Wonder Project

Rocket Challenge

Teacher lesson guide

Term 1 and 2, 2023

engineering new zealand te ao rangahau

POWERED BY CallaghanInnovation New Zealand's Innovation Agency

Module 1: Mission Command

Prep page

Overview

In this module, your students will meet their Mission Command (their teacher and ambassador), unpack their rocket kit, and learn what STEM roles suit them best before forming their superstar space crew.

Approximate timing

2 hours.

You are welcome to adjust the pacing based on what works best for your class.

Key activity sequence

- Complete pre challenge survey (teacher and student)
- Complete Mission Brief 1: STEM roles quiz
- Form a crew and assign crew roles
- Unpack your rocket kit
- Watch: How to think like an engineer video
- Learn the first step of the engineering design process – ask
- Complete Mission Brief 2: Ask

Module outcomes

- Understand how STEM is used in rocketry and Aotearoa's contribution to the space industry
- Form a crew and understand the importance of roles and responsibilities
- Explore the first stage of the engineering design process, ask

Preparation

Resources

From your rocket kit:

- Full rocket kit (with launcher pre-assembled)

School to supply:

- Technology for the ambassador's PowerPoint presentation

Print:

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

Pre-module checklist

Teachers

- ◯ Asked students to take home the parent information sheet
- ◯ Completed the teacher pre challenge survey
- ◯ Asked students to complete the student pre challenge survey

Ambassadors

- ◯ Prepared your career presentation

Both

- ◯ Read the teaching guide for Module 1 (pages 3–5)
- ◯ Checked the rocket kit has arrived
- ◯ Assembled the launcher – find instructional video here
- ◯ Joined the Wonder Project Facebook group
- ◯ Read through Module 1 of the Student Hub

Module 1:
Mission Command teaching guide

Use this overview as a reference as you go through **Module 1** in the **student Learning Hub** with your class.

Detailed information on each activity and key concept can be found in the **support notes document.**

ONLINE AMBASSADORS: the parts you can carry out online are coloured in pink.

Activity overview	What students will do	Teacher role	Ambassador role
Student and teacher pre challenge survey An important tool for us to improve the programme each year and continue our funding to keep the Wonder Project free for schools.	Each participating student should complete the student pre challenge survey before they begin the Rocket Challenge. Students can access the survey via the Survey Monkey link in the online Learning Hub and follow the prompts to submit their responses.	Each participating teacher should complete the teacher pre challenge survey before they begin the Rocket Challenge. Teachers can access the survey via the Survey Monkey link in the online Learning Hub and follow the prompts to submit their responses.	
Space is the limit **Video: Rocket Lab epic** Get students excited and ready for the Rocket Challenge. Introduces how we depend on science, technology, engineering and maths (STEM) to launch rockets into space.	Understand that their challenge will be to design, build and launch their own water rockets using STEM skills. Watch Rocket Lab's 'It's a test – launch day' video and get inspired by Kiwi STEM superstars working in rocketry.	Watch the video and highlight New Zealand's role in rocketry by discussing Rocket Lab – founded in Auckland, New Zealand in 2006 by Peter Beck. Peter is a Kiwi engineer, born in Invercargill, and features in the 'It's a test – launch day' video.	Get students excited about the challenge they'll be tackling. Support them to understand how STEM relates to rockets and how exciting it can be. Discuss some of the key STEM skills students will need to harness for the challenge – including teamwork, communication, open mindedness, creativity, problem solving and analysis.
Get your crew together **Meet your Mission Command** Establish the teacher and ambassador as Mission Command. Ambassador shares their STEM career story.	Meet their Mission Command, listen to their ambassador's career story, and ask questions.	Establish the members of Mission Command. Help the ambassador set up their presentation. Facilitate questions. If you don't have an ambassador, watch Evan Simmers' career story video, our special Wonder Project virtual Ambassador.	Meet the class and share your career story presentation (5 mins). Remember to leave time for questions! Use the tips provided in the Wonder Project video 'telling your story'.

