PrimaryConnections®
Linking science with literacy

Fully aligned with the Australian Curriculum

The PrimaryConnections program is supported by astronomer, Professor Brian Schmidt, 2011 Nobel Laureate

Smooth moves

Year 4

Physical sciences

Primary**Connections project**

Australian Government

Australian Academy of Science

Professional learning program

The Primary**Connections** program includes a sophisticated professional learning component and exemplary curriculum resources. Research shows that this combination is more effective than using each in isolation.

Professional Learning Facilitators are available throughout Australia to conduct workshops on the underpinning principles of the program: the Primary**Connections** 5Es teaching and learning model, linking science with literacy, investigating, embedded assessment and collaborative learning.

The Primary**Connections** website has contact details for state and territory Professional Learning Coordinators, as well as additional resources for this unit. Visit the website at:
www.science.org.au/primaryconnections

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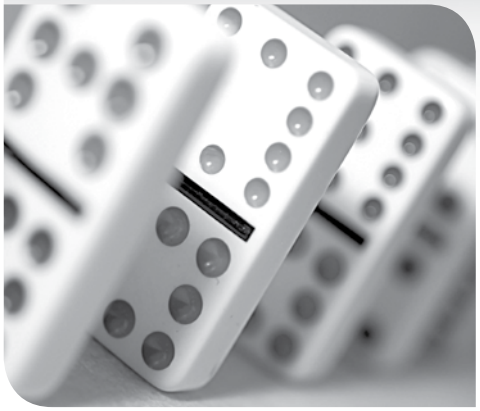

Why do balls roll? Why do apples fall from trees? Why do some things slide across ice but not on carpet? What makes our bikes stop when we brake? We use all types of forces including friction, gravity and pushes and pulls when we exercise, ride bicycles and drive cars. Engineers and scientists use their knowledge of forces and motion to design things for our homes, work and school.

The *Smooth moves* unit is an ideal way to link science with literacy in the classroom. It provides students with the opportunity to explore forces and motion. Through hands-on activities students identify forces that act at a distance and those that act in direct contact, and investigate how different-sized forces affect the movement of objects.

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GPO Box 783
Canberra ACT 2601
Telephone: (02) 9386 4544
Fax: (02) 9387 7755
Email: pc@science.org.au
www.primaryconnections.org.au

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Foreword

The Australian Academy of Science is proud of its long tradition of supporting and informing science education in Australia. 'Primary**Connections**: linking science with literacy' is its flagship primary school science program, and it is making a real difference to the teaching and learning of science in Australian schools.

The Primary**Connections** approach has been embraced by schools since its inception in 2004, and there is substantial evidence of its effectiveness in helping teachers transform their practice. It builds teacher confidence and competence in this important area, and helps teachers use their professional skills to incorporate elements of the approach into other areas of the curriculum. Beginning and pre-service teachers find the approach doable and sustainable. Primary**Connections** students enjoy science more than in comparison classes, and Indigenous students, in particular, show significant increases in learning using the approach.

The project has several components: professional learning, curriculum resources, research and evaluation, and Indigenous perspectives. With the development of an Australian curriculum in the sciences by ACARA in December 2010, it is an exciting time for schools to engage with science, and to raise the profile of Primary science education.

Students are naturally curious. Primary**Connections** provides an inquiry-based approach that helps students develop deep learning, and guides them to find scientific ways to answer their questions. The lessons include key science background information, and further science information is included on the Primary**Connections** website (www.science.org.au/primaryconnections/science-background-resource/).

Science education provides a foundation for a scientifically literate society, which is so important for engagement in key community debates, such as climate change, carbon emissions, and immunisation, as well as for personal decisions about health and well-being. The inquiry approach in Primary**Connections** prepares students well to participate in evidence-based discussions of these and other issues.

Primary**Connections** has been developed with the financial support of the Australian Government, and has been endorsed by education authorities across the country. The Steering Committee, comprised of Department of Education, Employment and Workplace Relations and Academy representatives, and the Reference Group, which includes representatives from all stakeholder bodies including states and territories, have provided invaluable guidance and support. Before publication, the science teacher background information on science is reviewed by a Fellow of the Academy of Science. All these inputs have ensured an award-winning, quality program.

The Fellows of the Academy are committed to ongoing support for teachers of science at all levels. I commend Primary**Connections** to you and wish you well in your teaching.

Professor Suzanne Cory, AC, PresAA FRS
President
Australian Academy of Science
2010–2013

The PrimaryConnections program

PrimaryConnections is an innovative program that links the teaching of science and literacy in the primary years of schooling. It is an exciting and rewarding approach for teachers and students, with a professional learning program and supporting curriculum resources. Further information about professional learning and other curriculum support can be found on the PrimaryConnections website: www.science.org.au/primaryconnections

The PrimaryConnections teaching and learning model

This unit is one of a series designed to exemplify the PrimaryConnections teaching and learning approach, which embeds inquiry-based learning into a modified 5Es instructional model with the five phases: *Engage*, *Explore, Explain*, *Elaborate* and *Evaluate* (Bybee, 1997). The relationship between the 5Es phases, investigations, literacy products and assessment is illustrated below:

PrimaryConnections 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 explanations	**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 PrimaryConnections 5Es teaching and learning model can be found at: www.science.org.au/primaryconnections/teaching-and-learning/

Developing students' scientific literacy

The learning outcomes in PrimaryConnections contribute to 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 (Programme for International Student Assessment & Organisation for Economic Co-operation and Development [PISA & OECD], 2009).

Linking science with literacy

PrimaryConnections 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.

PrimaryConnections develops the literacies of science that students need to learn and to represent their understanding of science concepts, processes and skills. Representations in PrimaryConnections 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

Assessment against the year level Achievement standards of the Australian Curriculum: Science (ACARA, 2012) is ongoing and embedded in PrimaryConnections units. Assessment is linked to the development of literacy practices and products. Relevant understandings and skills for each lesson 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 of the Science Inquiry Skills and of the Science Understanding in the *Evaluate* phase.

Alignment with 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, 2012).

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 scientific knowledge
Use and influence of science	How science knowledge and applications affect people's lives 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 regarding 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 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

AC All the material in this table is sourced from the Australian Curriculum.

There will be a minimum of four Primary**Connections** units for each year of primary school from Foundation to Year 6—at least one for each Science Understanding sub-strand of the Australian Curriculum. Each unit contains detailed information about its alignment with all aspects of the Australian Curriculum: Science and its links to the Australian Curriculum: English and Mathematics.

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 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.

References

Australian Curriculum Assessment and Reporting Authority (ACARA). (2012). *Australian Curriculum: Science*. www.australiancurriculum.edu.au

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

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.

Unit at a glance *Smooth moves*

Phase	Lesson	At a glance
ENGAGE	**Lesson 1** Games galore	To capture students' interest and find out what they think they know about how forces can be exerted by one object on another through direct contact or from a distance To elicit students' questions about different-sized forces and their effect
EXPLORE	**Lesson 2** Making moves	To provide hands-on, shared experiences of different-sized forces acting on an object
	Lesson 3 Feeling friction	To provide hands-on, shared experiences of friction (a force which acts through direct contact)
	Lesson 4 Faraway forces	To provide hands-on, shared experiences of gravity (a force which acts at a distance)
EXPLAIN	**Lesson 5** Figuring out forces	To support students to represent and explain their understanding and observations of how different forces affect the movement of objects, and to introduce current scientific views
ELABORATE	**Lesson 6** Catapult capers	To support students to plan and conduct an investigation to compare the effect of different sized forces on the motion of objects
EVALUATE	**Lesson 7** Forces finale	To provide opportunities for students to represent what they know about how forces can be exerted by one object on another through direct contact of from a distance, and to reflect on their learning during the unit

A unit overview can be found in Appendix 9, page 67.

Alignment with the Australian Curriculum: Science

This *Smooth moves* unit embeds all three strands of the Australian Curriculum: Science. The table below lists sub-strands and their content for Year 4. This unit is designed to be taught in conjunction with other Year 4 units to cover the full range of the Australian Curriculum: Science content for Year 4.

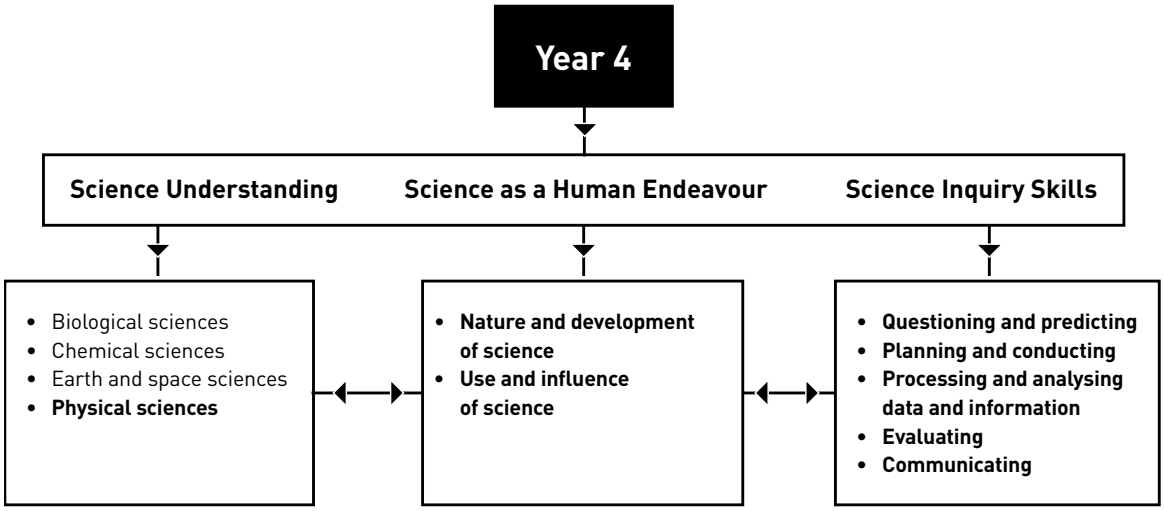
For ease of assessment the table below outlines the sub-strands and their aligned lessons.

Strand	Sub-strand	Code	Year 4 content descriptions	Lessons
Science Understanding	**Physical Sciences**	ACSSU076	Forces can be exerted by one object on another through direct contact or from a distance	1–7
Science as a Human Endeavour	**Nature and development of science**	ACSHE061	Science involves making predictions and describing patterns and relationships	1–7
	Use and influence of science	ACSHE062	Science knowledge helps people to understand the effect of their actions	3,4,5,7
Science Inquiry Skills	**Questioning and predicting**	ACSIS064	With guidance, identify questions in familiar contexts that can be investigated scientifically and predict what might happen based on prior knowledge	1,2,3,4,6
	Planning and conducting	ACSIS065	Suggest ways to plan and conduct investigations to find answers to questions	3,6
		ACSIS066	Safely use appropriate materials, tools or equipment to make and record observations, using formal measurements and digital technologies as appropriate	1,2,3,4,6
	Processing and analysing data and information	ACSIS068	Use a range of methods including tables and simple column graphs to represent data and to identify patterns and trends	6
		ACSIS216	Compare results with predictions, suggesting possible reasons for findings	1,2,3,4,6
	Evaluating	ACSIS069	Reflect on the investigation; including whether a test was fair or not	6
	Communicating	ACSIS071	Represent and communicate ideas and findings in a variety of ways, such as diagrams, physical representations and simple reports	1–7

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

Interrelationship of the Science strands

The interrelationship between the three strands—Science Understanding, Science as a Human Endeavour and Science Inquiry Skills—and their sub-strands is shown below. Sub-strands covered in this unit are in bold.



All the terms in this diagram are sourced from the Australian Curriculum.

Relationship to Overarching ideas

In the Australian Curriculum: Science, six overarching ideas support the coherence and developmental sequence of science knowledge within and across year levels. In *Smooth moves*, these overarching ideas are represented by:

Overarching idea	Incorporation in *Smooth moves*
Patterns, order and organisation	Students observe the movement of everyday objects and identify how forces are affecting the movement. They identify sequences of events and underlying cause and effect, and identify patterns, such as 'stronger' pushes make objects of the same mass move further.
Form and function	Students explore how the form of an object affects how it responds to different forces, in particular they identify that greater surface area in contact with other objects or surfaces can increase friction. If a machine's function is to maximise useful transfer of energy, for example, a bicycle transfers movement of pedals into movement of the whole machine, then its form is designed to minimise friction between parts.
Stability and change	Students identify that different forces can change the movement of objects, either slowing or increasing it, and that it is the sum of these forces that determines whether an object starts, continues or stops moving at a certain speed. They also identify that an object that is not moving has balanced forces acting upon it, for example, the pull of gravity is balanced by the push of the surface the object is resting upon.
Scale and measurement	Students vary the size of the force acting upon objects and then measure the distance travelled using formal measurement. They analyse and compare this data to extrapolate to other scales. Students explore how to represent their understanding of different-sized forces using scaled arrows.
Matter and energy	Students directly experience the phenomenon of movement energy being transferred between objects, affecting the movement of both, for example, the movement energy of a bowling ball being transferred to pins in a bowling game.
Systems	Students describe simple systems of forces acting on objects on Earth and explain them with force-arrow diagrams.

Curriculum focus

The Australian Curriculum: Science is described by year level, but provides advice across four year groupings on the nature of learners. Each year grouping has a relevant curriculum focus.

Curriculum focus Years 3–6	Incorporation in *Smooth moves*
Recognising questions that can be investigated scientifically and investigating them	Students formulate investigable questions about how various factors affect the movement of objects. They investigate forces that affect the movement of objects, using fair tests. They identify forces which act directly or from a distance, and represent their understanding in a variety of ways.

Achievement standards

The achievement standards of the Australian Curriculum: Science indicate the quality of learning that students typically demonstrate by a particular point in their schooling, for example, at the end of a year level. These standards will be reviewed regularly by ACARA and are available on the ACARA website.

