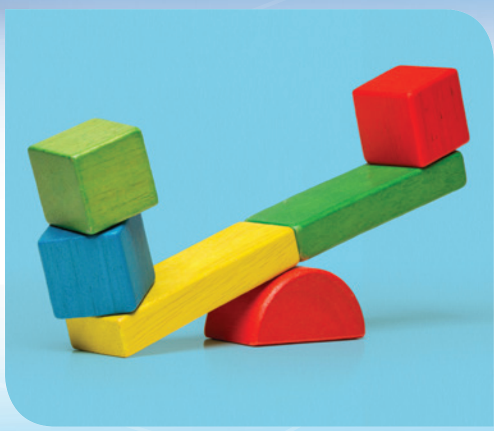
Fully aligned with the Australian Curriculum

Machine makers

Year 2

Physical sciences



About this unit Machine makers

Children are fascinated with machines. From an early age their world is surrounded by machines that move, make noises and light up. Machines they see daily range from the complicated, such as toasters, computers and lawnmowers, to ones so simple that they might not consider them to be machines at all, such as ramps and scissors. All machines, both complicated and simple, help us do work.

The *Machine makers* unit is an ideal way to link science with literacy in the classroom. Through hands-on activities students explore the different strengths of pushes and pulls required to manipulate and control the movement of objects to create their own amazing machine.

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Trial schools: Bundeena Public School, NSW; Coonabarabran Public School, NSW; Hill Top Public School, NSW; Illawarra Christian School, NSW; Inverell Public School, NSW; Kangaloon Public School, NSW; Newbridge Heights Public School, NSW; North Rocks Public School, NSW; Richmond Christian College, NSW; Soldiers Point Public School, NSW; Woy Woy Public School, NSW; Gulf Christian College, QLD; St James Lutheran College, QLD; Callington Primary School, SA; Apollo Bay P-12 College, VIC; Hamilton College, Junior Campus, VIC; Mallacoota P-12 College, VIC; Methodist Ladies’ College, VIC; Tucker Rd Bentleigh Primary School, VIC; Tyers Primary School, VIC; Arbor Grove Primary School, WA; Carmel Adventist College Primary, WA; Dunsborough Primary School, WA; East Kenwick Primary School, WA; Greenfields Primary School, WA; Joondalup Education Support Centre, WA; Kalgoorlie Primary School, WA; Mosman Park Primary School, WA; Peel Language Development School, WA

Contents

Foreword

Never has there been a more important time for science in Australia. More than ever, we need a scientifically-literate community to engage in debates about issues that affect us all. We also need imaginative thinkers to discover the opportunities in our exponentially expanding knowledge base. Teachers play a vital role in nurturing the minds of our future citizens and scientists.

The Australian Academy of Science has a long, proud history of supporting science education. Our primary education program, Primary**Connections**: linking science with literacy, now has over 15 years' experience in supporting teachers to facilitate quality learning experiences in their classrooms. Regular evaluations demonstrate the significant impact the program can have on both teacher confidence and student outcomes.

Primary**Connections** has been developed with the financial support of the Australian Government and endorsed by education authorities across the country. It has been guided by its Steering Committee, with members from the Australian Government and the Australian Academy of Science, and benefitted from input by its Reference Group, with representatives from all states and territories.

Key achievements of the program include engaging over 24,000 Australian teachers in professional learning workshops, producing multi award-winning curriculum resources, and developing an Indigenous perspective framework that acknowledges the diversity of perspectives in Australian classrooms.

The Primary**Connections** teaching and learning approach combines guided inquiry, using the 5Es model, with hands-on investigations. It encourages students to explore and test their own, and others', ideas and to use evidence to support their claims. It focuses on developing the literacies of science and fosters lasting conceptual change by encouraging students to represent and re-represent their developing understandings. Students are not only engaged in science, they feel that they can do science.

This is one of 40 curriculum units developed to provide practical advice on implementing the teaching and learning approach while meeting the requirements of the Australian Curriculum: Science. Trialled in classrooms across the country and revised based on teacher feedback, and with the accuracy of the teacher background information verified by Fellows of the Academy, the experience of many brings this unit to you today.

I commend Primary**Connections** to you and wish you well in your teaching.

Professor John Shine, AC Pres AA
President (2018–2022)
Australian Academy of Science

The PrimaryConnections teaching and learning approach

Primary**Connections** units embed inquiry-based learning into a modified 5Es instructional model. The relationship between the 5Es phases, investigations, literacy products and assessment is illustrated below:

Primary**Connections 5Es teaching and learning model**

Phase	Focus	Assessment focus
ENGAGE	Engage students and elicit prior knowledge	**Diagnostic assessment**
EXPLORE	Provide hands-on experience of the phenomenon	**Formative assessment**
EXPLAIN	Develop scientific explanations for observations and represent developing conceptual understanding Consider current scientific explanation	**Formative assessment**
ELABORATE	Extend understanding to a new context or make connections to additional concepts through a student-planned investigation	**Summative assessment** of the Science Inquiry Skills
EVALUATE	Students re-represent their understanding and reflect on their learning journey, and teachers collect evidence about the achievement of outcomes	**Summative assessment** of the Science Understanding

More information on Primary**Connections** 5Es teaching and learning model can be found at: www.primaryconnections.org.au

Reference: Bybee, R.W. (1997). *Achieving scientific literacy: from purposes to practical action*. Portsmouth, NH: Heinemann.

Developing students' scientific literacy

The Primary**Connections** program supports teachers in developing students' scientific literacy. Scientific literacy is considered the main purpose of school science education and has been described as an individual's:

- scientific knowledge and use of that knowledge to identify questions, acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues
- understanding of the characteristic features of science as a form of human knowledge and enquiry
- awareness of how science and technology shape our material, intellectual and cultural environments
- willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen

Reference: Programme for International Student Assessment & Organisation for Economic Co-operation and Development. (2009). *PISA 2009 assessment framework: key competencies in reading, mathematics and science*. Paris: OECD Publishing.

Linking science with literacy

Primary**Connections** has an explicit focus on developing students' knowledge, skills, understanding and capacities in science and literacy. Units employ a range of strategies to encourage students to think about and to represent science.

Primary**Connections** develops the literacies of science that students need to learn and to represent their understanding of science concepts, processes and skills. Representations in Primary**Connections** are multi-modal and include text, tables, graphs, models, drawings and embodied forms, such as gesture and role-play. Students use their everyday literacies to learn the new literacies of science. Science provides authentic contexts and meaningful purposes for literacy learning, and also provides opportunities to develop a wider range of literacies. Teaching science with literacy improves learning outcomes in both areas.

Assessment

Science is ongoing and embedded in Primary**Connections** units. Assessment is linked to the development of literacy practices and products. Relevant understandings and skills are highlighted at the beginning of each lesson. Different types of assessment are emphasised in different phases:

Diagnostic assessment occurs in the *Engage* phase. This assessment is to elicit students' prior knowledge so that the teacher can take account of this when planning how the *Explore* and *Explain* lessons will be implemented.

Formative assessment occurs in the *Explore* and *Explain* phases. This enables the teacher to monitor students' developing understanding and provide feedback that can extend and deepen students' learning.

Summative assessment of the students' achievement developed throughout the unit occurs in the *Elaborate* phase for the Science Inquiry Skills, and in the *Evaluate* phase for the Science Understanding.

Rubrics to help you make judgments against the relevant achievement standards of the Australian Curriculum are available on our website:
www.primaryconnections.org.au

Safety

SAFETY

Learning to use materials and equipment safely is central to working scientifically. It is important, however, for teachers to review each lesson before teaching, to identify and manage safety issues specific to a group of students. A safety icon (SAFETY) is included in lessons where there is a need to pay particular attention to potential safety hazards. The following guidelines will help minimise risks:

- Be aware of the school's policy on safety in the classroom and for excursions.
- Check students' health records for allergies or other health issues.
- Be aware of potential dangers by trying out activities before students do them.
- Caution students about potential dangers before they begin an activity.
- Clean up spills immediately as slippery floors are dangerous.
- Instruct students never to smell, taste or eat anything unless they are given permission.
- Discuss and display a list of safe practices for science activities.

Teaching to the Australian Curriculum: Science

The Australian Curriculum: Science has three interrelated strands—Science Understanding, Science as a Human Endeavour and Science Inquiry Skills—that together ‘provide students with understanding, knowledge and skills through which they can develop a scientific view of the world’ (ACARA 2018).

The content of these strands is described by the Australian Curriculum as:

Science Understanding	
Biological sciences	Understanding living things
Chemical sciences	Understanding the composition and behaviour of substances
Earth and space sciences	Understanding Earth’s dynamic structure and its place in the cosmos
Physical sciences	Understanding the nature of forces and motion, and matter and energy
Science as a Human Endeavour	
Nature and development of science	An appreciation of the unique nature of science and scientifi knowledge, including how current knowledge has developed over time through the actions of many people
Use and influence of science	How science knowledge and applications affect people 's lives, including their work, and how science is influenced by society and can be used to inform decisions and actions
Science Inquiry Skills	
Questioning and predicting	Identifying and constructing questions, proposing hypotheses and suggesting possible outcomes
Planning and conducting	Making decisions about how to investigate or solve a problem and carrying out an investigation, including the collection of data
Processing and analysing data and information	Representing data in meaningful and useful ways, identifying trends, patterns and relationships in data, and using this evidence to justify conclusions
Evaluating	Considering the quality of available evidence and the merit or significance of a claim, proposition or conclusion with reference to that evidence
Communicating	Conveying information or ideas to others through appropriate representations, text types and modes

Above material is sourced from the Australian Curriculum: Australian Curriculum Assessment and Reporting Authority (ACARA). (2018). *Australian Curriculum: Science*. www.australiancurriculum.edu.au

Primary**Connections** units support teachers to teach each Science Understanding detailed in the Australian Curriculum: Science from Foundation to Year 6. Units also develop students’ skills and knowledge of the Science as a Human Endeavour and Science Inquiry Skills sub-strands, as well as specific sub-strands within the Australian Curriculum: English, Mathematics and Design and Technologies. Detailed information about its alignment with the Australian Curriculum is provided in each unit.

Unit at a glance

Machine makers

Phase	Lesson	At a glance
ENGAGE	**Lesson 1** Pushes and pulls	To capture students' interest and find out what they think they know about how a push or a pull affects how an object moves. To elicit students' questions about pushes and pulls.
EXPLORE	**Lesson 2** Move it! ***Session 1*** Pushes and pulls all around ***Session 2*** Ready, set, go!	To provide students with hands-on, shared experiences of different ways to make objects move.
	Lesson 3 Ramp it up	To provide students with hands-on, shared experiences of using ramps to make objects move.
	Lesson 4 Lever it	To provide students with hands-on, shared experiences of using levers to make objects move.
	Lesson 5 Pulley power	To provide students with hands-on, shared experiences of using pulleys to make objects move.
EXPLAIN	**Lesson 6** Problem solvers	To support students to represent and explain their understanding of how a push or a pull affects how an object moves. To introduce current scientific views about using simple machines to move objects.
ELABORATE	**Lesson 7** Rube Goldberg ***Session 1*** Plan it firs ***Session 2*** Construction time	To support students to design and make their own Rube Goldberg machine using pushes and pulls.
EVALUATE	**Lesson 8** Our amazing machine	To provide opportunities for students to represent what they know about how a push or a pull affects how an object moves, and to reflect on their learning during the unit.

A unit overview can be found in Appendix 6, page 69.

Machine makers—Alignment with the Australian Curriculum

Machine makers is written to align to the Year 2 level of the Australian Curriculum: Science. The Science Understanding, Science Inquiry Skills, and Science as a Human Endeavour strands are interrelated and embedded throughout the unit (see page xi for further details). This unit focuses on the Physical sciences sub-strand.

Year 2 Science Understanding for the Physical Sciences:	**A push or a pull affects how an object moves or changes shape (ACSSU033)**
Guiding questions that inform the inquiry in *Machine makers*:	• What can you do to make objects move? • What happens to the push an object gives when you change the height of the ramp it falls down? • Can you use a lever (or a pulley) to make a push or a pull? • How can you join simple machines together to make a machine that does a simple task in a complicated way?

AC All the material in the first row of this table is sourced from the Australian Curriculum

Year 2 Achievement Standard

The Australian Curriculum: Science Year 2 achievement standard indicates the quality of learning that students should demonstrate by the end of Year 2.

By the end of Year 2, students describe changes to objects, materials and living things. They identify that certain materials and resources have different uses
and **describe examples of where science is used in people's daily lives.**

Students pose and respond to questions about their experiences and predict outcomes of investigations. They use informal measurements to make and compare observations. They record and represent observations and communicate ideas in a variety of ways.

The sections relevant to *Machine makers* are bolded above. By the end of the unit, teachers will be able to make evidence-based judgements on whether the students are achieving below, at or above the achievement standard for the sections bolded above.

Machine makers—Australian Curriculum: Key ideas

In the Australian Curriculum: Science, there are six key ideas that represent key aspects of a scientific view of the world and bridge knowledge and understanding across the disciplines of science. The below table explains how these are represented in *Machine makers*.

Key idea	Representation in *Machine makers*
Patterns, order and organisation	Students identify forces as pushes or pulls. They explore how different strengths of pushes and pulls affect the movement of objects. They discern between simple and complex machines.
Form and function	Students explore how push and pull forces affect the movement of objects. They investigate the features of simple machines that enable them to do a task.
Stability and change	Students discuss how a stable object has balanced forces acting on it. They explore how they can apply a force to change the movement of objects.
Scale and measurement	Students use informal measurements to determine distances travelled by objects. They use force-arrow diagrams to represent push and pull forces.
Matter and energy	Students observe the motion of objects and relate them to the forces acting on them.
Systems	Students identify and analyse simple machines and how they can be connected to construct complex machines.

Incorporating the key ideas

According to the Australian Curriculum: Science ‘from Foundation to Year 2, students learn that observations can be organised to reveal patterns, and that these patterns can be used to make predictions about phenomena’.

In Year 2, students describe the components of simple systems, such as stationary objects subjected to pushes or pulls, or combinations of materials, and show how objects and materials interact through direct manipulation. They observe patterns of growth and change in living things, and describe patterns and make predictions. They explore the use of resources from Earth and are introduced to the idea of the flow of matter when considering how water is used. They use ounting and informal measurements to make and compare observations and begin to recognise that organising these observations in tables makes it easier to show patterns.

In *Machine makers* students observe forces in their everyday lives, including forces related to simple machines. They describe the components of simple systems, such as stationary objects subjected to pushes and pulls, and show how objects move when subjected to pushes and pulls. They describe patterns and make predictions about the size or direction of a force and its effect on the movement of objects. They count marbles added to pulleys and use informal measurements, such as hand spans, to measure and compare the distances objects roll. They organise their observations into provided tables.

Machine makers—Australian Curriculum: Science

Machine makers embeds all three strands of the Australian Curriculum: Science. For ease of reference, the table below outlines the sub-strands covered in *Machine makers*, the content descriptions for Year 2 and the aligned lessons.

Strand	Sub-strand	Code	Year 2 content descriptions	Lessons
Science Understanding	**Physical sciences**	ACSSU033	A push or a pull affects how an objec moves or changes shape	1–8
Science as a Human Endeavour	**Nature and development of science**	ACSHE034	Science involves observing, asking questions about, and describing changes in, objects and events	1–8
	Use and influence of science	ACSHE035	People use science in their daily lives, including when caring for their environment and living things	1–6
Science Inquiry Skills	**Questioning and predicting**	ACSIS037	Pose and respond to questions, and make predictions about familiar objects and events	1–8
	Planning and conducting	ACSIS038	Participate in guided investigations to explore and answer questions	2–7
		ACSIS039	Use informal measurements to collect and record observations, using digital technologies as appropriate	3
	Processing and analysing data and information	ACSIS040	Use a range of methods to sort information, including drawings and provided tables and through discussion, compare observations with predictions	2–5
	Evaluating	ACSIS041	Compare observations with those of others	1–7
	Communicating	ACSIS042	Represent and communicate observations and ideas in a variety of ways	1–8

AC All the material in the first four columns of this table is sourced from the Australian Curriculum

General capabilities

The skills, behaviours and attributes that students need to succeed in life and work in the 21st century have been identified in the Australian Curriculum as general capabilities. There are seven general capabilities and they are embedded throughout the curriculum. For further information see: www.australiancurriculum.edu.au

For examples of our unit-specific general capabilities information see the next page.