Activity overview	What students will do	Teacher role	Ambassador role
Mission Brief 1: STEM roles quiz Draw out student understanding of what it means to work in STEM and highlight some of the exciting STEM job opportunities available to them.	Take the quiz to explore the exciting elements of STEM roles and understand which area of STEM might suit them best. Then, get into a crew of 3–6 classmates and use their quiz results to choose their role for the Rocket Challenge.	Guide students through the quiz activity. After the quiz, support students to form their crews of 3–6 classmates. Facilitate a wrap up discussion about the class's results. ***Ask:*** *What STEM role did you get? Is it the role you were expecting? What sort of projects do you think someone with that job would do? How do you think your quiz results line up with the Rocket Challenge roles?*	During the quiz, help students think about their responses to each question. After the quiz, support the wrap-up discussion by sharing 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 Unpack the kit and discuss what each item is for.	Help the ambassador unpack the rocket kit. Discuss how each item may be used.	Ensure the launcher is assembled before you start the challenge. Facilitate questions as the kit is unpacked. Print one sticker chart per student and distribute so they can start using the stickers in the rocket kit to track their progress. *Refer to 'unpack your rocket kit' on page 4 of the support notes for more information.*	Ensure the launcher is assembled before you start the challenge. Help unpack the rocket kit in front of the class with selected students. Call up students to pull an item out of the box and ask what they think it is for. Explain how each item might be used. *Refer to 'unpack your rocket kit' on page 4 of the support notes for more information.*
Smile for the camera Start to think about what parts of the challenge students would like to capture on film for their blast off competition video, or what they might like to include in their poster.	Document their Rocket Challenge experience through video and/or pictures for the Blast off competition. *Refer to pages 29 – 30 of the support notes for more information.*	Support students to capture their Rocket Challenge experience. ***Ask:*** *What story do you want to tell? How? What messages do you want to include?* *Refer to Mission Brief 13: Blast off competition for more information.*	Support students to capture their Rocket Challenge experience.
What's an engineer?			
Video: How to think like an engineer Introduces students to an engineering mindset and the engineering design process that they will use to imagine, create and improve their rockets.	Become familiar with what engineers do, the key skills engineers use to succeed and the four steps of the engineering design process – ask, imagine, create, improve.	Before the video, ***ask:*** *What do you think an engineer does?* Then, watch the video and support the ambassador to answer any questions. Put the engineering design process poster on the classroom wall. ***Ask:*** *What is important about the ask/imagine/create/improve stage? Why might it be helpful to go back and forth between each stage?*	Watch the video with students and then answer any questions about STEM they may have. Support discussion by giving real life examples of when you have seen or used the engineering design process (or similar) in your work. For example, think about a time you've had to problem solve or try lots of ideas to come up with the best solution.

Activity overview	What students will do	Teacher role	Ambassador role
Engineering design process – ask Explore the first step of the engineering design process.	Understand that engineers start projects by asking questions to help them define the problem they're trying to solve. Discuss the challenge question: 'I wonder how rockets fly?'	Facilitate discussion on the challenge question: 'I wonder how rockets fly'	Discuss how you have asked questions at the start of a project to help with the problem-solving process, and why it's important.
Mission Brief 2: Ask Helps students understand the first step of the engineering design process by asking them about their goals, and what they need to know more about to achieve their goals.	In their crews, think about their goals for the challenge. Then brainstorm some questions they need answered to help achieve their goals. *E.g. I wonder how rockets lift off the ground?* Finally, brainstorm some potential problems they might need to overcome.	Get the class into their crews and guide them through the activity. After the activity, ask each crew to share one of their questions and why they have chosen it. **Remember:** Ask students to start collecting the materials they will use in future modules!	During the activity, circulate each crew, support crew discussions, and help students think about their responses. There are no right or wrong answers. ***Ask:*** *How do you think the 'ask' stage helps us to understand the problem we need to solve?*

Module 2:
Fly

Prep page

Overview

In this module, your students will learn what it takes to launch a rocket, become health and safety experts, and perform their first test flight.

Approximate timing

2 hours.

You are welcome to adjust the pacing based on what works best for your class.

Key activity sequence

- Learn about rockets and how we use them
- Watch: 4 things to launch a rocket video
- Watch: Safety first video
- Complete health and safety relay (optional)
- Complete Mission Brief 3: Launch hazards
- Prepare for your first launch
- Watch: Launching your rocket video
- Perform your first test launch
- Complete Mission Brief 4: First test flights

Module outcomes

- Explore the societal benefits of rockets and space exploration
- Understand the basics of how to launch a rocket
- Understand the health and safety rules and plan risk mitigations
- Discover the concept of variables
- Perform the first test launch and explore the outcome of changing the water level variable
- Use metric units to find the volume of water to add to a rocket
- Analyse flight data to find the optimum water level for flight

Preparation

Resources

From your rocket kit:

- Optional health and safety relay activity resources:
  - Safety goggles
  - Safety vests
- Mission Brief 4: First test flights resources:
  - Assembled rocket launcher
  - Safety goggles
  - Safety vests
  - Clipboard
- Wonder Project stickers

School to supply:

- Mission Brief 4: First test flights resources:
  - 1.5 PET litre soda bottles (1 per crew)
  - Bike pump (foot pump version is best)
  - Bucket of water
  - Measuring cups
  - Phone or tablet to record flights
- Classroom resources including pens

Ambassador to supply:

- Optional health and safety relay activity resources:
  - 3 x hard hats from work

Print:

- 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)

Pre-module checklist

- ◯ Read the teaching guide for Module 2 (pages 6–8)
- ◯ Familiarised yourself with the launcher – find instructional video here
- ◯ Collected your resources
- ◯ Read through Module 2 of the Student Hub

Module 2:
Fly teaching guide

Use this overview as a reference as you go through **Module 2** in the **student Learning Hub** with your class.

Detailed information on each activity and key concept can be found in the **support notes document.**

ONLINE AMBASSADORS: the parts you can carry out online are coloured in pink.

Activity overview	What students will do	Teacher role	Ambassador role
Why rockets? Gives context to the challenge theme by exploring why rockets are an innovative STEM invention and how they benefit society.	Learn the different ways rockets are used to benefit society.	Facilitate discussion on why rockets are an innovative STEM invention. ***Ask:*** *What do you think we use rockets for? How do you think they benefit us on earth?*	Reinforce Aotearoa's contribution to the space industry by discussing Rocket Lab – founded in NZ and making it easier to do incredible things in space to benefit the world.
How do we launch a rocket?			
Video: 4 things to launch a rocket Introduces the four basic things that are required to launch a rocket, and reinforces the importance of teamwork: • Workshop • Rocket • Launchpad • Strong crew	Watch video, take notes, and get excited for their own launch.	Watch video with the class. ***Ask:*** *Why do you think it's important to have a good crew? What does good teamwork look like?*	After the video, provide an example of a time you worked in a team to get a job done. Why was it helpful to work as a team?
Safety first			
Video: Safety first Enforces that health and safety is the number one priority and summarises the 10 health and safety rules students should follow throughout the challenge.	Watch video and take notes on the health and safety rules they should follow throughout the challenge. Actively participate in a discussion on the importance of health and safety.	Watch video with the class. Discuss the importance of keeping safe around the rockets. Put up the health and safety poster.	After the video, lead discussion on how best to keep safe during the challenge. 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 read one of the rules to the class.
Optional health and safety relay activity A hands-on activity to get students moving outdoors and reinforce the importance of following health and safety rules.	Listen to the ambassador discuss health and safety at their work. Get into three teams and follow the instructions on the activity sheet.	Follow the instructions on the activity sheet and on page 9 of the support notes to get started. Choose a designated end point for students to walk to. Keep an eye out for students who are running or who aren't wearing the gear properly – they must start again.	Supply 3 x hard hats from work, if possible. At the beginning of the relay, discuss how you follow health and safety rules at your own work and why it's important. Support the teacher to get the activity started.

Activity overview	What students will do	Teacher role	Ambassador role
Mission Brief 3: Launch hazards Establish mitigations to potential launch risks and hazards.	Get into their crew and read the hazards and risks for pre and post launch. Brainstorm some ways to reduce risk and write them in the blank box on the mission brief. Share their answers with the class.	After students have completed the activity, get each crew to share one of their answers with the class.	Circulate crews as they are completing the activity. Contribute to discussion on risk mitigation. When students share their answer with the class, write them up on the whiteboard.
Prepare for launch			
Testing variables Introduces the concept of variables and the variable students will measure for their first test flights – water level.	Learn the concept of variables and why/how they are used in STEM. Understand the variable they will measure for their test flights is water level.	Support discussion on variables. Describe how the water level variable applies to the students' rockets. *Refer to the summary in Mission Brief 4.*	Lead discussion on variables and why they're an important tool when testing rockets, and in STEM broadly.
Video: Launching your rocket Describes how to set up the launcher and rocket for the test launch. Covers important health and safety information and a reminder on the roles of each crew member.	Watch the video and take notes of important health and safety information. Write down what water levels they would like to test to find the best flight variables. As a health and safety measure, **air pressure must not go over 60 psi.**	After the video, review the health and safety rules poster, revise each crew role and hand out health and safety gear. Assign a few students 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.* As a health and safety measure, **air pressure must not go over 60 psi.**
First test flights			
Mission Brief 4: First test flights Test flight using a plain **new** 1.5 litre carbonated drink bottle.	Crews will observe the effect of testing different water levels. Allow the ambassador to control the rocket launch. Write down the results of each test flight in the table provided. Make sure some of the test flights are filmed.	Support the ambassador to set up the basic water rockets – these should not have added fins at this stage. Ensure health and safety protocols are followed. Make sure each crew uses a **new** 1.5 litre carbonated drink bottle as plastic can deteriorate over time.	Set up the basic water rockets – these should not have added fins at this stage. Launch each test flight. In later test flights, students will get the opportunity to do the launch themselves. Take note of which water level resulted in the best performance to support the students' analysis.
Understanding your data Analyse the data collected from Mission Brief 4 to figure out the optimum water levels for flight.	Using the table of data in Mission Brief 4, figure out which water levels resulted in the best flight with their crew. Write down their results at the bottom of the mission brief.	After the activity, get each crew to share their result with the class. Come to a collective agreement on which water levels produced the best flight.	Circulate the crews as they analyse their data. Use your observations from each flight to support their analysis. Support students to understand how air pressure and water levels relate to force.