By the end of this unit, teachers will be able to make evidence-based judgments on whether the students are achieving below, at or above the Australian Curriculum: Science Year 4 achievement standard. Rubrics to help teachers make these judgments will be available on the website: http://www.australiancurriculum.edu.au/GeneralCapabilities/Overview/General-capabilities-in-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 units. For further information see: www.australiancurriculum.edu.au/Generalcapabilities

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

Smooth moves—Australian Curriculum General capabilities

General capabilities	Australian Curriculum description	*Smooth moves* examples
Literacy	Literacy knowledge specific to the study of science develops along with scientific understanding and skills. Primary**Connections** learning activities explicitly introduce literacy focuses and provide students with the opportunity to use them as they think about, reason and represent their understanding of science.	In *Smooth moves* the literacy focuses are: • annotated drawings • science journals • word walls • storyboards • role-plays • narratives • force-arrow diagrams • tables • graphs.
Numeracy	Elements of numeracy are particularly evident in Science Inquiry Skills. These include practical measurement and the collection, representation and interpretation of data.	Students: • collect, represent and interpret data through tables and graphs • measure distances objects move when subject to different-sized forces • use force-arrow diagrams to indicate size and direction of forces in everyday examples.
Information and communication technology (ICT) competence	ICT competence is particularly evident in Science Inquiry Skills. Students use digital technologies to investigate, create, communicate, and share ideas and results.	Students are given optional opportunities to: • use interactive resource technology to view, record and discuss information • communicate with a school in another country to discuss what they know about gravity in the world.
Critical and creative thinking	Students develop critical and creative thinking as they speculate and solve problems through investigations, make evidence-based decisions, and analyse and evaluate information sources to draw conclusions. They develop creative questions and suggest novel solutions.	Students: • use reasoning to develop questions for inquiry • formulate, pose and respond to questions • consider different ways of thinking about forces, such as pushes, pulls, friction and gravity • make evidence-based claims about forces and motion.
Ethical behaviour	Students develop ethical behaviour as they explore principles and guidelines in gathering evidence and consider the implications of their investigations on others and the environment.	Students: • ask questions respecting each other's point of view.
Personal and social competence	Students develop personal and social competence as they learn to work effectively in teams, develop collaborative methods of inquiry, work safely, and use their scientific knowledge to make informed choices.	Students: • work collaboratively in teams • listen to and follow instructions to safely complete investigations • participate in discussions.
Intercultural understanding	Intercultural understanding is particularly evident in Science as a Human Endeavour. Students learn about the influence of people from a variety of cultures on the development of scientific understanding.	• 'Cultural perspectives' opportunities are highlighted. • Important contributions made to science by people from a range of cultures are highlighted.

All the material in the first two columns of this table is sourced from the 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.

Two of these are embedded within this unit as described below. For further information see: www.australiancurriculum.edu.au/CrossCurriculumPriorities

Aboriginal and Torres Strait Islander histories and cultures

PrimaryConnections has developed an Indigenous perspective framework that has informed practical reflections on intercultural understanding. It can be accessed at: www.science.org.au/primaryconnections/indigenous

Smooth moves focuses on the Western science way of making evidence-based claims about the movement of objects in their environment. Students explore forces, such as pushes, pulls, friction, gravity and magnetism, and how the movement or shape of objects can be understood through the interaction of different forces on an object. They perform fair test investigations about how the size of a force acting on an object can affect its movement.

Indigenous cultures might have different explanations for the observations of objects changing motion, direction or shape, particularly as forces, such as gravity and magnetism, can only be explored through the effects they have on objects (they cannot be seen).

PrimaryConnections recommends working with Indigenous community members to access contextualised, relevant Indigenous perspectives.

Sustainability

The *Smooth moves* unit provides opportunities for students to develop an understanding of how forces act upon objects on Earth, including direct forces, such as pushes and pulls, as well as forces which act at a distance such as gravity. Through investigating how the available surface area of an object affects the amount of friction an object experiences, students describe how well designed machines are more efficient. Students also experience the effect of gels on reducing friction. This can assist them to develop knowledge, skills and values for making decisions about individual and community actions that contribute to sustainable and conservative patterns of energy use, for example, keeping machinery well oiled to keep them efficient and to reduce wear and tear.

Alignment with the Australian Curriculum: English and Mathematics

Strand	Sub-strand	Code	Year 4 content descriptions	Lessons
English–Language	**Language variation and change**	ACELA1487	Understand that Standard Australian English is one of many social dialects used in Australia, and that while it originated in England it has been influenced by many other languages	1–7
	Language for interaction	ACELA1488	Understand that social interactions influence the way people engage with ideas and respond to others for example when exploring and clarifying the ideas of others, summarising students' own views and reporting them to a larger group	1–7
		ACELA1489	Understand the differences between the language of opinion and feeling and the language of factual reporting or recording	1–7
	Text structure and organisation	ACELA1490	Understand how texts vary in complexity and technicality depending on the approach to the topic, the purpose and the intended audience	1
	Expressing and developing ideas	ACELA1498	Incorporate new vocabulary from a range of sources into students' own texts including vocabulary encountered in research	1–7
English–Literacy	**Interacting with others**	ACELY1687	Interpret ideas and information in spoken texts and listen for key points in order to carry out tasks and use information to share and extend ideas and information	1–7
		ACELY1688	Use interaction skills such as acknowledging another's point of view and linking students' response to the topic, using familiar and new vocabulary and a range of vocal effects such as tone, pace, pitch and volume to speak clearly and coherently	1–7
		ACELY1689	Plan, rehearse and deliver presentations incorporating learned content and taking into account particular purposes and audiences	5,7
	Creating texts	ACELY1694	Plan, draft and publish imaginative, informative and persuasive texts containing key information and supporting details for a widening range of audiences, demonstrating increasing control over text structures and language features	2,7

Strand	Sub-strand	Code	Year 4 content descriptions	Lessons
Mathematics–Measurement and Geometry	**Using units of measurement**	ACMMG084	Use scaled instruments to measure and compare lengths, masses, capacities and temperatures	2,6
Mathematics–Statistics and Probability	**Chance**	ACMSP092	Describe possible everyday events and order their chances of occurring	1,2,3,4,6,7
	Data representation and interpretation	ACMSP095	Select and trial methods for data collection, including survey questions and recording sheets	2,3
		ACMSP096	Construct suitable data displays, with and without the use of digital technologies, from given or collected data. Include tables, column graphs and picture graphs where one picture can represent many data values	6
		ACMSP097	Evaluate the effectiveness of different displays in illustrating data features including variability.	
English–Literature	**Creating literature**	ACELT1607	Create literary texts that explore students' own experiences and imagining.	

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

Other links are highlighted at the end of lessons where possible. These links will be revised and updated on the website: www.science.org.au/primaryconnections/curriculum-resources/

Teacher background information

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. A force can cause an object to start moving, stop moving or change its direction. A force applied to an object might cause it to change its motion by transferring energy to the object. It is the energy (movement or kinetic energy) that enables the object to move. Stationary objects also have forces acting on them. Consider a book on the floor; it experiences a downward gravitational pull force but this is balanced by an equal upward push force from the floor, resulting in the book remaining stationary.

Force has two aspects: magnitude and direction. The magnitude of the force refers to the size or amount of force exerted, for example, if it is a strong or a weak push.

More than one force can act on an object at any one time, for example, our standing body is pulled down to the ground and the ground pushes back. We are able to be stationary because even though there are two forces acting on us, these forces are of equal magnitude in opposite directions. The forces are therefore said to be balanced, enabling us to experience constant motion rather than sinking into the ground or rising into the air. An object moving at a steady speed in a straight line is also experiencing balanced forces: its motion is constant, it is not changing.

An object's motion changes when the forces acting on it are not balanced. Unbalanced forces can make stationary objects move. Forces can make moving objects move faster or more slowly, come to a stop or change direction. Forces can also change the shape of objects. If you push a stationary ball it starts to move along the ground. If it hits a wall it might stop, change shape or change the direction in which it is moving. If the push is large enough, the ball might do all of these things.

Different-sized forces 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.

Forces can act through direct contact, such as physical pushes and pulls, friction, and air or water resistance. Some forces act at a distance, such as gravity and magnetism.

Forces are commonly represented on diagrams using arrows which show both the direction and size of the force. Further information about representing forces can be found in Lesson 3 'Water, water everywhere' in *Push-pull* (Year 2, Physical sciences).

Students' conceptions

Taking account of students' existing ideas is important in planning effective teaching approaches which help students understand science. Students develop their own ideas during their experience 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 and if a body is moving there is force acting on it only in the direction of motion. 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. 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.

Many students might think that the amount of motion is proportional to the strength of the force. For the same object a larger push will cause the object to go faster. However, once the object is moving it will continue to move at the same speed unless acted upon by other forces, such as friction and air resistance. Therefore, a fast moving object, for example, a cricket ball, might not still have any force applied to it. Also, there are a lot of forces that do not result in motion. For example, a heavy stationary object might have a large gravitational force and a large push back from the table it is on, so even though there are large forces acting on the object, there is no motion.

Students might believe that for an object to be moving constantly, it must have a constant force acting on it. Objects don't 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 across the water for some time. It will gradually slow down because of friction with the water. 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 energy lost through friction or air resistance.

In the *Smooth moves* unit, concepts such as friction, gravity and movement are investigated. As the unit progresses, students have the opportunity to explore these concepts and use different ways to represent forces and motion using arrows, including some scientific conventions of force-arrow diagrams.

It is recommended that the *Push-pull* unit be taught before the *Smooth moves* unit to provide students with learning opportunities that introduce and explain concepts about forces and motion which are used in the *Smooth moves* unit.

To access more in-depth science information in the form of text, diagrams and animations, refer to the Primary**Connections** Science Background Resource which has now been loaded on the Primary**Connections** website: www.science.org.au/primaryconnections/science-background-resource/

Note that this background information is intended for the teacher only.

Lesson 1 Games galore

AT A GLANCE

To capture students' interest and find out what they think they know about how forces can be exerted by one object on another through direct contact or from a distance.

To elicit students' questions about different-sized forces and their effect.

Students:

- play a game in collaborative learning teams
- describe how to play the game
- create an annotated drawing of their game, using captioning to describe forces acting on objects.

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 force exerted on an object, either through direct contact or from a distance, can affect the movement of the object, making predictions and recording observations of the effect that different-sized forces have on objects, and representing and communicating their findings.

ENGAGE

Key lesson outcomes

Science

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

- describe forces and motion
- observe the effect that different-sized forces have on objects
- caption their annotated drawing with descriptions of the forces used in their game.

Literacy

Students will be able to:

- contribute ideas to a class
- discussion about ways to move a marble
- understand the purpose and features of a science journal
- create an annotated drawing of their game
- use talk to describe their game and contribute to a team discussion about forces
- record observations in the class science journal.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page 5).

Teacher background information

Objects are stationary because the forces acting on them are balanced. For example, a book on a table is being pulled down by gravity and the table is pushing up. These forces are of the same magnitude in different directions and so they cancel each other out. To make a stationary object move, a new unbalanced force must be applied. Forces can act through direct contact, such as physical pushes and pulls, or at a distance, such as gravity and magnetism. Forces transfer energy to objects and it is the energy (movement or kinetic energy) that enables objects to move.

Everyday activities show how forces are used to start things moving, change their direction or change the speed at which they move, making a pram or trolley speed up or slow down, opening a door or kicking a ball. Dropping a toy shows how the force of the Earth's gravity can move objects.

Objects with a large mass have more inertia, that is, they need larger forces to start them moving, speed them up, slow them down or change their direction. Objects with less mass have less inertia, that is, they need smaller forces to change their motion.

When an object is moving over a surface, its motion is opposed by a force called 'friction'. Friction results from contact between two surfaces. The amount of friction relates to how 'grippy' the surfaces in contact are. For example, a rough surface will exert more friction than a smooth surface and thus you will experience less friction making it easier to slip when walking on polished floorboards than on carpet. Moving objects slow down and stop because the force of friction acts on the object, transforming the object's movement energy into heat and sound energy. This slows the object's movement to a stop unless more force is applied in the direction of motion.

Equipment

FOR THE CLASS

- class science journal
- word wall
- 'Smooth moves' information wall
- team skills chart
- team roles chart
- marbles
- several self-adhesive notes per student

FOR EACH TEAM

- role wristbands or badges for Director, Manager and Speaker
- each team member's science journal
- equipment for 1 game (see 'Preparation')

Preparation

- Read 'How to organise collaborative learning teams' (Appendix 1). Display an enlarged copy of the team skills chart and the team roles chart in the classroom. Prepare role wristbands or badges and the equipment table.
- Read 'How to use a science journal' (Appendix 2).
- Read 'How to use a word wall' (Appendix 3).
- Organise games for students to play in collaborative learning teams or as a whole class, for example:
  - Marbles
  - Dominos
  - Red light, green light
  - Soccer
  - Mouse trap
  - Dodge 'em cars
  - Ten pin bowling
  - Cricket
  - Softball
  - Tee ball
  - Duster hockey
  - Blow soccer.
- *Optional:* Store the 'Smooth moves' information wall, science journal and word wall on an interactive whiteboard or on a computer connected to a projector. Check the Primary**Connections** website to see if an accompanying interactive resource has been developed: www.science.org.au/primaryconnections

Lesson steps

1. Ask students to sit in a circle and place a marble in the middle of the circle. Ask students to suggest different ways they could move the marble and test some of the students' ideas, for example, hit it, blow it, collide another marble into it, drop it, catapult it with an elastic band, roll it.
2. Introduce the 'Smooth moves' information wall and explain that this is where the class will record information, pictures, questions, ideas and reflections during the unit.
3. Record, on self-adhesive notes, the different ways that students could move the marble and place on the 'Smooth moves' information wall.

4 Ask students if the responses can be categorised (put into groups). Groups might include: ways to move the marble using direct contact, such as parts of your body or using another object; and using large or small pushes.

Note: This is an opportunity to assess students' prior knowledge of forces and motion.

5 Discuss the terms 'push' and 'pull' and record students' ideas on the 'Smooth moves' information wall.

6 Explain that students will be working in collaborative learning teams to play a game, observe the different pushes and pulls that might be used in the game and create an annotated drawing of their game, captioned by descriptions of pushes and pulls and the movement that occurred. 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?

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

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 wear role wristbands or badges to help them (and you) know which role each team member has. Draw students' attention to the equipment table and discuss its use. Explain that this table is where Managers will collect and return equipment.

7 Form teams and allocate roles. Ask Managers to collect equipment for their team game. Allow time for each team (or the class) to play their allocated game and complete their annotated drawing.

8 Ask Speakers to share their team's game with the class and their ideas about the pushes and pulls that were used in the game and the motion that occurred. For example:

- 'We had to push the button down'
- 'We had to pull the cricket bat back to hit the ball properly'
- 'The ball went further with a big hit'
- 'The ten-pins didn't fall down unless the ball hit them hard enough'.