Machine makers—Australian Curriculum: General capabilities

General capabilities	Australian Curriculum description	*Machine makers* examples
Literacy	Students develop a broader literacy capability as they explore and investigate their world. By learning the literacy of science, students understand that language varies according to context and they increase their ability to use language flexible.	In *Machine makers* the literacy focuses are: • science journals • word walls • annotated drawings • T-charts • ideas maps • tables.
Numeracy	Many elements of numeracy are particularly evident in Science Inquiry Skills. These include practical measurement and the collection, representation and interpretation of data from investigations.	Students: • measure and compare the distance a toy car is pushed using informal units.
Information and Communication Technology (ICT) capability	Students develop ICT capability when they research science concepts and applications, investigate scientific phenomena and communicate their scientific understandings. In particular, they use their ICT capability to access information; collect, analyse and represent data; model and interpret concepts and relationships; and communicate science ideas, processes and information.	Students are given opportunities to: • view and discuss relevant videos.
Critical and creative thinking	Students develop capability in critical and creative thinking as they learn to generate and evaluate knowledge, ideas and possibilities, and use them when seeking new pathways or solutions.	Students: • ask and answer questions, describe and explain their ideas, make suggestions and join in discussions • make predictions • design, make and appraise to build a simple Rube Goldberg machine.
Personal and social capability	Students develop personal and social capability as they engage in science inquiry, learn how scientific knowledge informs and is applied in their daily lives, and explore how scientific debate provides a means of contributing to their communities.	Students: • participate in discussions • work collaboratively in teams • listen to and follow instructions to safely complete investigations.
Ethical understanding	Students develop the capacity to form and make ethical judgements in relation to experimental science, codes of practice, and the use of scientific information and science applications.	Students: • ask questions of others, respecting each other's point of view.
Intercultural understanding	Students learn to appreciate the contribution that diverse cultural perspectives have made to the development, breadth and diversity of science knowledge and applications.	• Important contributions made to science by people from a range of cultures are highlighted.

AC All the material in the first two columns of this table is sourced from the Australian Curriculum

Machine makers—Australian Curriculum: English

Strand	Sub-strand	Code	Year 2 content descriptions	Lessons
Language	**Language for interaction**	ACELA1461	Understand that language varies when people take on different roles in social and classroom interactions and how the use of key interpersonal language resources varies depending on context	1–8
	Text structure and organisation	ACELA1463	Understand that different types of texts have identifiable text structures and language features that help the text serve its purpose	1–8
		ACELA1466	Know some features of text organisation including page and screen layouts, alphabetical order, and different types of diagrams, for example timelines	1–8
	Expressing and developing ideas	ACELA1470	Understand the use of vocabulary about familiar and new topics and experiment with and begin to make conscious choices of vocabulary to suit audience and purpose	1–8
Literacy	**Interacting with others**	ACELY1666	Listen for specific purposes and information, including instructions, and extend students' own and others' ideas in discussions	1–8
		ACELY1667	Rehearse and deliver short presentations on familiar and new topics	2–5, 7, 8
		ACELY1789	Use interaction skills including initiating topics, making positive statements and voicing disagreement in an appropriate manner, speaking clearly and varying tone, volume and pace appropriately	1–8
	Creating texts	ACELY1671	Create short imaginative, informative and persuasive texts using growing knowledge of text structures and language features for familiar and some less familiar audiences, selecting print and multimodal elements appropriate to the audience and purpose	1–8

Machine makers—Australian Curriculum: Mathematics

Strand	Sub-strand	Code	Year 2 content descriptions	Lessons
Number and Algebra	**Number and place value**	ACMNA027	Recognise, model, represent and order numbers to at least 1000	3, 5
Measurement and Geometry	**Using units of measurement**	ACMMG037	Compare and order several shapes and objects based on length, area, volume and capacity using appropriate uniform informal units	3–5
		ACMMG038	Compare masses of objects using balance scales	4
Statistics and Probability	**Data representation and interpretation**	ACMSP048	Identify a question of interest based on one categorical variable. Gather data relevant to the question	3, 5

All the material in the first four columns of this table is sourced from the Australian Curriculum

Machine makers—Australian Curriculum: Design and Technologies

Strand	Code	Year 2 content descriptions	Lessons
Knowledge and understanding	ACTDEK002	Explore how technologies use forces to create movement in products	1–5
	ACTDEK004	Explore the characteristics and properties of materials and components that are used to produce designed solutions	2–5
Processes and Production Skills	ACTDEP005	Explore needs or opportunities for designing, and the technologies needed to realise designed solutions	1–5
	ACTDEP006	Generate, develop and record design ideas through describing, drawing and modelling	2–5, 7
	ACTDEP007	Use materials, components, tools, equipment and techniques to safely make designed solutions	2–5, 7
	ACTDEP008	Use personal preferences to evaluate the success of design ideas, processes and solutions including their care for environment	7
	ACTDEP009	Sequence steps for making designed solutions and working collaboratively	7

All the material in the first four columns of this table is sourced from the Australian Curriculum

Machine makers—Australian Curriculum: Cross-curriculum priorities

There are three cross-curriculum priorities identified by the Australian Curriculum:

- Aboriginal and Torres Strait Islander histories and cultures
- Asia and Australia's engagement with Asia
- Sustainability.

One of these is embedded within *Machine makers*, as described below.

Aboriginal and Torres Strait Islander histories and cultures

The Primary**Connections** Indigenous perspectives framework supports teachers' implementation of Aboriginal and Torres Strait Islander histories and cultures in science. The framework can be accessed at: www.primaryconnections.org.au

Machine makers focuses on the Western science method of making evidence-based claims about the ways objects move. It also focuses on machines identified or classed by Western scientists, such as ramps, levers, pulleys and Rube Goldberg machines.

Aboriginal and Torres Strait Islander Peoples might have other names for, or versions of, simple machines that make objects move. They might have different traditional uses for machines, such as a Woomera (spear throwing lever) or digging stick.

Primary**Connections** recommends working with Aboriginal and Torres Strait Islander community members to access local and relevant cultural perspectives. Protocols for engaging with Aboriginal and Torres Strait Islander community members are provided in state and territory education guidelines. Links to these are provided on the Primary**Connections** website.

Teacher background information

This information is intended as teacher information only. It provides teachers with information relevant to the science concept so they can feel more confident and competent to teach each lesson. The content and vocabulary of this information is at a more detailed and advanced level than what is required for students.

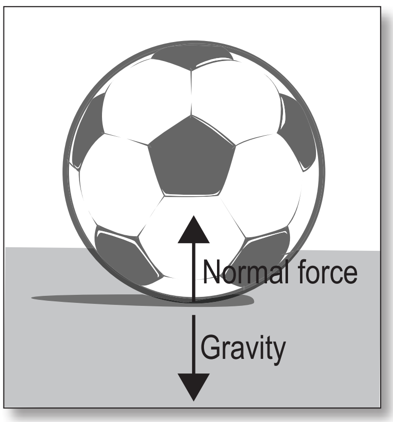
Introduction to forces and motion

A force is an external influence that can change the motion, direction or shape of objects. Examples of forces include pushes, pulls, friction, gravity and magnetism. A force can be applied to an object, but is not a property of the object itself. All living and non-living things can apply and be affected by forces. Put simply (and as a handy rhyme):

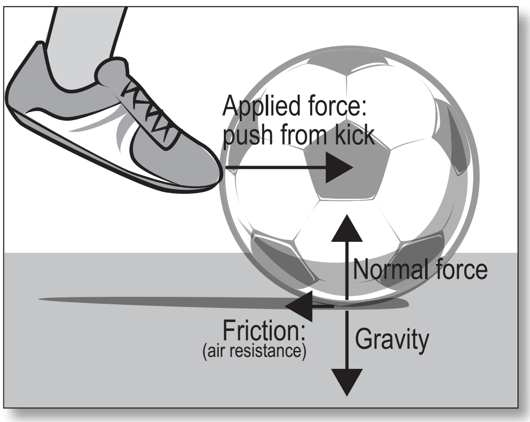
Forces move things in their way:
They can also make them stay
Speed them up or make them slow
Forces change the way things go.

Forces also make things change:
Make them bend or break or twist,
Make their shapes look really strange
Stretch them out or squash them – squish!

Force has two aspects: magnitude and direction. The magnitude of the force refers to the size, or amount, of force exerted, for example, a strong or a weak kick (push force) to a soccer ball. Stationary objects, for example, a soccer ball at rest (see diagram below left), remain stationary because there are two forces of equal magnitude acting on them (the pull from gravity and the opposing push from surfaces (normal force)). To start moving to a desired speed, a stationary object requires an imbalanced force to be applied, for example, the stationary soccer ball receives a kick (see diagram below right). Once that speed is reached, it only requires a small push to balance out forces that are slowing it down, such as air resistance and friction. Forces are commonly represented on diagrams using arrows, which show both the direction and size (magnitude) of the force.



Forces acting on a soccer ball at rest



Forces acting on a soccer ball that is being kicked by a foot

Note: The diagrams above are not force-arrow diagrams in the strictest sense, as scientists would portray all forces acting on an object's centre of mass. It is also not what you would expect students to be able to draw. The concept of normal force (which refers to a force perpendicular to the two surfaces in contact, generally as a result of resisting gravity) is formally introduced at high school.

When forces acting on an object are balanced (when every force has an equal and opposing force), the object will not start moving. However, the object might break or deform, depending on the direction and magnitude of the forces, the shape of the object and the materials it is made of. For example, an egg under a rock will not move: the downward push by the rock and the downwards pull by gravity in the egg are matched by an upwards push from the ground. However, if the rock is too heavy it may cause the egg to break (change shape) as the egg can no longer withstand all the forces acting upon it.

Forces of different magnitude have different effects on different objects. For a given object, a larger force will produce a bigger effect than a smaller force. For example, a big push will make a swing move a lot while a small push will only make the swing move a little. The effect of a force on an object also depends on the object's mass, which is the amount of matter in the object. For a given force, an object with a smaller mass will experience a greater effect than one with a larger mass. For example, a small push on a light wooden block will make it move a long distance, while the same small push on a heavy wooden block will not make it move as far.

Teaching points

In this unit, students will learn about the push and pull forces in simple machines. They will then combine simple machines and pushes and pulls in a series to make a Rube Goldberg machine (a machine that does something simple in a complicated way). There are many videos illustrating complicated versions of these machines, and care needs to be taken to manage students' expectations of what they can realistically produce (see Lesson 6, 'Teacher Background Information').

Students at this age tend to draw arrows in diagrams to represent movement rather than forces. Because of this, *Machine makers* focuses on annotated drawings as a literacy focus for students rather than force-arrow diagrams. This also helps to ensure that students' representations focus on the effects of forces (pushes and pulls).

At this age, students tend to think about pushes and pulls that they can see or feel the effects of. As such, they might develop concepts about gravity as a force that pulls objects down to the Earth. Gravity is a force caused by the interaction between two masses, of which the gravitational pull of the Earth on objects is but one example. Concepts about gravity are specifically mentioned in the Science Understandings of older years, therefore this conception is not directly addressed in the unit.

Students' conceptions

Taking account of students' existing ideas is important in planning effective teaching app oaches that help students learn science. Students develop their own ideas during their experiences in everyday life and might hold more than one idea about an event or phenomenon.

Students often associate forces and motion with living things, particularly humans and animals. Forces act on all objects regardless of whether they are living or non-living, sometimes resulting in motion and/or change of shape or direction. Students might have the view that force is a property of an object, however, a force is an external factor that affects an object, not something that is an internal property of an object.

Students might think that if an object is not moving there is no force acting on it. Although a person is standing still and not moving, there are still two forces acting on the person: a downward gravitational pull force and an upward push force from the ground (normal force). As these forces are balanced, there is no movement. If the person starts to walk then these forces are still present but there are other forces also acting, for example, friction.

Students might believe that for an object to be moving constantly, it must have a constant force acting on it. Objects do not need to be continuously pushed or pulled to continue moving. Think about throwing a ball. Once it leaves your hand there is no longer any throwing force being applied yet it continues to move. It will slow down because of air resistance and be pulled down to the Earth because of gravity. Think about a boat on a calm lake. If you turn the engine off it will continue to glide ac oss the water for some time. It will gradually slow down because of friction with the water and air resistance. Think about trying to push a brick across a slippery surface like ice. Initially you need a big push to get it moving, but once it is sliding you only need to push it occasionally to overcome the momentum lost through friction or air resistance.

To access more in-depth science information in the form of text, diagrams and animations, refer to the Primary**Connections** Science Background Resource, available on the Primary**Connections** website: www.primaryconnections.org.au.

Lesson 1 Pushes and pulls

AT A GLANCE

To capture students' interest and find out what they think they know about how a push or a pull affects how an object moves

To elicit students' questions about pushes and pulls.

Students:

- observe a 'Dog treat feeder' machine
- create an annotated drawing of the machine
- watch a video of a simple machine and discuss its components *(optional)*.

Lesson focus

The focus of the *Engage* phase is to spark students' interest, stimulate their curiosity, raise questions for inquiry and elicit their existing beliefs about the topic. These existing ideas can then be taken account of in future lessons.

Assessment focus

Diagnostic assessment is an important aspect of the *Engage* phase. In this lesson you will elicit what students already know and understand about how:

- a push or a pull affects how an object moves

You will also monitor their developing Science Inquiry Skills (see page xi).

Key lesson outcomes

Science

Students will be able to represent their current understanding as they:

- identify pushes and pulls in a 'Dog treat feeder' machine
- discuss their ideas about how to make objects move.

Literacy

Students will be able to:

- engage in discussions about pushes and pulls
- annotate a drawing to show ideas about pushes and pulls.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page xii).

Teacher background information

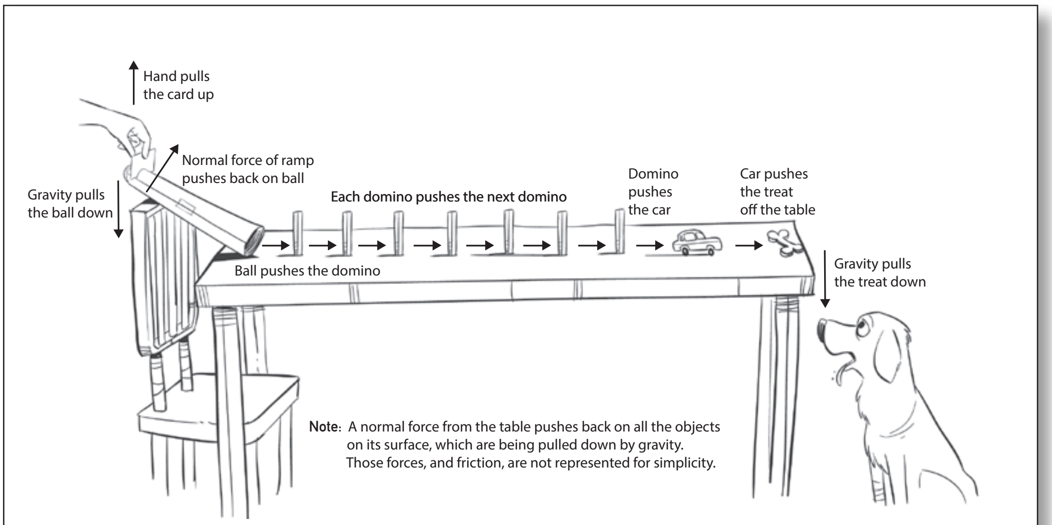
Simple machines

Machines are all around us. Cars, cranes, dishwashers, computers and power saws are all examples of complex machines and all make a particular task easier to complete. However, these complex machines are made up of a number of simpler machines.

In the most general sense, a machine is any device that can be used to perform a task. Scientists describe a machine as a device for transmitting or modifying a force or motion. Something as simple as a stick can be considered a machine, as you push one side and it transmits that push to the other side. Almost all machines used in our daily lives are made up of a combination of six simple machines that are described as levers, wheels and axles, inclined planes (ramps), gears, and pulleys.

Rube Goldberg machines

Rube Goldberg machines are a combination of many simple machines connected so that an initial applied force sets off a chain of reaction forces. These forces can be identified as pushes or pulls. The Rube Goldberg machine of a 'Dog treat feeder' demonstrated in this lesson has the following push and pull forces (see annotated drawing below).



'Dog treat feeder' machine showing push and pull forces

The majority of applied forces in Rube Goldberg machines tend to be pushes, with the pull of gravity constantly acting on objects causing them to roll down ramps and to fall into pulleys (bringing one side of the pulley downward).

Students' conceptions

Students might think that machines must have a motor, such as a car or lawnmower. Machines are any device that transmits or modifies force and motion. They do not need a motor to provide a push or a pull. Machines with a motor are complex machines, which are made up of several simple machines, including levers, wheels and axles, inclined planes (ramps), gears, and pulleys. The motors are also made up of these machines.

Students might think that the only forces acting on objects are contact forces, such as a physical push or pull. Non-contact forces, such as gravity or magnetism act at a distance.