Remember: Ask students to start collecting the materials they will use in future modules!

Module 3:
Force

Prep page

Overview

In this module, your students will be introduced to Sir Isaac Newton and explore his first law of motion, learn the second step in the engineering design process and design their rocket.

Approximate timing

2 hours.

You are welcome to adjust the pacing based on what works best for your class.

Key activity sequence

- Watch: Newton's first law video
- Discover the forces of flight
- Complete Mission Brief 5: Forces of flight
- Learn the second step of the engineering design process – imagine
- Complete Mission Brief 6: Imagine
- Plan which resources to bring in for the next module

Module outcomes

- Understand Newton's first law
- Understand the concept of force
- Discover the four forces of flight and how they affect the motion of rockets
- Represent their rocket through drawing

Preparation

Resources

From your rocket kit:

- Wonder Project stickers

School to supply:

- Ball to demonstrate Newton's first law
- Mission Brief 6: Imagine resources:
  - Decorations and colourful pens/pencils
- Classroom resources including pens

Print:

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

Pre-module checklist

- ◯ Read the teaching guide for Module 3 (pages 10–11)
- ◯ Collected your resources
- ◯ Read through Module 3 of the Student Hub

Module 3:
Force teaching guide

Use this overview as a reference as you go through **Module 3** in the **student Learning Hub** with your class.

Detailed information on each activity and key concept can be found in the **support notes document.**

ONLINE AMBASSADORS: the parts you can carry out online are coloured in pink.

Activity overview	What students will do	Teacher role	Ambassador role
Newton's laws			
Video: Newton's first law Introduces students to the concept of force, Newton's laws and how they apply to rocket flight. Details 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.**	Watch the video and take notes. Participate in a Q&A session led by their ambassador to understand what force is, and the effect it has on the motion of objects. Understand that their rocket will not lift off the ground without a force acting on it. Test Newton's first law outside by kicking and stopping some bouncy balls in their crews.	Print and display Newton's laws poster. Support Q&A session with reference to the poster. If it's a nice day, go outside to test Newton's first law with some bouncy balls.	Lead a Q&A session on force and Newton's first law. Give applied examples of force. E.g., when you push a window open on a sunny day, you are using force to open it. Support the bouncy ball activity by circulating the crews and asking them questions about the forces the ball is experiencing.
Mission Brief 5: Forces of flight Outlines the forces that students' rockets will experience during flight and reinforces learning with a 'fill in the blanks' activity.	Learn that the forces their rockets will experience during flight are thrust, drag, weight and lift, and how each force will act on their rocket. Then, get into their crews and fill in the blanks on the mission brief with support from Mission Command.	Explain each force of flight to students while the ambassador demonstrates on a plain bottle. Support students to fill in the blanks on their mission brief.	Support the teacher's explanation of each force of flight by demonstrating using a plastic bottle. Then, circulate each crew as they fill out their mission briefs and answer questions.
Engineering design process – imagine			
Imagine Explore the second step of the engineering design process.	Understand that after defining the problem they are trying to solve, engineers imagine some solutions to the problem. Apply this to the challenge question (I wonder how rockets fly?) by imagining some ways to improve their basic rockets.	Facilitate discussion on the 'imagine' phase. ***Ask:** How do you think we could improve our basic rockets to make them fly better?*	Discuss how you have imagined some solutions to a project in your job.

