite bottles.
- The psi limit for the Rocket Challenge is **60** psi.

Inclusivity tips

- Rocket launches can be loud and overwhelming for some ākonga. It's a very exciting experience which can also lead to screaming and other loud noises. Consider:
  - Offering ear plugs or headphones
  - Doing separate launches with some ākonga

Ready for launch!

For the first test launch series in Mission Brief 4, allow the ambassador to set up and launch the rockets. All other rocket launches can be set up by ākonga.

Expected results:

- The optimum water level should be around 250ml or 1/3 bottle.
- The distance a water rocket can travel at 60 psi depends on several factors:
  - Rocket design
  - Water level
  - Launch angle (45° is often the best for distance)
  - Air resistance and wind conditions
- On average, a well-designed 2 litre bottle rocket can travel 15–30 metres at 60 psi.
- With an optimized design, some rockets can reach up to 45 metres.
- Play video: Launching your rocket

Mission Brief 5:
Forces of flight

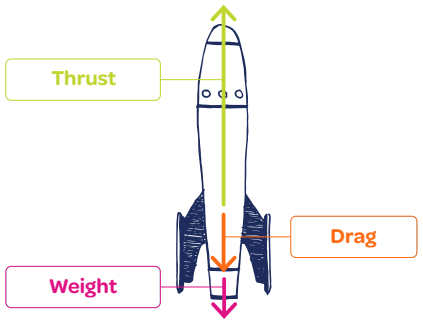
Step 1 answers:

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

Step 2 answers:

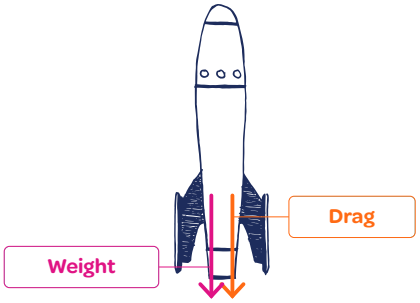
During launch

Force = thrust – (drag + weight)



After thrust has finished

Force = drag + weight



Mission Brief 7:
Create

Example answers

- Rockets should have a streamlined body because: it reduces air resistance.
- A nosecone helps with flight by: cutting through the air and reducing drag.
- Rockets are more stable when: there's more weight at the top, and more drag force at the base.
- Fins help with flight by: stabilising the rocket.

Rocket prototype creation tips

- Try filling the bottles with water. It will give it stability, cool it down if using hot glue, and let ākonga know early if they get a leak.
- If using hot glue, try using the "skip weld" method of applying a series of dots rather than a straight line. Allow glue to dry and harden for 24 hours before launching.

Nosecone	Ākonga shouldn't attach their nosecone with any adhesives. During lift-off, the air-pressure will hold it in place. It will also then be easier for them to add a parachute later in the challenge.
Fins	We recommend experimenting with different materials. However, the following will be most efficient: • Plastic ice cream containers • Coroplast or corflute • Durable cardboard
Weight distribution	Rockets are more stable if there's more weight at the top, and more drag force at the base. Try screwing something into the nosecone's cap to add weight and act as a 'payload': • A small coin • Blu Tack • A blob of hot glue A payload is the object or entity carried by a rocket's nosecone. This could include a satellite, space probe, or another spacecraft with humans, animals or cargo.

Mission Brief 8: Rocket weight distribution

Test one: Centre of mass

The centre of mass is the place on the rocket where all the mass is concentrated, and the rocket's weight is evenly balanced on both sides. It's best if the centre of mass is closer to the rocket's nose.

Improvements:

- If ākonga find their centre of mass is closer to the rocket's tail than its nose, they could try adding more weight to the nosecone or reducing the size of their rocket's fins.
- They could also try replacing the material of their rocket fins with something lighter.

Test two: Centre of pressure

The centre of pressure is the place on your rocket where all the forces of flight are concentrated. It's best if the centre of pressure is closer to the tail of the rocket.

Improvements:

- If ākonga find the centre of pressure is closer to the rocket's nose than its tail, they could try increasing the size of their fins.

Activity extension

Ākonga can check their rocket's stability by doing the swing test.

Improvements:

- If the rocket flies backwards, this could mean the centre of pressure is too far forward. It can be moved backwards by increasing the size of the rocket's fins.
- If their rocket starts to cartwheel, this could mean that the centre of mass and centre of pressure are too close together. These can be separated by adding weight to the nosecone and increasing the size of the rocket's fins.

Mission Brief 9:
Fact card frenzy!

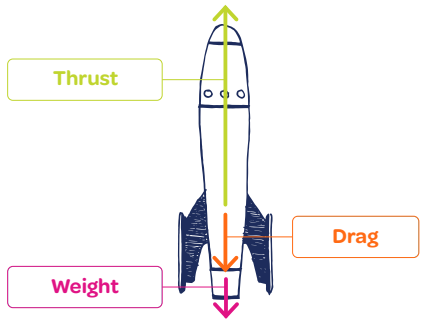
Example answers

Topic 1: What are the forces of flight?

Thrust, drag, weight, lift.

Bonus: Draw and label a rocket with the forces of flight.

Force = thrust - (drag + weight)



Topic 2: Describe one of Newton's laws.

1) 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.

Bonus: Add an example of this law in action.

1) Kicking and stopping balls. 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 the friction of the ground underneath it.

Topic 3: What are the four steps of the engineering design process?

Ask, imagine, create, improve.

Bonus: Give an example of when your crew used the engineering design process.

Imagining designs for rocket prototypes.

Topic 4: What does STEM stand for?

Science, technology, engineering, maths.

Bonus: List some skills that STEM superstars have.

Teamwork, communication, open mindedness, creativity, problem solving, analysis.

Mission Brief 11:
Improve

Example answers

What we've learned about force	The thrust force works in opposition to drag and weight.
We can use this information to improve our rocket by:	Distributing our rocket's weight better by adding a payload to the nosecone.
What we've learned about Newton's laws	Force = mass x acceleration So, you need more force to launch a heavy rocket.
We can use this information to improve our rocket by:	Making our fin material lighter so there is less force required for lift-off.
What we've learned about aerodynamic design variables	Fins are stabilisers and work best when they're evenly spread across the rocket.
We can use this information to improve our rocket by:	Moving our fins so they're more evenly spread.
What we've learned from testing our rockets	The best water level for launch is 250ml.
We can use this information to improve our rocket by:	Ensuring we measure 250ml of water accurately every time we launch.

Making a parachute

You can add a parachute into the rocket's nosecone to improve it. We suggest ākonga come up with their own solutions to make an effective parachute. If they need more guidance, you can follow these instructions:

Step 1	If using a plastic bag, cut off the handles.
Step 2	Cut four small holes around the edge of your chosen material. The holes should be evenly spread and on opposite sides of the material.
Step 3	Cut four pieces of string about 30–40cm in length.
Step 4	Thread one end of the string through one of the holes and tie a knot. Repeat with the other pieces of string.
Step 5	Attach the other end of the pieces of string to the rocket, underneath the nosecone, with your chosen adhesive. Place the nosecone back on top.

Challenge conclusion

Example answer

I wonder how rockets fly?

- We can understand how a rocket flies thanks to Newton's three laws of motion:

Law one:	The rocket is at rest until the thrust force acts on it. In the water rockets, this is created because of the water being expelled.
Law two:	The rocket's mass impacts the force acting on it. It will fly for a longer distance if its weight distribution is efficient.
Law three:	The rocket will blast upwards in the opposite direction of the water being expelled.

- The rocket's flight is also improved by other aerodynamic design features like fins, a streamlined body, and a nosecone that cut through the air, and reduce drag.