Note: In the *Engage* phase, do not provide formal definitions or correct students' answers as the purpose is to elicit students' prior knowledge of forces and motion, different-sized forces and their effect on objects.

9 Introduce the class science journal and discuss its purpose and features. Record teams' responses in the class science 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 to help us with our claims and evidence.

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.

10 Commence a class word wall and discuss its purpose and features. Record words and images to support the development of vocabulary related to the unit.

Invite students to contribute words from different languages to the word wall, reminding students that Standard Australian English is one of many social dialects used in Australia.

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 which we have seen or heard about the topic.

Curriculum links

Intercultural understanding

- Many cultures have a rich history of children's games and pastimes. Encourage students to share examples from their own culture.
- Organise for students to play Indigenous games. See www.ausport.gov.au/participating/indigenous/games. If you have contact with local Indigenous community members and/or Indigenous Education Officers contact them about relevant, local Indigenous knowledge about traditional games.

Lesson 2 Making moves

EXPLORE

AT A GLANCE

To provide hands-on, shared experiences of different-sized forces acting on an object.

Students:

- explore the effect of different-sized forces on rolling cans
- contribute to a class discussion about how to represent different-sized forces
- use arrows to represent different-sized forces.

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 different-sized pushes and pulls (direct contact forces) affect objects, and predicting what might happen when different forces are applied to an object. You will also monitor their developing science inquiry skills (see page 2).

Key lesson outcomes

Science

Students will be able to:

- observe, compare and record the use of different-sized forces to move cans
- make predictions and give reasons about the movement of objects
- draw conclusions about the effect of different-sized forces on the movement of objects.

Literacy

Students will be able to:

- understand the purpose and features of a storyboard
- contribute to a class discussion about different-sized forces
- represent their understanding of different-sized forces using different-sized arrows.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page 5).

Teacher background information

If an object is moving, it is also said to have 'momentum'. The more momentum an object has the harder it is to stop. Just as an object requires a large force to make it travel quickly, a fast moving object will require a large force to stop it moving. For example, when we run, we have more momentum than when we walk, hence a bigger force is needed to make us stop. The same is true for cars; it is easier to stop a car when it is moving slowly than when it is moving fast. This is why slower speed limits are in place around areas where there might be lots of people, such as schools, hospitals and shopping centres. Objects with more mass require a larger initial force to move at the same speed as objects with less mass. Similarly, a more massive object will require a larger force to stop it moving than an object with less mass travelling at the same speed. For example, at a given speed, stopping a bicycle requires less force than stopping a car, and both require less force than stopping a truck.

Friction between the object and the surface it moves over also makes a difference to how hard or easy it is for an object to stop. For example, it is easier to stop running on a tarred road than to stop sliding on ice.

Equipment

FOR THE CLASS

- class science journal
- word wall
- 'Smooth moves' information wall
- team skills chart
- team roles chart

FOR EACH TEAM

- role wristbands or badges for Director, Manager and Speaker
- each team member's science journal
- 2 full tin cans of the same weight (eg, 300 g tinned tomato cans)
- table or flat surface

Preparation

- Organise a safe, open space for students to run and walk over a distance.
- Organise tables or flat surfaces for teams to roll tin cans.
- *Optional:* Draw storyboards on an interactive whiteboard or on a computer connected to a projector. Check the PrimaryConnections website to see if an accompanying interactive resource has been developed: www.science.org/primaryconnections

Lesson steps

1 Review the previous lesson and contributions made to the word wall and 'Smooth moves' information wall.

2 Move students to an open, outdoor space and ask students to:

SAFETY

- run over a distance and stop suddenly
- walk the same distance and stop suddenly.

3 Discuss the difference between stopping suddenly when running compared to when walking. Ask questions, such as:

- What did you feel when you were running?
- What did you feel when you were walking?
- Was it easier to stop running or walking? Why do you think this is?

4 Return to the classroom and explain that students will be working in collaborative learning teams to explore how different-sized pushes and pulls affect objects. They will use different-sized pushes to roll two cans on a flat surface, for example, a table. They will also compare the differences in how easy it is to stop them.

5 Form teams and allocate roles. Ask Managers to collect team equipment. Allow time for teams to explore rolling the cans.

6 Discuss each team's findings and ask questions, such as

- What was the difference in size of each push used to move each can? (One was a larger push; the other push was smaller.)
- What happened to each can after different-sized pushes were used to make it move? (The can that had a larger push rolled faster and went further along the table compared to the can with the smaller push.)
- What conclusions can you draw about different-sized pushes and pulls and their effect on objects? (From this test, we can tell that a larger force makes the can roll faster and further than a smaller force.)
- What could you use to stop each can rolling? (You could use a brick or a heavy box to stop each can.)
- Could you use a light object to stop the can rolling? (Only if it has a small push, because the light object wouldn't stop the fast-moving can because it doesn't push enough against the can.)

7 Ask students to brainstorm the different ways they could show or represent different-sized pushes. Ask students to provide reasons for their suggestions and record these representations and reasons in the class science journal.

8 Explain that students will create a storyboard in their science journal, represent the size of the push used to move each can and show what happened to each can after the push. Discuss the purpose and features of a storyboard and model how to create a storyboard in the class science journal.

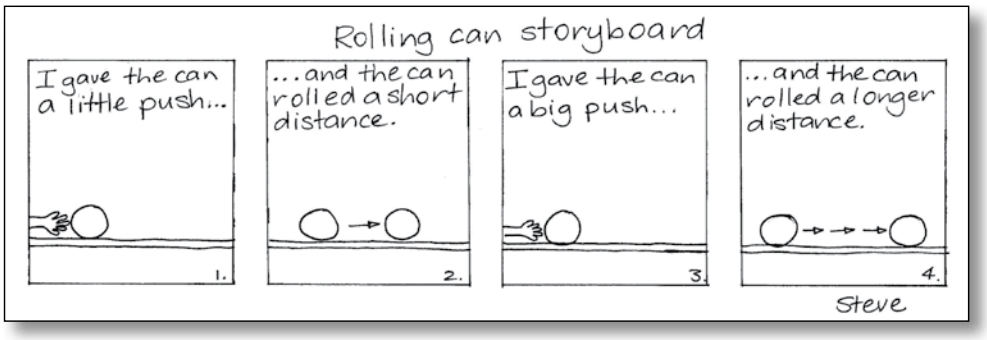
Literacy focus

Why do we use a storyboard?

We use a **storyboard** to show important steps of a process in the order that they happen.

What does a storyboard include?

A **storyboard** includes a title and a series of drawings. Each step in the storyboard is numbered and includes a caption describing the step.



Student's storyboard work sample

Optional: Use hypothetical scenarios to explore moving other objects, such as, blowing bubbles and moving boulders.

9 Ask students to review the games they explored in Lesson 1, asking questions, such as:

- What things in your game can you push? (The ball, the domino.)
- What would happen if you gave that a larger push? (The ball would roll further.)
- What would happen if you gave that a smaller push? (The ball wouldn't roll very far.)

10 Update the word wall and add any further contributions to the 'Smooth moves' information wall.

Curriculum links

Science

- Compare rolling empty cans and cans of different mass.

English

- Explore comparative language, such as large, larger, small, smaller, fast and slow.

Technology

- Design a 'Knock-em over' sideshow game using weighted cans.

Health and Physical Education

- Research and discuss road safety and how speed affects braking distance.

EXPLORE

Lesson 3 Feeling friction

EXPLORE

AT A GLANCE

To provide hands-on, shared experiences of friction (a force which acts through direct contact).

Students:

- observe how friction is different with different surfaces
- explore what more or less friction feels like
- use arrows to represent frictional forces.

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:

- the force of friction, a direct force which opposes movement when the surfaces of two objects are in contact with one another, and exploring ways of reducing and increasing friction between surfaces. You will also monitor their developing science inquiry skills (see page 2).

Key lesson outcomes

Science

Students will be able to:

- identify forces that act in direct contact
- investigate frictional forces between an object and different surfaces
- observe and describe ways of reducing and increasing friction.

Literacy

Students will be able to:

- contribute to a class discussion about friction
- use oral, written and visual language to describe observations of pulling objects across different surfaces.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page 5).

Teacher background information

Friction is a force that opposes the movement of one surface across another. The force of friction acts by direct contact between two surfaces. Friction occurs between all types of materials whether they are solids, liquids or gases. Friction is caused by the interaction between surfaces causing them to 'stick' together and oppose the movement between them.

To make something move, we need to apply enough force (transfer enough energy to the object) to overcome the force of friction opposing that movement. Moving objects slow down and stop because the force of friction acts against the movement (changes the movement energy to heat, and sometimes sound energy) and slows the object to a stop. A friction force opposes the direction of movement, so when depicting friction on force-arrow diagrams the friction force-arrow is drawn in the direction opposing the motion.

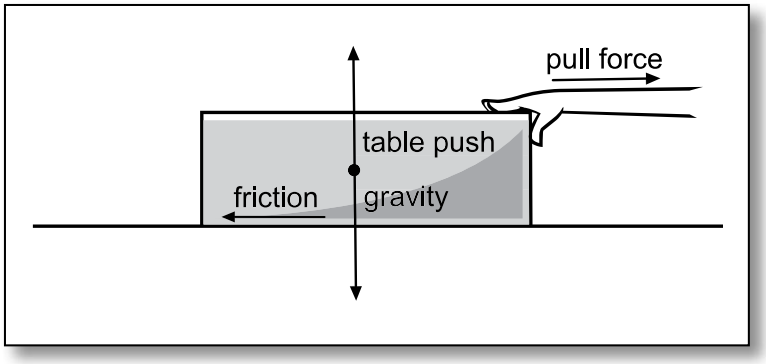


Diagram of forces including friction

Scientists and engineers try to find ways to both increase and decrease friction. This is because there are situations where friction is helpful and other situations where friction is a problem for us. Think about trying to walk on wet kitchen tiles in bare feet (more friction would help) and then trying to slide down a slippery dip with wet trousers (less friction would help).

Everyday applications of friction include:

- allowing us to move: the soles of our shoes grip the ground and help us to push off when walking;
- slowing things down: the brakes on a bicycle decrease the speed of the bicycle and heat the wheel while friction between the tyre and the road stops the bicycle from simply sliding along;
- keeping things in place: tuning pegs on guitars and violins stay in place and keep the instrument in tune, nails hold materials together and objects on a gentle slope do not slide;
- transforming movement energy into heat energy: it can be used to create fire, for example, by rubbing sticks together.

Friction can have some disadvantages. Frictional forces cause surfaces to wear: the soles of shoes wear down, tread on tyres wears down, moving parts in machinery wear down and need to be replaced. Friction generates heat and this can be a problem if things get too hot.

Ways to reduce friction include:

- adding a lubricant: a liquid, such as water, oil or detergent makes surfaces slippery
- reducing the force pushing the two objects together: a lighter object is easier to move across a surface than a heavy object.

Equipment

FOR THE CLASS

- class science journal
- word wall
- 'Smooth moves' information wall
- team skills chart
- team roles chart
- long length of rope
- 1 pair of disposable gloves per student
- detergent

FOR EACH TEAM

- role wristbands or badges for Director, Manager and Speaker
- each team member's science journal
- heavy object (see 'Preparation')
- range of different surfaces (see 'Preparation')

Preparation

SAFETY

- Be aware of allergies that students might have. Students might suffer from allergies to different substances and detergents as well as the latex used in disposable gloves.
- Prepare a heavy object for each team, such as an ice-cream container half-filled with sand, a shoe-box filled with blocks or a heavy book.
- Organise a range of different surfaces for students to investigate, such as lino, carpet, grass, floorboards and asphalt.
- Refer to 'Introduction to forces and motion' in the 'Teacher background information' in *Push-pull* (PrimaryConnections Year 2 unit, Physical sciences).

Lesson steps

1. Review the previous lesson and contributions made to the word wall and 'Smooth moves' information wall.
2. Move students to an outdoor grassed or soft-mat area. Divide the class into two even groups and explain that each team will collectively pull one end of a long rope towards them but still keep it over a central line marked in the ground. Discuss 'balance' and explain how each end of the rope is being pulled but is still balanced.
3. Explain that the class will now play a game of 'Tug of war' and will see which team can pull the other team across the central line marked on the ground.
4. As a class, discuss what things made it hard to pull the other team across the line, such as slippery surface, no grip between hands and the rope.

5 Ask the team that didn't win to put disposable gloves on their hands and repeat the 'Tug of war' game with the other team (who have bare hands). Ask students to describe the difference between bare hands and wearing gloves when pulling the rope. Encourage students to provide reasons for their responses.

6 Invite the rest of the class to put disposable gloves on their hands and ask everyone to rub their gloved hands together. Ask students to describe what it feels like and why they think it feels like that. (The material that the glove is made of enables us to feel more grip when we rub our hands together.)

7 Explain that students are going to apply some detergent to the gloves on their hands and compare how it feels to rubbing just the gloves together. Ask students to apply a small amount of detergent to their gloved hands and ask questions, such as:

- What does the detergent feel like when you rub your gloved hands together?
- Is it easier to rub your gloved hands together with or without the detergent?
- Why do you think it feels different?

8 Introduce and discuss the term 'friction', as something that acts between two surfaces in contact producing grip. Ask students if they think the gloves without detergent had more or less friction than the gloves with detergent. Record students' responses in the class science journal.

9 Introduce and discuss the term 'force'. Explain that forces can affect objects in different ways, including the way they move. Explain to students that forces are usually thought of as pushes and pulls and can also include forms such as friction, gravity and magnetism.

10 Explain that students will be working in collaborative learning teams to pull a heavy object across different surfaces to investigate the friction force between the surfaces. Ask students to predict if there will be a large or small amount of friction between the heavy object and each surface and record their ideas in their science journal.

11 Form teams and allocate roles. Ask Managers to collect team equipment and allow time for teams to test and observe moving the heavy object over different surfaces.

