Transforming Energy

FUTURE MAKERS TEACHER RESOURCE

QGC | FUTUREMAKERS | QUEENSLAND MUSEUM NETWORK | Queensland Government

Future Makers

Future Makers is an innovative partnership between Queensland Museum Network and Shell's QGC business aiming to increase awareness and understanding of the value of science, technology, engineering and maths (STEM) education and skills in Queensland.

This partnership aims to engage and inspire people with the wonder of science, and increase the participation and performance of students in STEM-related subjects and careers – creating a highly capable workforce for the future.

Cover image: Diesel electric 1250 Class: No.1262 on display at The Workshops Rail Museum, Ipswich. © Queensland Museum, Peter Waddington.

QUEENSLAND MUSEUM NETWORK

Queensland Government

Contents

Workshop Overview

Energy – in all its forms – is an integral part of our lives. Within this workshop, students design products and systems that incorporate different forms of energy, and identify the energy transfers and transformations that occur in locomotives. Students also investigate the history of electricity in Queensland, design a battery-powered toy car and use the specifications of different vehicles to plan a journey across Queensland.

Within this workshop, you will engage with various objects from Queensland Museum's Cultures and Histories collection. This collection is comprised of objects that are significant to the people of Queensland. Cultural and historical collections provide a tangible link to human innovation and experience. The researching and collecting of our cultures and histories documents the present, and the very recent past, for the future.

This workshop has been structured using the 5E's instructional model.

The following topics and concepts are explored in each aspect of the workshop:

ENGAGE **EXPLORE** **EXPLAIN**	**Queensland Museum Toy Factory** Design and create an innovative toy for children. Design prompts encourage students to incorporate different forms of energy into their designs.
EXPLORE **EXPLAIN** **ELABORATE** **EVALUATE**	**Gravity Run** Use a gravity run to explore energy, energy transfers and transformations. Then modify the gravity run to incorporate other forms of energy that are not present in the system.
EXPLORE **EXPLAIN** **ELABORATE**	**Locomotives at Work** Use locomotives from The Workshops Rail Museum's collection to explore energy transfers and transformations. Interpret Sankey diagrams and calculate the hypothetical energy efficiency of various locomotives.
EXPLAIN **ELABORATE**	**Managing Collections at The Workshops Rail Museum** Learn about the work of Rob Shiels, Curator of Transport at The Workshops Rail Museum.
ENGAGE **EXPLORE**	**Electricity Brings Prosperity** Consider and reflect on an electrical advertisement from the 20th century, develop an understanding of the history of electricity in Brisbane, and write a journal from the perspective of a member of the public witnessing electric lighting for the first time.
EXPLORE **EXPLAIN** **ELABORATE** **EVALUATE**	**Electrifying Vehicles** Explore the story of the Lucas Bedford electric van, make a battery-powered car in a hands-on design challenge, and use the specifications of different electric vehicles to plan a road trip across Queensland.

ENGAGE – EXPLORE – EXPLAIN

Queensland Museum Toy Factory

Teacher Resource

In this activity, students are engineers tasked with developing an innovative toy for babies. Year 6 students investigate how they can use electrical energy in a toy to help a baby recognise colours or learn about cause and effect. Year 8 students investigate how they can use motion, force and energy in a toy to help a baby learn how to walk. Students work in pairs to complete this activity.

Aspects of this activity assume Year 6 students understand electrical systems and components, and Year 8 students understand energy, energy transfers and transformations. However, it is possible to deliver this activity at the start of a unit of work about energy (electrical or otherwise). In this instance, we recommend students respond to concept specific questions (i.e. draw a circuit diagram of the toy; draw a flow diagram to represent the energy transfers and transformations that occur in the toy) after they have developed sufficient knowledge about these concepts.

During the initial design phase, students may gain inspiration for their toy design from Queensland Museum collections. Visit Queensland Museum's Online Collections webpage and search 'toy' to explore the collection. Further prompts and questions that you can use to guide students through this activity are provided on the following pages.

A toy from Queensland Museum's collection. This clockwork toy canary is operated by a winding key (seen in the image on the left). This example demonstrates one way kinetic energy can be incorporated into a toy's design. QM, Peter Waddington.

After students have designed their toy, they create an advertisement that persuades an adult to purchase the toy for a child. Students could produce a print, television, radio or digital advert.

