

EXPLORE – EXPLAIN – ELABORATE – EVALUATE

Stomp Rocket Design Challenge

Teacher Resource

Students are tasked with designing and building a stomp rocket that can travel to a chosen planet. Students will follow the design-thinking framework to investigate relevant aspects of the design challenge.



Based on your school's STEM agenda, the *Stomp Rocket Design Challenge* can be incorporated into a lesson or two, or modified to become a cross-disciplinary project-based unit. A cross-disciplinary task will integrate the Australian Curriculum subjects of Science, Technologies and Mathematics to address the design challenge.

Building a Stomp Rocket Launcher

Materials

Plastic Soft Drink Bottle and Bike Tube

- 1 x empty 1 or 1.5 litre plastic soft drink bottle
- 1 x 1 metre bike tube
- 1 x 50cm PVC pipe, 2.5cm in diameter
- Utility knife
- Gaffer tape

Foot pump

- 1 x foot pump
- 1 x 50cm PVC pipe, 2.5cm in diameter
- Utility knife
- Gaffer tape

500mL Plastic Bottle and Plastic Straw

- 1 x empty 500mL plastic bottle with lid
- 1 x plastic straw
- PVA glue

Please note: Total number of materials required to implement the design challenge will depend on the number of student groups completing the task. Each group may have access to their own rocket launcher. Alternatively, rocket launchers may be shared between groups of students.

Method

If using a plastic soft drink bottle and bike tube:

1. Use a utility knife to cut a 1 metre section of bike tube.
2. Attach one end of the bike tube to the opening of the soft drink bottle and tape in place securely.



3. Attach the other end of the bike tube to the PVC pipe and tape in place securely.
4. To use the stomp rocket launcher, students:
 - a. Design and create their rocket using paper and tape. Students may like to use spare pieces of PVC pipe to help construct their rocket.
 - b. Place the bottle on the ground in an open area pointing away from other people. Gently rest one foot or hand on the bottle to keep it in place.
 - c. Slide the rocket over the open end of the PVC pipe, ensuring the pipe is pointing horizontally, towards the intended target.
 - d. Step or press firmly down on the bottle to shoot the rocket into the air.
 - e. Press the bottle back into its original shape.

If using a foot pump:

1. Ensure the foot pump hose is securely attached to the 'inflate' hole. Attach one end of the PVC pipe to the end of the hose. Gaffer tape may need to be wrapped around the join to ensure the connection is air-tight.
2. To use the stomp rocket launcher, students:
 - a. Design and create their rocket using paper and tape. Students may like to use spare pieces of PVC pipe to help construct their rocket.
 - b. Place the foot pump on the ground in an open area pointing away from other people. Gently rest one foot or hand on the foot pump to keep it in place.
 - c. Slide the rocket over the open end of the PVC pipe, ensuring the pipe is pointing horizontally, towards the intended target.
 - d. Step or press firmly down on the foot pump to launch the rocket into the air.

If using a 500mL plastic bottle and plastic straw:

1. Carefully cut a hole approximately the same diameter as the plastic straw into the lid. The lid should be resting on a flat surface during completion this task.
2. Tightly screw the lid onto the bottle. Insert the straw into the lid. Approximately two-thirds of the straw should remain outside the bottle.
3. Use PVA glue to secure the straw to the lid.
4. To use the stomp rocket launcher, students:
 - a. Design and create their rocket using paper and tape. Students may like to use spare straws to help construct their rocket.
 - b. Hold the bottle in their hands and slide the rocket over the plastic straw.
 - c. Ensure the bottle is used in an open area facing away from other people. Point the bottle towards the intended target. Firmly squeeze the bottle to launch the rocket into the air.

Representing the Solar System

In order to represent how far students' rockets are able to travel, you could:

- Measure the space available for rocket launch and develop a scale based on this space. This option will be most suitable if working indoors with limited space. The 500mL plastic bottle and plastic straw will make the best stomp rocket launcher in a limited enclosed space.
- Go outside and create a larger scale to model how far students' rockets are able to travel. Planets could be represented using sports markers, traffic cones or bollards. To add an extra challenge, students may be required to fly their rockets through a series of upright hoops, with the hoops representing planets of the solar system (however the scaled distance will need to be different to the scaled planet diameter for hoops large enough to fly through). PVC pipes may be used to construct bases and stands to hold the hoops upright. The soft drink bottle or foot pump will make the best stomp rocket launcher in this instance.