Equipment

FOR THE CLASS

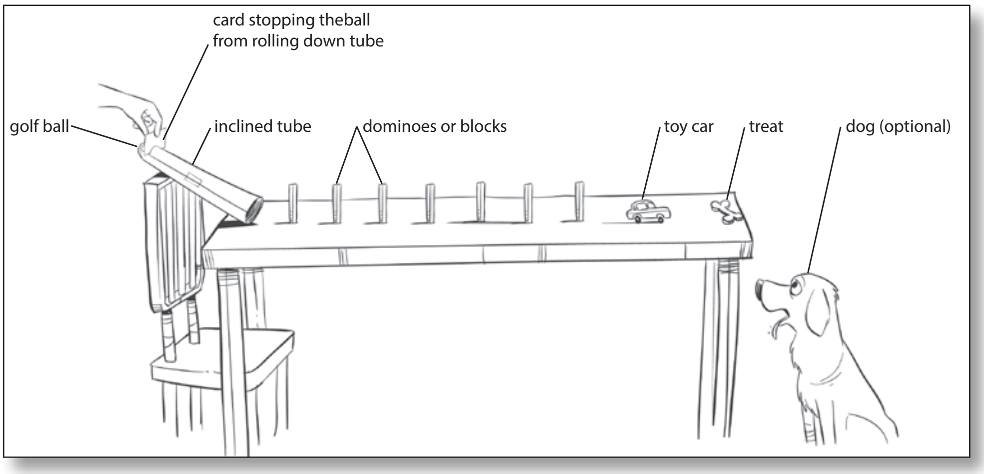
- class science journal
- word wall
- 1 enlarged copy of 'Give the dog a treat' (Resource sheet 1)
- golf ball or tennis ball
- 1 large sheet of card to make a tube (see 'Preparation')
- 1 small sheet of card or postcard
- 1 roll of masking tape
- set of dominoes, books or blocks (e.g. MAB flats)
- 1 small toy car
- 1 dog treat
- screen or box to hide 'Dog treat feeder' machine (see 'Preparation')
- *optional:* equipment to play a video (see 'Preparation')

FOR EACH STUDENT

- science journal
- 1 copy of 'Give the dog a treat' (Resource sheet 1)
- *optional:* equipment to make a 'Dog treat feeder' machine (see 'Preparation')

Preparation

- Read 'How to use a science journal' (Appendix 2).
- Read 'How to use a word wall' (Appendix 3).
- Prepare a page in the class science journal with the heading, 'Our questions about how pushes and pulls make things move'.
- Make a tube by rolling and taping a sheet of card. Ensure it is wide enough for the ball to roll down. Approximately 4 cm from the end of the tube, cut a slit about half way into the tube (see diagram at the top of page 4). Slot a sheet of card or postcard into the slot so that it forms a barrier to prevent the ball rolling down the tube.
  Tip: If the ball still rolls down, make a deeper cut into the tube to ensure the small card sits far enough into the tube to stop the ball.
- Set up and test the 'Dog treat feeder' machine as shown below. Hide final set-up from students behind a screen or under a box.
  Note: If you place the machine under a cloth you will knock things over.
  Tip: If the car is not hitting the treat with sufficient force to knock it over, try moving the car nearer to the treat, using a round treat and/or using larger blocks.



‘Dog treat feeder’ machine with labels

- *Optional:* Collect equipment for students to set up their own ‘Dog treat feeder’ machine (see lesson step 11). Source extra dominoes, cars, cardboard for tubes and dog treats. Keep materials, including tubes, for later investigations.
- *Optional:* Source a video of a simple Rube Goldberg machine, for example:
  - The GoldieBlox “Princess machine”: https://www.youtube.com/watch?v=IIGyVa5Xftw
  - http://www.digitaltrends.com/cool-tech/best-rube-goldberg-machines/

  Note: The videos will generate a lot of interest and discussion but may give students unrealistic expectations of what they will be able to build themselves.

Lesson steps

1 Ask students what they think a machine is and if they can identify any machines in the classroom. Explain that a machine is something that makes it easier for us to do work.

2 Explain that you have a special way of feeding a dog a treat using a machine. Introduce the ‘Dog treat feeder’ machine (see ‘Preparation’). Ask students questions such as:

- How do you think the machine works? Why do you think that?
- Why do you think it is called a machine?

Note: This line of questioning will help you identify students’ conceptions about how things move and why, and whether they use words such as push and pull. In the *Engage* phase, do not provide any formal definitions or correct students’ answers as the purpose is to elicit students’ prior knowledge and possible alternative conceptions.

3 Introduce the class science journal and discuss its purpose and features. Record students’ thoughts in the journal.

Literacy focus

Why do we use a science journal?

We use a **science journal** to record what we see, hear, feel and think so that we can look at it later.

What does a science journal include?

A **science journal** includes dates and times. It might include written text, drawings, measurements, labelled diagrams, photographs, tables and graphs.

ENGAGE

4 Ask students to watch carefully and then release the ball into the tube by pulling up the small sheet of card (see ‘Preparation’). If the machine does not immediately work, explain that you’re still working on your invention and set it up again.

Tip: If your ‘Dog treat feeder’ machine does not work the first time, invite students to suggest how to make it work. If it still doesn’t work, use this failure as the reason to investigate machines further before students attempt to create their own ‘Dog treat feeder’ machine that works later in the unit (See lesson step 9).

5 After the treat has fallen (or after a few failed attempts), ask questions such as:

- What is unusual about this way of giving a dog a treat?
- What happened when…?
- What made each of the parts move?
- How does this machine use pushes and pulls to make the objects move?

Record students’ ideas in the class science journal.

6 Ask students if they have any questions about how the ‘Dog treat feeder’ machine worked and add to the ‘Our questions’ section of the class science journal (see ‘Preparation’).

7 Explain that this feeder is called a Rube Goldberg machine and that Rube Goldberg was a man who became famous for making machines that do simple things in a very complicated way.

8 *Optional:* Play a video of another Rube Goldberg machine (see ‘Preparation’). Write students’ observations of what moved and why in the class science journal. Add any extra questions to the ‘Our questions’ section.

9 Explain that students are going to be learning about pushes and pulls in order to build their own Rube Goldberg machine, for example, to feed a pet a treat. Introduce the word wall and discuss its purpose and features.

Literacy focus

Why do we use a word wall?

We use a **word wall** to record words we know or learn about a topic. We display the **word wall** in the classroom so that we can look up words we are learning about and see how they are spelled.

What does a word wall include?

A **word wall** includes a topic title or picture and words that we have seen or heard about the topic.

Add the words ‘push’, ‘pull’ and ‘machine’ to the word wall.

Invite students to contribute words from different languages to the word wall, including local Indigenous names of objects and actions if possible, and discuss different communication systems of different languages.

10 Introduce ‘Give the dog a treat’ (Resource sheet 1). Read through and discuss how inventors make notes about things they have seen and how they work in order to help them with their own ideas. Discuss the purpose and features of an annotated drawing.

Literacy focus

Why do we use an annotated drawing?

We use an **annotated drawing** to show an idea or object.

What does an annotated drawing include?

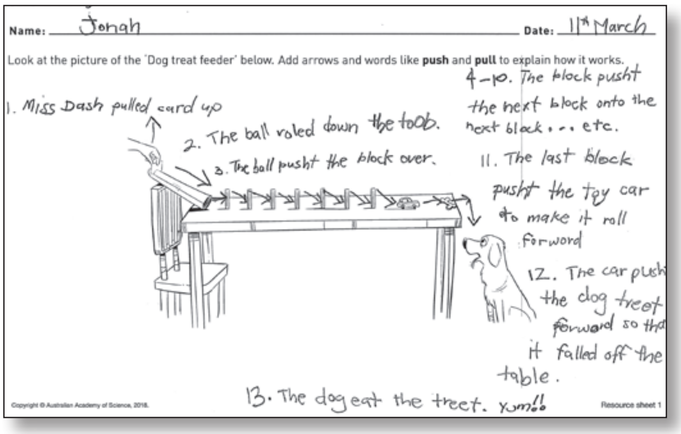
A **annotated drawing** includes a picture and words or descriptions about the idea or object.

11 Ask students to think about questions such as:

- What things were pushed to make them move?
- What things were pulled to make them move?
- What might be a different way to give the ball or car a push?
- What other pulls could you add to the machine?

Optional: Ask students to create their own ‘Dog treat feeder’ machine to observe, alone or in groups.

12 Allow time for students to complete their copy of ‘Give the dog a treat’ (Resource sheet 1).



Work sample of ‘Give the dog a treat’ (Resource sheet 1)

Optional: Ask students to discuss their annotated drawing with a partner.

13 Ask students what they would like to find out about in order to design their own ‘Pet treat feeder’ machine. Record students’ questions on the ‘Our questions’ page in the class science journal (see ‘Preparation’).

14 Ask students what words from today’s lesson they would like added to the word wall.

ENGAGE

Curriculum links

Science

- Play the game 'Mousetrap'. Identify pushes and pulls in the game.

Science as Human Endeavour/The Arts

- Explore the illustrated works of Rube Goldberg, for example using *The Art of Rube Goldberg* ISBN: 1-4197-0852-X, see:
  https://www.youtube.com/watch?v=8KtTKCBMLCE

Design and Technologies

- Explore how some simple machines work.

Indigenous perspectives

- Explore how Indigenous peoples used tools and technologies to solve problems and make simple machines.

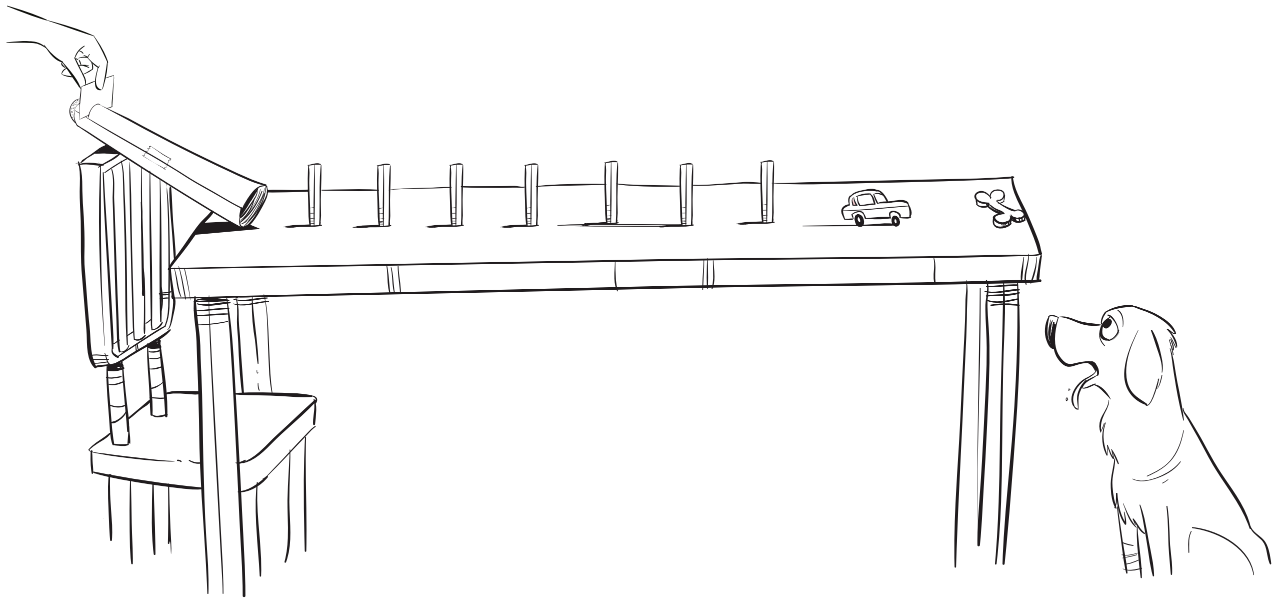
  Primary**Connections** recommends working with Aboriginal and Torres Strait Islander community members to access local and relevant cultural perspectives. Protocols for engaging with Aboriginal and Torres Strait Islander community members are provided in state and territory education guidelines. Links to these are provided on the Primary**Connections** website (www.primaryconnections.org.au).

ENGAGE

Give the dog a treat

Name: ______________________________ **Date:** ______________

Look at the picture of the 'Dog treat feeder' below. Add arrows and words like **push** and **pull** to explain how it works.



Lesson 2 Move it!

EXPLORE

AT A GLANCE

To provide students with hands-on, shared experiences of different ways to make objects move.

Session 1 Pushes and pulls all around

Students:

- identify pushes and pulls in a video and around the school
- record their observations in a T-chart.

Session 2 Ready, set, go!

Students:

- work in teams to investigate ways to make a toy car move from one place to another.

Lesson focus

The *Explore* phase is designed to provide students with hands-on experiences of the science phenomenon. Students explore ideas, collect evidence, discuss their observations and keep records, such as science journal entries. The *Explore* phase ensures all students have a shared experience that can be discussed and explained in the *Explain* phase.

Assessment focus

Formative assessment is an ongoing aspect of the *Explore* phase. It involves monitoring students' developing understanding and giving feedback that extends their learning. In this lesson you will monitor students' developing understanding of how:

- a push or a pull affects how an object moves

You will also monitor their developing Science Inquiry Skills (see page xi).

Key lesson outcomes

Science

Students will be able to:

- recognise pushes and pulls that make objects move
- identify different ways to make an object move.

Literacy

Students will be able to:

- record observations in a T-chart
- contribute thoughts to a class ideas map
- record observations in a table.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page xii).

Teacher background information

Pushes and pulls are both forces. They are described with reference to the object that they are acting upon: a push can be described as a force imparted by something moving towards the object and a pull as a force imparted by something moving away from the object. When we push something, we move our hand away from ourselves (and towards the object). When we pull something, we move our hand towards ourselves (bringing the object with it).

A push or pull can act through direct contact, such as a marble hitting a toy car, or from a distance, such as gravity pulling a book towards the centre of the Earth or magnets repelling (pushing away) or attracting (pulling towards) each other. All forces can be explained in terms of pushes or pulls or combinations of the two, such as a twist. The table below gives some common examples:

Pull (contact force)	Opening a door towards you
Push (contact force)	Throwing a ball
Pull (gravity)	Dropping a pen
Pull (magnetic force)	Magnet attaching to a fridge
Pull (contact force)	Towing a car
Push and pull (contact forces)	Twisting a tap on.

The position and motion of objects can be changed by pushing or pulling. In Rube Goldberg machines, the initial push or pull is generally applied by a person and the follow-on pushes and pulls are in relation to objects. For example, a child pushes a marble causing it to move away from their body and down a ramp, the ball increases in speed due to the pull of gravity being greater than the frictional forces between the ramp and the ball. The marble collides with a car pushing the car into motion in a direction away from the marble.

Students' conceptions

Students might believe that force is a property of an object; that the object has force or force is within the object. Expressions such as ‘May the force be with you’ or other meanings for force, such as ‘Police force’ can often reinforce this conception. A force is an external influence that can change the motion, direction or shape of objects. A force can be applied to an object but is not a property of the object itself.

Students might associate forces with movement, and movement with living things, and therefore believe that only living things exert forces. Forces such as friction and gravity are not exerted by living things.

Students might think that forces are acting only when an object moves and therefore that gravity acts only on falling objects. Although a book sitting on a table is pulled down by gravity, the table pushes back up against the book. The book is motionless because these two forces are balanced.

Session 1 Pushes and pulls all around

Equipment

FOR THE CLASS

- class science journal
- word wall
- 1 enlarged copy of 'Push pull pursuit' (Resource sheet 2)
- *optional:* 1 enlarged copy of 'Information note for families' (Resource sheet 3)
- equipment to play a video (see 'Preparation')
- *optional:* digital camera

FOR EACH STUDENT

- science journal
- 1 copy of 'Push pull pursuit' (Resource sheet 2)
- *optional:* 1 copy of 'Information note for families' (Resource sheet 3)
- *optional:* 1 extra copy of 'Push pull pursuit' (Resource sheet 2)
- *optional:* clipboard

EXPLORE

Preparation

- Source the video 'Pushing and pulling'.
  See: https://www.stem.org.uk/resources/elibrary/resource/32044/pushing-and-pulling
- Prepare a T-chart on a page in the class science journal (or on a whiteboard) as follows:

Pushes and pulls all around

Pushes	Pulls

Lesson steps

1. Review the previous lesson, focusing students' attention on the pushes and pulls that made different parts of the 'Dog treat feeder' machine move.
2. Explain that students will be watching a video, 'Pushing and pulling' (see 'Preparation'), and that after watching the video they will be doing a 'Think: Pair: Share' activity. Ask students to watch the people and notice when they use pushes and pulls to make things move.
3. After watching the video, explain that students will now 'Think' about the pushes and pulls that they observed in the video. Ask students not to talk for 20 seconds while they think.

   Optional: Watch the video again.

4 Ask students to 'Pair' with another student. Explain that students will take turns to listen to each other's ideas about the pushes and pulls they saw, and agree on one push and one pull to share with the class.

5 Introduce the T-chart (see 'Preparation'). Discuss the purpose and features of a T-chart.

Literacy focus

Why do we use a T-chart?

We use a **T-chart** to organise information so that we can understand it more easily.

What does a T-chart include?

A **T-chart** includes two columns with headings. Information is put into the columns based on the headings.

EXPLORE

Pushes	Pulls
Jake pushed the helmet down on Dan's head.	They pulled on their wetsuits.
They pushed the canoe into the water.	They pulled the canoe out of the rack.
They pushed the oar in the water to make the canoe turn.	They pulled the oar in the water to make the canoe go.
Jake accidentally pushed Dan into the water.	They pulled the canoe out of the water.
	Jake pulled Dan out of the water.