12 Ask Speakers to share and explain their team findings with the class.

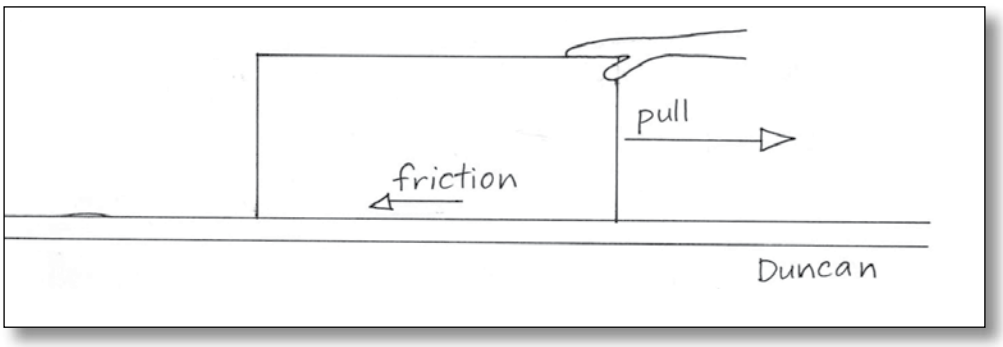
Ask questions, such as:

- How were the surfaces different?
- What did it feel like when you pulled the heavy object across each surface?
- Was there a difference in the size of the pull needed to pull the heavy object across each surface? Why do you think that?
- How did friction affect the movement of the heavy object?
- Did your team findings match the predictions you made?

13 Review the class science journal and the different ways to represent different-sized forces recorded in Lesson 2. Ask students to brainstorm how to use arrows to represent friction and how it affects the movement of the heavy object.

Note: Focus students' attention on friction as a force that opposes the direction of motion.

EXPLORE



Friction drawing student work sample

14 Ask students to create a drawing in their science journal which represents the force used to pull the heavy object across each surface and the opposing friction force. Encourage students to use different-sized arrows to represent a large or small pull and an opposing arrow to represent a large or small amount of friction.

15 Update the word wall and add any further contributions to the 'Smooth moves' information wall.

EXPLORE

Curriculum links

Science

- Explore how friction is used on a bicycle, such as slip-resistant pedals, handle bar grips and braking mechanisms.
- Investigate how cyclists increase and decrease friction, such as streamlined helmets, light weight frames, tight clothing.

English

- Explore other uses of the term 'force', for example, 'police force'.

Studies of Society and Environment

- Explore the history of the wheel.

Health and Physical Education

- Discuss different uses for safety signs and where they are used in the school and community.

Lesson 4 Faraway forces

AT A GLANCE

To provide hands-on, shared experiences of gravity (a force which acts at a distance).

Students:

- participate in a class game: 'Going up'
- observe how gravity makes objects fall
- participate in a discussion about gravity around the world
- represent gravity acting on objects around the world.

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:

- the force of gravity, a force that acts from a distance on and between all objects, and how to communicate their ideas about gravity and the different ways they experience it in their lives. You will also monitor their developing science inquiry skills (see page 2).

Key lesson outcomes

Science

Students will be able to:

- identify forces that act at a distance
- explore gravity's effect on an object
- discuss gravity and the different ways they experience it in their lives.

Literacy

Students will be able to:

- contribute to a class discussion about gravity
- use oral and visual language to represent their understanding of gravity.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page 5).

Teacher background information

When we drop things, we see that the Earth's gravitational force (gravity) 'pulls' them down to the ground. We know that magnets can 'push' and 'pull' other magnets and can pull things made of iron (or steel) towards them. Both magnetism and gravity are forces that act at a distance rather than through direct contact. Though we cannot see the force, we can see the effect it has on objects.

Gravity

Isaac Newton is claimed to have said, 'What goes up, must come down' when he saw an apple fall from the tree he was sitting beneath. He is one of the scientists who have developed our understanding of forces, including gravity.

Every object exerts a gravitational force on other objects but it can be hard to detect unless at least one of the objects has a large mass. 'Mass' is a measure of the amount of matter an object has while 'weight' is the measure of gravitational pull that acts on an object.

The weight of an object is related to the mass of the object and the magnitude of the gravitational force acting on the object. The weight of an object will change if the gravitational force acting on it changes, but its mass will not. For example, the Moon is not as massive as the Earth so its gravitational force is not as strong. Because of this, objects will not be attracted as strongly to the centre of the Moon as they would be to the centre of the Earth, and their weight on the Moon is less than their weight on Earth.

The Earth has such a large mass that the gravitational attraction between it and most things is very noticeable; when we jump into the air, the Earth's gravitational force pulls us back towards the Earth's centre very quickly. We can also feel the pull of the Earth's gravity when we try to lift things; the more mass something has, the greater the pull of gravity and the greater the lifting force we need to use. Gravity acts on an object regardless of whether or not the object is moving. It does not require the object to be surrounded by air or water or anything else and can therefore act in the vacuum of space.

Students' conceptions

For many students, the idea of force might be limited to those forces involving physical contact. Though we experience many forces that have direct contact, there are also forces that act at a distance, such as gravity, magnetism and electrical forces.

Some students might think that falling is a property of an object itself rather than the effect of gravity acting between the Earth and the object. As with all forces, gravity is an external influence which acts between objects, causing them to come together.

Students might not understand that gravitational attraction is a general phenomenon that constantly acts on all objects. They might believe that gravity is related to air pushing down on an object. Air pressure and resistance are forces which are quite different from gravity and affect objects in different ways.

Equipment

FOR THE CLASS

- class science journal
- word wall
- 'Smooth moves' information wall
- 1 globe
- 1 balloon per class/group

FOR EACH TEAM

- each team member's science journal

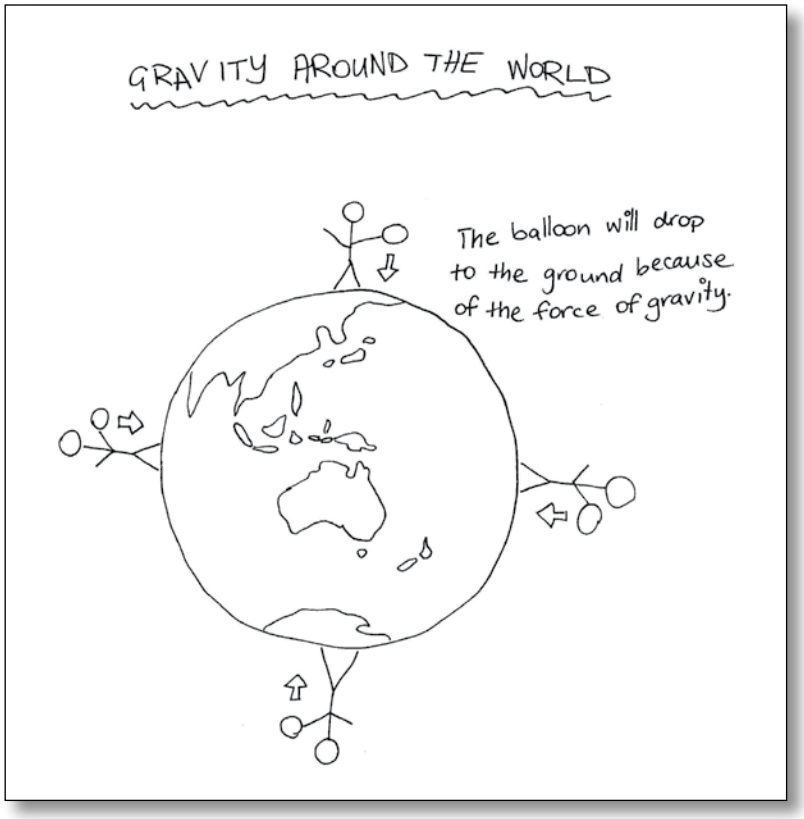
Preparation

- Organise an open space and an air-filled balloon for students to play the game 'Going up' as a class or in small groups.
- Be aware of allergies that students might have. Students may suffer from allergies to the latex used in the balloon.
- *Optional:* Provide a picture of the world on an interactive whiteboard or on a computer connected to a projector. Check the Primary**Connections** website to see if an accompanying interactive resource has been developed: www.science.org/primaryconnections

Lesson steps

1. Review the previous lesson and contributions made to the word wall and 'Smooth moves' information wall.
2. Invite students to play the game 'Going up' as a class or in small groups. Explain that the aim is for students to keep a balloon moving by hitting it up in the air and not letting it fall to the ground. Ask students to predict what might happen to the balloon if they don't keep it moving during the game.
3. Discuss what is happening to the balloon in the game. Encourage students to think of what happened to the balloon each time someone hit it and what happened when someone didn't hit it. Record students' responses in the class science journal.
4. Introduce a globe to the class and discuss the different countries that people live in around the world. Ask one student to show the class where Australia is located on the globe.
5. Ask students if they have friends or family who live in other countries. As a class, discuss some of these countries and where they are located on the globe. Ask students if they think people experience gravity in those countries. Encourage them to provide reasons for their responses.
6. Ask students to draw a picture of the world in their science journals. Ask them to draw four people in different places around the globe with an air-filled balloon in their hand. Explain that students will draw an arrow to show where the balloon will go if each person around the globe dropped the balloon.

Note: It is important that students create the entire drawing so you can elicit their understanding of gravity.



'Gravity around the world' student work sample

7 As a class, discuss gravity and the different ways people experience it in their lives. Introduce the term 'gravity' as a force that pulls things towards the centre of the Earth.

Ask questions, such as:

- How do we know that gravity exists?
- What effects of gravity can we see or experience?
- What does the balloon activity tell us about gravity?
- What might happen if there was no gravity?

8 Invite students to review their picture of the world in their science journal. Ask students to make any changes to the direction of the arrows in their picture to represent their understanding of the direction of gravitational force acting on each balloon in the picture.

Update the word wall and add any further contributions to the 'Smooth moves' information wall.

Curriculum links

Science

- Investigate the story of Isaac Newton and gravity.

Information and Communication Technology (ICT)

- Communicate with a school in another country and discuss what they know about gravity in the world.

Lesson 5 Figuring out forces

AT A GLANCE

To support students to represent and explain their understanding and observations of how different forces affect the movement of objects, and to introduce current scientific views.

Students:

- explain their understanding of the forces acting in their game from Lesson 1
- use role-play and narrative to describe and represent forces acting in a real-life scenario.

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.

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 different forces affect the motion of objects and that science involves representing and communicating ideas about forces in a real-life scenario. You will also monitor their developing science inquiry skills (see page 2).

EXPLAIN

Key lesson outcomes

Science

Students will be able to:

- develop an explanation for forces acting on objects in a game
- use different-sized arrows to represent different-sized forces
- identify and explain the role of forces present in a real-life scenario.

Literacy

Students will be able to:

- understand the purpose and features of a narrative
- understand the purpose and features of a role-play
- participate in a role-play to explain the forces present in a real-life scenario
- understand the purpose and features of a force-arrow diagram
- contribute to a class discussion about forces and motion.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page 5).

Teacher background information

When something changes, energy is involved. Energy is abstract but you can often detect it through the effect it has on your body: you can see patterns of light, you can feel the warmth created by heat energy, though you cannot see or feel magnetic energy. Energy from the Sun drives the growth of plants and the development of rainstorms, while energy from chemical reactions gives life to animals and is important to modern industry.

Some important characteristics of energy include:

- Energy exists in different forms, such as light, sound, heat, electricity and movement.
- Energy can be transformed (changed) from one form to another, for example, kicking a ball transforms chemical energy in our bodies to movement energy in the ball.
- Energy can be transferred from one location to another, for example, electrical energy moves along wires from a power station to our houses.
- Energy can be changed into other forms but it cannot be created or destroyed.
- Energy can be stored in many ways. Batteries and fossil fuels are stores of chemical energy.

When forces are applied to an object, energy is transferred or transformed. When a football player kicks a ball, movement energy in his foot is transferred to the ball. When hands are rubbed together, friction transforms movement energy into heat energy. When you turn on a switch, electrical energy from the power station is transformed into light energy in your room.

Forces act on stationary and moving objects. The forces acting on stationary objects are balanced. They cancel each other out so we are often not aware of them. When forces are acting on a moving object, the effect depends on the size of the force and the mass of the object.

Force-arrow diagrams

Force-arrow diagrams are used to represent the direction and the size of forces acting in a particular situation. The length of a force-arrow represents magnitude and the direction of the arrow shows the direction in which the force is acting. When drawing force-arrow diagrams, longer arrows in the direction of the force are used to represent a larger force while a shorter arrow in the direction of the force is used to represent a smaller force. Asking students to label the force-arrows will assist with their representations and explanations of forces and motion.

Equipment

FOR THE CLASS

- class science journal
- word wall
- 'Smooth moves' information wall
- team roles chart
- team skills chart

FOR EACH TEAM

- role wristbands or badges for Director, Manager and Speaker
- each team member's science journal
- equipment and props for role-play (see 'Preparation')
- several cardboard arrows (see 'Preparation')

Preparation

- Organise a range of equipment or props that could assist teams in their real-life scenario role-play, such as boxes, books or a small trolley.
- Prepare some large cardboard arrows for each team to assist teams in their role-play.
- *Optional:* Draw force-arrow diagrams on an interactive whiteboard or on a computer connected to a projector. Check the Primary**Connections** website to see if an accompanying interactive resource has been developed: www.science.org/primaryconnections

Lesson steps

1. Review the previous lesson and contributions made to the word wall. Review the 'Smooth moves' information wall and information recorded about the forces and motion in each game in Lesson 1. Ask students if they would like to contribute any further information to this section from what they have learned.
2. Explain that students will be working in collaborative learning teams to create a real-life scenario and use their understanding of forces and motion to explain the forces acting in the scenario, such as pushing a trolley or pulling a box. Explain that students will use role-play and narrative to present their scenario to the class. Discuss the purpose and features of role-plays and narratives.

Literacy focus

Why do we use a role-play?

We use a **role-play** as a physical representation of a system, process or situation.

What does a role-play include?

A **role-play** might include speech, gestures, actions and props.

Literacy focus

Why do we use a narrative?

We use a **narrative** to tell the story of connected events. It is often used to entertain and inform the audience.

What does a narrative include?

A **narrative** might be spoken or in written form and might include pictures or props.

Optional: Encourage students to develop narratives and role-plays about games from different cultures, including Indigenous cultures, explored in Lesson 1.

3 Form teams and allocate roles. Ask Managers to collect props and equipment that their team might need. Encourage teams to cut cardboard arrows to an appropriate size and use as props to assist in explaining their understanding of different-sized forces acting in the scenario and how the forces affect the movement of objects.

4 Allow time for each team to present their role-plays and narratives to the class. Engage the class in a discussion about each role-play and narrative, providing informal peer assessment to each team about their representation and explanation of the forces present in their scenario.