Student launching a stomp rocket using a foot pump.

Implementing the Design Challenge

1. Investigate students' prior knowledge of rockets by asking:

- What do you already know about rockets?
- Where do they go? Why do we build them?
- How are they shaped?
- What parts do rockets need to operate properly?

Record students' responses to these questions, and any other questions they may raise during this discussion.

2. Introduce students to the design challenge:

Design, build and launch a paper rocket that can travel to a planet in our model solar system.

This chosen planet may be:

- The planet previously explored by student groups in *Beyond Earth: Colonising Space*; or,
- A planet freely selected by student groups.

Provide students with an opportunity to examine the stomp rocket they will use within the design challenge. Explore how the stomp rocket works with students. The following prompts may be used to guide this investigation:

- Year 5

Revise forces. Ask students to:

Identify any pushes or pulls acting on the stomp rocket.

Consider how a large and small push might affect the way in which the rocket moves through the air.

- Year 7

Revise forces. Ask students to identify the balanced and unbalanced forces acting on the stomp rocket.

- Year 10

Revise forces. Use the laws of physics to describe the motion of the rocket.

Ask students to identify any factors that could influence how far the rocket travels.

Responses may include the capacity of the bottle, the diameter and length of the straw or hose used, the size of the force used to launch the rocket, the mass of the rocket, the features of rocket including shape and fins, angle of launch, wind speed etc.

During this time students should also see the distance their rockets will need to travel, whether this is using a paper-based scale, a larger outdoor scale or an alternative representation of distance.

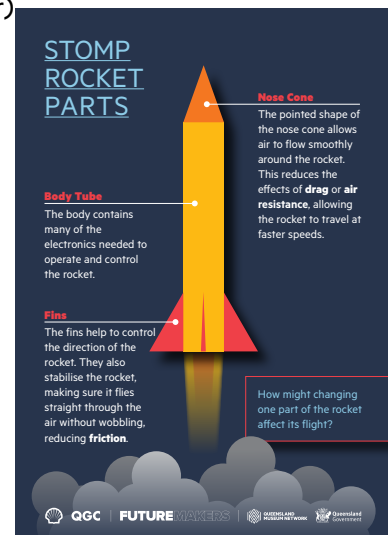
3. Share or negotiate any specific challenge requirements, restrictions or criteria for success with students. These may include:

- Size of student groups (three students per group)
- Student roles
- Materials to complete the challenge
- Time limit to complete the challenge

4. Divide students into small groups, ensuring each group knows which planet their rocket must reach and their individual roles, if assigned. These may be the groups they worked with to design and develop a shelter in *Beyond Earth: Colonising Space* or new groups.

Provide students with time to conduct research to gather additional ideas and information that will inform the design of their rocket. Students use this information to write a design proposal and gain approval from the lead scientist (the classroom teacher) before constructing. The proposal should include:

- Background information on rockets and how they are designed to travel to space (students may like to use the *Stomp Rocket Parts* poster to assist in the completion of this task)
- Selected planet and the distance their rocket must travel from Earth, based on the chosen scale
- A labelled sketch or digital representation of the rocket
- Justification for design
- Materials required to build the rocket
- Control, independent and dependent variables to be tested



The Stomp Rocket Parts poster may be printed from Queensland Museum Learning Resources and displayed in the classroom.

5. Following approval from the lead scientist, students create their rockets.
6. Provide students with at least three test flights to evaluate the design of their rocket. Students identify dependent and control variables, record their observations and relevant measurements for each test flight, including distance travelled.

During this time, students may also:

- Identify the forces acting on the rocket as it moves through the air.
 - Construct force-arrow diagrams that represent the type, size and direction of forces acting on the rocket.
 - Explore how the application of different forces and/or the angle of launch affects the flight of the rocket.
 - Identify and record any energy transfers or transformations present immediately before, during and after the rocket launch.
 - Calculate the speed at which the rocket travels.
7. Students refine the design and construction of their rockets to increase distance travelled before re-testing. During this time, students should share their observations, challenges experiences and discuss what they should change to address or resolve these problems. Following subsequent testing, students should describe how any changes made to the rocket influenced its performance.