Class work sample of pushes and pulls observed in video

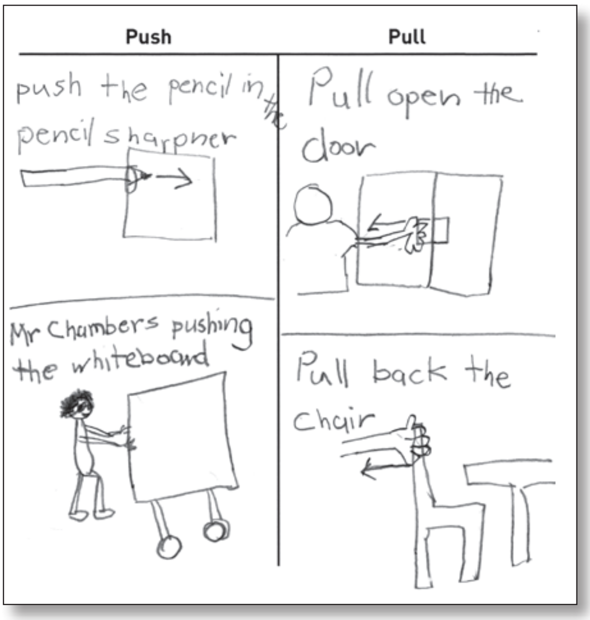
6 Ask each pair to 'Share' their one push and one pull with the rest of the class. Record responses in the T-chart.

7 Introduce the enlarged copy of 'Push pull pursuit' (Resource sheet 2). Explain that students will be walking around the school and looking for objects that are pushed or pulled to make them move. For example, the school gardener pushing a wheelbarrow, the librarian pulling books off a shelf. Model how to record an example on the resource sheet.

SAFETY

Note: Ask students to be careful while they are investigating and not to push or pull things that are fragile and/or too heavy or dangerous, such as chemical containers, tools or appliances.

Optional: Take photos of each object being pushed or pulled to move. Add the photos to the T-chart in the class science journal.



Work sample of 'Push pull pursuit' (Resource sheet 2)

8 Allow time for students to complete the activity. As a class, discuss some of the pushes and pulls that students identified

9 *Optional:* Explain that students are going to look for pushes and pulls at home and on their way to or from school:

- Introduce the enlarged copy of 'Information note for families' (Resource sheet 3). Discuss when students are to complete the new copy of 'Push pull pursuit' (Resource sheet 2) and model writing the date in the space provided on 'Information note for families' (Resource sheet 3).
- Brainstorm places that students might investigate at home, such as, the kitchen, the backyard, the living room, and on the way to school, such as a car, a bike, a scooter.
- Remind students to be careful while they are investigating.

Work sample of 'Push pull pursuit' (Resource sheet 2) completed at home

10 Ask students what words from today's lesson they would like added to the word wall.

EXPLORE

Push pull pursuit

Name: ______________________ **Date:** ____________

Find objects that you push or pull to make them move.

Write, draw or take a photo of what you find. Add it to the T-chart below.

Push	Pull

Information note for families

Name: ______________________ **Date:** ____________

Introducing the 'Push pull pursuit' task

This term, our class is observing how a push or a pull affects the way an object moves as part of the science unit, *Machine makers*.

Students have been observing objects around the school that need to be pushed or pulled to make them move. Some pushes and pulls that might happen at home include: a wheelbarrow being pushed along in the garden, doors that open or close when they are pushed or pulled, or zippers on clothing being pulled up or down.

Students are asked to complete the attached resource sheet 'Push pull pursuit'. They are asked to draw (or photograph) two objects at home being pulled to move and two objects at home being pushed to move.

Students are asked to complete and return this activity to school by:

____

Class teacher

EXPLORE

Session 2 Ready, set, go!

Equipment

FOR THE CLASS

- class science journal
- word wall
- team roles chart
- team skills chart
- 1 enlarged copy of 'Make it go!' (Resource sheet 4)
- box of equipment to make the toy car move (see 'Preparation')

FOR EACH TEAM

- each team member's science journal
- role wristbands or badges for Manager and Speaker
- 1 copy of 'Make it go!' (Resource sheet 4) per team member
- 1 toy car

Preparation

- Prepare an ideas map in the class science journal as follows:

What different ways can we push or pull the toy car to make it move?

- Prepare a page in the class science journal with the heading "Our ideas to improve the 'Dog treat feeder' machine".
- Collect equipment for students to use to move the toy car, such as string, glue, tape, drinking straws, cardboard, scrap wood, rubber bands, blocks, washers, popsticks, balloons, magnets and cotton reels. Place the equipment in a box.

Lesson steps

1. *Optional:* Ask some students to share pushes and pulls that they observed at home.
2. Review the image of the 'Dog treat feeder' machine from Lesson 1. Ask students what object pushes the toy car to make it move (the last falling block or domino).
3. Show students the collected materials and the toy car. Explain that students will be exploring other objects and ways that they might use to make a toy car move in their Rube Goldberg machine.
4. Explain that students will work in collaborative learning teams to explore the question: 'What different ways can you push or pull a toy car to make it move from one place to another?'
5. Introduce the ideas map in the class science journal (see 'Preparation'). Discuss the purpose and features of an ideas map.

Literacy focus

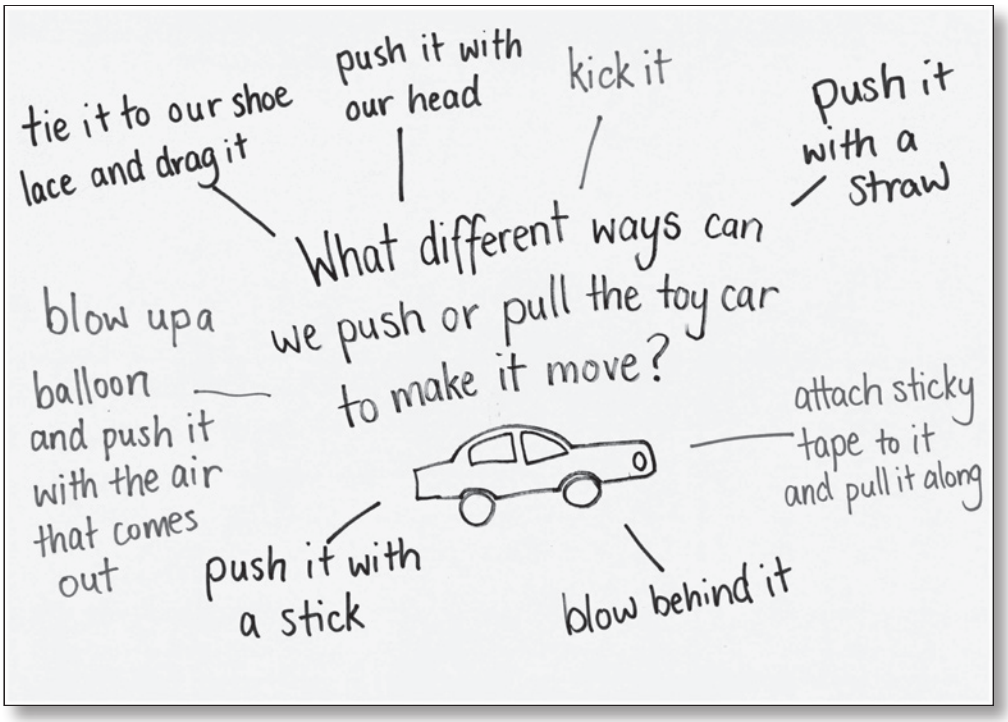
Why do we use an ideas map?

We use an **ideas map** to show our thoughts about a topic.

What does an ideas map include?

An **ideas map** includes a title in the centre. Ideas are written around it and arrows are drawn between similar ideas. An **ideas map** might include pictures and symbols.

6. Brainstorm ways to move the toy car and record these on the ideas map. For example, pushing, pulling, hitting, throwing, sliding, rolling, dropping, blowing.



Work sample of class ideas map

EXPLORE

7 Introduce the box of collected materials (see ‘Preparation’) and ask students to consider how they might use the materials. Add any extra thoughts to the class ideas map.

8 Introduce the enlarged copy of ‘Make it go!’ (Resource sheet 4). Discuss the purpose and features of a table.

Literacy focus

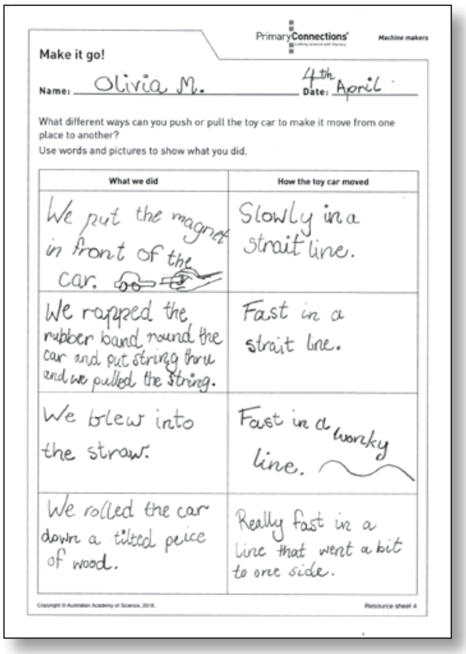
Why do we use a table?

We use a **table** to organise information so that we can understand it more easily.

What does a table include?

A **table** includes a title, columns with headings and information organised under each heading.

9 Model how to record an observation on the enlarged copy of ‘Make it go!’ (Resource sheet 4).



PrimaryConnections Machine makers

Make it go!

Name: Olivia M. Date: 4th April

What different ways can you push or pull the toy car to make it move from one place to another?
Use words and pictures to show what you did.

What we did	How the toy car moved
We put the magnet in front of the car.	Slowly in a strait line.
We rapped the rubber band round the car and put string thru and we pulled the string.	Fast in a strait line.
We blew into the straw.	Fast in a worky line.
We rolled the car down a tilted peice of wood.	Really fast in a line that went a bit to one side.

Resource sheet 4

Work sample of ‘Make it go!’ (Resource sheet 4)

10 Form pairs and allocate roles. Ask Managers to collect their team’s toy car and some materials from the box. Explain that Managers will return materials to the box once their team has finished using them so that other teams can access them.

If students are using collaborative learning teams for the first time, introduce and explain the team skills chart and the team roles chart. Explain that students will use role wristbands or badges to help them (and you) know which role each member should be doing.

11 Allow time for teams to complete the activity.

12 Ask Speakers to share how they were able to get the toy car to move. Ask questions such as:

- What ways did you use to push or pull the toy car to make it move?
- Did you use other objects to make the car move? What did they do?
- Which ways made the toy car go fast? Leave the floor? Go in a zigzag?
- Record students' ideas on the class ideas map in the class science journal, using a different-coloured pen.

13 Introduce the 'Our ideas' page in the class science journal (see 'Preparation'). Ask students what ideas they have and record them on the page.

14 Review students' questions on the 'Our questions' page of the class science journal to see if any have been answered.

15 Update the word wall with words and images.

Curriculum links

English

- Identify adjectives to describe how the toy car moved.

Mathematics

- Measure the distance the toy car travels after each push or pull.

Make it go!

Name: ______________________ **Date:** ____________

What different ways can you push or pull the toy car to make it move from one place to another?

Use words and pictures to show what you did.

Lesson 3 Ramp it up

AT A GLANCE

To provide students with hands-on, shared experiences of using ramps to make objects move.

Students:

- work in teams to investigate how changing the height of a ramp affects the push a rolling ball gives to a toy car.

Lesson focus

The *Explore* phase is designed to provide students with hands-on experiences of the science phenomenon. Students explore ideas, collect evidence, discuss their observations and keep records, such as science journal entries. The *Explore* phase ensures all students have a shared experience that can be discussed and explained in the *Explain* phase.

Assessment focus

Formative assessment is an ongoing aspect of the *Explore* phase. It involves monitoring students' developing understanding and giving feedback that extends their learning. In this lesson you will monitor students' developing understanding of how:

- a push or a pull affects how an object moves

You will also monitor their developing Science Inquiry Skills (see page xi).

Key lesson outcomes

Science

Students will be able to:

- identify that a higher ramp causes the toy car to be pushed further by the ball
- make claims based on evidence.

Literacy

Students will be able to:

- contribute to discussions about their investigation
- record observations in a table.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page xii).

Teacher background information

Ramps

Ramps, also known as inclined planes, are simple machines that enable objects to move more easily from a high position to a low position or vice versa. Pushing an object uphill on a ramp requires less effort than pushing that object directly upwards. The trade-off is that the object must be pushed over a greater distance on a ramp. For example, if you compare the length of a ladder to that of a staircase going to the same height, the ladder is much shorter. Climbing the ladder requires more effort but over a shorter time.

Ramps are also important for accessibility, by providing a sloped surface for wheelchairs or trolleys to travel up or down. The speed at which an object rolls down a ramp depends on many factors, including the shape and material of the rolling object, the angle of the plane and material it is made from and any external forces, such as wind.

The mass of an object can influence the rate at which it rolls down a ramp (as it can affect forces such as friction created by rubbing against the surface of ramp), but it is often negligible. Two balls of different mass rolling down a ramp (or falling through the air) will reach the bottom at the same time. This is because, although the attraction (the pull) between objects of greater mass and the Earth are stronger, the objects of greater mass also require a bigger pull (or push) to get moving. It turns out that for the ball with more mass the extra pull from gravity is equal to the extra pull it needs to get moving and so the two balls fall at the same speed.

Two balls of different mass may fall, or roll down a ramp, at the same speed but they do not have the same impact on landing. The heavier ball will give the next object a bigger push. Alternatively, it will roll much further before coming to a complete stop. For example, if a golf ball and table tennis ball (of equal size and shape) were to roll down a ramp and hit a toy car they would both hit the car at roughly the same time after release, but the golf ball would apply a greater force to the toy car, sending it further.

Students' conceptions

Students might think that an object of greater mass will fall, or roll downhill, faster than an object of less mass because gravity pulls it more strongly. The object of greater mass is pulled more strongly but also requires more pull in order to move. What can change is that an object of less mass might be slowed more noticeably by other forces such as air resistance: a feather and a lead ball fall at exactly the same rate in a vacuum (if there is no air) but on Earth the lead ball will hit the ground first.

Students might think that the strength (magnitude) of an applied force is proportional to the movement of an object, that is, a strong push will always make an object move a long distance. However, some strong forces do not result in any movement at all. For example, you might push a large granite boulder and not move it at all. The boulder has a strong gravitational pull towards the Earth, and an equally large push back from the surface it is on, so even though there are large forces acting on the object, there is no motion.

Students might think that objects in motion require an ongoing force to keep them in motion. Once an object is moving it will continue to move at the same speed unless acted upon by other forces, such as friction and air resistance.

Equipment

FOR THE CLASS

- class science journal
- word wall
- team roles chart
- team skills chart
- 1 enlarged copy of 'Higher and higher' (Resource sheet 5)
- 1 golf ball or hard-boiled egg (see 'Preparation')

FOR EACH TEAM

- each team member's science journal
- role wristbands or badges for Manager and Speaker
- 1 copy of 'Higher and higher' (Resource sheet 5) per team member
- 5 small blocks or books of equal width (approximately 2 cm)
- 1 cardboard or plastic tube
- 1 toy car
- 1 golf ball or tennis ball
- 10 popsticks
- *optional:* glue stick
- *optional:* 1 x A3 sheet of paper
- *optional:* additional 10 popsticks

Preparation

- Read 'How to facilitate evidence-based discussions' (Appendix 4).
- Locate a flat, smooth area, for example, smooth concrete, to conduct the investigation. **Note:** Toy cars may not travel very far on carpet.
- Decide what class demonstration to use to explore the notion of increased impact when objects fall from a higher place (see lesson step 12) for example:
  - Drop a (boiled) egg from increasing heights until it breaks.

    Note: Check for egg allergies in the class.
  - Ask students at what height they would be comfortable with a golf ball being dropped on their head.

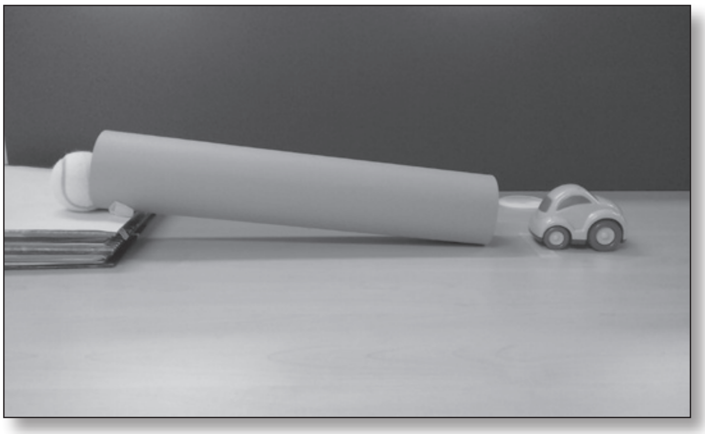
  Tip: If students are comfortable with this concept you can shorten the lesson by omitting lesson steps 12 and 13.