Activity overview	What students will do	Teacher role	Ambassador role
Mission Brief 6: Imagine Imagine some rocket design features that will improve its flight.	Using the bottle outline on the mission brief, brainstorm some design feature ideas for their crew's rocket. Design ideas should improve the rocket's flight and take the forces of flight into consideration.	Ask students to reflect on test flight one results. Then, support each crew to imagine some features that will improve their rocket's flight. Designs should be creative and unique and can be improved later. Pick some examples to share with the class and get crews to share their reasoning behind their design ideas.	Support each crew to imagine some features that will improve their rocket's flight. ***Ask:*** *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

It's planning time Get a plan together to bring rocket designs to life by noting down required resources and assigning people to bring them into class.	In their crew, decide what recyclable materials they want to use to construct their rocket design features and write a list. Decide as a crew who's responsible for bringing in what.	Make suggestions on which materials will be best to collect. *Refer to page 19 of the support notes for materials we suggest students use.*	Support the class by discussing the properties and benefits of different materials.

Remember: Make sure to bring in materials to construct your rocket prototypes in Module 4. You'll also need some string and a ruler.

Module 4: Aerodynamics

Prep page

Overview

In this module your students will learn about Newton's second law and aerodynamics and how this applies to rockets. They will then continue the engineering design process by creating and testing a rocket prototype.

Approximate timing

2–3 hours.

You are welcome to adjust the pacing based on what works best for your class.

Key activity sequence

- Watch: Newton's second law video
- Discover aerodynamics and how it relates to rockets
- Learn the third step of the engineering design process – create
- Watch: Modifying your rocket video
- Complete Mission Brief 7: Create
- Complete Mission Brief 8: Rocket stability

Module outcomes

- Understand Newton's second law
- Understand aerodynamics and why it's important
- Undertake functional modelling of rocket prototype using design and knowledge on aerodynamics to inform decision making
- Evaluate and test rocket fitness of purpose and stability
- Learn the importance of testing and improving

Preparation

Resources

From your rocket kit:

- Wonder Project stickers

School to supply:

- Paper to make paper planes
- Mission Brief 7: Create resources:
  - 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
- Mission Brief 8: Rocket stability resources:
  - Ruler
  - String

Print:

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

Pre-module checklist

- ◯ Read the teaching guide for Module 4 (pages 13–14)
- ◯ Collected your resources
- ◯ Read through Module 4 of the Student Hub

Module 4:
Aerodynamics teaching guide

Use this overview as a reference as you go through **Module 4** in the **student Learning Hub** with your class.

Detailed information on each activity and key concept can be found in the **support notes document.**

ONLINE AMBASSADORS: the parts you can carry out online are coloured in pink.

Activity overview	What students will do	Teacher role	Ambassador role
Newton's second law			
Video: Newton's second law Details Newton's second law with real-life examples and applies to the forces of flight: **Force = mass x acceleration**	Watch the video and take notes. Ask questions after the video in a Q&A session. Understand that the heavier a rocket is, the more force required to lift it off the ground.	Refer back to Newton's laws poster to support students' understanding of Newton's second law.	Lead a Q&A session on Newton's second law. Give applied examples of the law. E.g., 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 Outlines how aerodynamics can be used to improve the flight of a heavy object.	Understand that aerodynamics is the study of how air moves around an object and that it affects a rocket's forces of flight. Test aerodynamics by making different types of paper planes and observing which design flies the best. Learn the features of a rocket that make it aerodynamic and start thinking about how they can apply this to their rocket design.	Discuss the concept of aerodynamics with students and how it relates to rocketry. Use the paper plane activity to segue into a discussion on the key features a rocket needs to fly successfully. Ask students if they can identify any of these features and why they think each feature helps with flight (fins, nosecone, streamlined design, good weight distribution).	Support discussion on aerodynamics. Test aerodynamics with students by helping them create some different paper planes and asking them to predict how different designs will change its flight (e.g., a balanced shape helps with stability and reduces drag). After the flights, ***ask:*** *What features do you think made this paper plane fly better?*
Engineering design process – create			
Create Explore the third step of the engineering design process.	Understand that after engineers have done their planning, they create a prototype or model that helps them test their ideas. Testing their prototype helps them come up with ideas to improve it.	Facilitate discussion on the 'create' phase. ***Ask:*** *Why do you think it's helpful to test ideas with a prototype?*	Discuss how you have tested ideas or created a prototype in your role.