5 Review the class science journal and discuss the different ways that students have represented different-sized forces acting on objects in each lesson. Discuss the limitations of having a range of representations, for example, not everyone has the same representation therefore not everyone will understand what's being represented. Introduce the scientific convention for representing different-sized forces: large forces are represented with a long arrow, smaller forces are represented with a shorter arrow.

6 Explain that students will create a force-arrow diagram of their scenario. Discuss the purpose and features of a force-arrow diagram.

Literacy focus

Why do we use a force-arrow diagram?

We use a **force-arrow** diagram to show push and pull forces.

What does a force-arrow diagram include?

A **force-arrow** diagram uses arrows to show the direction of forces. A pull is shown by an arrow pointing away from the object. A push is shown by an arrow pointing towards the object.

7 Ask students to share their force-arrow diagrams with other class members, discussing their use of the scientific convention for representing different-sized forces. Ask students to engage in authentic conversations about their representations and their understanding of the forces acting in their scenario. Encourage students to explain, give reasons and justify their thinking, and prompt other students to agree or give alternative explanations.

Note: Authentic conversations can take place in the form of 'Think-pair-share' and 'Turn and talk' strategies but can also be taught explicitly to become an embedded structure for students' discourse within the classroom.

8 Update the word wall and add any further contributions to the 'Smooth moves' information wall.

Lesson 6 Catapult capers

AT A GLANCE

To support students to plan and conduct an investigation to compare the effect of different-sized forces on the motion of objects.

Students:

- plan and conduct an investigation of the effect of different-sized forces on the movement of an object
- discuss variables to change, measure and keep the same
- observe and record the results of their investigation
- create a table and column graph to represent and compare measurements.

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 2). Rubrics will be available on the website to help you monitor students' inquiry skills.

ELABORATE

Key lesson outcomes

Science

Students will be able to:

- plan and conduct an investigation of the effect of different-sized forces on the movement of an object
- construct a graph to represent their results
- summarise and compare results of the investigation.

Literacy

Students will be able to:

- understand the purpose and features of a table
- understand the purpose and features of a graph
- use written language to represent and record findings using a table and column graph
- record observations and measurements.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page 5).

Equipment

FOR THE CLASS

- class science journal
- word wall
- team skills chart
- team roles chart
- 'Smooth moves' information wall
- self-adhesive notes
- 1 enlarged copy of 'Forces investigation planner' (Resource sheet 1)
- 1 copy of 'Measuring forces' (Resource sheet 2)
- 1 table
- 1 empty matchbox
- 20 paperclips
- 1 thick elastic band
- ruler
- 1 length of streamer
- self-adhesive tape

FOR EACH TEAM

- role wristbands or badges for Director, Manager and Speaker
- each team member's science journal
- 1 copy of 'Forces investigation planner' (Resource sheet 1) per team member
- 1 copy of 'Measuring forces' (Resource sheet 2)
- 1 table
- 1 matchbox
- 20 paperclips
- 1 thick elastic band
- ruler
- 3 lengths of streamers

Preparation

- Read 'How to write questions for investigation' (Appendix 4).
- Read 'How to conduct a fair test' (Appendix 5).
- Read 'How to construct and use a graph' (Appendix 6).
- Read 'How to facilitate evidence-based discussions' (Appendix 7).
- Prepare an enlarged copy of the 'Forces investigation planner' (Resource sheet 1).
- Prepare the empty matchbox by putting 20 paperclips inside and cut the thick elastic band (vertically at one point) for each team. Place a small amount of self-adhesive tape around the matchbox to enclose paper clips inside the matchbox.
- *Optional:* Display 'Forces investigation planner' (Resource sheet 1) on an interactive whiteboard or on a computer connected to a projector. Check the Primary**Connections** website to see if an accompanying interactive resource has been developed: www.science.org/primaryconnections

Lesson steps

1. Review the previous lesson and contributions made to the word wall and 'Smooth moves' information wall. Review students' understanding of forces and the scientific convention for representing different-sized forces and their direction.
2. Introduce the matchbox and elastic band to the students. Explain that students will be working in collaborative learning teams to devise ways to move the matchbox using the elastic band.

3 Form teams and allocate roles. Ask Managers to collect team equipment. Allow time for teams to tinker with the matchbox and elastic band and discuss their ideas.

4 Ask students to discuss how they could use the elastic band to change the size of the force on the matchbox, for example, by pulling the elastic band back further or less.

5 Ask students what things (variables) might affect the movement of the matchbox, such as the size of the push from the elastic band, the surface of the table, the surface of the matchbox and the weight of the matchbox.

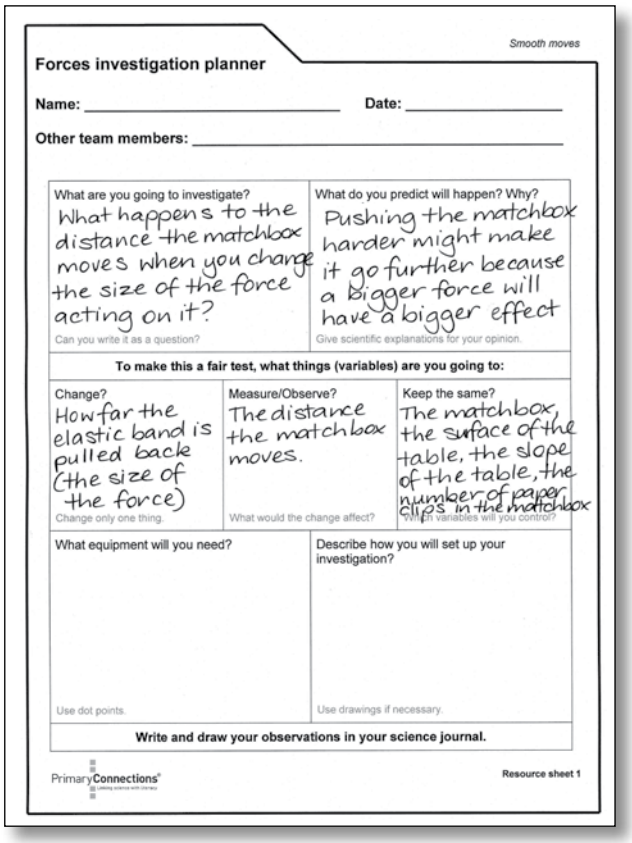
Record students' responses on self-adhesive notes.

6 Introduce the enlarged copy of the 'Forces investigation planner' (Resource sheet 1). Model how to develop a question for investigation. For example, we might choose to investigate 'What happens to the distance the matchbox moves when you change the size of the force acting on it?'.

7 Introduce the term 'variables' as things that can be changed, measured or kept the same in an investigation. Explain that when a variable is kept the same it is said to be 'controlled'. Ask students why it is important to keep some things the same when you are measuring changes (to make the test fair and so we know what caused the observed changes). For example:

- **change:** how far the elastic band is pulled back (the size of the force);
- **measure/observe:** the distance the matchbox moves;
- **keep the same:** the matchbox, the number of paperclips in the matchbox, slope of the table, the surface of the table.

Place self-adhesive notes from Lesson step 5 in the appropriate positions on the enlarged investigation planner.



Smooth moves

Forces investigation planner

Name: _____ **Date:** _____

Other team members: _____

What are you going to investigate?	What do you predict will happen? Why?
What happens to the distance the matchbox moves when you change the size of the force acting on it?	Pushing the matchbox harder might make it go further because a bigger force will have a bigger effect
Can you write it as a question?	Give scientific explanations for your opinion.

To make this a fair test, what things (variables) are you going to:

Change?	Measure/Observe?	Keep the same?
How far the elastic band is pulled back (the size of the force)	The distance the matchbox moves.	The matchbox, the surface of the table, the slope of the table, the number of paper clips in the matchbox
Change only one thing.	What would the change affect?	What variables will you control?

What equipment will you need?	Describe how you will set up your investigation?
Use dot points.	Use drawings if necessary.

Write and draw your observations in your science journal.

PrimaryConnections

Resource sheet 1

Enlarged 'Forces investigation planner'

ELABORATE

8 Discuss ways to keep the investigation fair. Ask questions, such as:

- What would happen if each team had matchboxes of different weight and used different-sized forces to move it? (We have changed two variables so we don't know which one made the difference to the distance the matchbox moved.)
- What if each team tested their matchbox on a different surface? (If we change the surface that we test the matchbox on and the size of the force used to move the matchbox then we don't know which one made the difference to the distance the matchbox moved.)

9 Explain that students are going to re-form their collaborative learning teams and investigate how different-sized forces affect the movement of an object.

10 Model how to set up the investigation equipment and how students will use the elastic band and the different positions on 'Measuring forces' (Resource sheet 2) to use three different-sized forces on the matchbox. Explain that students will use lengths of streamers to measure the distance the matchbox moved, starting from either 'Position A', 'Position B' or 'Position C'. Model how students will measure from each position, measure each streamer length with a ruler and transfer the data to the table to display the data.

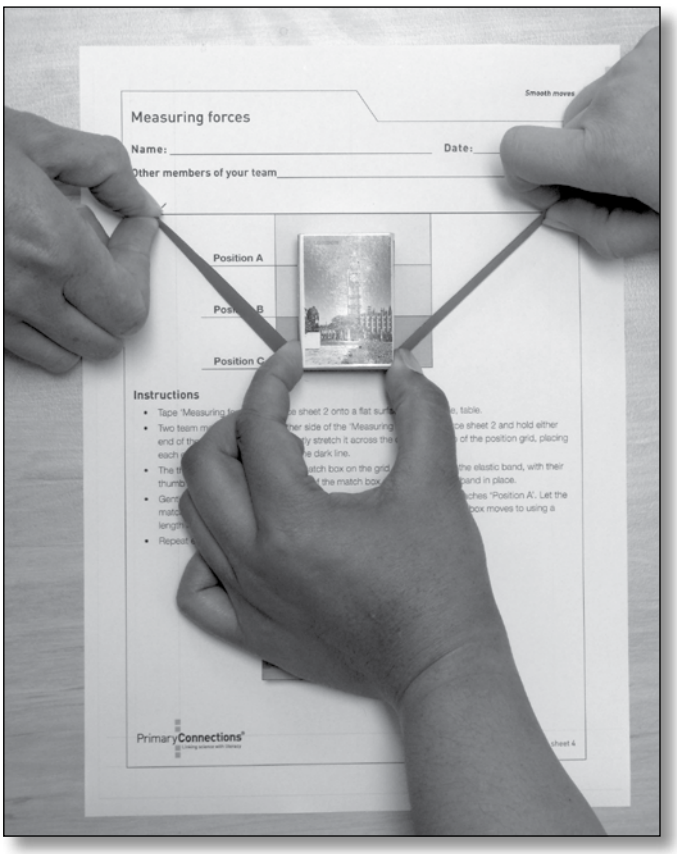


Photo of investigation set-up

11 Introduce the 'Finding out about forces' table in the 'Forces investigation planner' (Resource sheet 1). Discuss the purpose and features of a table and explain that teams will record their findings in the table.

ELABORATE

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.

12 Ask teams to set up their investigation equipment and allow time for teams to conduct their investigations and record their findings in the table.

13 Model how to construct a graph to represent the information recorded in their 'Finding out about forces' table. Discuss the purpose and features of a graph. Ask students to use their results in the 'Finding out about forces' table to construct a graph.

Literacy focus

Why do we use a graph?

We use a **graph** to organise information so we can look for patterns. We use different types of graphs, such as picture, column, or line graphs, for different purposes.

What does a graph include?

A **graph** includes a title, axes with labels on them and the units of measurement.

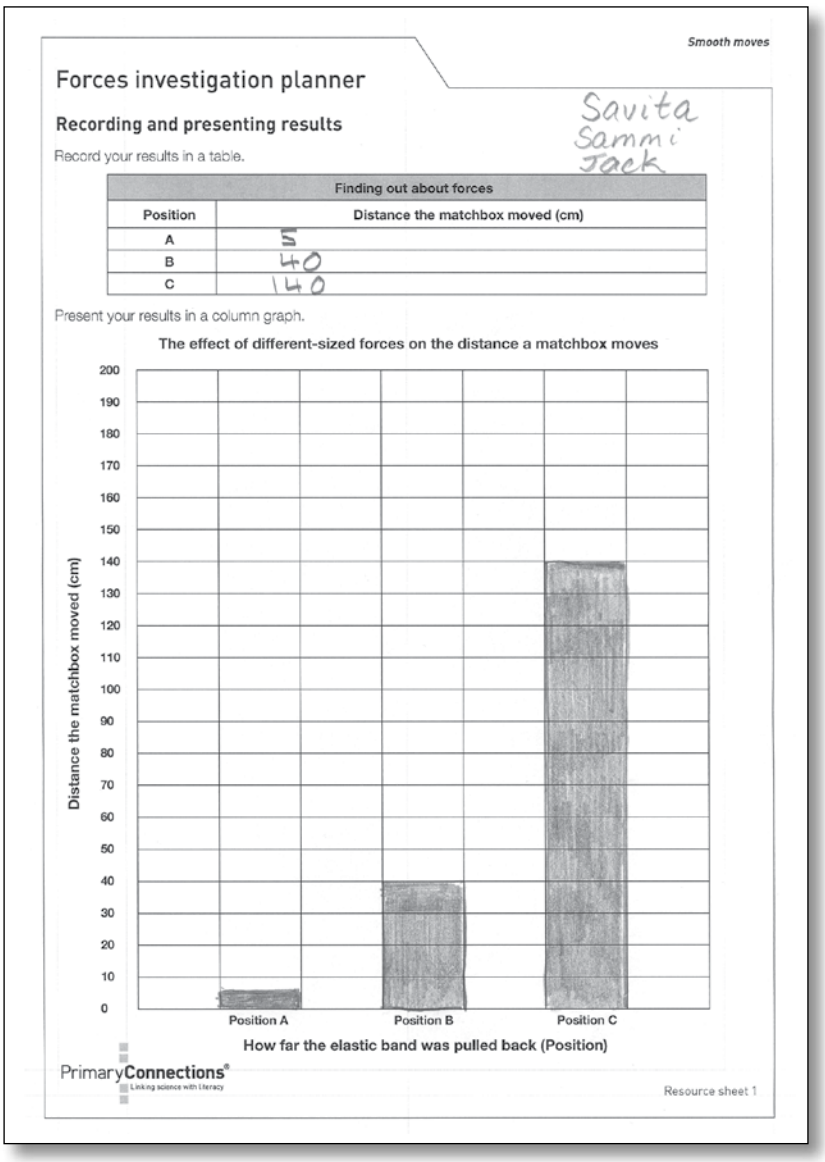
14 Ask students to use their results in the table to construct a graph. Ask students to analyse and compare graphs and look for patterns and relationships, asking questions, such as:

- What is the story of your graph?
- When did the matchbox move the longest/shortest distance? Why do you think that?
- Using the data from the graph, what can you tell us about relationship between the size of force and the effect on the matchbox?