Lesson steps

1. *Optional:* Ask some students to share pushes and pulls that they observed at home.
2. Discuss what a ramp is and why ramps are useful.
3. Review the image of the 'Dog treat feeder' machine from Lesson 1 and discuss which part of the machine is like a ramp (the tube). Ask questions such as:
   - What do you think would happen if we made the ramp higher?
   - What do you think would happen if we made the ramp lower?

EXPLORE

4 Introduce the enlarged copy of 'Higher and higher' (Resource sheet 5). Read through and discuss. Explain that students will work in collaborative learning teams to investigate the question:'What happens to how far a toy car is pushed by a ball when you change the height of the ramp?'



Example set-up of investigation

Optional: Ask teams to investigate different questions, such as:

- 'What happens to how far a toy car is pushed by a ball when you change the mass or size of the ball?'
- What happens to how far a toy car is pushed by a ball when you change the surface that the toy car is on?'

5 Explain that teams will roll a ball down a ramp and measure how far the toy car is pushed by the ball using popstick lengths or widths. Model how to measure using popsticks.

6 Demonstrate how teams will place one block under the ramp and roll the ball down the ramp towards the toy car at the end of the ramp. Model how to record the observation on the enlarged copy of 'Higher and higher' (Resource sheet 5).

7 Explain that teams will repeat the process adding an extra block each time. Ask students to predict what they think will happen to how far a toy car is pushed by a ball as the ramp is made higher, and give reasons for their predictions.

Record students' predictions and reasoning on the enlarged copy of 'Higher and higher' (Resource sheet 5).

8 Form pairs and allocate roles. Ask Managers to collect team equipment. Allow time for teams to complete the activity.

Optional: Ask teams to create a picture graph of their results by gluing the popsticks onto an A3 sheet of paper.

9 Ask Speakers to present their team's results. Ask questions such as:

- What happened to how far the toy car was pushed as you made the ramp higher?
- Why do you think that some teams had different results? (For example, different equipment, the cars travelling across different surfaces, some pushing the ball down the ramp instead of just letting it go.)

Ask students to question each other using the 'Science question starters' in Appendix 4.

10 As a class, discuss what claims students can make after doing the investigation. Record students' claims in the class science journal.
Note: Remind students to provide evidence for their claims, for example:

Our claim is: The more blocks we put under the ramp, the further the toy car was pushed by the ball.

Our evidence is:

- A ramp 1 block high pushed the toy car 1 popstick length.
- A ramp 2 blocks high pushed the toy car 4 popstick lengths.
- A ramp 3 blocks high pushed the toy car 6 popstick lengths.

11 Discuss how adding more blocks under the ramp meant that the ball started higher and pushed the toy car further.

12 Introduce the class demonstration to explore the notion of increased impact when objects fall from a higher place (see 'Preparation').

13 Explain that scientists claim that objects fall down because they are pulled to the centre of the Earth by gravity. The further the objects fall, the more pull from gravity they receive. The more pull they receive, the harder they will hit the next object (the bigger push they will give to the next object).

14 Ask students what might happen if the ramp was made higher or lower in the 'Dog treat feeder' machine. Record students' ideas on the 'Dog treat feeder' machine' page in the class science journal.

Note: Students will have opportunities to test these ideas while making their own 'Pet treat feeder' machine in the *Elaborate* phase.

15 Review the 'Our questions' page in the class science journal to see if any questions have been answered.

16 Update the word wall with words and images.

EXPLORE

Curriculum links

Science

- Explore the school grounds to look for ramps, such as slides, wheelchair ramps, roofs or stair railings. Discuss what the purpose of each ramp is.
- Investigate how to make a marble roll and stop at an exact spot using a ramp.
- Make a marble maze using a shoebox, straws and a marble.
- Play the game 'Pushing and pulling'. Students use pushes and pulls to move a series of different animals up a hill from a boat to their new home in a zoo.
  See: http://splash.abc.net.au/home#!/media/1390665/pushing-and-pulling

Higher and higher

Name: ______________________ **Date:** ____________

Question: What happens to how far a toy car is pushed by a ball when you change the height of the ramp?

Predict:

I predict ____

____

because ____

____

Observe: What did you observe?

Claim: We found out that the higher we made the ramp ______________________

____

Lesson 4 Lever it

AT A GLANCE

To provide students with hands-on, shared experiences of using levers to make objects move.

Students:

- discuss how to use a lever to make objects move without touching them
- work in teams to investigate how far a lever pushes a car when it is hit by balls of different mass rolling down a ramp.

Lesson focus

The *Explore* phase is designed to provide students with hands-on experiences of the science phenomenon. Students explore ideas, collect evidence, discuss their observations and keep records, such as science journal entries. The *Explore* phase ensures all students have a shared experience that can be discussed and explained in the *Explain* phase.

Assessment focus

Formative assessment is an ongoing aspect of the *Explore* phase. It involves monitoring students' developing understanding and giving feedback that extends their learning. In this lesson you will monitor students' developing understanding of how:

- a push or a pull affects how an object moves

You will also monitor their developing Science Inquiry Skills (see page xi).

Key lesson outcomes

Science

Students will be able to:

- identify how a lever transmits pushes and pulls
- discuss why different balls create different pushes rolling down the same ramp.

Literacy

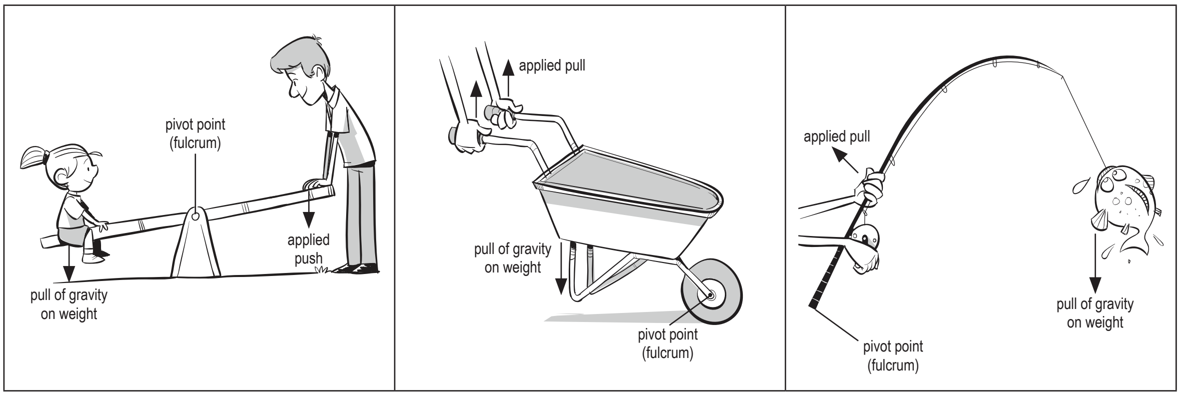
Students will be able to:

- create a labelled diagram
- engage in, and contribute to, discussions about how levers make it easier to push objects.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page xii).

Teacher background information

Levers are probably the most commonly used simple machine. They are often used to make it easier to move a load. Levers have a long, rigid body and a point around which they pivot. When the pivot point (fulcrum) is in between the force you apply and the load, it is known as a first class lever. Seesaws are a great example of a first class lever: the pivot point is in the middle, and you push down on one side and the other side goes up. The closer you move the pivot point to the load you are lifting, the less effort is required to push down (but you also push down much further for a much smaller lift on the other side).



First class lever **Second class lever** **Third class lever**

A wheelbarrow is a second class lever: the fulcrum is the end with the wheel, you lift the other end and the weight is in the between the fulcrum and the area you are lifting.

A fishing rod is a third class lever: the weight is one end, it pivots on the other and you pull it above the fulcrum.

Levers can be made to pivot up and down, like a catapult, or to pivot sideways to strike an object, like a baseball bat or door. The ability to transmit the force from one end to another depends on the material the lever is made of. For example, if you are using a crowbar to lift something you need the bar itself to stay straight and strong despite the strong forces being applied on either side. If a seesaw was made of bendy material then both sides would end up on the ground. It is the stiffness of the board or bar that enables the force to be transmitted – sometimes in a different direction as in the case of a seesaw where a push down on one side becomes a push up on the other.

EXPLORE

Equipment

FOR THE CLASS

- class science journal
- word wall
- team roles chart
- team skills chart
- 1 enlarged copy of 'Mini machine' (Resource sheet 6)
- 1 toy car
- 1 tennis ball
- 1 roll of masking tape
- 1 pen with a lid (see 'Preparation')
- 1 ruler
- 1 cardboard or plastic tube
- equipment to play a video (see 'Preparation')
- 5 small blocks

FOR EACH TEAM

- each team member's science journal
- role wristbands or badges for Manager and Speaker
- 1 copy of 'Mini machine' (Resource sheet 6) per team member
- 1 toy car
- 1 table tennis ball
- 1 marble
- 1 tennis ball
- 1 golf ball
- 1 roll of masking tape
- 1 pen with a lid
- 1 ruler
- 1 cardboard or plastic tube
- 5 small blocks or books of equal width (approximately 2 cm)
- 10 popsticks
- *optional:* glue stick
- *optional:* 1 x A3 sheet of paper
- *optional:* additional 10 popsticks

EXPLORE

Preparation

- Prepare one lever for each team using a ruler attached to a round barrelled pen with a lid and clip (see diagram below). Use masking tape to secure the ruler to the lid so that it does not shift. Loosely place the lid on the pen so that the lid (with ruler) freely swivels. Securely fix the rest of the pen to the table with masking tape.

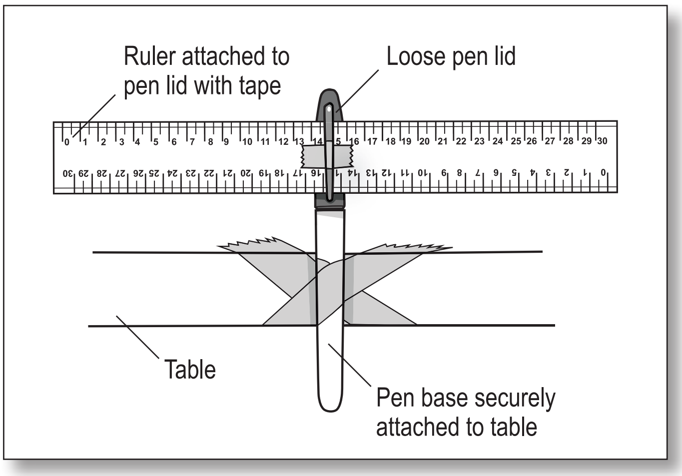


Diagram of pen and ruler lever

- *Optional:* Set up a full mini machine (see Resource sheet 6) for each team prior to lesson.

EXPLORE

Lesson steps

1 *Optional:* Ask some students to share pushes and pulls that they observed at home.

2 Review the image of the 'Dog treat feeder' machine from Lesson 1 and discuss which objects push others in different parts of the machine (the ball pushes the first domino, the dominos push each other in turn, the last domino pushes the car and the car pushes the treat off the table)

3 Explain that in this lesson students will be learning about another way to push objects that is not currently in the 'Dog treat feeder' machine, but that they might consider adding to their own Rube Goldberg machine.

4 Introduce the pen and ruler lever (see 'Preparation'). Hold the pen and ruler lever horizontally along a table (so that it looks like a seesaw) and push each side in turn to show how it works. Ask students:

- What kind of simple machine do you think this is? (A lever.)
- Where have you seen a lever that works like this? (For example, a seesaw.)
- What happens when you push down on one side of a lever? (The other side lifts up.)

5 Stand the pen and ruler lever up on the desk and discuss how this lever is like a seesaw but that instead of going up and down (vertically) it goes back and forth (horizontally).

6 As a class, discuss how to make the lever push a toy car without anyone touching the lever.

7 Introduce 'Mini machine' (Resource sheet 6). Explain that students will be working in their collaborative learning teams to explore how far a lever pushes a toy car when different types of balls are rolled down a ramp to push the other side of the lever.

8 Model how to set up the mini machine and conduct the investigation. Discuss how teams will measure how far the toy car is pushed, such as by using the length or width of a popstick.

9 Ask students to predict which ball will work best at pushing the lever to make the toy car go further and why they think that.

10 Form pairs and allocate roles. Ask Managers to collect team equipment. Allow time for teams to complete the activity.

3. Observe. What did you observe?

Ball	How far did the lever push the toy car?
marble	the car only moved 1 popstick wide
golf ball	the car moved 17 popsticks wide
table tennis ball	the car did not move
tennis ball	the car moved 8 popsticks wide

4. Claim. We found that the golf ball

made the car go further. We think this is because it was the most heavy ball.

Work sample of 'Mini machine' (Resource sheet 6)

Optional: Ask teams to create a picture graph of their results by gluing the popsticks onto an A3 sheet of paper.

11 Ask Speakers to share their team's results. Discuss what claims students can make from their investigation. For example:

- We claim that the heavier balls made the lever push the toy car further.
- We claim that the bigger balls made the lever push the toy car further because they hit more of the lever.

Record students' claims and evidence in the class science journal. Remind students to provide evidence for their claims.

12 Ask students to think of ideas of how a lever could be added to the 'Dog treat feeder' machine. List ideas on the 'Our ideas' page in the class science journal.

13 Review students' questions on the 'Our questions' page of the class science journal to see if any have been answered.

14 Update the word wall with words and images.

EXPLORE

Curriculum links

Science

- Make a lever to wag the dog's tail.
  See: http://www.primaryscience.ie/media/pdfs/col/wag_the_dog.pdf
- Make a marshmallow catapult. See Questacon website: https://www.questacon.edu.au/outreach/programs/science-circus/activities/marshmallow-catapult

Indigenous perspectives

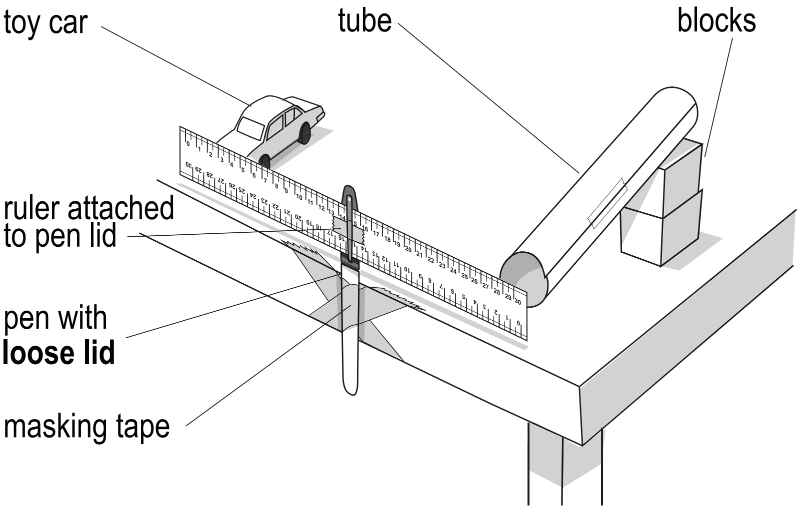
- Explore how Indigenous peoples applied the principles of levers, for example, when digging, moving heavy objects or creating devices to throw spears.

  Primary**Connections** recommends working with Aboriginal and Torres Strait Islander community members to access local and relevant cultural perspectives. Protocols for engaging with Aboriginal and Torres Strait Islander community members are provided in state and territory education guidelines. Links to these are provided on the Primary**Connections** website (www.primaryconnections.org.au).

Mini machine

Name: ______________________________ **Date:** ______________

1. Set up: Follow the diagram to make your mini machine.



2. Roll each ball down the ramp. The ball will push one side of the lever. The other side of the lever will then push the toy car. Measure how far the car is pushed each time.

3. Observe. What did you observe?

marble	
golf ball	
table tennis ball	
tennis ball	

4. Claim. We found that the ______________________________

made the car go further. We think this is because ______________________________

____

____

Lesson 5 Pulley power

AT A GLANCE

To provide students with hands-on, shared experiences of using pulleys to make objects move.

Students:

- consider ways to lift an object
- compare lifting up a heavy bucket with and without a simple pulley.

EXPLORE

Lesson focus

The *Explore* phase is designed to provide students with hands-on experiences of the science phenomenon. Students explore ideas, collect evidence, discuss their observations and keep records, such as science journal entries. The *Explore* phase ensures all students have a shared experience that can be discussed and explained in the *Explain* phase.

Assessment focus

Formative assessment is an ongoing aspect of the *Explore* phase. It involves monitoring students' developing understanding and giving feedback that extends their learning. In this lesson you will monitor students' developing understanding of how:

- a push or a pull affects how an object moves

You will also monitor their developing Science Inquiry Skills (see page xi).

Key lesson outcomes

Science

Students will be able to:

- identify how a pulley can be used to lift objects.

Literacy

Students will be able to:

- discuss ideas to solve a problem
- create an annotated drawing.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page xii).

Teacher background information

A pulley is a simple machine that lifts objects. Although a pulley is classified as one of the six simple machines that make up all machines, it technically contains two other simple machines: a wheel and an axle.