Activity overview	What students will do	Teacher role	Ambassador role
Video: Modifying your rocket Instructional video that outlines the modifications students can make to their basic rocket to improve its flight	Watch video and take notes.	Watch video with students. Facilitate class discussion on potential modifications. ***Ask:*** *How many fins do you think a rocket should have? What size should the fins be? What materials should you use and why?*	Watch video with students.
Mission Brief 7: Create Create a rocket prototype using their design from Mission Brief 6, and knowledge on aerodynamics and force.	Using the instructions from the video and the mission brief as a reference, create their rocket prototype in their crew. Students should consider their design from Mission Brief 6 and their new knowledge on aerodynamics.	Support students to put together their prototypes. Encourage teams to consider the best shapes to use to support aerodynamics. *Refer to safety tip on page 18 of the support notes if using hot glue.* *Refer to page 17 of the support notes for a summary on the optimum aerodynamic design features for each rocket.*	Ensure that all crews have enough material to create their rockets. Discuss how geometry and measurement can help construction and improve aerodynamics.

Rocket stability check

Mission Brief 8: Rocket stability Check whether the prototypes are stable and aerodynamic enough for lift-off with three simple tests and amend as required.	Following the instructions in the mission brief, perform three tests on their rocket to ensure it's ready for lift-off. If the rocket doesn't perform well in the test, think about the best way to modify and improve the rocket and try again.	Support students to conduct their stability tests. If students' rockets aren't stable, encourage them to think about the best way to improve their stability. *Refer to pages 20–21 of the support notes for a summary of suggested improvements if rockets aren't stable.*	Support students to conduct their stability tests. Give them words of encouragement as they make modifications. Give examples of a time something you worked on failed and you had to improve it.

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

Prep page

Overview

In this module, your students will learn Newton's third and final law of motion and what this has to do with thrust. They will then put their prototypes to the test in their second test launch.

Approximate timing

2–3 hours.

You are welcome to adjust the pacing based on what works best for your class.

Key activity sequence

- Watch: Newton's third law video
- Learn more about thrust
- Complete Mission Brief 9: Fact cart frenzy!
- Explore and observe aerodynamic design variables
- Prepare for your prototype test flights
- Perform your prototype test flights
- Complete Mission Brief 10: Prototype test flights
- Complete measuring trajectory activity (optional)

Module outcomes

- Understand Newton's third law
- Understand thrust and why it's important
- Launch rocket prototypes and collect observational data – including on how forces are acting on the rocket during flight
- Use metric units to find the appropriate volume of water to add to the rocket
- Evaluate rocket prototype fitness of purpose to refine further developments

Preparation

Resources

From your rocket kit:

- Mission Brief 10: Prototype test flights resources:
  - Assembled rocket launcher
  - Safety goggles
  - Safety vests
  - Clipboard
- Wonder Project stickers

School to supply:

- Balloons to demonstrate Newton's third law
- Mission Brief 10: Prototype test flights resources:
  - Students' 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
- Optional measuring trajectory activity resources:
  - Projector, whiteboard + whiteboard pen
  - OR, tracing paper, pencil + laptop/tablet
- Classroom resources including pens

Print:

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

Pre-module checklist

- ◯ Read the teaching guide for Module 5 (pages 24–26)
- ◯ Re-familiarised yourself with the launcher – find instructional video here
- ◯ Collected your resources
- ◯ Read through Module 5 of the Student Hub

Module 5:
Thrust teaching guide

Use this overview as a reference as you go through **Module 5** in the **student Learning Hub** with your class.

Detailed information on each activity and key concept can be found in the **support notes document.**

ONLINE AMBASSADORS: the parts you can carry out online are coloured in pink.