Maker Space

Maker Spaces are 'creative spaces where people gather to tinker, create, invent, and learn.'[1] They promote the development of problem-solving skills, critical and creative thinking, inquiry capabilities, design thinking skills, the ability to work collaboratively and autonomously, scientific understanding, technological capabilities, communication skills, reflective thinking and resilience.[2]

1 Hughes, J. (2017). *Meaningful Making: Establishing a Makerspace in Your School or Classroom.* Ontario Ministry of Education. https://brocku.ca/supporting-coaches/wp-content/uploads/sites/247/Hughes-J.-2017-April-Meaningful-Making-Establishing-a-Makerspace-in-Your-School-or-Classroom.pdf

2 Bower et al. (2018). *Makerspaces in Primary School Settings: Advancing 21st Century and STEM Capabilities using 3D Design and 3D Printing.* Macquarie University. https://primarymakers.com/

The Maker Space at *SparkLab, Sciencentre* encourages visitors to get hands on and design and create solutions to challenging questions. User-centred design is a key aspect of *SparkLab's* Maker Space. Here, children design a solution for a specific user – whether that be a person who needs to travel down a zip line or take a seat on a chair.

In a Maker Space, children firstly think of some possible solutions for their user. They then select a solution, make a prototype of the solution, test it out, improve on their design and then test their design again to explore the effects of any modifications. You can learn more about *SparkLab's* Maker Space by watching the *SparkLab*: Design Process video.

A variety of materials from which children can construct a prototype should be provided in a Maker Space. There should be enough materials to allow for a range of different solutions, but not too many materials so that choices become overwhelming. Suggested materials for the *Queensland Museum Toy Factory: Maker Space* activity are listed on the following pages.

The Shake It Up Maker Space in action at SparkLab, Sciencentre. QM, Peter Waddington.

Curriculum Links

Science

YEAR 6

Science Understanding

Electrical energy can be transferred and transformed in electrical circuits and can be generated from a range of sources (ACSSU097)

Science as a Human Endeavour

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

Science Inquiry Skills

Identify, plan and apply the elements of scientific investigations to answer questions and solve problems using equipment and materials safely and identifying potential risks (ACSIS103)

Compare data with predictions and use as evidence in developing explanations (ACSIS221)

Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS110)

YEAR 8

Science Understanding

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

Science as a Human Endeavour

People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity (ACSHE136)

Science Inquiry Skills

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

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

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

Design and Technologies

YEAR 5 AND 6

Design and Technologies Knowledge and Understanding

Investigate how electrical energy can control movement, sound or light in a designed product or system (ACTDEK020)

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

Design and Technologies Processes and Production Skills

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

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

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

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

YEAR 7 AND 8

Design and Technologies Knowledge and Understanding

Analyse how motion, force and energy are used to manipulate and control electromechanical systems when designing simple, engineered solutions (ACTDEK031)

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

Design and Technologies Processes and Production Skills

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

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

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

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

English

YEAR 6

Language

Investigate how vocabulary choices, including evaluative language can express shades of meaning, feeling and opinion (ACELA1525)

Literacy

Plan, draft and publish imaginative, informative and persuasive texts, choosing and experimenting with text structures, language features, images and digital resources appropriate to purpose and audience (ACELY1714)

YEAR 8

Language

Understand how rhetorical devices are used to persuade and how different layers of meaning are developed through the use of metaphor, irony and parody (ACELA1542)

Literacy

Create imaginative, informative and persuasive texts that raise issues, report events and advance opinions, using deliberate language and textual choices, and including digital elements as appropriate (ACELY1736)

Experiment with text structures and language features to refine and clarify ideas to improve the effectiveness of students' own texts (ACELY1810)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Composing texts through speaking, writing and creating

Text knowledge

Grammar knowledge

Information and Communication Technologies

Investigating with ICT

Managing and operating ICT

Critical and Creative Thinking

Inquiring – identifying, exploring and organising ideas

Generating ideas, possibilities and actions

Reflecting on thinking and processes

Analysing, synthesising and evaluating reasoning and procedures

Personal and Social Capability

Social management

Queensland Museum Toy Factory

Teacher Resource

Prompts and Questions

The following prompts and questions can be used to guide students through this activity. Students are expected to cycle through this process, and between the test and refine stages, multiple times.

Consider the Challenge

- What are the requirements of the design challenge?
- How could you measure success?

Think of Some Solutions

- What are some real-world examples of baby toys that meet your design brief?
- What materials and components are used in the toy design?
- What equipment and processes are needed to make the toy?
- What ideas do you have for a design?

Make a Prototype

- What materials could you use in your design?
- How will the properties of different materials affect what you use?
- What components could you use in your design? What will these components do?
- Create a labelled diagram of your design. Explain and justify your ideas in the diagram.
- How will you work safely?
- Now that you are making your design, how suitable are the materials and components? What changes might you need to make to the design of the toy?