A simple fixed pulled, consists of a single wheel, fixed on an axle. A rope or string is threaded along a groove in the wheel. One side of the string is tied to the load that is to be lifted. The other side is pulled down, lifting the load up. This type of pulley requires the same force to pull as if you were to lift the load directly upwards, but it can feel easier to pull. Imagine you have to lift a heavy load, like a bucket of water, up to a window washer on the third floor of a building. You could tie a rope to the bucket, stand on the third floor, and pull the sting upwards. In order to pull it straight up without spilling, you would need to extend your arms and therefore use more of your biceps. Or you can attach a pulley at the third floor, stand at the ground level, and lift the bucket by pulling straight down. It would be the same amount of work in either case, but the action of pulling down on the string is smoother and allows for better posture, allowing you to use stronger back muscles and avoid potential muscle strain.

More complicated pulley systems can reduce the effort required to pull heavy loads. These often involve the rope passing backwards and forwards through several wheels in order to increase the distance the rope is pulled. The amount of force required to move a section of the rope decreases, but the amount of rope you have to pull increases.

In this lesson, students will make something similar to a simple fixed pulled, but not technically a pulley because it does not have a wheel. Without the wheel there is much more friction, and without the grooves in the wheel the rope is more likely to slide around. However it still has the same basic concept—a downwards pull on one side becomes an upwards pull on the other side. While the friction between the rope and the branch increases the effort needed, it will still feel much easier than lifting the object directly for the reasons discussed above.

Equipment

FOR THE CLASS

- class science journal
- word wall
- team roles chart
- team skills chart
- 1 enlarged copy of 'Lunchtime' (Resource sheet 7)
- 4 buckets filled with sand (see 'Preparation')
- 4 lengths of rope or string of at least 2 m (see 'Preparation')
- *optional:* 4 pairs of gloves (see 'Preparation')

FOR EACH TEAM

- each team member's science journal
- role wristbands or badges for Manager and Speaker
- 1 copy of 'Lunchtime' (Resource sheet 7)

Preparation

- Fill four large buckets halfway with sand, or other heavy items, so that the weight of the buckets is almost too heavy to be lifted by a student.
- Find equipment in the playground with a bar over which a rope or string can be slung, such as monkey bars or a tree trunk.
- Find four lengths of rope or string that are long enough to sling over the monkey bars or tree trunk with one end tied to the bucket and the other low enough for students to reach.

  Note: Having four sets of equipment enables you to set up four parallel stations for students to experience the pulley system. You can provide less, it will simply take longer.

  Optional: Find four pairs of gloves for students to wear when pulling the rope or string in order to help avoid potential rope burn.

EXPLORE

Lesson steps

1. *Optional:* Ask some students to share pushes and pulls that they observed at home.
2. Review the image of the 'Dog treat feeder' machine from Lesson 1 and discuss where a 'pull' is used in the machine (for example, at the very beginning of the machine the card is pulled up to release the ball). Explain that in this lesson students will be exploring another 'pull' that might be added to this machine and/or to their own Rube Goldberg machine.

   Note: Students might mention that the treat is pulled by gravity once pushed off the table. This is true. However, when the treat was on the table it was also being pulled by gravity, as were the other objects on the table. The table 'pushes back' on those objects and so there was no movement. Once the treat is off the table, the pull from gravity results in movement.
3. Introduce the enlarged copy of 'Lunchtime' (Resource sheet 7). Read and discuss the problem and what the students can see in the image. Explain that students are going work in collaborative learning teams to think how the basket of food could get up to the children in the treehouse using the rope and a pull force.
4. Ask teams to listen to each other's ideas and then to agree on one idea. Ask teams to create an annotated drawing of that idea. Review the purpose and features of an annotated drawing.
5. Form pairs and allocate roles. Allow time for teams to complete the activity.

Work sample of 'Lunchtime' (Resource sheet 7)

EXPLORE

6 Ask Speakers to present their team's ideas.

7 Take students outside (see 'Preparation'). Show them the buckets and allow time for students to take turns to lift a bucket and describe how easy or hard it is to lift. Discuss whether they are using a push or pull to lift the bucket and in what direction.

8 Place the rope or string over the monkey bars or tree branch and tie the end around the bucket. Explain that students are going to take turns to pull on the string in order to lift the bucket to the height of their head.

SAFETY

Note: Ask students to stand behind the students pulling the buckets, not on the side of the buckets. Explain that students should not wrap the rope or string around any part of their body (in particular their wrists or fingers) or lift the bucket higher than their heads.

Student investigating the bucket pulley system

9 Explain to students that this is a type of pulley. Allow time for students to experience using the pulley and describe how easy or hard it is to lift. Discuss whether they are using a push or pull to lift the bucket and in what direction.

10 Back in the classroom, review ‘Lunchtime’ (Resource sheet 7) and ask students if or how their ideas have changed after using the pulley.

11 Ask students where they think a pulley could be added to the ‘Dog treat feeder’ machine. List ideas on the ‘Our ideas’ page in the class science journal

12 Review students’ questions on the ‘Our questions’ page of the class science journal to see if any have been answered.

13 Update the word wall with words and images.

Curriculum links

English

- Read *The Lighthouse keeper’s lunch* by Ronda Armitage (ISBN 9781407143781) and discuss the use of a pulley to move a lunch basket.

Lunchtime

Name: ______________________________ **Date:** ________________

Write and draw your ideas

Lesson 6 Problem solvers

AT A GLANCE

To support students to represent and explain their understanding of how a push or a pull affects how an object moves

To introduce current scientific views about using simple machines to move objects.

Students:

- discuss pushes and pulls in a video of a Rube Goldberg machine
- identify why simple machines are not working
- draw annotated drawings of their suggested solutions to make the machines work.

Lesson focus

In the *Explain* phase students develop a literacy product to represent their developing understanding. They discuss and identify patterns and relationships within their observations. Students consider the current views of scientists and deepen their own understanding.

EXPLAIN

Assessment focus

Formative assessment is an ongoing aspect of the *Explain* phase. It involves monitoring students' developing understanding and giving feedback that extends their learning. In this lesson you will monitor students' developing understanding of how:

- a push or a pull affects how an object moves

You will also monitor their developing Science Inquiry Skills (see page xi).

You are also able to look for evidence of students' use of appropriate ways to represent what they know and understand about how a push or a pull affe ts how an object moves, and give them feedback on how they can improve their representations.

Key lesson outcomes

Science

Students will be able to:

- explain how pushes and pulls make objects move
- identify why a simple machine won't work
- identify how to fix a simple machine.

Literacy

Students will be able to:

- use words and pictures to explain what they know about pushes and pulls
- draw an annotated drawing showing how a machine works
- contribute to discussions.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page xii).

Teacher background information

Image 1: Why won't both dominoes fall over?

Issue: The dominoes are positioned too far apart for the first one to fall and push the other.

Possible solutions:

- Place the dominoes closer together so that the first falls on the second.
- Add more dominoes, or other objects, in between the current dominoes, so that they fall on and push one another.
- Use a larger ball and have the dominoes stand side by side.

Image 2: Why won't the toy car move?

Issue: The ball is not moving because the forces acting on it are balanced (there is no slope to roll down).

Possible solutions:

- Lift the end of the ramp furthest from the car so that the ball rolls down and hits the car, pushing it forward.
- Apply a force to the ball to make it roll towards and hit the car, pushing the car forward.

Image 3: Why won't the black ball roll into the bucket?

Issue: The white ball pushes the lever, which, in turn, pushes the black ball in the opposite direction, causing it to roll in that direction, which is not towards the bucket.

Possible solutions:

- Move the lever so that the white ball strikes it in the opposite direction to where the black ball needs to roll to fall into the bucket.
- Move the bucket, so that it is in the path of the black ball's motion.

Image 4: Why isn't the bricklayer getting the brick?

Issue: The weight of the spanner and bucket is not greater than the brick and bucket and therefore will not pull the brick up.

Possible solutions:

- Add more tools to the bucket, so that the weight of the bucket and tools exceeds the weight of the brick, pulling the brick up.
- Pull the rope with her hands, to lift the brick up.

Note: These are the simplest solutions. There are no specified constraints on equipment so students might have more ingenious ideas.

Managing students' expectations

When students view videos of Rube Goldberg machines they might develop high expectations of what they can create with limited classroom time and resources. Many elaborate Rube Goldberg machines that are available to view on the internet take many hours, often days, to construct and/or have large teams of people working on them. If students are interested in looking at videos of Rube Goldberg machines look for videos that:

- acknowledge the time and people who developed it;
- were developed by students closer to their age; and/or
- show the many failed attempts before getting the machine to work.

Equipment

FOR THE CLASS

- class science journal
- word wall
- 1 enlarged copy of 'Why won't it work?' (Resource sheet 8)
- equipment to play a video (see 'Preparation')
- *optional:* equipment to set up scenarios (see 'Preparation')

FOR EACH STUDENT

- science journal
- 1 copy of 'Why won't it work?' (Resource sheet 8)

Preparation

- Draw a diagram of a simple machine that won't work in the class science journal, for example, an image of a ball that is too large to go down a cardboard tube (used as a ramp) to push a toy car.
- Source a video of a Rube Goldberg machine that shows repeated failures before success, for example, Audri's Monster Trap.
  See: https://www.youtube.com/watch?v=IMboI4cOAuQ
- *Optional:* Set up each of the four scenarios shown in 'Why won't it work?' (Resource sheet 8).

EXPLAIN

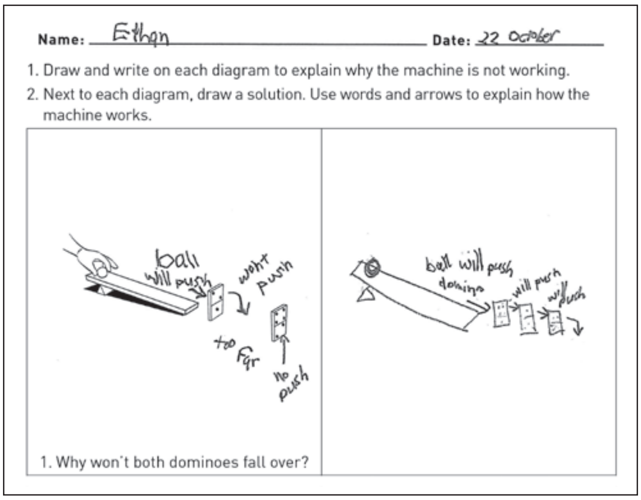
Lesson steps

1. Review the previous lessons using the class science journal.
2. Remind students that they have been exploring simple machines in order to design their own simple 'Pet treat feeder' machine.
3. Introduce the video (see 'Preparation'). Ask students to look at what makes objects move in the Rube Goldberg machine in the video.
4. After viewing the video ask questions such as:
   - What kinds of pushes could you see in the video?
   - What kinds of pulls?
   - What simple machines pushes did you observe in the video?
   - What went wrong with some of the machines?

   Record students' responses in the class science journal.
5. Explain that students are going to look at some diagrams that other inventors have made of machines that are not working.
6. Introduce the diagram in the class science journal (see 'Preparation'). Discuss why the machine might not be working and model drawing an annotated drawing of a working version of the machine next to it (for example, with a smaller ball). Review the purpose and features of an annotated drawing.
7. Introduce 'Why won't it work?' (Resource sheet 8) and read through with students. Ask students to think about each machine, identify why it might not be working and draw an annotated drawing of a working version of the machine in the box next to it.

   Optional: Set up each of the four scenarios.
8. Allow time for students to complete the activity.

Work sample of 'Why won't it work?' (Resource sheet 8)



9. Ask students to share their ideas with a partner. Encourage students to provide their reasons while discussing their answers, for example, 'I don't think that will work because…'. Remind students to question each other using the 'Science question starters' in Appendix 4.
10. As a class, record a description of the problems identified with each machine and some agreed solutions of how to fix it in the class science journal.
11. Review 'Our questions' in the class science journal to see if any can be answered.

12 Update the word wall with words and images.

Curriculum links

Design and Technologies/History

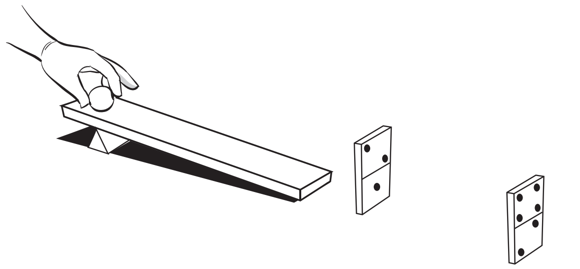
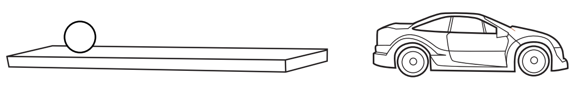
- Explore how historical machines used pushes and pulls to create movement.

EXPLAIN

Why won't it work?

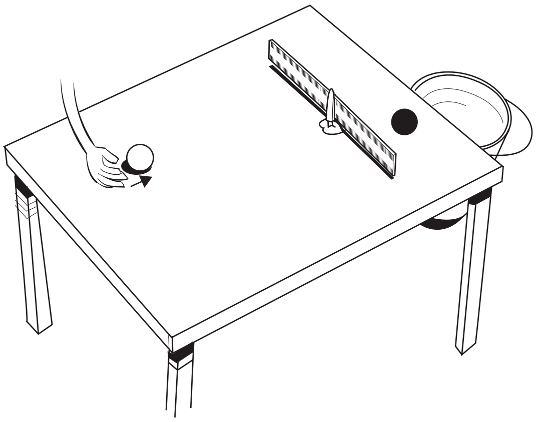
Name: ______________________________ **Date:** ______________

1. Draw and write on each diagram to explain why the machine is not working.
2. Next to each diagram, draw a solution. Use words and arrows to explain how the machine works.

 1. Why won't both dominoes fall over?	
 2. Why won't the toy car move?	

Why won't it work?

Name: ______________________________ **Date:** ______________

 3. Why won't the black ball roll into the bucket?	
 4. Why isn't the bricklayer getting the brick?	

Lesson 7 Rube Goldberg

AT A GLANCE

To support students to design and make their own Rube Goldberg machine using pushes and pulls.

Session 1 Plan it first

Students:

- work in teams to plan a Rube Goldberg machine to meet design criteria
- draw an annotated drawing and create an equipment list.

Session 2 Construction time

Students:

- follow their plan to construct a Rube Goldberg machine
- improve their machine as necessary to ensure it works.

Lesson focus

In the *Elaborate* phase students plan and conduct an open investigation to apply and extend their new conceptual understanding in a new context. It is designed to challenge and extend students' Science Understanding and Science Inquiry Skills.

Assessment focus

Summative assessment of the Science Inquiry Skills is an important focus of the *Elaborate* phase (see page ix).

Key lesson outcomes

Science

Students will be able to:

- generate ideas and construct a Rube Goldberg machine
- identify how to make different objects move through different pushes and pulls.

Literacy

Students will be able to:

- create an annotated drawing of their ideas
- discuss their ideas about how to build and fix their machine using appropriate words.

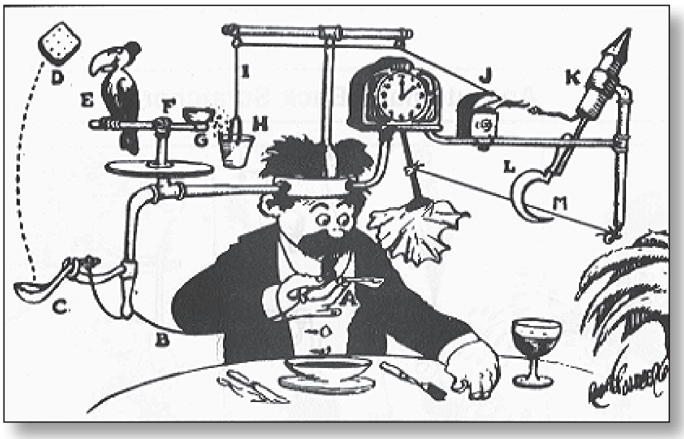
ELABORATE

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page xii).

Teacher background information

Rube Goldberg machines

Reuben Goldberg, more commonly known as Rube Goldberg, was an American artist, author and engineer. Most famously, he is known for his cartoons depicting machines that perform simple tasks in very complicated ways.



Rube Goldberg's cartoon *Self-Operating Napkin*

Simple machines are generally used to make work easier. In a Rube Goldberg machine, the aim is to do a simple task in a more complicated way. As such, the simple machines do not need to trade off force for distance to make the work easier. They could simply change the direction of the force to send another object in the opposite direction, for example, a seesaw lever or a simple fixed pulled.

When building Rube Goldberg machines, the most common issues are objects not colliding (as they are not lined up or do not travel far enough) and objects not colliding with enough force to create a change. Here are a few suggestions for teams with these issues:

- Increase the size of the impacting object. For example, a marble rolling down a cardboard tube could be replaced by a tennis ball rolling down a tube made from an A3 sheet of card.
- Use guides to direct balls. For example, tape two rulers or two pencils along the table to make a channel for a ball to roll along.
- Increase the force applied from one object to another. For example, increasing the angle on a ramp so that a ball accelerates faster and hits the next object with greater force.

ELABORATE

Setting up simple machines

Here are a few simple ways students can set up inclined planes (ramps), levers and pulleys using readily available materials.