Extension opportunities exist for students who successfully complete the design challenge within the allocated time. These may include:

- Changing the independent variable and investigating how this affects the rocket's flight.
 - Modifying the rocket so that it can travel as far as possible.
 - Increasing the rocket's stability during flight.
 - Increasing the speed at which the rocket travels through the air.
 - Designing a self-inflating parachute that can be attached to the rocket and activated after launching the rocket upward.
8. Students reflect on and evaluate their final design and experiences:
 - What new knowledge/understandings helped you make decisions about your rocket design?
 - Are there any further changes you could make to improve your design?
 - What were the main challenges you experienced during the design process? How did you overcome these?
 - What have you learnt about science and design from this activity?
 - How could you apply this knowledge and understanding to your learning in other contexts?
 - What more would we like to know about space, space travel and/or rockets?

Curriculum Links

Science

YEAR 5

Science Understanding

The Earth is part of a system of planets orbiting around a star (the sun) (ACSSU078)

Science Inquiry Skills

With guidance, pose clarifying questions and make predictions about scientific investigations (ACSIS231)

Identify, plan and apply the elements of scientific investigations to answer questions and solve problems using equipment and materials safely and identifying potential risks (ACSIS086)

Decide variables to be changed and measured in fair tests, and observe measure and record data with accuracy using digital technologies as appropriate (ACSIS087)

Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data using digital technologies as appropriate (ACSIS090)

Compare data with predictions and use as evidence in developing explanations (ACSIS218)

Reflect on and suggest improvements to scientific investigations (ACSIS091)

Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS093)

YEAR 7

Science Understanding

Change to an object's motion is caused by unbalanced forces, including Earth's gravitational attraction, acting on the object (ACSSU117)

Science Inquiry Skills

Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS124)

Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS125)

Measure and control variables, select equipment appropriate to the task and collect data with accuracy (ACSIS126)

Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate (ACSIS129)

Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence (ACSIS130)

Reflect on scientific investigations including evaluating the quality of the data collected, and identifying improvements (ACSIS131)

Use scientific knowledge and findings from investigations to evaluate claims based on evidence (ACSIS132)

Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS133)

YEAR 8

Science Understanding

Energy appears in different forms, including movement (kinetic energy), heat and potential energy, and energy transformations and transfers cause change within systems (ACSSU155)

Science Inquiry Skills

Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS139)

Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS140)

Measure and control variables, select equipment appropriate to the task and collect data with accuracy (ACSIS141)

Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate (ACSIS144)

Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence (ACSIS145)

Reflect on scientific investigations including evaluating the quality of the data collected, and identifying improvements (ACSIS146)

Use scientific knowledge and findings from investigations to evaluate claims based on evidence (ACSIS234)

Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS148)

Design and Technology

YEAR 5 AND 6

Design and Technologies: Knowledge and Understanding

Investigate characteristics and properties of a range of materials, systems, components, tools and equipment and evaluate the impact of their use (ACTDEK023)

Design and Technologies: Processes and Production Skills

Critique needs or opportunities for designing, and investigate materials, components, tools, equipment and processes to achieve intended designed solutions (ACTDEP024)

Generate, develop and communicate design ideas and processes for audiences using appropriate technical terms and graphical representation techniques (ACTDEP025)

Select appropriate materials, components, tools, equipment and techniques and apply safe procedures to make designed solutions (ACTDEP026)

Negotiate criteria for success that include sustainability to evaluate design ideas, processes and solutions (ACTDEP027)

Develop project plans that include consideration of resources when making designed solutions individually and collaboratively (ACTDEP028)

YEAR 7 AND 8

Design and Technologies: Knowledge and Understanding

Analyse ways to produce designed solutions through selecting and combining characteristics and properties of materials, systems, components, tools and equipment (ACTDEK034)

Design and Technologies: Processes and Production Skills

Critique needs or opportunities for designing and investigate, analyse and select from a range of materials, components, tools, equipment and processes to develop design ideas (ACTDEP035)