Test It Out

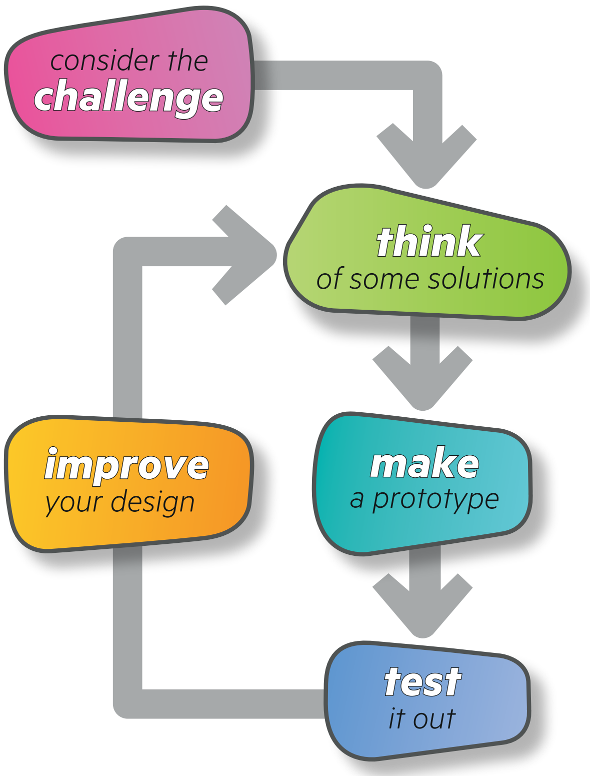
- Test out your design. What did you notice?
- Does the toy meet the needs of the user?
- Did the toy operate as you intended?
- What part of your design worked really well?

Improve Your Design

- What changes will you make to improve your design?
- How could you modify the toy to better meet the needs of the user?
- What ideas could you incorporate from someone else's design?
- Continue to test and refine until you are satisfied with your design.

Evaluate Your Design

- What aspects of your toy are you very satisfied with, and why?
- Describe any further changes you could make to improve the toy.
- What were the main challenges you experienced during the design process? How did you overcome these challenges?
- If you started again, what would you do differently?
- What have you learnt about science or design from this activity?
- Did the design meet your idea of success?



Queensland Museum Toy Factory

Teacher Resource

Material Suggestions

We recommend the following materials for your classroom's Maker Space. You can substitute some materials for others or provide additional materials that are not listed below. Ensure students know how to work safely with electrical components before they create their designed solutions.

Materials for the Surface of the Toy

- Paper
- Fabric
- Cellophane
- Patty papers
- Milk bottle lids or similar
- Paper clips

Connectors

- Straws
- Paddle pop sticks
- Skewers
- Pipe cleaners
- Rubber bands
- String
- Thumbtacks
- Split pins

Joiners

- Masking tape

Electrical Components

- Electrical wire or alligator clips with lead wire
- Aluminium foil
- Electrical tape
- Electric buzzers
- LED lights
- Motors
- Switches (toggle, contact, slide or paperclips, thumbtacks, split pins)
- Batteries
- Battery snaps and/or holders

Tools

- Scissors

Queensland Museum Toy Factory

Student Activity

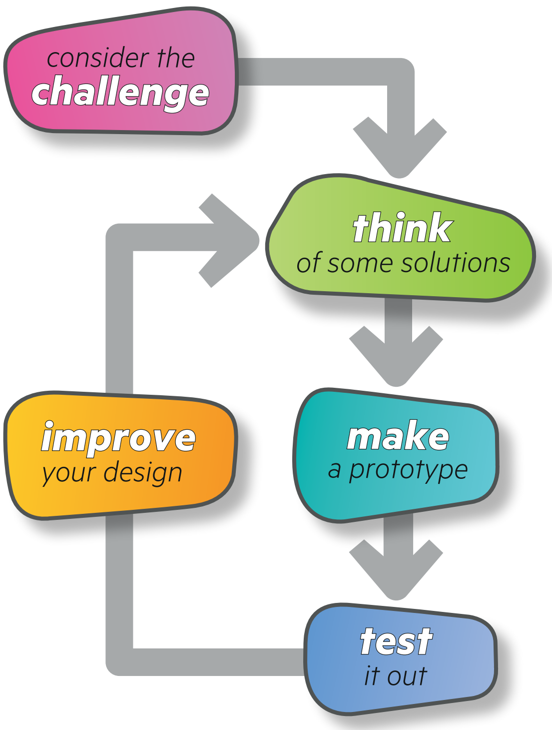
Year 6

Task:

Design and create a toy that will help a baby recognise different colours or learn about cause and effect.

You must:

- **Consider the challenge.** What are the requirements of the design challenge?
- **Think of some solutions.** Investigate real-world examples of baby toys. How do these toys help a baby recognise different colours or learn about cause and effect? What ideas do you have for a design?
- **Make a prototype.** What materials and components will you use? How will you work safely? Create a labelled diagram of your design, and then construct your prototype.
- **Test it out.** What did you notice? Does the toy achieve the design prompt? Does the toy meet the needs of a baby?
- **Improve your design.** How can you make your toy better achieve the design prompt and meet the needs of a baby? Keep testing and refining until you are satisfied with your design.
- **Evaluate your design.** What aspects of your design are you very satisfied with, and why? What challenges did you experience during the design process, and how did you overcome them?



Respond to the following questions after you have designed your toy.