Inclined planes (ramps)

- Two rulers with a gap between for a ball to roll along
- Cardboard or plastic tubes
- Card rolled into tubes
- Book with an indent at the binding for a ball to roll along

Levers

- Pen and ruler – horizontal pivot
- Pen and ruler – vertical pivot
- Straw, skewers and popsticks
- Triangle and rectangle blocks and tape

Pulleys

- Pens and pencils with string (not strictly a pulley as there is no wheel on the pencil axle, but for the purposes of this the friction between the rope and the string is negligible.)
- Rolling pin and rope/strap.
- Coat hanger and cotton reel

For all these machines, masking tape is the recommended adhesive because it adheres well to most surfaces and is easy to tear, therefore not requiring scissors.

Session 1 Plan it first

Equipment

FOR THE CLASS

- class science journal
- word wall
- team roles chart
- team skills chart
- 1 enlarged copy of 'Our Rube Goldberg machine' (Resource sheet 9)
- 1 design criteria poster (see 'Preparation')
- box of equipment for students to use in their machines (see 'Preparation')
- marking pen

FOR EACH TEAM

- each team member's science journal
- role wristbands or badges for Manager and Speaker
- each team member's completed copy of 'Give the dog a treat' (Resource sheet 1) from Lesson 1
- 2 copies of 'Our Rube Goldberg machine' (Resource sheet 9)
- 1 bag
- *optional:* label for bag

Preparation

- Prepare a poster illustrating the design criteria that the students' machines need to meet, for example:
  - completes the activity it was built to do (such as delivers a treat or waters a plant)
  - has no more than five simple machines or section
  - includes at least two different pushes and one pull
  - can be safely made in the classroom
  - includes re-purposed, recycled or recyclable materials that are easy to find.

  Tip: If time and equipment permit, consider specifying the need to feature simple machines, such as a ramp, a lever and/or a pulley.
- Collect a variety of materials for students to create their machines, such as books, rulers, balls of different sizes and mass, dominoes, blocks (e.g. MAB flats), marbles, cardboard sheets, egg cartons, straws, margarine or yoghurt containers, tissue boxes, cardboard or plastic tubes, string, rope, wire, popsticks, cardboard boxes and adhesive tac.

  Note: Include equipment collected for previous lessons.

Lesson steps

1 Review previous lessons using the class science journal and word wall, in particular students' ideas on how to improve the 'Dog treat feeder' from Lesson 1.

2 Explain that students will be working in collaborative learning teams to design and make their own 'Pet treat feeder' Rube Goldberg machine, which uses pushes and pulls of simple machines to feed a pet a treat.

Optional: Encourage teams to choose a different action for their machine to accomplish, such as:

- drop a bottle in a recycling bin
- water a plant
- plant seeds in a pot of soil
- pop a balloon.

3 Introduce the design criteria poster (see 'Preparation'). Read through and discuss.

4 Ask students to review their initial copy of 'Give the dog a treat' (Resource sheet 1) and to assess that machine against those criteria. Discuss students' thoughts as a class to create an agreed understanding of the design criteria.

5 Introduce the enlarged copy of 'Our Rube Goldberg machine' (Resource sheet 9). Explain that in this session teams will plan their machine and create an annotated drawing to show how it will work.

6 Introduce the bags and the box of equipment (see 'Preparation'). Explain that once teams have created their equipment list, they will collect their equipment from the box and put it in a bag ready to make their machines in the next session.

7 Form pairs and allocate roles. Ask Managers to collect one copy of 'Our Rube Goldberg machine' (Resource sheet 9) and a bag for the team. Ask teams to write their names on their bags to ensure they can find them

8 Allow time for teams to complete their design and to identify the equipment that they will need.

9 Ask teams to share their design and collected equipment with another team for feedback. Encourage students to use the 'Science question starters' (see Appendix 4) when questioning each other.

Optional: Ask teams to refer to the design criteria poster when providing feedback on other teams' designs.

10 Ask Managers to collect a fresh copy of 'Our Rube Goldberg machine' (Resource sheet 9). Allow times for teams to draw their final design and to identify and collect their equipment.

11 Remind students that they will construct their Rube Goldberg machine in the next session.

ELABORATE

Our Rube Goldberg machine

Team members' names: ______________________ **Date:** ______________

Draw a plan of your Rube Goldberg machine. Use words and arrows to show how it works.

Our design:

Equipment we will need:

Session 2 Construction time

Equipment

FOR THE CLASS

- class science journal
- word wall
- team roles chart
- team skills chart
- design criteria poster (see Session 1, 'Preparation')
- box of equipment for students to use in their machines (see Session 1, 'Preparation')
- digital device(s) to capture videos or photos of completed machines

FOR EACH TEAM

- each team member's science journal
- role wristbands or badges for Manager and Speaker
- completed copy of 'Our Rube Goldberg machine (Resource sheet 9) from Session 1
- bag of equipment collected in Lesson 7, Session 1
- 1 roll of masking tape

Lesson steps

1 Explain that teams will now make their machine that they planned in the previous session.

2 Re-form pairs. Ask Managers to collect team equipment.

3 Allow time for teams to make and test their machine. Ask questions such as:

- That's interesting, have you thought about ... ?
- What would happen if ... ?
- What happens when ... ?
- How could you test that ... (certain part of machine or criteria) works?

Note: If teams have difficulty with their machine, encourage them to think of how to improve their design so that it works next time, by focusing on what is working and identifying potential problems, as they did in Lesson 6 on 'Why won't it work?' (Resource sheet 8).

4 Take videos (or photographs) of teams' Rube Goldberg machines for presentations in the next lesson.

5 Review students' questions on the 'Our questions' page of the class science journal to see if any have been answered.

6 Update the word wall with words and images.

ELABORATE

Lesson 8 Our amazing machine

AT A GLANCE

To provide opportunities for students to represent what they know about how a push or a pull affects how an object moves, and to reflect on their learning during the unit.

Students:

- present their final Rube Goldberg machine and explain the pushes and pulls that make it work
- reflect on their learning during the unit.

Lesson focus

In the *Evaluate* phase students reflect on their learning journey and create a literacy product to re-represent their conceptual understanding.

Assessment focus

Summative assessment of the Science Understanding descriptions is an important aspect of the *Evaluate* phase. In this lesson you will be looking for evidence of the extent to which students understand how:

- a push or a pull affects how an object moves

Key lesson outcomes

Science

Students will be able to:

- explain how pushes and pulls affect the movement of objects in their machine.

Literacy

Students will be able to:

- create an annotated drawing
- use oral and written language to show their understanding and reflect on their experiences.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page xii).

Equipment

FOR THE CLASS	FOR EACH TEAM
• class science journal • word wall • team roles chart • team skills chart • equipment to play a video (see 'Preparation')	• each team member's science journal • role wristbands or badges for Manager and Speaker • photo or video of their Rube Goldberg machine (see Lesson 7, Session 2)

Lesson steps

1 Explain that teams will present their Rube Goldberg machine to the class using photos and/or videos taken during Lesson 7, Session 2. Ask students to focus on the pushes and pulls that make different objects move in their machine, and the choices they made during the design process.

2 Re-form pairs and allow time for them to prepare their short presentation.

3 Ask teams to present their machine. Ask questions such as:

- What simple machines did you use?
- Where are the pushes and pulls that make the objects move?
- What materials did you use and why?
- Which parts did you have trouble getting to work? Why wasn't it working? How did you improve it so that it did work?
- Does your machine meet the design criteria?
- Are there any improvements that would make your machine work better?

4 *Optional:* Ask students to draw an annotated drawing of their favourite Rube Goldberg machine from Lesson 7 with a suggested improvement, or a new machine that they have thought of. Ask students to include annotations of its push and pull forces.

Note: You can choose to modify the design criteria from Lesson 7 for this imagined machine, for example, it could be larger than the classroom and have more sections.

5 Review students' questions on the 'Our questions' page of the class science journal to see if any have been answered.

6 Ask students to reflect on the unit. Ask questions such as

- What did you learn about how machines push and pull objects to make them move?
- What was the most interesting thing that you learned about pushes, pulls and simple machines?
- What are some things that you have learned that you didn't know before?
- Which activity helped you learn something new?
- Which activity did you like best?
- What are you still wondering about?

Appendix 1
How to organise collaborative learning teams (F–Year 2)

Introduction

Students working in collaborative teams is a key feature of the Primary**Connections** inquiry-based program. By working in collaborative teams students are able to:

- communicate and compare their ideas with one another
- build on one another's ideas
- discuss and debate these ideas
- revise and rethink their reasoning
- present their final team understanding through multi-modal representations.

Opportunities for working in collaborative learning teams are highlighted throughout the unit.

Students need to be taught how to work collaboratively. They need to work together regularly to develop effective group learning skills.

The development of these collaborative skills aligns to descriptions in the Australian Curriculum: English. See page xiii.

Team structure

The first step towards teaching students to work collaboratively is to organise the team composition, roles and skills. Use the following ideas when planning collaborative learning with your class:

- Assign students to teams rather than allowing them to choose partners.
- Vary the composition of each team. Give students opportunities to work with others who might be of a different ability level, gender or cultural background.
- Keep teams together for two or more lessons so that students have enough time to experience working together successfully. If you cannot divide the students in your class into teams of three, form two teams of two students rather than one team of four. It is difficult for students to work together effectively in larger groups.
- Keep a record of the students who have worked together as a team so that by the end of the year each student has worked with as many others as possible.

Team roles

Students are assigned roles within their team (see below). Each team member has a specific role but all members share leadership responsibilities. Each member is accountable for the performance of the team and should be able to explain how the team obtained its results. Students must therefore be concerned with the performance of all team members. It is important to rotate team jobs each time a team works together so that all students have an opportunity to perform different roles.

For F–Year 2, teams consist of two students: Manager and Speaker. (For Year 3–Year 6, teams consist of three students: Director, Manager and Speaker.) Each member of the team should wear something that identifies them as belonging to that role, such as a wristband, badge or colour-coded clothes peg. This makes it easier for you to identify which role each student is doing and it is easier for the students to remember what they and their team mates should be doing.

Manager

The Manager is responsible for collecting and returning the team's equipment.
The Manager also tells the teacher if any equipment is damaged or broken. All team members are responsible for clearing up after an activity and getting the equipment ready to return to the equipment table.

Speaker

The Speaker is responsible for asking the teacher or another team's Speaker for help.
If the team cannot resolve a question or decide how to follow a procedure, the Speaker is the only person who may leave the team and seek help. The Speaker shares any information they obtain with team members. The teacher may speak to all team members, not just to the Speaker. The Speaker is not the only person who reports to the class; each team member should be able to report on the team's results.

Director (Year 3–Year 6)

The Director is responsible for making sure that the team understands the team investigation and helps team members focus on each step. The Director is also responsible for offering encouragement and support. When the team has finished, the Director helps team members check that they have accomplished the investigation successfully. The Director provides guidance but is not the team leader.

Team skills

Primary**Connections** focuses on social skills that will help students work in collaborative teams and communicate more effectively.

Students will practise the following team skills throughout the year:

- Move into your teams quickly and quietly
- Stay with your team
- Take turns.

To help reinforce these skills, display enlarged copies of the team skills chart (see the end of this Appendix) in a prominent place in the classroom.

Supporting equity

In science lessons, there can be a tendency for boys to manipulate materials and girls to record results. Primary**Connections** tries to avoid traditional social stereotyping by encouraging all students, irrespective of their gender, to maximise their learning potential. Collaborative learning encourages each student to participate in all aspects of team activities, including handling the equipment and taking intellectual risks.

Observe students when they are working in their collaborative teams and ensure that both girls and boys are participating in the hands-on activities.

TEAM ROLES

Manager
Collects and returns all materials the team needs

Speaker
Asks the teacher and other team speakers for help

TEAM SKILLS

1 Move into your teams quickly and quietly

2 Stay with your team

3 Take turns

Appendix 2
How to use a science journal

Introduction

A science journal is a record of observations, experiences and reflections. It contains a series of dated, chronological entries. It can include written text, drawings, labelled diagrams, photographs, tables and graphs.

Using a science journal provides an opportunity for students to be engaged in a real science situation as they keep a record of their observations, ideas and thoughts about science activities. Students can use their science journals as a useful self-assessment tool as they reflect on their learning and how their ideas have changed and developed during a unit.

Monitoring students' journals allows you to identify students' alternative conceptions, find evidence of students' learning and plan future learning activities in science and literacy.

Maintaining a science journal aligns to descriptions in the Australian Curriculum: Science and English. See pages xi and xiii.

Using a science journal

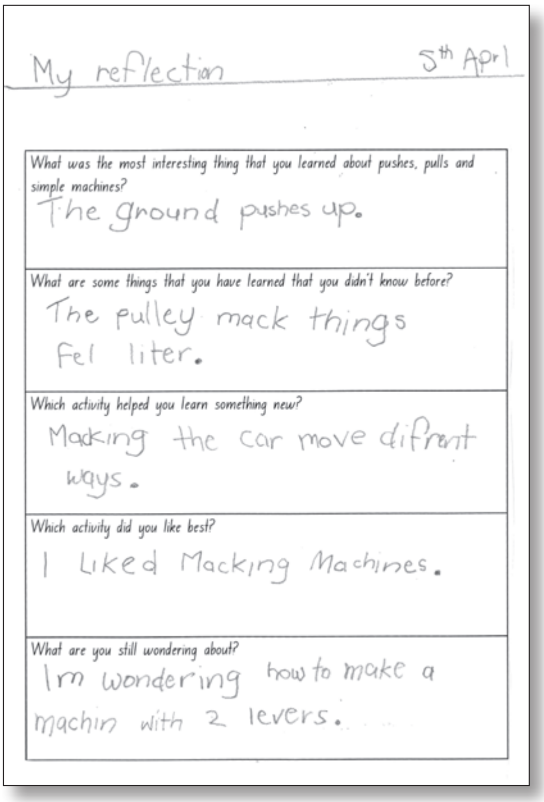
1. At the start of the year, or before starting a science unit, provide each student with a notebook or exercise book for their science journal or use an electronic format. Tailor the type of journal to fit the needs of your classroom. Explain to students that they will use their journals to keep a record of their observations, ideas and thoughts about science activities. Emphasise the importance of including pictorial representations as well as written entries.
2. Use a large project book or A3 paper to make a class science journal. This can be used at all year levels to model journal entries. With younger students, the class science journal can be used more frequently than individual journals and can take the place of individual journals.
3. Make time to use the science journal. Provide opportunities for students to plan procedures and record predictions, and their reasons for predictions, before an activity. Use the journal to record observations during an activity and reflect afterwards, including comparing ideas and findings with initial predictions and reasons. It is important to encourage students to provide evidence that supports their ideas, reasons and reflections
4. Provide guidelines in the form of questions and headings and facilitate discussion about recording strategies, such as note-making, lists, tables and concept maps. Use the class science journal to show students how they can modify and improve their recording strategies.
5. Science journal entries can include narrative, poetry and prose as students represent their ideas in a range of styles and forms.

6 In science journal work, you can refer students to display charts, pictures, diagrams, word walls and phrases about the topic displayed around the classroom. Revisit and revise this material during the unit. Explore the vocabulary, visual texts and ideas that have developed from the science unit, and encourage students to use them in their science journals.

7 Combine the use of resource sheets with journal entries. After students have pasted their completed resource sheets in their journal, they might like to add their own drawings and reflections

8 Use the science journal to assess student learning in both science and literacy. For example, during the *Engage* phase, use journal entries for diagnostic assessment as you determine students' prior knowledge.

9 Discuss the importance of entries in the science journal during the *Explain* and *Evaluate* phases. Demonstrate how the information in the journal will help students develop literacy products, such as posters, brochures, letters and oral or written presentations.


My reflection 5th April

What was the most interesting thing that you learned about pushes, pulls and simple machines?
The ground pushes up.

What are some things that you have learned that you didn't know before?
The pulley mack things fel liter.

Which activity helped you learn something new?
Macking the car move difrent ways.

Which activity did you like best?
I Liked Macking Machines.

What are you still wondering about?
Im wondering how to make a machin with 2 levers.

***Machine makers* student science journal**

Appendix 3
How to use a word wall

Introduction

A word wall is an organised collection of words and images displayed in the classroom. It supports the development of vocabulary related to a particular topic and provides a reference for students. The content of the word wall can be words that students see, hear and use in their reading, writing, speaking, listening and viewing.

Creating a class word wall, including words from different dialects and languages, aligns to descriptions in the Australian Curriculum: English. See page xiii.

Goals in using a word wall

A word wall can be used to:

- support science and literacy experiences of reading, viewing, writing and speaking
- provide support for students during literacy activities across all key learning areas
- promote independence in students as they develop their literacy skills
- provide a visual representation to help students see patterns in words and decode them
- develop a growing bank of words that students can spell, read and/or use in writing tasks
- provide ongoing support for the various levels of academic ability in the class
- teach the strategy of using word sources as a real-life strategy.

Organisation

Position the word wall so that students have easy access to the words. They need to be able to see, remove and return word cards to the wall. A classroom could have one main word wall and two or three smaller ones, each with a different focus, for example, high-frequency words.