15 Ask teams to discuss and record answers to the questions and summarise their findings in the 'Explaining results' and 'Evaluating the investigation' sections of the 'Forces investigation planner' (Resource sheet 1).

16 Ask Speakers to share their team's findings with the class. Encourage students to question each other using the 'Science question starters' in 'How to facilitate evidence-based discussions' (Appendix 7).

17 Update the word wall and add any further contributions to the 'Smooth moves' information wall.



Smooth moves

Forces investigation planner

Recording and presenting results

Record your results in a table.

Savita
Sammi
Jack

Finding out about forces	
Position	Distance the matchbox moved (cm)
A	5
B	40
C	140

Present your results in a column graph.

PrimaryConnections®
Linking science with literacy

Resource sheet 1

Team sample of graph

ELABORATE

Forces investigation planner

Team members' names:_____

Date:_____

What are you going to investigate?	What do you predict will happen? Why?
Can you write it as a question?	Give scientific explanations for your prediction.

To make this a fair test, what things (variables) are you going to:

Change?	Measure/Observe?	Keep the same?
Change only one thing.	What would the change affect?	Which variables will you control?

What equipment will you need?	Describe how you will set up your investigation?
Use dot points.	Use drawings if necessary.

Write and draw your observations in your science journal.

Forces investigation planner

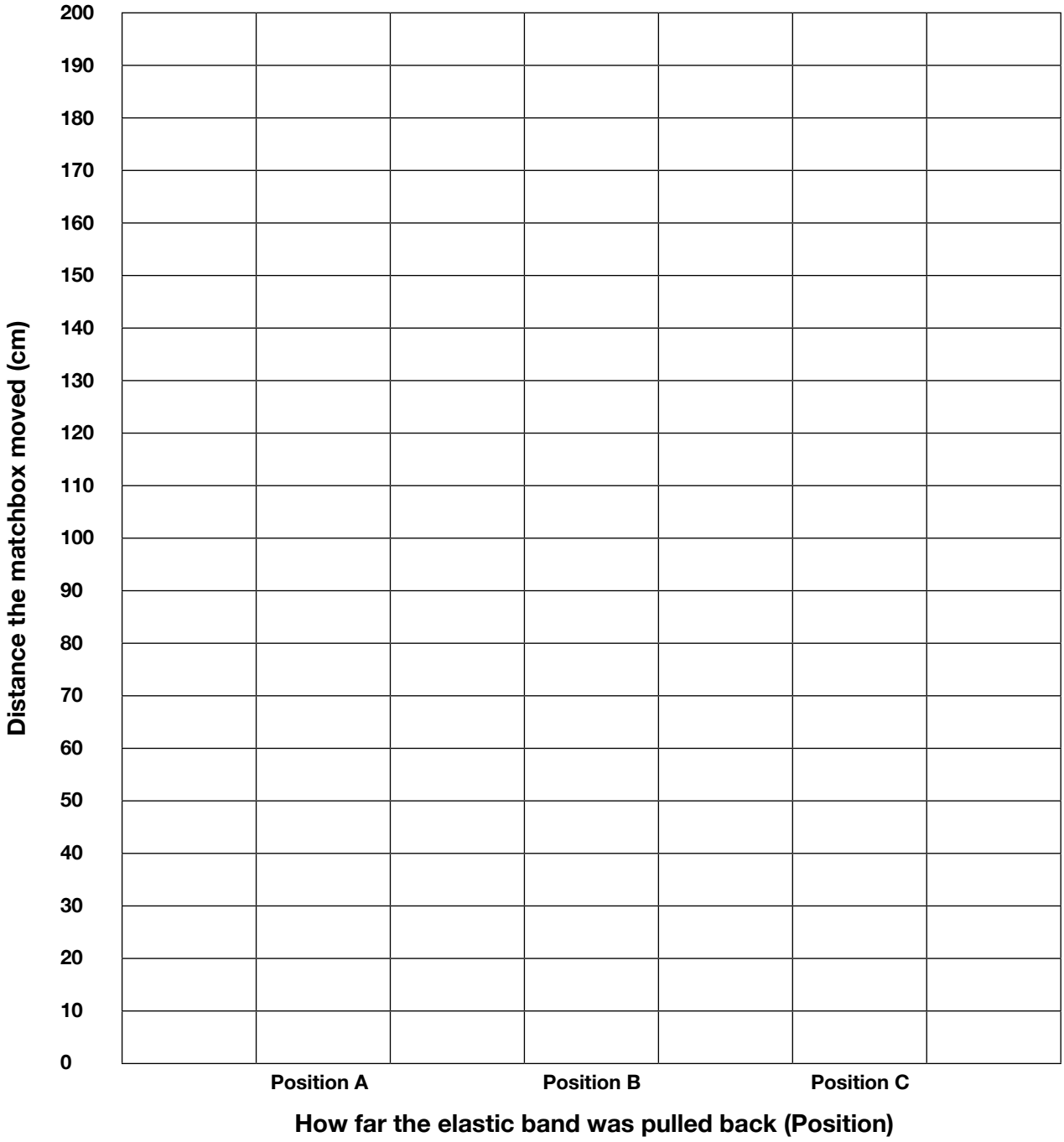
Recording and presenting results

Record your results in a table.

Finding out about forces	
Position	**Distance the matchbox moved (cm)**
A	
B	
C	

Present your results in a column graph.

The effect of different-sized forces on the distance a matchbox moves



Forces investigation planner

Explaining results

What happened to the matchbox when you changed how far the elastic band was pulled back?
Why did this happen?
Did the result match your prediction? If not, how was it different?

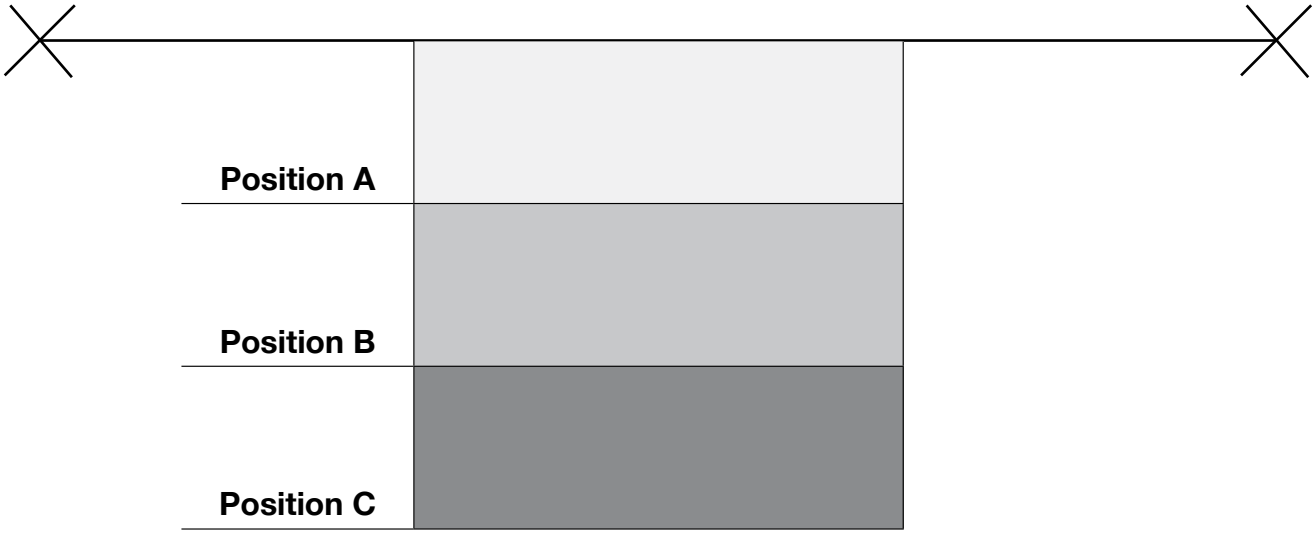
Evaluating the investigation

What challenges did you experience during the investigation?
How did you, or could you, overcome them?
How could you improve this investigation? (fairness, accuracy)

Measuring forces

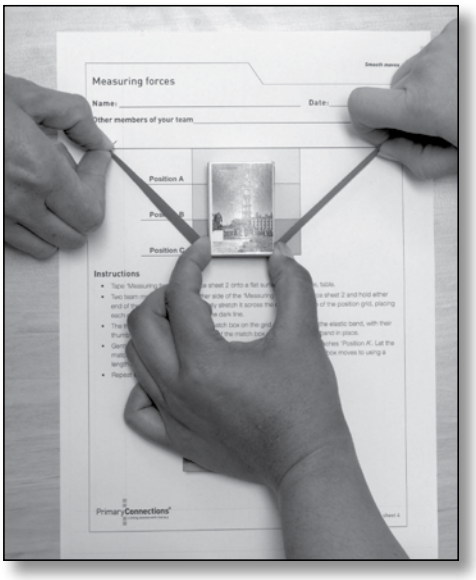
Team members' names:_____

Date:_____



Instructions

- Tape 'Measuring forces' (Resource sheet 2) onto a flat surface, for example a table.
- Two team members stand on either side of the 'Measuring forces' (Resource sheet 2) and hold either end of the cut elastic band and gently stretch it across the dark line on top of the position grid, placing each end on the 'X' at the ends of the dark line.
- The third team member places the matchbox on the grid, in the middle of the elastic band, with their thumb and index finger on either side of the matchbox, holding the elastic band in place.
- Gently pull the matchbox back so the side with the elastic band against it reaches 'Position A'. Let the matchbox go and measure the distance from 'Position A' to where the matchbox moves to using a length of streamer.
- Repeat each step for 'Position B' and 'Position C'.



Lesson 7 Forces finale

AT A GLANCE

To provide opportunities for students to represent what they know about how forces can be exerted by one object on another through direct contact or from a distance, and to reflect on their learning during the unit.

Students:

- review the unit, using the class science journal, word wall and 'Smooth moves' information wall
- create a game representing their understanding of forces acting on objects
- draw an annotated drawing of their new game
- 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 forces can be exerted by one object on another through direct contact or from a distance and that people use science to describe patterns and relationships.

Literacy products in this lesson provide useful work samples for assessment using the rubrics provided on the Primary**Connections** website.

EVALUATE

Key lesson outcomes

Science

Students will be able to:

- identify and describe different forces and motion
- explain that forces can act through direct contact or at a distance
- represent different-sized forces using different arrow lengths.

Literacy

Students will be able to:

- contribute to team discussions about forces acting on objects
- use visual and oral language to represent and describe forces using arrows
- use oral, written and visual language to describe forces and reflect on their learning during the unit.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page 5).

Equipment

FOR THE CLASS

- class science journal
- word wall
- 'Smooth moves' information wall
- selection of equipment from games (see Lesson 1)
- team roles chart
- team skills chart

FOR EACH TEAM

- role wristbands or badges for Director, Manager and Speaker
- each team member's science journal
- selection of materials to construct game (see 'Preparation')

Preparation

- Display equipment for games from Lesson 1.
- Organise a selection of materials for teams to use when constructing their games, such as cardboard, yoghurt containers, plastic tubing, foam balls.

Lesson steps

1. Review the previous lesson and contributions made to the word wall and the 'Smooth moves' information wall. Review students' understanding of the scientific convention for representing different-sized forces.
2. Review the games that students explored in Lesson 1 and the information they recorded on the 'Smooth moves' information wall.
3. Explain that students will be working in collaborative learning teams to create their own game, present it to the class and use their understanding of forces to explain the forces and movement that occur in their game.

Encourage teams to use ideas from the games they played in Lesson 1 when constructing their game for this lesson.

Note: As an alternative to making a game, teams can play and describe another game from Lesson 1 which they did not play.

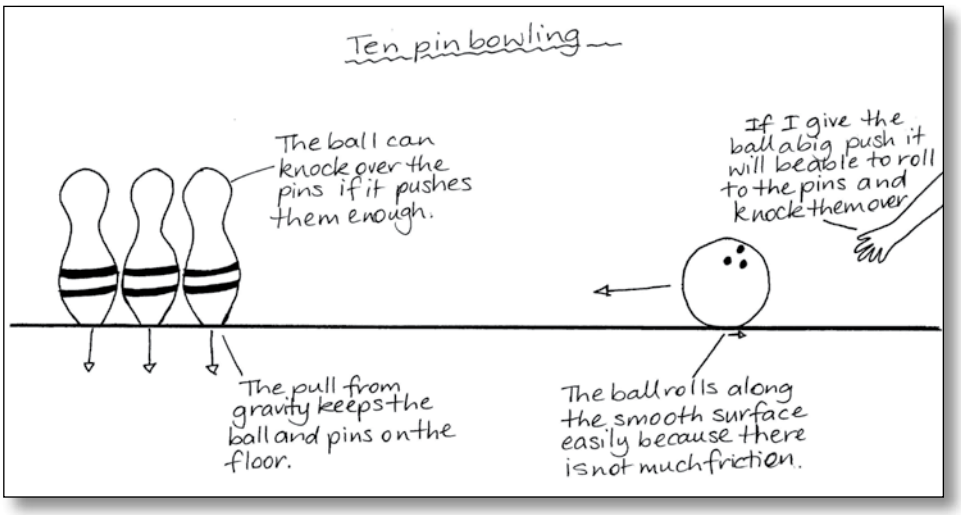
4 Form teams and allocate roles. Ask teams to plan and design their game. Ask Managers to collect any equipment and materials they might need to construct their game.

5 Ask teams to present their game to the class and discuss the forces and movement that occur in their game. Ask questions, such as:

- How are pushes and pulls used in your game?
- What can you tell us about the movement of objects occurring in your game?
- How would a large push or pull affect the game?
- How would a small push or pull affect the game?
- How do large and small pushes affect the movement of objects in your game?
- How are friction and gravity used in your game?

Optional: Allow time for teams to play each other's games.

6 Ask students to review their annotated drawing from Lesson 1 and create another annotated drawing of their team's constructed game, using captions and force-arrows to describe the forces and movement acting in the game.