1. Identify the electrical components used to make the toy. Draw the electrical symbol for these components, and then describe the purpose of the components.

Electrical Component	**Symbol**	**Purpose**

2. Explain how electrical energy was used to control movement, sound or light in your toy.

3. Draw a circuit diagram of the toy.

Queensland Museum Toy Factory

Student Activity

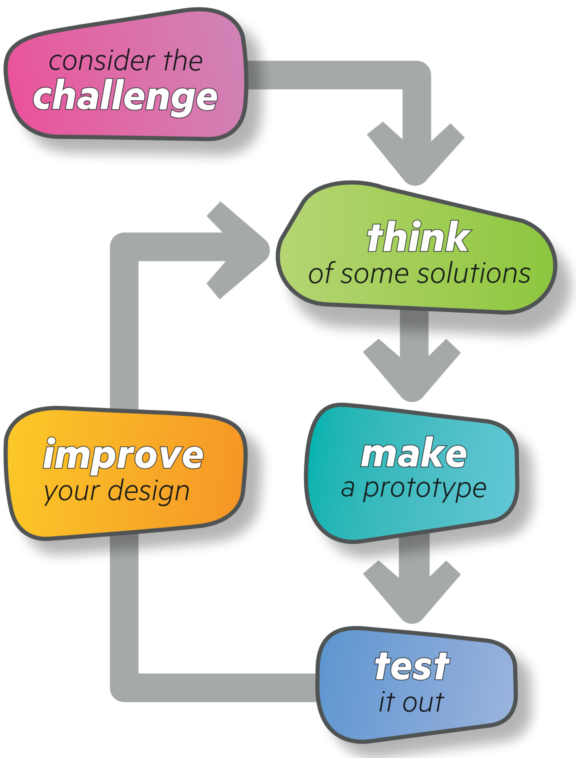
Year 8

Task:

Design and create a toy that will help a baby learn how to walk.

You must:

- **Consider the challenge.** What are the requirements of the design challenge?
- **Think of some solutions.** Investigate real-world examples of baby toys. How do these toys use motion, force and energy to help a baby learn how to walk? What ideas do you have for a design?
- **Make a prototype.** What materials and components will you use? How will you work safely? Create a labelled diagram of your design, and then construct your prototype.
- **Test it out.** What did you notice? Does the toy achieve the design prompt? Does the toy meet the needs of a baby?
- **Improve your design.** How can you make your toy better achieve the design prompt and meet the needs of a baby? Keep testing and refining until you are satisfied with your design.
- **Evaluate your design.** What aspects of your design are you very satisfied with, and why? What challenges did you experience during the design process, and how did you overcome them?



Respond to the following questions after you have designed your toy.

1. Identify the forms of energy used by the toy.

2. Describe any energy transfers and/or transformations that occur in the toy.

3. Draw a flow diagram to represent the energy transformations that occur in the toy.

Queensland Museum Toy Factory

Student Activity

Make Me Want That Toy!

You have designed your toy, and now it is time to sell your toy! Create an advertisement that persuades adults to purchase your toy for their child. Consider the following:

- How you will advertise your toy? Will you produce a print, television, radio or digital advert?
- What persuasive language will make your toy a 'must have' item?
- What visual effects will you use? Think carefully about images, fonts and colours.
- How will you appeal to emotion, logic and reason, or credibility and character?

Describe or draw your advertisement in the space below.

EXPLORE – EXPLAIN – ELABORATE – EVALUATE

Gravity Run

Teacher Resource

The gravity run is a collaborative, open-ended exhibit at *SparkLab, Sciencentre*. Here, visitors work together to problem-solve building a successful ball run using a series of pipes, curves, wheels, hanging bells and balls. They may also extend the challenge to create a run that fits to set criteria.

In this activity, students use a gravity run as a tool to explore different forms of energy, including electrical energy, as well as energy transfers and transformations. They work in groups of two or three to improve the gravity run by designing a new part for the run that incorporates electrical energy (Year 6) and/or other forms of energy that are not already present in the system (Year 8). Please note, this activity assumes Year 6 students have developed knowledge and understanding of electrical systems and components, and Year 8 students have developed knowledge and understanding of energy, energy transfers and transformations.

Children building and testing the gravity run at SparkLab, Sciencentre. Image: John Nguyen.

Before engaging with this activity, you may like to view the gravity run in action at *SparkLab, Sciencentre*. You could view a video of the gravity run challenge or visit *SparkLab, Sciencentre* to build and test your own gravity run. Registered teachers are invited to a free preview of *SparkLab, Sciencentre*. Contact the Queensland Museum Bookings Officer via phone (07) 3153 4401 or email education@qm.qld.gov.au to arrange your free entry.

Detailed step-by-step instructions for this activity can be seen below. It is recommended that you use these instructions to guide your students through the activity.