Activity overview	What students will do	Teacher role	Ambassador role
Newton's second law			
Video: Newton's third law Details Newton's third law with real-life examples and applies to thrust: **For every action there is an equal and opposite reaction.**	Watch the video and take notes. Ask questions after the video in a Q&A session. Blow up and release some balloons to test the law and as a simple analogy of how a rocket works.	Refer back to Newton's laws poster to support students' understanding of Newton's third law. Lead balloon activity as a simple analogy of how a rocket works. *Refer to page 22 of the support notes for more information.*	Lead a Q&A session on Newton's third law. Give applied examples of the law. E.g., horse pulling a cart, jumping on the ground, hammering a nail.
Thrust Apply Newton's third law to the forces of flight by exploring thrust and how it helps launch rockets.	Understand the connection between Newton's third law, the force of thrust and rocket launches.	Discuss how the balloon activity relates to thrust and rockets. ***Ask:** How do you think thrust relates to rocket launch? How is the thrust force created in your water rockets?*	Support discussion on thrust. Relate back to other forces of flight – thrust works in opposition to drag and weight.
Mission Brief 9: Fact card frenzy! Cement challenge learning to date by creating some fact cards students can use to test each other's knowledge.	Follow the instructions on the mission brief to create their fact cards. More advanced students can have a go at the bonus challenge and/or research and create their own cards.	Circulate each crew and support them to answer each question without referring to their notes. When students are done, use their flashcards to test them. This activity can be used to assess student knowledge and understanding on forces and Newton's laws. *Refer to pages 2–3 of the support notes for more information.*	Circulate each crew and support them to answer each question without referring to their notes. Ask questions that might jog their memory. When students are done, use their flashcards to test them.
Prepare for launch			
Rocket aerodynamic design variables Identify the key aerodynamic design variables to observe and test during the prototype test flight.	Decide on one or two key aerodynamic design variables to observe during their prototype test flight. Then, use their observations to evaluate how their prototype performed and what aerodynamic design variables could be improved.	Ask students to recall the key aerodynamic design features a rocket needs to fly. Support them to choose one or two to observe during their test flight. *For a full list of key aerodynamic design features, refer to page 17 of the support notes.*	Ask students to think about their aerodynamic design variables in terms of: • Strength and durability • Safety and stability • Efficiency and reliability

Activity overview	What students will do	Teacher role	Ambassador role
Mission Brief 10: Prototype test flights Test rocket prototypes to figure out which aerodynamic design variables work best and inform further rocket improvements. Includes table to record the results of each test flight.	In crews, take turns setting up their test flights using their rocket prototypes. Crews will observe one or two aerodynamic design variables and make notes on how the design could be improved in the table provided. Make sure some of the test flights are filmed. After the launch, review their data and write down their findings in the blank spaces provided.	Ensure health and safety protocols are followed and that students don't pump to over 60 psi. *If your class is doing the optional measuring trajectory activity, film the rocket launches using the instructions on page 25 of the support notes.* After the launch, support students to analyse their data and make a list of the design improvements they could consider.	Allow students to set up the launcher under your supervision. Supervise each launch, ensuring students don't pump to over 60 psi. Ensure students are keeping the water level and air pressure constant so they can accurately observe the effect of aerodynamic design variables. Take note of which aerodynamic design variables performed best to support the students' analysis.
Optional measuring trajectory activity Plot the trajectory of each prototype test flight. Use this data to inform possible design changes.	Using the video of their rocket launch and the instructions in the activity sheet, plot the trajectory of their prototype. Think about what the trajectory means and how it can be used to inform rocket design changes. Write analysis in the box provided.	Help students project their rocket launch video onto the whiteboard. ***Ask:** What do you think this trajectory means? What trajectory would be better? How do you think we could achieve that?*	Support students to analyse their rocket trajectory and what aerodynamic design elements they could change to improve it.

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!

Prep page

Overview

In this module your students will make final improvements to their rockets. Then, they'll celebrate their achievements by sending their rocket on its final flight.

Approximate timing

2–3 hours.

You are welcome to adjust the pacing based on what works best for your class.

Key activity sequence

- Learn the fourth step of the engineering design process – improve
- Complete Mission Brief 11: Improve
- Prepare for your final flights
- Perform your final flights
- Complete Mission Brief 12: Final flights
- Complete measuring trajectory activity (optional)
- Host a whānau showcase (optional)
- Complete Mission Brief 13: Blast off competition (optional)
- Complete post challenge surveys (teacher, student and ambassador)

Module outcomes

- Evaluate rocket prototype fitness of purpose to make final improvements
- Use metric units to find the distance the rocket travelled and the angle of rocket launch
- Reflect on learnings
- Share and celebrate challenge successes and failures

Preparation

Resources

From your rocket kit:

- Mission Brief 12: Final flights resources:
  - Assembled rocket launcher
  - Safety goggles
  - Safety vests
  - Clipboard
  - Example parachute
- Wonder Project stickers

School to supply:

- Resources to make a parachute
- Mission Brief 11: Improve resources:
  - Students' prototype rockets (1 per crew)
  - Materials to improve rocket prototypes
  - Hot glue guns, or other adhesives
  - Decorations
  - Classroom resources including scissors
- Mission Brief 12: Final flights resources:
  - Students' 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
- Classroom resources including pens

Print:

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

Pre-module checklist

- ◯ Read the teaching guide for Module 6 (pages 19–20)
- ◯ Re-familiarised yourself with the launcher – find instructional video here
- ◯ Collected your resources
- ◯ Read through Module 6 of the Student Hub

Module 6:
Blast-off! teaching guide

Use this overview as a reference as you go through **Module 6** in the **student Learning Hub** with your class.