Generate, develop, test and communicate design ideas, plans and processes for various audiences using appropriate technical terms and technologies including graphical representation techniques (ACTDEP036)

Select and justify choices of materials, components, tools, equipment and techniques to effectively and safely make designed solutions (ACTDEP037)

Independently develop criteria for success to evaluate design ideas, processes and solutions and their sustainability (ACTDEP038)

Use project management processes when working individually and collaboratively to coordinate production of designed solutions (ACTDEP039)

Mathematics

YEAR 5

Measurement and Geometry

Choose appropriate units of measurement for length, area, volume, capacity and mass (ACMMG108)

Statistics and Probability

Construct displays, including column graphs, dot plots and tables, appropriate for data type, with and without the use of digital technologies (ACMSP119)

YEAR 7

Statistics and Probability

Calculate mean, median, mode and range for sets of data.

Interpret these statistics in the context of data (ACMSP171)

Describe and interpret data displays using median, mean and range (ACMSP172)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Composing texts through speaking, writing and creating

Numeracy

Recognise and using patterns and relationships

Using measurement

ICT Capability

Investigating with ICT

Creating with ICT

Critical and Creative Thinking

Identifying, exploring and organising information and ideas

Generating ideas, possibilities and actions

Reflecting on thinking and processes

Analysing, synthesising and evaluating reasoning and procedures

Personal and Social Capability

Social management

Stomp Rocket Design Challenge

Student Activity

Design, build and launch a rocket that can travel to one of the planets in our solar system.

You must:

- **Investigate** how rockets are designed to reach space.
- **Design** a rocket that can travel to one of the planets in the model solar system and be launched from the stomp rocket launcher provided by your teacher.
- **Create** a prototype of your rocket from recyclable materials supplied by your teacher.
- **Test** the prototype's ability to reach your chosen planet using the stomp rocket launcher.
- **Refine** the rocket design and construction so that it can reach your chosen planet.
- **Collaborate** in teams of three. Your teacher may allocate a role to each team member.
- **Evaluate** continuously to design a rocket that is able to travel to your chosen planet.



Investigate and Design

You must write a proposal to explain the design of the rocket and gain approval from your lead scientist (in this case, your teacher) before creating your rocket.

Your proposal should include:

- Background information on rockets and how they are designed to travel to space
- The planet your rocket will travel to, and the distance your rocket must travel from Earth based on the scale chosen by your teacher
- Control, independent and dependent variables to be tested
- Labelled sketch or digital representation of the rocket
- Justification for design
- Materials required to build the rocket

Once your proposed design has been approved, you can create your rocket prototype.

Investigate how rockets have been designed to travel to space. Record your findings below.

Our rocket will travel to:

Distance of this planet from the Earth:

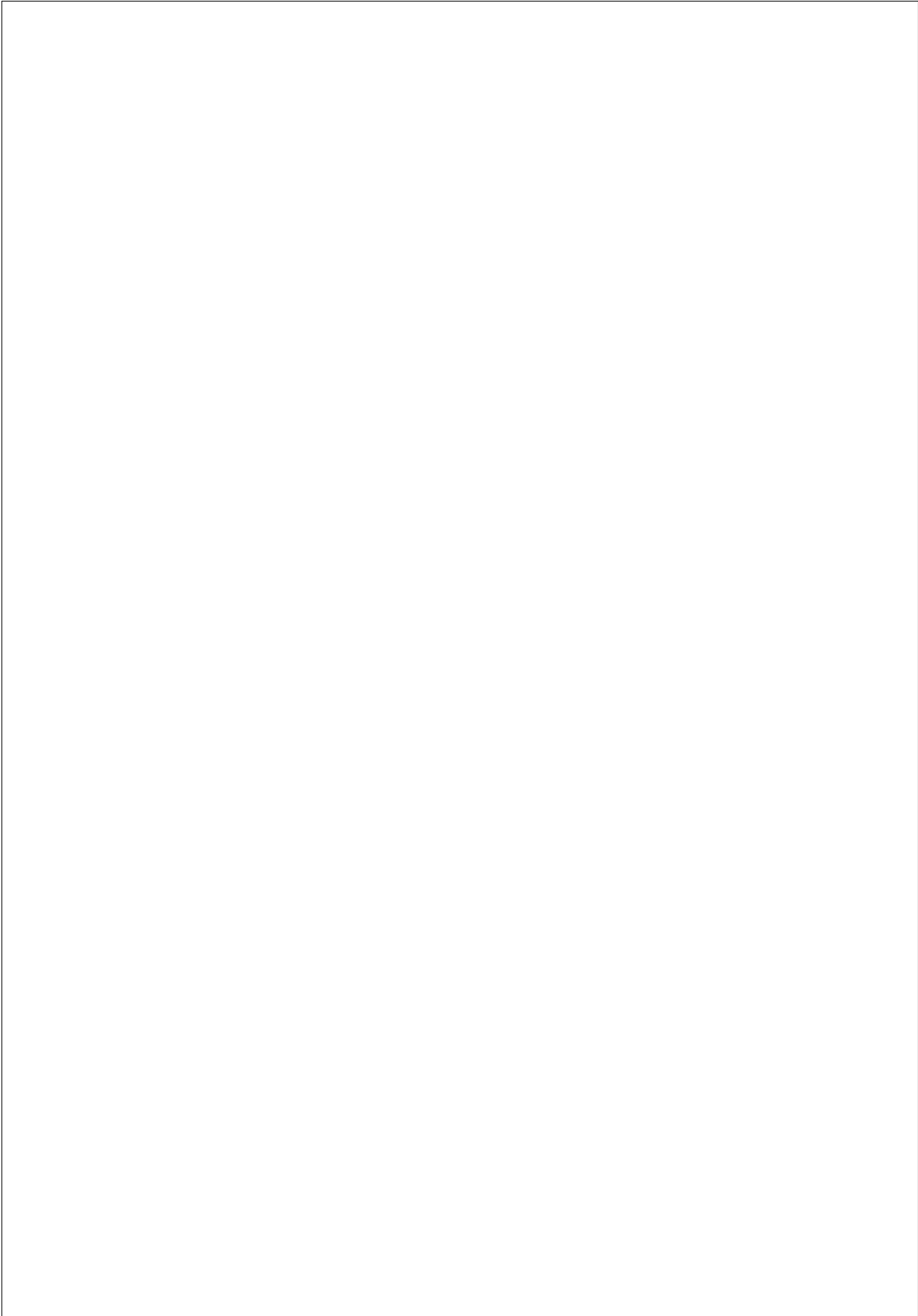
Explain how a scale will be used to model the distance of this planet from the Earth:

Distance from Earth to your planet according to the scale above:

Consider the variables you will explore in this challenge. What will you:

Change? (independent variable)	Measure? (dependent variable)	Keep the same? (control variables)

Draw a labelled diagram of your rocket. Make sure you identify the materials you will use to make the rocket, and explain and justify the selection of its parts.



Create

Create your rocket using the materials provided. Record any modifications required as you build the rocket.

Modification	Reason

Test

The lead scientist will guide you to the rocket test zone and demonstrate how to use the stomp rocket launcher. You will have three test flights to determine how far the rocket can travel and evaluate the rocket's design. Record your findings on the next page.

Refine

Based on your observations, modify the rocket's design to make it travel further, and the re-test in the rocket test zone. Continue to refine and test until your rocket is able to reach your chosen planet.