1. Consider where you would like to create the gravity run at school. Is there a free wall in the classroom, or will you need to use wall space outside?
2. Consider how you will stick materials like cardboard or plastic to this surface. Could you use masking tape, gaff tape, thumbtacks, velcro or magnets?
3. Gather the following materials prior to delivering the activity in the classroom. You may choose to substitute some materials for others or provide additional materials that are not listed below. Some materials will be saved for later, when students are required to improve the gravity run.

Pre-Selected Materials

- Track materials, such as cardboard, cardboard tubes, flexible plastic, PVC pipes etc.
- Balls, such as golf balls or ping pong balls
- Adhesive materials, such as masking tape, gaff tape, thumbtacks, velcro, magnets etc. These materials can be used to construct the tracks and to stick the track materials to the wall. Which adhesives you work with will depend on your chosen wall surface.
- Start sign
- Finish sign

Improvement Materials

- Scissors
- Additional adhesive materials
- Additional track materials
- Cardboard, paper, fabric etc.
- String
- Rubber bands
- Paddle pop sticks
- Bells
- Electrical wire
- Electrical tape
- Batteries
- Battery snaps and/or holders
- Electric buzzers
- LED lights or bulbs
- Switches (toggle, contact, slide, paper clips)
- Thumbtacks
- Aluminium foil

4. When you are ready to deliver the activity, gather students around the wall. Stick the Start and Finish signs to the wall. Ensure the Start sign is higher and further along the wall than the Finish sign. Ensure the pre-selected materials are with you too. (Alternatively, your students could develop a free-standing gravity run, or use everyday materials to create a platform for their gravity run such as books stacked at different heights.)

5. Ask students: ***How could we design a track for a ball to travel from the start to the finish?*** Provide students with time to explore the pre-selected materials and to discuss their ideas in small groups. Student groups may like to sketch their ideas using paper or a digital medium.

6. Use student ideas to construct a gravity run as a class or in groups. Test the gravity run. Ask students to make predictions about how the ball may travel through the run, recording observations for each test (see *Student Activity: Constructing a Gravity Run*). Year 8 students could also record the speed at which each ball travels through the run.

7. **YEAR 6**

   Ask students: ***How could we introduce electrical energy into the system? What could we do with the electrical energy?*** As an example, students could suggest incorporating a switch into the system, and when a ball rolls over the switch, a bulb might light up or a buzzer might sound.

   Share the challenge with students: ***Improve the gravity run so that it incorporates electrical energy.*** Students work in groups of three to complete the challenge. Students should firstly examine the existing gravity run and consider where and how they could introduce electrical energy into the system. Students then create a diagram (sketched or digital) to represent their ideas. Following this, students may construct their modified part and test it within the existing system. Students can use supplied modification materials or source their own materials to complete the task. Students evaluate their modified part, and then share it with the class.

   YEAR 8

   Revise the concept of energy and different forms of energy with students. Ask students to identify the different forms of energy present within the system, as well as the energy transfers and transformations that occur in the system. Ask students: ***What forms of energy are not present in this system?*** Discuss responses as a class group.

   Share the challenge with students: ***Improve the gravity run so that it incorporates at least two 'new' forms of energy.*** Students work in groups of three to complete the challenge. Students should firstly examine the existing gravity run and consider where and how they could introduce different forms of energy into the system. Students then create a diagram (sketched or digital) to represent their ideas. Following this, students may construct their modified part and test it within the existing system. Students can use supplied modification materials or source their own materials to complete the task. Students evaluate their modified part, and then share it with the class.

Curriculum Links

Science

YEAR 6

Science Understanding

Electrical energy can be transferred and transformed in electrical circuits and can be generated from a range of sources (ACSSU097)

Science as a Human Endeavour

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE098)

Science Inquiry Skills

With guidance, pose clarifying questions and make predictions about scientific investigations (ACSIS232)

Identify, plan and apply the elements of scientific investigations to answer questions and solve problems using equipment and materials safely and identifying potential risks (ACSIS103)

Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS110)

YEAR 8

Science Understanding

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

Science Inquiry Skills

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

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

Design and Technologies

YEAR 5 AND 6

Design and Technologies Knowledge and Understanding

Investigate how electrical energy can control movement, sound or light in a designed product or system (ACTDEK020)

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

Design and Technologies Processes and Production Skills

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

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

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

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

YEAR 7 AND 8

Design and Technologies Knowledge and Understanding

Analyse how motion, force and energy are used to manipulate and control electromechanical systems when designing simple, engineered solutions (ACTDEK031)

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

Design and Technologies Processes and Production Skills

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

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

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

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

General Capabilities

Literacy

Composing texts through speaking, writing and creating

Critical and Creative Thinking

Generating ideas, possibilities and actions

Reflecting on thinking and processes

Analysing, synthesising and evaluating reasoning and procedures

Personal and Social Capability

Social management

Gravity Run

Student Activity

Constructing a Gravity Run

Construct a gravity run with your class or in groups. You may choose to attach the gravity run to a wall, design a free standing gravity run, or use everyday materials to create a platform for your gravity run. Test the gravity run, and record observations about how the ball travels through the run below.