Choose robust material for the word cards. Write or type words on cardboard and perhaps laminate them. Consider covering the wall with felt-type material and backing each word card with a self-adhesive dot to make it easy for students to remove and replace word cards.

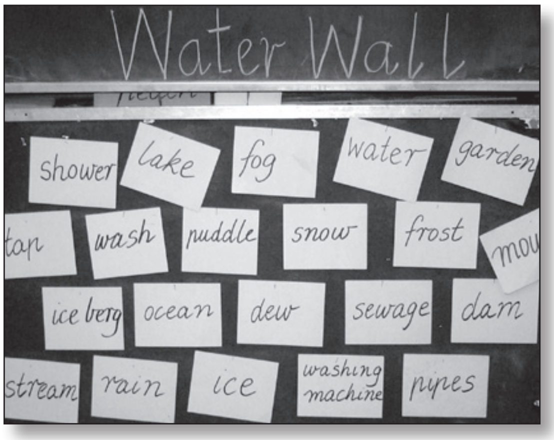
Word walls do not need to be confined to a wall. Use a portable wall, display screen, shower curtain or window curtain. Consider a cardboard shape that fits with the unit, for example, an apple for a needs unit.

The purpose is for students to be exposed to a print-rich environment that supports their science and literacy experiences.

Organise the words on the wall in a variety of ways. Place them alphabetically, or put them in word groups or groups suggested by the unit topic, for example, words for a unit about how forces make things move might be arranged under the headings ‘How things move’ and ‘Things that move’.

Invite students to contribute words from different languages to the word wall. Group words about the same thing, for example, different names of the same piece of clothing on the word wall so that students can make the connections. Identify the different languages used, for example, by using different-coloured cards or pens to record the words.

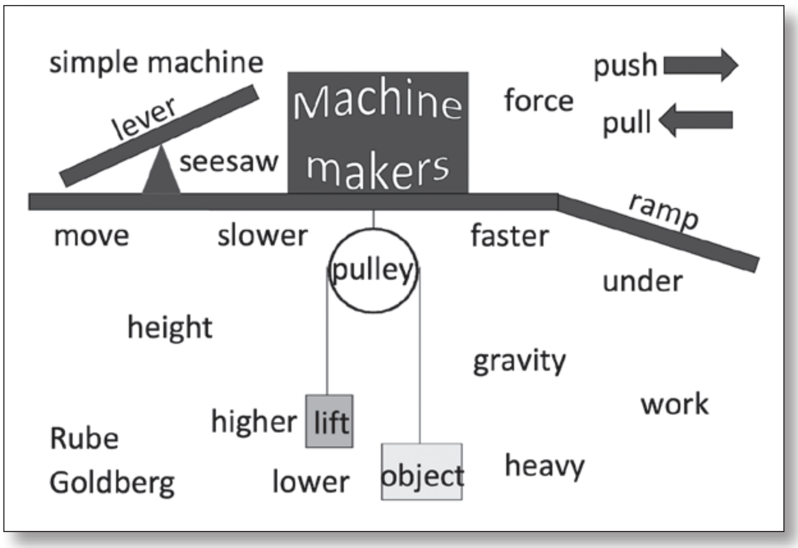
***Schoolyard safari* word wall**



***Water works* word wall**

Using a word wall

1. Limit the number of words to those needed to support the science and literacy experiences in the classroom.
2. Add words gradually, and include images where possible, such as drawings, diagrams or photographs. Build up the number of words on the word wall as students are introduced to the scientific vocabulary of the unit
3. Encourage students to interact with the word wall. Practise using the words with students by reading them and playing word games. Refer to the words during science and literacy experiences and direct students to the wall when they need a word for writing. Encourage students to use the word wall to spell words correctly.
4. Use the word wall with the whole class, small groups and individual students during literacy experiences. Organise multi-level activities to cater for the individual needs of students.



***Machine makers* word wall**

Appendix 4
How to facilitate evidence-based discussions

Introduction

Argumentation is at the heart of what scientists do; they pose questions, make claims, collect evidence, debate with other scientists and compare their ideas with others in the field

In the primary science classroom, argumentation is about students:

- articulating and communicating their thinking and understanding to others
- sharing information and insights
- presenting their ideas and evidence
- receiving feedback (and giving feedback to others)
- finding flaws in their own and others' reasoning
- reflecting on how their ideas have changed

It is through articulating, communicating and debating their ideas and arguments that students are able to develop a deep understanding of science content.

Establish norms

Introduce norms before starting a science discussion activity. For example:

- Listen when others speak.
- Ask questions of each other.
- Criticise ideas not people.
- Listen to and discuss all ideas before selecting one.

Question, Claim, Evidence and Reasoning

In science, arguments that make claims are supported by evidence. Sophisticated arguments follow the **QCER** process:

- We claim that the heavier balls made the toy car go further.

We claim that the bigger balls worked better because they hit more of the lever.

Q What **question** are you trying to answer? For example, 'How far does a lever push a toy car when different objects are rolled down a slope onto the other side?'

C The **claim**. For example, 'The heavier balls made the lever push the toy car further.'

E The **evidence**. For example, 'When we rolled the heavy balls down the ramp, the car went further after being hit by the lever.'

R The **reasoning**. How the evidence supports the claim. (Not required at Year 2 level but in this case: 'We think the heavier balls gave a harder push to the lever on one side so the lever gave a harder push to the car'.)

Students need to be encouraged to move from making claims only, to citing evidence to support their claims. Older students develop full conclusions that include a claim, evidence and reasoning. This is an important characteristic of the nature of science and an aspect of scientific literacy. Using 'Science question starters' (see next section) helps to promote evidence-based discussion in the classroom.

Science question starters

Science question starters can be used to model the way to discuss a claim and evidence for students. Teachers encourage team members to ask these questions of each other when preparing their claim and evidence. They might also be used by audience members when a team is presenting its results. (See Primary**Connections** 5Es video, *Elaborate*).

Science question starters

Asking for evidence	I have a question about ________________. How does your evidence support your claim__________ ? What other evidence do you have to support your claim ________________________ ?
Agreeing	I agree with ________ because ______________.
Disagreeing	I disagree with __________ because __________. One difference between my idea and yours is _________.
Questioning further	I wonder what would happen if ______________? I have a question about ________________. I wonder why ____________________? What caused ____________________? How would it be different if ______________? What do you think will happen if ______________?
Clarifying	I'm not sure what you meant there. Could you explain your thinking to me again?

DISCUSSION SKILLS

1 Listen when others speak

2 Ask questions of each other

3 Criticise ideas not people

4 Listen to and discuss all ideas before selecting one

Appendix 5
Machine makers equipment list

Equipment and materials												
A3 sheet of paper *optional*	1 per team					●	●					
A4 sheet of paper	1 per student											●
bag	1 per team									●		
bag of equipment collected in Lesson 7, Session 1	1 per team										●	
box of equipment for students to use in their machines	1 per class									●	●	
box of equipment to make the toy car move	1 per class				●							
blocks, small	5 per class						●					
blocks, small, or books of equal width (approximately 2 cm)	5 per team					●	●					
buckets filled with san	4 per class							●				
card, large sheet to make a tube	1 per class		●									
card, small, or postcard	1 per class		●									
clipboard *optional*	1 per student			●								
dog treat	1 per class		●									
dominoes, set of, books or blocks (e.g. MAB flats)	1 per class		●									
equipment to set up scenarios *optional*	per class								●			
equipment to make a ‘Dog treat feeder’ machine *optional*	1 per student		●									
glue stick *optional*	1 per team					●	●					
golf ball	1 per team						●					
golf ball or hard-boiled egg	1 per class					●						
golf ball or tennis ball	1 per class		●									
golf ball or tennis ball	1 per team				●	●	●					
label for bags *optional*	1 per team									●		

Equipment and materials												
marble	1 per team						•					
marking pen	1 per class									•		
masking tape, roll	1 per class		•				•					
masking tape, roll	1 per team						•		•	•		
gloves, pair *optional*	4 per class							•				
pen, with a lid	1 per team						•					
pen, with a lid	1 per class						•					
popsticks	10 per team					•	•					
popsticks, additional *optional*	10 per team					•	•					
rope or string, of at least 2 m	4 per class							•				
ruler	1 per team						•					
ruler	1 per class						•					
screen or box to hide 'Dog treat feeder' machine	1 per class		•									
table tennis ball	1 per team						•					
tennis ball	1 per team		•			•	•					
tennis ball	1 per class						•			•		
toy car	1 per team				•	•	•					
toy car	1 per class		•		•	•	•					
tube, cardboard or plastic	1 per team					•	•					

Resource sheets												
‘Give the dog a treat’ (RS1)	1 per student		●							●		
‘Give the dog a treat’ (RS1), enlarged	1 per class		●									
‘Push pull pursuit’ (RS2)	1 per student			●								
‘Push pull pursuit’ (RS2) additional copy *optional*	1 per student			●								
‘Push pull pursuit’ (RS2), enlarged	1 per class			●								
‘Information note for families’ (RS3) *optional*	1 per student		●									
‘Information note for families’ (RS3), enlarged *optional*	1 per class			●								
‘Make it go!’ (RS4)	1 per student				●							
‘Make it go!’ (RS4), enlarged	1 per class				●							
‘Higher and higher’ (RS5)	1 per student					●						
‘Higher and higher’ (RS5), enlarged	1 per class					●						
‘Mini machine’ (RS6)	1 per student						●					
‘Mini machine’ (RS6), enlarged	1 per class						●					
‘Lunchtime’ (RS7)	1 per team							●				
‘Lunchtime’ (RS7), enlarged	1 per class							●				
‘Why won’t it work?’ (RS8)	1 per student								●			
‘Why won’t it work?’ (RS8), enlarged	1 per class								●			
‘Our Rube Goldberg machine’ (RS9)	2 per team									●	●	
‘Our Rube Goldberg machine’ (RS9), enlarged	1 per class									●		
Teaching tools												
class science journal	1 per class		●	●	●	●	●	●	●	●	●	●
student science journal	1 per student		●	●	●	●	●	●	●	●	●	●
word wall	1 per class		●	●	●	●	●	●	●	●	●	●
team roles chart	1 per class					●	●	●		●	●	
team skills chart	1 per class					●	●	●		●	●	
design criteria poster	1 per class									●	●	
role wristbands or badges for Manager and Speaker	1 set per team					●	●	●		●	●	
Multimedia												
digital camera *optional*	1 per class			●								
digital device(s) to capture videos or photos	1 per class										●	
equipment to play a video	1 per class		●	●			●		●			●
photo or video of their Rube Goldberg machine	1 per team											●

Appendix 6
Machine makers unit overview

		SCIENCE OUTCOMES*	LITERACY OUTCOMES*	LESSON SUMMARY	ASSESSMENT OPPORTUNITIES
		Students will be able to represent their current understanding as they:	Students will be able to:	Students:	
ENGAGE	**Lesson 1** Pushes and pulls	• identify pushes and pulls in a 'Dog treat feeder' machine. • discuss their ideas about how to make objects move.	• engage in discussions about pushes and pulls • annotate a drawing to show ideas about pushes and pulls.	• observe a 'Dog treat feeder' machine • create an annotated drawing of the machine • watch a video of a simple machine and discuss its components *(optional)*.	**Diagnostic assessment** • Science journal entries • Class discussions • 'Give the dog a treat' (Resource sheet 1) • Contributions to 'Our questions'
		Students will be able to:	Students will be able to:	Students:	
EXPLORE	**Lesson 2** Move it! ***Session 1*** Pushes and pulls all around ***Session 2*** Ready, set, go!	• recognise pushes and pulls that make objects move • identify different ways to make an object move.	• record observations in a T-chart • contribute thoughts to a class ideas map • record observations in a table.	***Session 1*** Pushes and pulls all around • identify pushes and pulls in a video and around the school • record their observations in a T-chart. ***Session 2*** Ready, set, go! • work in teams to investigate ways to make a toy car move from one place to another.	**Formative assessment** • Science journal entries • Class discussions • 'Push pull pursuit' (Resource sheet 2) • 'Make it go!' (Resource sheet 4) • Contributions to 'Our ideas'

*These lesson outcomes are aligned to relevant descriptions of the Australian Curriculum. See page xi for Science, page xiii for English and page xiv for Mathematics and Design and Technologies.

		SCIENCE OUTCOMES*	LITERACY OUTCOMES*	LESSON SUMMARY	ASSESSMENT OPPORTUNITIES
		Students will be able to:	Students will be able to:	Students:	
EXPLORE	**Lesson 3** Ramp it up	• identify that a higher ramp causes the toy car to be pushed further by the ball • make claims based on evidence.	• contribute to discussions about their investigation • record observations in a table.	• work in teams to investigate how changing the height of a ramp affects the push a rolling ball gives to a toy car.	**Formative assessment** • Science journal entries • Class discussions • 'Higher and higher' (Resource sheet 5) • Contributions to 'Our ideas'
EXPLORE	**Lesson 4** Lever it	• identify how a lever transmits pushes and pulls • discuss why different balls create different pushes rolling down the same ramp.	• create a labelled diagram • engage in, and contribute to, discussions about how levers make it easier to push objects.	• discuss how to use a lever to make objects move without touching them • work in teams to investigate how far a lever pushes a car when it is hit by balls of different mass rolling down a ramp.	**Formative assessment** • Science journal entries • Class discussions • 'Mini machine' (Resource sheet 6) • Contributions to 'Our ideas'

*These lesson outcomes are aligned to relevant descriptions of the Australian Curriculum. See page xi for Science, page xiii for English and page xiv for Mathematics and Design and Technologies.

		SCIENCE OUTCOMES*	LITERACY OUTCOMES*	LESSON SUMMARY	ASSESSMENT OPPORTUNITIES
		Students will be able to:	Students will be able to:	Students:	
EXPLORE	**Lesson 5** Pulley power ***Session 1*** Feeling hungry	• identify how a pulley can be used to lift objects.	• discuss ideas to solve a problem • create an annotated drawing.	• consider ways to lift an object • compare lifting up a heavy bucket with and without a simple pulley.	**Formative assessment** • Science journal entries • Class discussions • 'Lunchtime' (Resource sheet 7) • Contributions to 'Our ideas'
EXPLAIN	**Lesson 6** Problem solvers	• explain how pushes and pulls make objects move • identify why a simple machine won't work • identify how to fix a simple machine.	• use words and pictures to explain what they know about pushes and pulls • draw an annotated drawing showing how a machine works • contribute to discussions.	• discuss pushes and pulls in a video of a Rube Goldberg machine • identify why simple machines are not working • draw annotated drawings of their suggested solutions to make the machines work.	**Formative assessment** • Science journal entries • Class discussions • 'Why won't it work?' (Resource sheet 8)

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		SCIENCE OUTCOMES*	LITERACY OUTCOMES*	LESSON SUMMARY	ASSESSMENT OPPORTUNITIES
		Students will be able to:	Students will be able to:	Students:	
ELABORATE	**Lesson 7** Rube Goldberg ***Session 1*** Plan it first ***Session 2*** Construction time	• generate ideas and construct a Rube Goldberg machine • identify how to make different objects move through different pushes and pulls.	• create an annotated drawing of their ideas • discuss their ideas about how to build and fix their machine using appropriate words.	***Session 1*** Plan it first • work in teams to plan a Rube Goldberg machine to meet design criteria • draw an annotated drawing and create an equipment list. ***Session 2*** Construction time • follow their plan to construct a Rube Goldberg machine • improve their machine as necessary to ensure it works.	**Summative assessment** of Science Inquiry Skills • Science journal entries • Class discussions • 'Our Rube Goldberg Machine' (Resource sheet 9)
EVALUATE	**Lesson 8** Our amazing machine	• explain how pushes and pulls affect the movement of objects in their machine.	• create an annotated drawing • use oral and written language to show their understanding and reflect on their experiences.	• present their final Rube Goldberg machine and explain the pushes and pulls that make it work • reflect on their learning during the unit.	**Summative assessment** of Science Understanding • Science journal entries • Class discussions • Annotated drawings (*Optional*) • Oral presentations

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PrimaryConnections Units

Year	Biological sciences	Chemical sciences	Earth and space sciences	Physical sciences
F	*Staying alive*	*That's my hat!*	*Weather in my world*	*On the move*
	Growing well	*What's it made of?*		
1	*Schoolyard safari*	*Spot the difference*	*Changes all around*	*Look! Listen!*
	Dinosaurs and more	*Bend it! Stretch it!*	*Up, down and all around*	
2	*Watch it grow!*	*All mixed up*	*Water works*	*Machine makers*
				Push-pull
3	*Feathers, fur or leaves?*	*Melting moments*	*Night and day*	*Heating up*
4	*Plants in action*	*Material world*	*Beneath our feet*	*Magnetic moves*
	Friends or foes?			
	Among the gum trees	*Package it better*		*Smooth moves*
5	*Desert survivors*	*What's the matter?*	*Earth's place in space*	*Light shows*
6	*Marvellous micro-organisms*	*Change detectives*	*Creators and destroyers*	*Circuits and switches*
	Rising salt		*Earthquake explorers*	*Essential energy*

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