Recording Results

1. Record the results gathered from each test flight in the tables below.

Test Flight 1

Trial	Distance
Trial 1	
Trial 2	
Trial 3	
Average Flight Distance	
Observations	

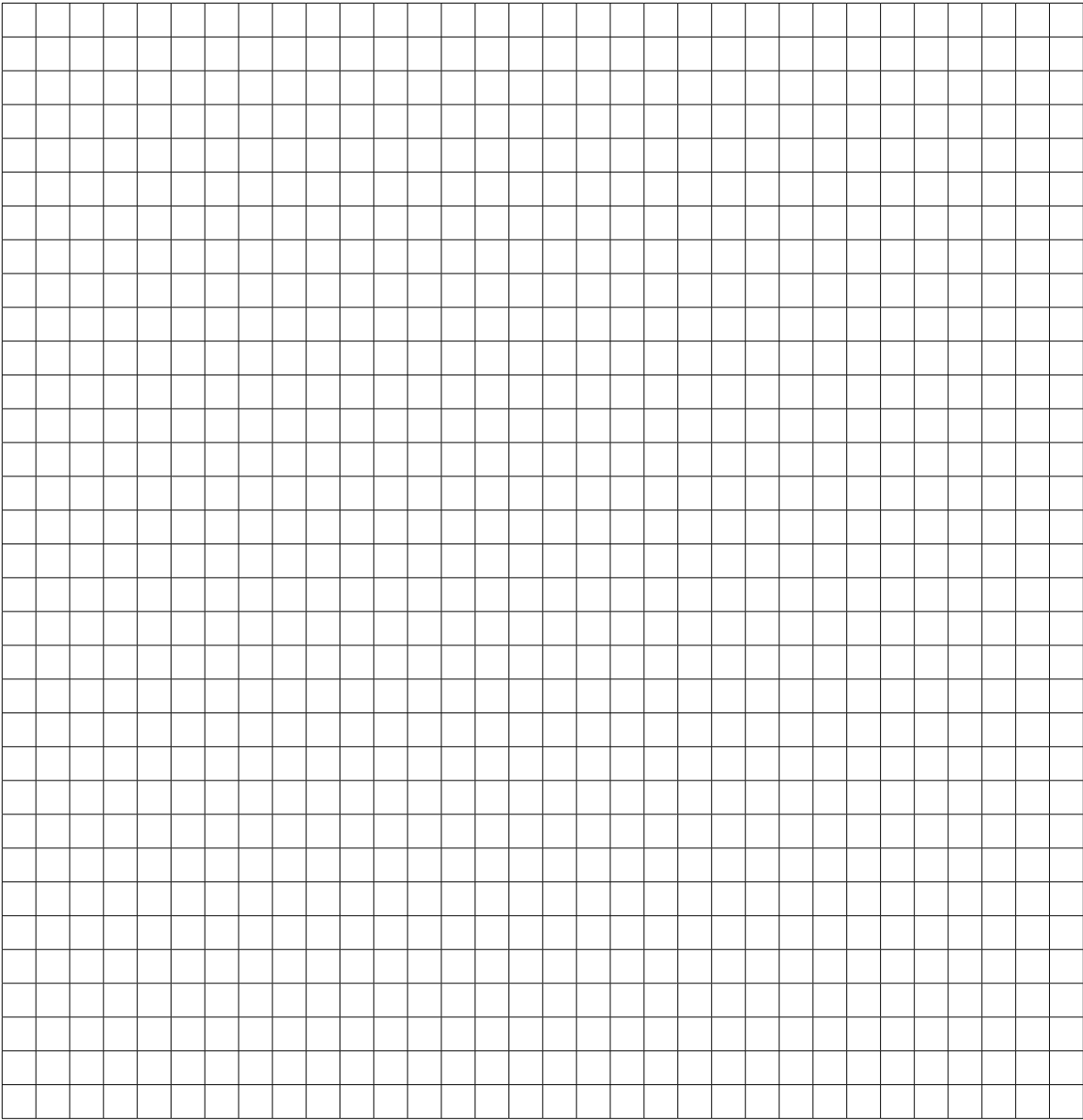
Test Flight 2

Trial	Distance
Trial 1	
Trial 2	
Trial 3	
Average Flight Distance	
Observations	

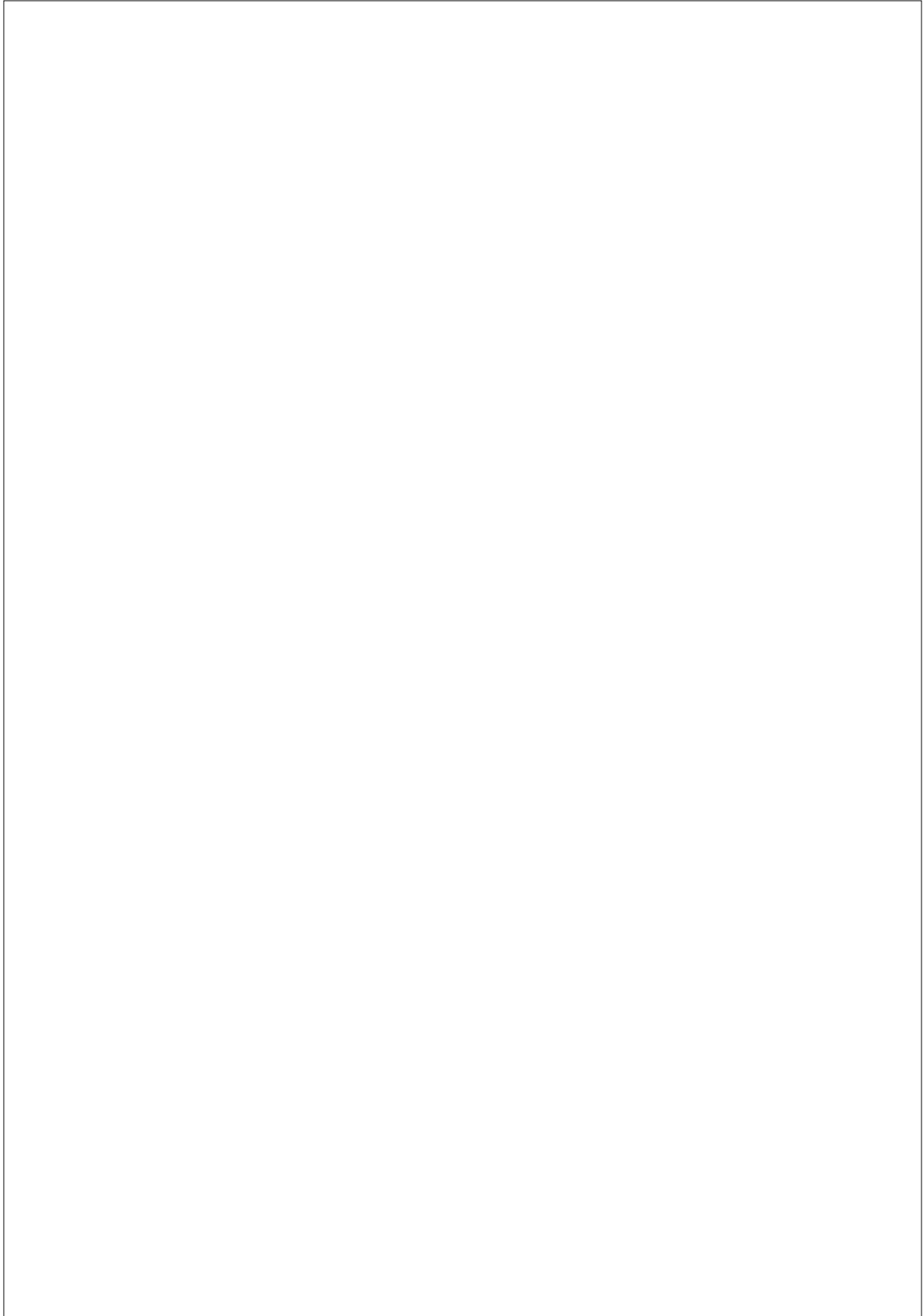
Test Flight 3

Trial	Distance
Trial 1	
Trial 2	
Trial 3	
Average Flight Distance	
Observations	

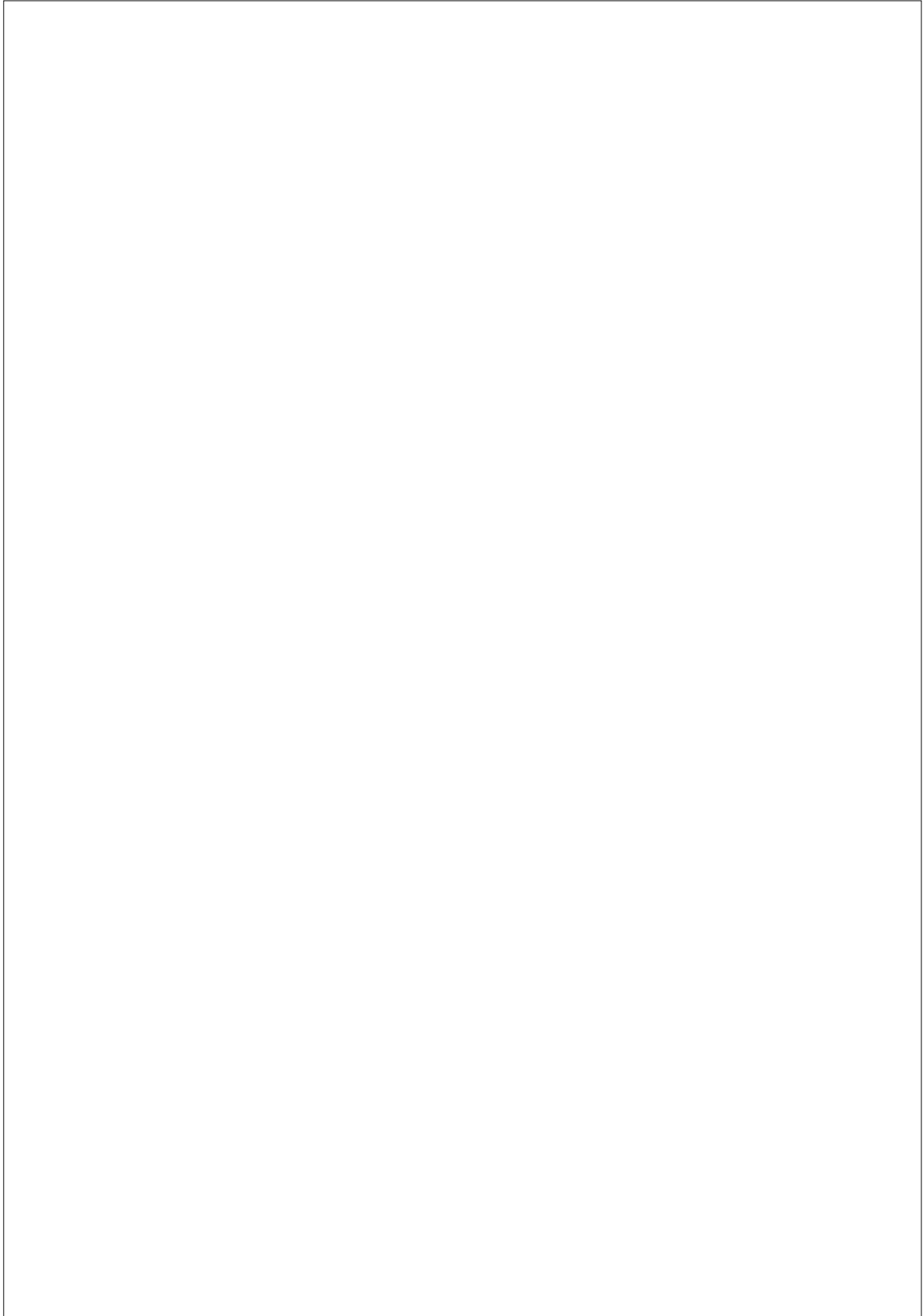
2. Graph the results gathered from each test flight below.



3. Construct a force-arrow diagram to record the type, size and direction of forces that acted on the rocket as it moved through the air.

A large, empty rectangular box with a thin black border, intended for the student to draw a force-arrow diagram. The box is oriented vertically and occupies most of the page's width and height.

4. Identify and represent the energy transfers and transformations that occur as the rocket is launched and moves through the air.



Discussing Results

1. Did the rocket reach your chosen planet during the first test flight? Why?

2. What did you do to increase distance travelled for the next test flight?

3. Were these changes effective? Why?

4. What further tests would you conduct in the future?

5. How would you change this rocket if it were to really travel into space:

- a) Manned
- b) Unmanned

Evaluate

Reflect on your actions with your team or class after you have completed the design challenge. You might like to think about the following questions to assist with your reflection:

- What new knowledge/understandings helped you make decisions about your rocket design?
- Are there any further changes you could make to improve your design?
- What were the main challenges you experienced during the design process? How did you overcome these?
- What have you learnt about science and design from this activity?
- How could you apply this knowledge and understanding to your learning in other contexts?
- What more would we like to know about space, space travel and/or rockets?