Test Number	Prediction	Observations

Gravity Run

Student Activity

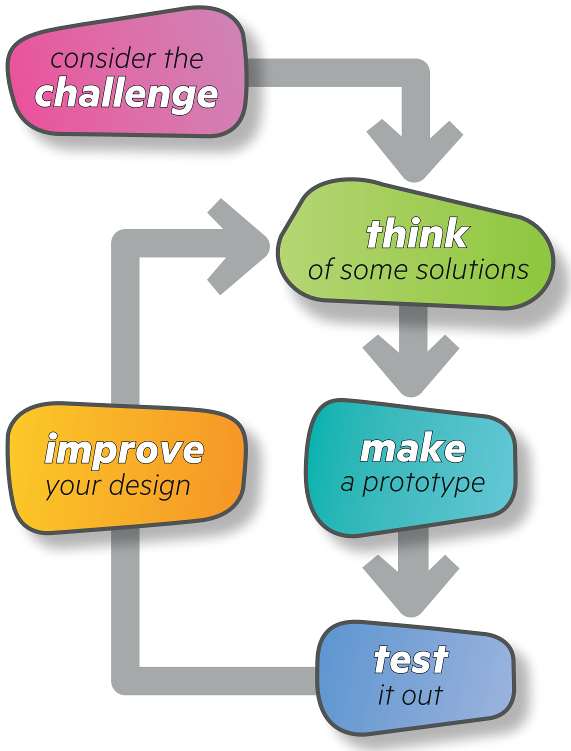
Year 6 Design Challenge

Task:

Improve the gravity run so that it incorporates electrical energy.

You must:

- **Consider the challenge.** What are the requirements of the design challenge?
- **Think of some solutions.** How you could introduce electrical energy into the gravity run? What ideas do you have for a design?
- **Make a prototype.** What materials and components will you use? How will you work safely? Create a labelled diagram of your design, and then construct your prototype.
- **Test it out.** Test the new part in the gravity run. What did you notice? Did the new part operate as you intended?
- **Improve your design.** Keep testing and refining until you are satisfied with your design.
- **Evaluate your design.** What aspects of your design are you very satisfied with, and why? What challenges did you experience during the design process, and how did you overcome them?



Consider the Challenge

What are the requirements of the design challenge? Identify and record these requirements, and the criteria for success, below.

Think of Some Solutions

Examine the gravity run. How could you introduce electrical energy into this system? Brainstorm ideas with your group. Record your ideas below.

Make a Prototype

Design a new part for the gravity run that incorporates electrical energy. Consider the electrical components and materials you will need to build the new part, as well as the properties of these components and materials.

Create a labelled diagram of your design. Make sure you identify and justify the electrical components and materials you will use in your design.

Construct your prototype.

Explain any changes that were made to the design as you created the prototype.

Draw a circuit diagram of the new part of your gravity run.

Test It Out

Test the new part in the gravity run. Record your observations below.

Explain your observations. Consider what you already know about electrical energy and the properties of different materials. Make sure you include scientific language in your explanation.

Improve Your Design

Explain how you could improve your design.

Make these improvements and then re-test your design. Explain and evaluate the effect of these modifications.

Draw a revised circuit diagram to show these modifications.

Keep testing and refining until you are satisfied with your design.

Evaluate Your Design

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

- Explain how your knowledge of science helped you to make decisions about your design.
- Evaluate your final design. Which aspects are you most satisfied with? Which aspects would you further improve on? How would you make these improvements?
- Describe the main challenges you experienced during the design process. Explain how you overcame these challenges.
- Explain what you have learnt about electrical energy and/or the design process from this activity.

Explore More!

- What is the longest gravity run you can make?
- What happens when you change the angles of the run?
- Can you make the ball jump at one point of the run?
- Can you make the ball roll up a slope?
- How can you make a run that takes exactly 10 or 20 or 30 seconds to complete?