Sample of annotated drawing

Optional: Invite teams to use their understanding of forces and motion to make a 'Playground for a marble'. They might have a competition to see which playground can keep the marble moving the longest. Teams can explain the effects of forces (including gravity and friction) on the motion of the marble.

7 Ask students to also review the *Smooth moves* unit in their science journal, recording their responses to questions, such as:

- What activity did you enjoy doing? Why?
- What new things have you learnt? What activities helped you learn them?
- What are you still wondering about?
- What did you learn about working in a team?

EVALUATE

Appendix 1
How to organise collaborative learning teams (Year 3–Year 6)

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 7.

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.

The development of these collaborative skills aligns to descriptions in the Australian Curriculum: English. See page 7.

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 Year 3–Year 6, teams consist of three students: Director, Manager and Speaker. (For F–Year 2, teams consist of two students: 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 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

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

PrimaryConnections 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
- Speak softly
- Stay with your team
- Take turns
- Perform your role.

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 SKILLS

1 Move into your teams quickly and quietly

2 Speak softly

3 Stay with your team

4 Take turns

5 Perform your role

TEAM ROLES

Manager

Collects and returns all materials the team needs

Speaker

Asks the teacher and other team speakers for help

Director

Makes sure that the team understands the team investigation and completes each step

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, measurements, 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.

Keeping a science journal aligns to descriptions in the Australian Curriculum: Science and English. See pages 2 and 7.

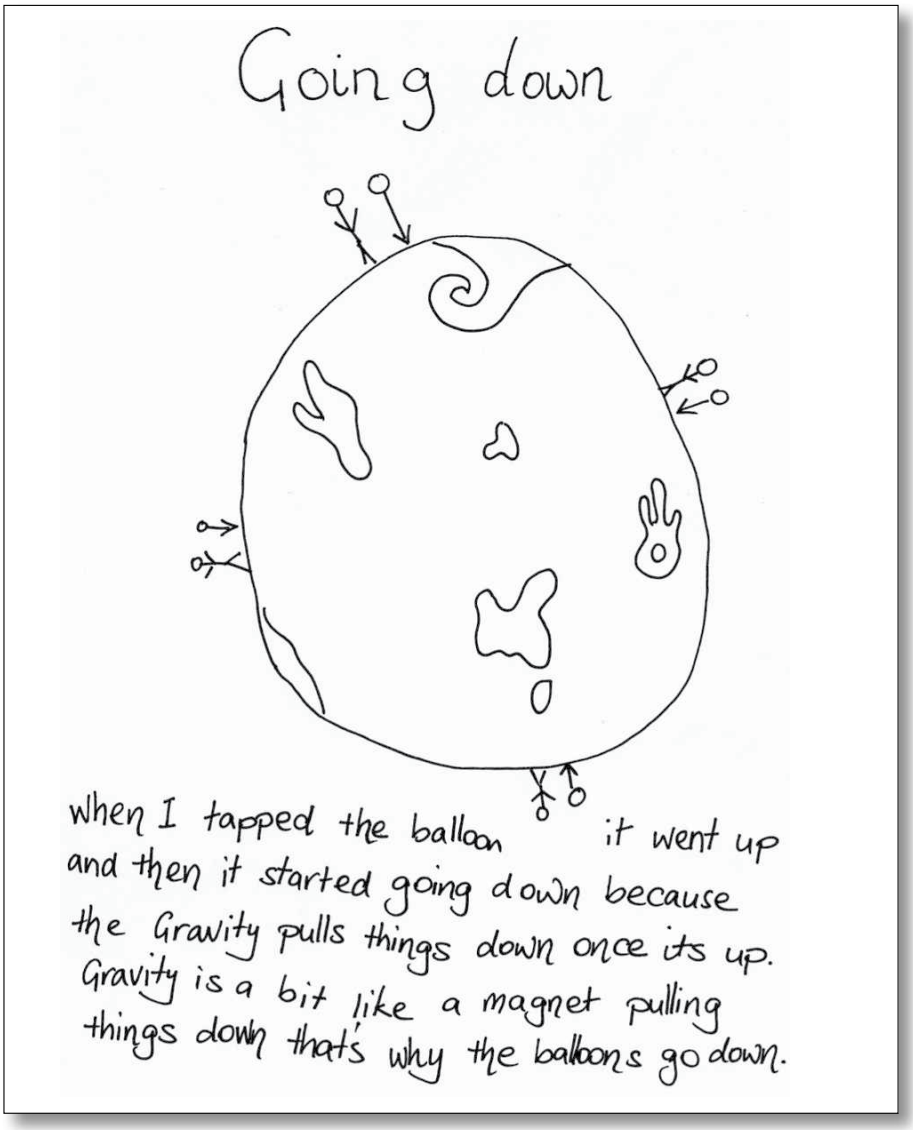
Using a science journal

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.



***Smooth moves* 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 7.

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

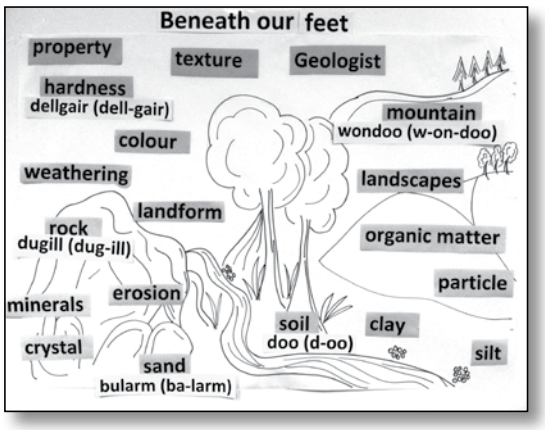
Position the word wall so that students have easy access to the words. They need to be able to see, remove and return word cards to the wall. A classroom could have one main word wall and two or three smaller ones, each with a different focus, for example, high-frequency words.

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-fastening dot to make it easy for students to remove and replace word cards.

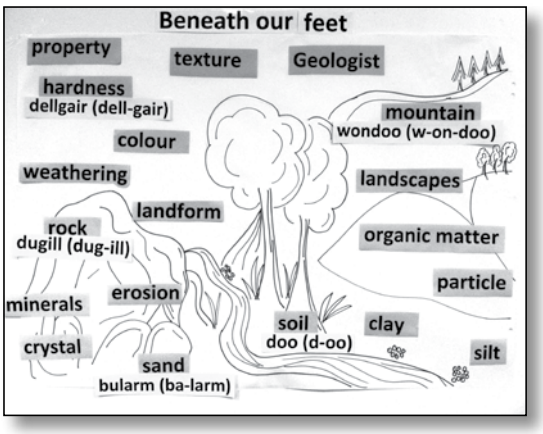
Word walls do not need to be confined to a wall. Use a portable wall, display screen, shower curtain or window curtain. Consider a cardboard shape that fits with the unit, for example, an animal silhouette for an animal characteristics unit. The purpose is for students to be exposed to a print-rich environment 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 *Smooth moves* unit might be organised using headings, such as ‘Pushes’, ‘Pulls’ and ‘Friction’.

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 animal, 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.



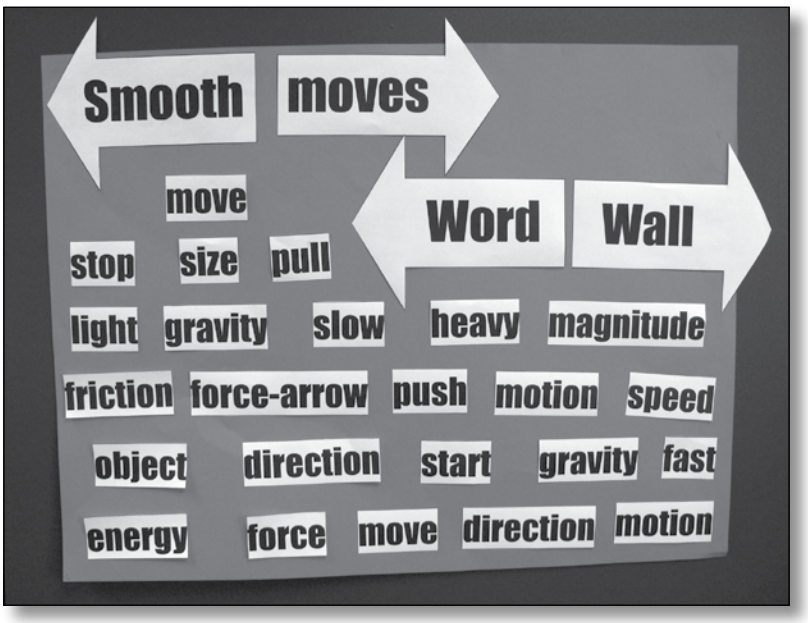
***Plants in action* word wall**



***Material world* 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.



***Smooth moves* word wall**

Appendix 4
How to write questions for investigation

Introduction

Scientific inquiry and investigation are focused on and driven by questions. Some questions are open to scientific investigation, while others are not. Students often experience difficulty in developing their own questions for investigation.

This appendix explains the structure of questions and how they are related to variables in a scientific investigation. It describes an approach to developing questions for investigation and provides a guide for constructing investigable questions with your students. Developing their own questions for investigation helps students to have ownership of their investigation and is an important component of scientific literacy.

The structure of questions for investigation

The way that a question is posed in a scientific investigation affects the type of investigation that is carried out and the way information is collected. Examples of different types of questions for investigation include:

- How does/do…?
- What effect does…?
- Which type of…?
- What happens to…?

All science investigations involve *variables.* Variables are things that can be changed, measured or kept the same (controlled) in an investigation.

- The **independent variable** is the thing that is changed during the investigation.
- The **dependent variable** is the thing that is affected by the independent variable, and is measured or observed.
- **Controlled variables** are all the other things in an investigation that could change but are kept the same to make it a fair test.

An example of the way students can structure questions for investigation is:

What happens to_____ when we change _____?

dependent variable **independent variable**

The type of question for investigation in *Smooth moves* refers to two variables and the relationship between them, for example, an investigation of the variables that affect how far a matchbox moves. The question for investigation could be:

Q1: What happens to the distance the matchbox moves when we change the size of the force acting on it?

In this question, *the distance the matchbox moves* depends on *the size of the force acting on it*. The size of the force acting on it is the thing that is **changed** (independent variable) and the distance the matchbox moves is the thing that is **measured or observed** (dependent variable).

Q2: What happens to the distance the matchbox moves when we change the angle of the surface of the table?

In this question, *the distance the matchbox moves* depends on *the angle of the surface of the table*. The angle of the surface is the thing that is **changed** (independent variable) and the distance the matchbox moves is the thing that is **measured or observed** (dependent variable).

Developing questions for investigation

The process of developing questions for investigation in *Smooth Moves* is to:

- Provide a context and reason for investigating.
- Pose a general focus question in the form of: 'What things might affect _____ (**dependent variable**)?'.

  For example, 'What things might affect the movement of a matchbox?'.

  - Use questioning to elicit the things (**independent variables**) students think might affect the **dependent variable**, such as the surface type, the mass of the matchbox, the size of the force acting on it.

  Each of the **independent variables** can be developed into a question for investigation, for example, the mass of the matchbox. These are the things that might be changed (**independent variables**), which students think will affect the thing that is measured or observed (**dependent variable**).
- Use the scaffold 'What happens to _____ when we change _____?' to help students develop specific questions for their investigation, for example, 'What happens to the distance the matchbox moves when you change the mass of the matchbox?'.
- Ask students to review their question for investigation after they have conducted their investigation and collected and analysed their information.
- Encouraging students to review their question will help them to understand the relationship between what was changed and what was measured in their investigation. It also helps students to see how the information they collected relates to their prediction.

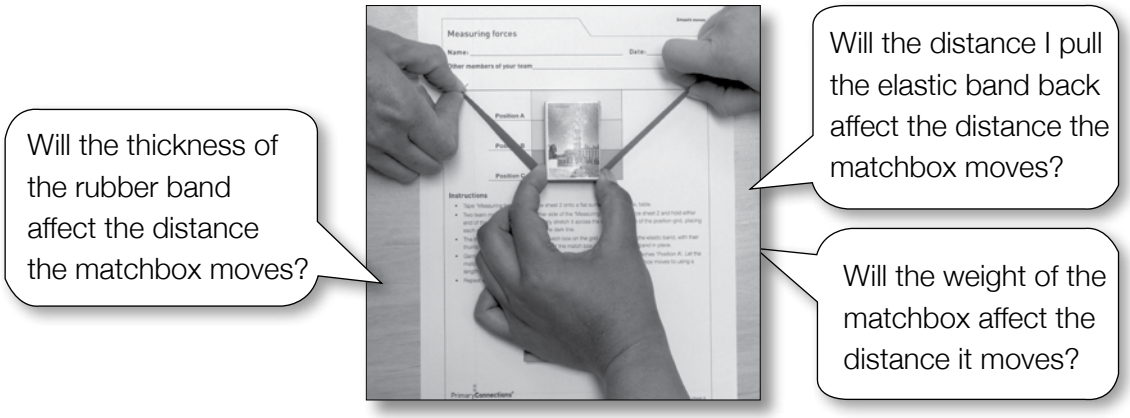
Appendix 5
How to conduct a fair test

Introduction

Scientific investigations involve posing questions, making predictions, planning and conducting tests, interpreting and representing evidence, explaining results and communicating findings.

Planning a fair test

In *Smooth moves*, students investigate the things that affect the distance a matchbox moves. All of these investigations are used to answer questions for inquiry about forces and their effect on motion of objects.



All scientific investigations involve variables. Variables are things that can be changed (independent), measured/observed (dependent) or kept the same (controlled) in an investigation. When planning an investigation, to make it a fair test, we need to identify the variables.

It is only by conducting a fair test that students can be sure that what they have changed in their investigation has affected what is being measured/observed.

'**C**ows **M**oo **S**oftly' is a useful scaffold to remind students how to plan a fair test:

Cows: **Change** one thing (independent variable)

Moo: **Measure/Observe** another thing (dependent variable) and

Softly: keep the other things (controlled variables) the **Same**.

To answer the question of inquiry 'Does the size of the force affect the distance a matchbox moves?', students could investigate whether a matchbox moves a greater or lesser distance when a larger force is applied (pulled back further). Students could:

CHANGE	how far the elastic band is pulled back (the size of the force)	Independent variable
MEASURE/OBSERVE	the distance the matchbox moves	Dependent variable
KEEP THE **SAME**	the thickness of elastic, the surface of the table, the weight of the matchbox	Controlled variables

Appendix 6
How to construct and use a graph (Year 4)

Introduction

A **graph** organises, represents and summarises information so that patterns and relationships can be identified. Understanding the conventions of constructing and using graphs is an important aspect of scientific literacy.