Detailed information on each activity and key concept can be found in the **support notes document.**

ONLINE AMBASSADORS: the parts you can carry out online are coloured in pink.

Activity overview	What students will do	Teacher role	Ambassador role
Engineering design process – improve			
Improve Explore the fourth and final step of the engineering design process.	Understand that after engineers have created and tested their ideas, they use the data from their testing to make improvements.	Facilitate discussion on the 'improve' phase. ***Ask:*** *Why do you think it's helpful to test and improve your ideas? How will you improve your rockets?*	Explain a time that you have improved on an idea at work.
A safe landing Create a parachute that can be used to improve the rockets. This can be done as part of Mission Brief 11.	Consider adding a parachute to their nosecone to improve their rocket design. Use the parachute supplied in the kit as a guide.	Support students to create their own parachutes based on the one supplied in the kit. This can be done as part of Mission Brief 11. *Refer to pages 27–28 of the support notes for some suggested methods to create the parachutes.*	Support students to add their parachutes to their nosecones. You may like to create your own rocket design with a parachute to demonstrate to kids.
Mission Brief 11: Improve Using data gained from the prototype test flight and optional trajectory plotting, improve rockets to achieve the ultimate flight.	In their crews, think about what they learned from testing their rocket prototypes and any areas of their rocket that may need improving. Then, think about some methods to improve it. Use this information to make improvements to their rocket to get it ready for its final flight.	Ask each crew to think about what they learned from testing their prototype and/or plotting their rocket trajectory.	Support each crew to understand their data. ***Ask:*** *Why do you think your rocket flew this way? How could you change this for next time?* Encourage crews to consider geometry and think about the shape of their design elements in relation to aerodynamics.
Final flight			
Mission Brief 12: Final flights Send your rockets on their final mission! Record the distance each rocket travels and its time in the air to decide which rocket had the most successful flight.	Set up their test flights using their improved rockets. Assign one crew member to time how long the rocket was in the air, one to measure the distance it travelled, and one to write down the results on the mission brief. Film each flight. After the launch, review their data and write down their final analysis in the blank spaces provided.	Ensure health and safety protocols are followed, that students 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, support students to do their final analysis and decide on the best performing rocket.	Allow students to set up the launcher under your supervision. Supervise each launch, ensuring students don't pump to over 60 psi. Ensure the water level and air pressure are kept constant and the launch angle is set to 45˚ so the only variable is each crew's rocket. Support students to film their flights.

Activity overview	What students will do	Teacher role	Ambassador role
Whānau showcase Invite whānau to visit the classroom so students can show off their rockets and perform an example launch.	Invite their whānau to visit the classroom. Show off their rockets and new STEM knowledge in a quick presentation. Choose one of the best rockets to perform an example launch with.	Select a member of each crew to present something they learned from the challenge and show off their rocket design. Support students to 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 students don't pump to over 60 psi.

I wonder how to tell our story?

Mission Brief 13: Blast off competition Make and share a poster or short video of the Rocket Challenge experience to win a prize.	Using the instructions on the mission brief, plan, film and edit a creative video or create a poster that captures the Rocket Challenge experience.	Support students with filming and editing their videos or making their posters.	Encourage students to reflect on their Rocket Challenge experiences and think about which parts they want to include in their video or poster.

Surveys

Student and teacher post challenge survey An important tool for us to improve the programme each year and continue our funding to keep the Wonder Project free for schools. We can supply teachers with the survey data from their school which will show the impact the Rocket Challenge has had on students' perceptions towards STEM, and how much they've learned.	Each participating student should complete the student post challenge survey after they complete the Rocket Challenge. Students can access the survey via the Survey Monkey link in the online Learning Hub and follow the prompts to submit their responses.	Each participating teacher should complete the teacher post challenge survey after they complete the Rocket Challenge. Teachers can access the survey via the Survey Monkey link in the online Learning Hub and follow the prompts to submit their responses.	