Gravity Run

Student Activity

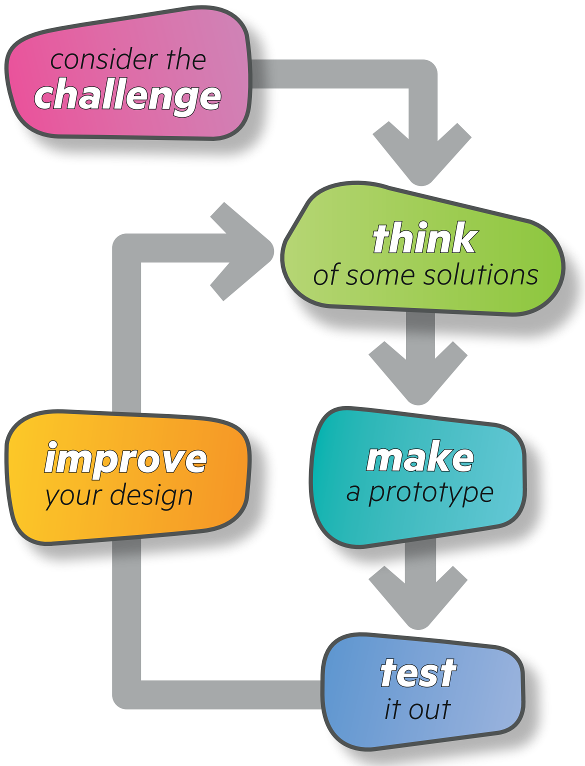
Year 8 Design Challenge

Task:

Improve the gravity run so that it incorporates at least two 'new' forms of energy.

You must:

- **Consider the challenge.** What are the requirements of the design challenge?
- **Think of some solutions.** Which forms of energy are not present in the gravity run? How you could incorporate at least two of these forms of energy into the system?
- **Make a prototype.** What materials and components will you use? How will you work safely? Create a labelled diagram of your design, and then construct your prototype.
- **Test it out.** Test the new part in the gravity run. What did you notice? Did the new part operate as you intended?
- **Improve your design.** Keep testing and refining until you are satisfied with your design.
- **Evaluate your design.** What aspects of your design are you very satisfied with, and why? What challenges did you experience during the design process, and how did you overcome them?



Consider the Challenge

What are the requirements of the design challenge? Identify and record these requirements, and the criteria for success, below.

Think of Some Solutions

Examine the gravity run. How could you introduce at least two 'new' forms of energy into this system? Brainstorm ideas with your group. Record your ideas below.

Make a Prototype

Design a new part for the gravity run that incorporates two 'new' forms of energy. Consider the materials and components you will need to build the new part, as well as the properties of these components and materials.

Create a labelled diagram of your design. Make sure you identify and justify the materials and components you will use in your design.

Construct your prototype.

Explain any changes that were made to the design as you created the prototype.

Test It Out

Test the new part in the gravity run. Record your observations below.

Explain your observations. Consider how motion, force and energy are used to manipulate and/or control parts within the system. Make sure you include scientific language in your explanation.

Draw a flow diagram to represent the energy transfers and transformations that occur in the gravity run, including the forms of energy added by your new design.

Calculate the speed at which the ball travels through the improved system. Compare this to the speed at which the ball travelled in the original system. Provide an explanation for any differences.

Improve Your Design

Explain how you could improve your design.

Make these improvements then re-test your design. Explain and evaluate the effect of these modifications.

Draw a revised flow diagram to show the effect of these modifications.

Continue testing and refining until you are satisfied with your design.

Evaluate Your Design

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

- Explain how your knowledge of science helped you to make decisions about your design.
- Evaluate your final design. Which aspects are you most satisfied with? Which aspects would you further improve on? How would you make these improvements?
- Describe the main challenges you experienced during the design process. Explain how you overcame these challenges.
- Explain the limitations of the system. Which forms of energy were you unable to include in the system, and why?
- Explain what you have learnt about electrical energy and/or the design process from this activity.

Explore More!

- What is the longest gravity run you can make?
- What happens when you change the angles of the run?
- Can you make the ball jump at one point of the run?
- Can you make the ball roll up a slope?
- How can you make a run that takes exactly 10 or 20 or 30 seconds to complete?

EXPLORE – EXPLAIN – ELABORATE

Locomotives at Work

Teacher Resource

The Workshops Rail Museum, located in Ipswich, Queensland, is a site steeped in history.

For decades, the site was the centre of rail construction, maintenance and technology for Queensland's burgeoning rail industry. Between 1865 to 1997, 217 locomotives, 871 carriages, 11,801 wagons, 2,016 vans, 96 railmotors and 143 trailers were constructed at the Ipswich Railways Workshops, and thousands of workers called the site home. During its peak in the Second World War, over 3,000 people worked on the site, making it Queensland's largest employer at the time. In the 1990s, the site ceased operations for most types of work, except for the maintenance of Queensland Rail's heritage fleet. They are now the oldest continually running railway workshops in Australia.

Ipswich Railway Workshops from the air, circa 1950.

In this activity, students use locomotives from The Workshops Rail Museum's collection to explore energy transfers and transformations. Students interpret Sankey diagrams and calculate the hypothetical energy efficiency of various locomotives. Students can view the locomotives used in this activity at The Workshops Rail Museum.

Following this activity, students could complete The Future of Rail: A Design Challenge.
In this resource, students design a 'clean' train and rail system for Queensland.