During a scientific investigation, observations and measurements are made and measurements are usually recorded in a table. Graphs can be used to organise the data to identify patterns, which help answer the research question and communicate findings from the investigation.

The Australian Curriculum: Mathematics describes data representation and interpretation for Year 4 as follows:

- Construct suitable data displays, with and without the use of digital technologies, from given or collected data. Include tables, column graphs and picture graphs where one picture can represent many data values.
- Evaluate the effectiveness of different displays in illustrating data features including variability.

Once you have decided to construct a graph, two decisions need to be made:

- What type of graph? and
- Which variable goes on each axis of the graph?

What type of graph?

The type of graph used depends on the type of data to be represented. Many investigations explore the effect of changing one variable while another is measured or observed.

Picture graph

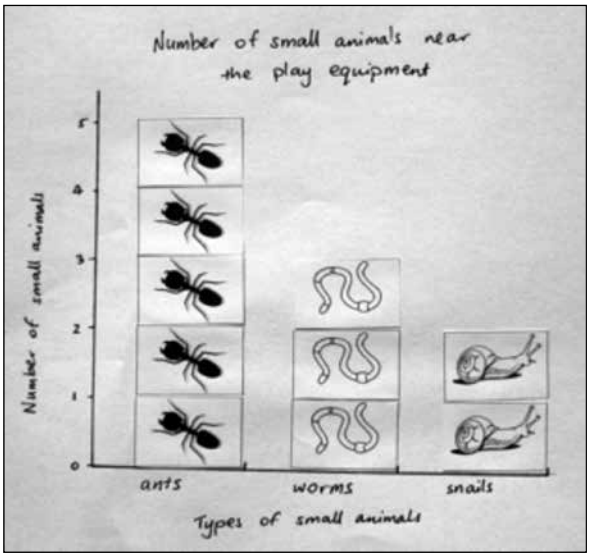
Picture graphs support students in the transition from using physical representations to representing information using symbols or pictures in columns. The symbols or pictures must be the same size.

Table A shows the results recorded for an investigation of the types of small animals found in different environments. This information is represented in Graph A by using one small picture for each animal in Table A.

Table A: Number of small animals near the play equipment

Types of small animals	Number of small animals
ant	5
worm	3
snail	3

Graph A: Number of small animals near the play equipment



In the graph above, each picture might also represent a number of animals, for example, 1 picture = 5 animals found.

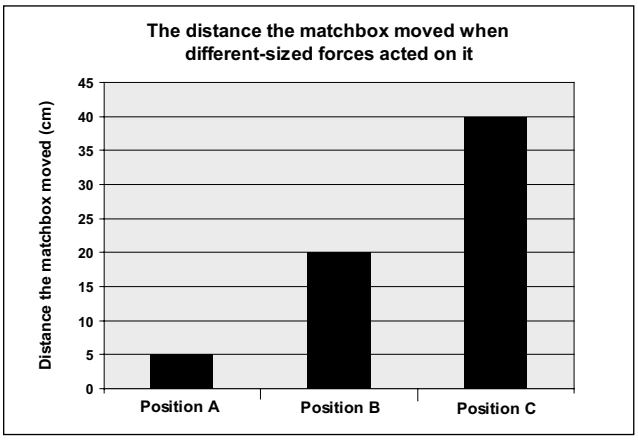
Column graph

Where data for one of the variables are in **categories** (that is, we use **words** to describe it, for example, Position A) a **column graph** is used. Graph B below shows how the results of an investigation of the effect of different-sized forces and the distance a matchbox moves **(data in categories)** have been constructed as a **column graph.**

Table B: The effect of different-sized forces on the distance a matchbox moves

Finding out about forces	
Position A	5 cm
Position B	20 cm
Position C	40 cm

Graph B: The effect of different-sized forces on the distance a matchbox moves



Which variable goes on each axis?

It is conventional in science to plot the variable that has been changed on the horizontal axis (X axis) and the variable that has been measured/observed on the vertical axis (Y axis) of the graph.

Graph titles and labels

Graphs have titles and each variable is labelled on the graph axes, including the units of measurement. The title of the graph is usually in the form of 'The effect of one variable on the other variable'. For example, 'The effect of different-sized forces on the distance a matchbox moves (Graph B)'.

Steps in analysing and interpreting data

Step 1 Organise the data (for example, construct a graph) so you can see the pattern in data or the relationship between data for the variables (things that we change, measure/observe or keep the same).

Step 2 Identify and describe the pattern or relationship in the data.

Step 3 Explain the pattern or relationship using science concepts.

Questioning for analysis

Teachers use effective questioning to assist students to develop skills in interrogating and analysing data represented in graphs. For example:

- What is the story of your graph?
- Do the data in your graph reveal any patterns?
- Is this what you expected? Why?
- Can you explain the pattern? Why did this happen?
- What do you think the pattern would be if you continued the line of the graph?
- How certain are you of your results?

Analysis

Analysis of Graph A shows that different numbers of small animals were found near the play equipment. Students could compare graphs of different environments to determine which environments suit which animals. For example, if lots of ants were found in the garden, near the play equipment and in the lunch area students might conclude that ants can live in lots of places in the schoolyard. If ants were only found in the garden, students might conclude that the ants prefer a garden habitat because they aren't found in other places.

Analysis of Graph B shows that the more force is applied to the matchbox the further it will move. This is because a larger force will have a greater effect on an object than a smaller force acting on the same object.

Appendix 7
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.

Claim, Evidence and Reasoning

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

Q – What **question** are you trying to answer? For example, 'What happens to the distance the matchbox moves when you change the size of the force acting on it?'

C – The **claim**, for example, 'The larger the force, the further the matchbox moves'.

E – The **evidence**, for example, 'We pulled an elastic band holding a matchbox back to different lengths and released it. The further we pulled it backwards, the larger the force acting on the matchbox when the band was released. We measured the distance travelled by the matchbox and it was further when the force was larger.'

R – The **reasoning**: saying how the evidence supports the claim, for example, 'We conducted a fair test and the only thing we changed was the distance the elastic band was pulled back. So that is what made the matchbox travel further.'

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 PrimaryConnections 5Es DVD, Chapter 5).

Science question starters

Question type	Question starter
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?

Appendix 8
Smooth moves equipment list

EQUIPMENT ITEM	QUANTITIES	Lesson	1	2	3	4	5	6	7
Equipment and materials									
arrows, cardboard	several per team						●		
balloon	1 per class or group					●			
cans, full, tin and of the same weight	2 per team			●					
detergent	small quantity per student				●				
elastic band, thick	1 per class/team							●	
equipment or props for role-play	selection per team						●		
games	1 per team		●						●
globe	1 per class					●			
gloves, disposable	1 pair per student				●				
marbles	1 per class		●						
matchbox	1 per class/team							●	
materials (eg, cardboard, yoghurt containers, plastic tubing, foam balls)	selection per team								●
object, heavy	1 per team				●				
paperclips	20 per class/team							●	
rope	1 length per class				●				
ruler	1 per class/team							●	
self-adhesive notes	several per student		●						
self-adhesive notes	several per class							●	
self-adhesive tape	1 roll per class							●	
surfaces (eg, lino, carpet, grass, floorboards and asphalt)	several per team				●				
streamers	1 length per class/ 3 lengths per team							●	
table or flat surface	1 per team			●					
table	1 per class/team							●	

EQUIPMENT ITEM	QUANTITIES	Lesson	1	2	3	4	5	6	7
Resource sheets									
'Forces investigation planner' (Resource sheet 1)	1 per student							●	
'Forces investigation planner' (Resource sheet 1), enlarged	1 per class							●	
'Measuring forces' (Resource sheet 2)	1 per class/team							●	
Teaching Tools									
class science journal	1 per class		●	●	●	●	●	●	●
team roles chart	1 per class		●	●	●		●	●	●
team skills chart	1 per class		●	●	●		●	●	●
student science journal	1 per student		●	●	●	●	●	●	●
word wall	1 per class		●	●	●	●	●	●	●
'Smooth moves' information wall	1 per class		●	●	●	●	●	●	●

Appendix 9
Smooth moves 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** Games galore	• describe forces and motion • observe the effect that different-sized forces have on objects • caption their annotated drawing with descriptions of the forces used in their game.	• contribute ideas to a class discussion about ways to move a marble • understand the purpose and features of a science journal • create an annotated drawing of their game • use talk to describe their game and contribute to a team discussion about forces • record observations in the class science journal.	• play a game in collaborative learning teams • describe how to play the game • create an annotated drawing of their game, using captioning to describe forces acting on objects.	**Diagnostic assessment** • Science journal entries • Class discussions • Word wall contributions • Annotated drawings

* These lesson outcomes are aligned to relevant descriptions of the Australian Curriculum. See page 2 for Science and page 7 for English and Mathematics.

		SCIENCE OUTCOMES*	LITERACY OUTCOMES*	LESSON SUMMARY	ASSESSMENT OPPORTUNITIES
		Students will be able to:	Students will be able to:	Students:	
EXPLORE	**Lesson 2** Making moves	• observe, compare and record the use of different-sized forces to move tin cans • make predictions and give reasons about the movement of objects • draw conclusions about the effect of different-sized forces on the movement of objects.	• understand the purpose and features of a storyboard • contribute to a class discussion about different-sized forces • represent their understanding of different-sized forces using different-sized arrows.	• explore the effect of different-sized forces on rolling cans • contribute to a class discussion about how to represent different-sized forces • use arrows to represent different-sized forces.	**Formative assessment** • Science journal entries • Class discussions • Word wall contributions • Storyboards
	Lesson 3 Feeling friction	• identify forces that act in direct contact • investigate frictional forces between an object and different surfaces • observe and describe ways of reducing and increasing friction.	• contribute to a class discussion about friction • use oral, written and visual language to describe observations of pulling objects across different surfaces.	• observe how friction is different with different surfaces • explore what more or less friction feels like • use arrows to represent frictional forces.	**Formative assessment** • Science journal entries • Class discussions • Word wall contributions • Drawings

* These lesson outcomes are aligned to relevant descriptions of the Australian Curriculum. See page 2 for Science and page 7 for English and Mathematics.

		SCIENCE OUTCOMES*	LITERACY OUTCOMES*	LESSON SUMMARY	ASSESSMENT OPPORTUNITIES
		Students will be able to:	Students will be able to:	Students:	
EXPLORE	**Lesson 4** Faraway forces	• identify forces that act at a distance • explore gravity's effect on an object • discuss gravity and the different ways they experience it in their lives.	• contribute to a class discussion about gravity • use oral and visual language to represent their understanding of gravity.	• participate in a class game: 'Going up' • observe how gravity makes objects fall • participate in a discussion about gravity around the world • represent gravity acting on objects around the world.	**Formative assessment** • Science journal entries • Class discussions • Word wall contributions • Drawings
EXPLAIN	**Lesson 5** Figuring out forces	• develop an explanation for forces acting on objects in a game • use different-sized arrows to represent different-sized forces • identify and explain the role of forces present in a real-life scenario.	• understand the purpose and features of a narrative • understand the purpose and features of a role-play • participate in a role-play to explain the forces present in a real-life scenario • understand the purpose and features of a force-arrow diagram • contribute to a class discussion about forces and motion.	• explain their understanding of the forces acting in their game from Lesson 1 • use role-play and narrative to describe and represent forces acting in a real-life scenario.	**Formative assessment** • Science journal entries • Class discussions • Word wall contributions • Role-plays • Narratives • Force-arrow diagrams

* These lesson outcomes are aligned to relevant descriptions of the Australian Curriculum. See page 2 for Science and page 7 for English and Mathematics.

		SCIENCE OUTCOMES*	LITERACY OUTCOMES*	LESSON SUMMARY	ASSESSMENT OPPORTUNITIES
		Students will be able to:	Students will be able to:	Students:	
ELABORATE	**Lesson 6** Catapult capers	• plan and conduct an investigation of the effect of different-sized forces on the movement of an object • construct a graph to represent their results • summarise and compare results of the investigation.	• understand the purpose and features of a table • understand the purpose and features of a graph • use written language to represent and record findings using a table and column graph • record observations and measurements.	• plan and conduct an investigation of the effect of different-sized forces on the movement of an object • discuss variables to change, measure and keep the same • observe and record the results of their investigation • create a table and column graph to represent and compare measurements.	**Summative assessment** • Science journal entries • Class discussions • Word wall contributions • 'Forces investigation planner' (Resource sheet 1) • Tables • Graphs
EVALUATE	**Lesson 7** Forces finale	• identify and describe different forces and motion • explain that forces can act through direct contact or at a distance • represent different-sized forces using different arrow lengths.	• contribute to team discussions about forces acting on objects • use visual and oral language to represent and describe forces using arrows • use oral, written and visual language to describe forces and reflect on their learning during the unit.	• review the unit, using the class science journal, word wall and 'Smooth moves' information wall • create a game representing their understanding of forces acting on objects • draw an annotated drawing of their new game • reflect on their learning during the unit.	**Summative assessment** • Science journal entries • Class discussions • Word wall contributions • Annotated drawings

* These lesson outcomes are aligned to relevant descriptions of the Australian Curriculum. See page 2 for Science and page 7 for English and Mathematics.

PrimaryConnections®
Linking science with literacy

Australian Academy of Science

Professional learning

*Primary**Connections:** linking science with literacy* is an innovative program linking the teaching of science with the teaching of literacy in primary schools. The program includes a professional learning component and curriculum units aligned to the Australian Curriculum: Science.

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Year	Biological sciences	Chemical sciences	Earth and space sciences	Physical sciences
F	*Staying alive*	*What's it made of?*	*Weather in my world*	*On the move*
1	*Schoolyard safari*	*Spot the difference*	*Up, down and all around*	*Look! Listen!*
2	*Watch it grow!*	*All mixed up*	*Water works*	*Push pull*
3	*Feathers, fur or leaves?*	*Melting moments*	*Night and day*	*Heating up*
4	*Plants in action*	*Material world*	*Beneath our feet*	*Smooth moves*
	Friends and foes	*Package it better*		
5	*Desert survivors*	*What's the matter?*	*Earth's place in space*	*Light shows*
6	*Marvellous micro-organisms*	*Change detectives*	*Earthquake explorers*	*It's electrifying*
				Essential energy

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