Curriculum Links

Science

YEAR 8

Science Understanding

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

Science Inquiry Skills

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

Mathematics

YEAR 8

Number and Algebra

Solve problems involving the use of percentages, including percentage increases and decreases, with and without digital technologies (ACMNA187)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Composing texts through speaking, writing and creating

Locomotives at Work

Teacher Resource

Student Answers

In the *Student Activity: Locomotives at Work*, students are provided with a series of jumbled statements that describe how a steam and a diesel electric locomotive work. Students are required to read the statements and then write them in the correct order. The correct order for both locomotives can be seen below. You can use this information to check and correct students' responses.

Steam Locomotive

1. Fuel (usually coal) is burned in the firebox to make hot gases.
2. The gases pass through boiler tubes that run the length of the water-filled boiler.
3. The gases heat the surrounding water and turns it into steam.
4. The steam rises to the steam dome, where it is forced through a series of tubes into the cylinder.
5. The steam drives the piston in the cylinder, pushing it forward.
6. The steam escapes through a one way opening, and the piston can slide back again.
7. The pistons are connected to the driving wheels with rods. As the piston moves back and forth, it moves the rods, which then makes the wheels turn.

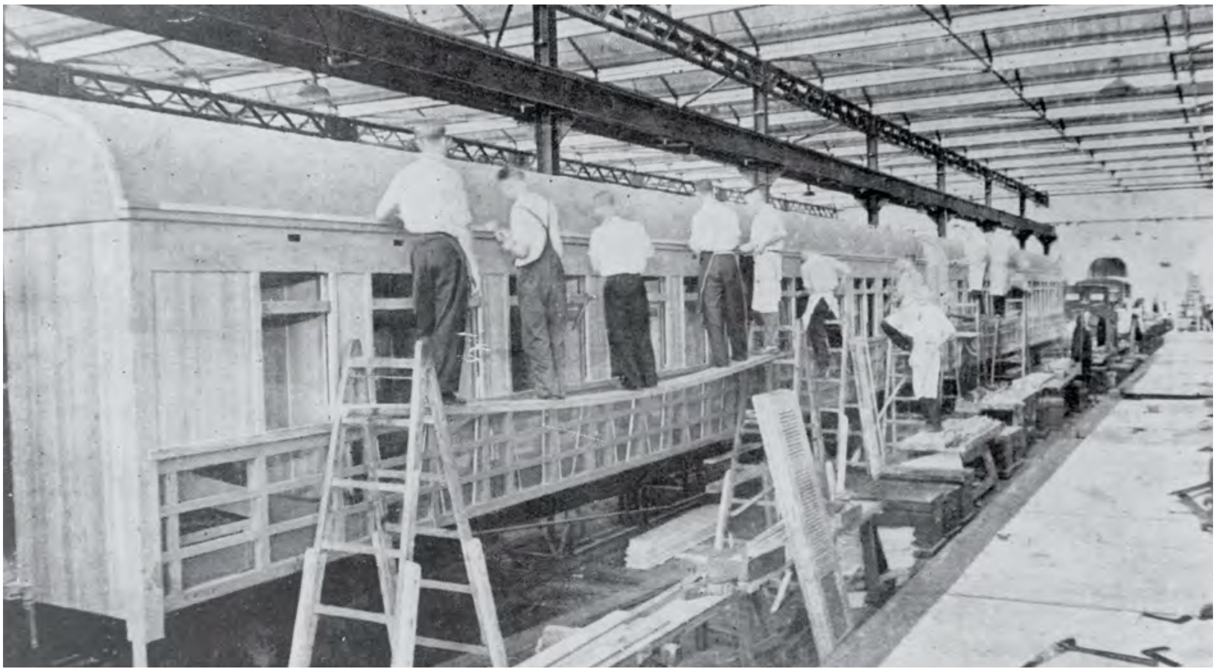
Diesel Electric Locomotive

1. The engine draws air into the cylinders.
2. Pistons are located inside the cylinders. This intake of air pushes the pistons down.
3. As the pistons move back up, they compress the air inside the cylinders.
4. Diesel fuel is injected directly into the cylinders. The fuel is delivered to the engine from the fuel tank by an electric pump.
5. The heat of the compressed air ignites the fuel. These explosive bursts push the pistons back down. This movement turns a crankshaft.
6. The movement of the crankshaft drives a generator, which makes electricity.
7. The electricity is distributed to the electric traction motors, which drive the wheels.

Locomotives at Work

Student Activity

Rail has been an integral industry in the development of Queensland, especially in Ipswich. The construction of the original Ipswich Railway Workshops began in 1864 at a site adjacent to the Bremer River in North Ipswich. As the railways expanded, a much larger site was needed, so the Workshops moved to its current location (The Workshops Rail Museum site) between 1884 and 1888. For decades, the site was the centre of rail construction, maintenance and technology for Queensland's burgeoning rail industry. The workshops still operate today, just on a far smaller scale!



Workmen constructing carriages in the carriage and wagon shop, circa 1925.

Ipswich Railway Workshops staff, circa 1910.

In this activity, you will use locomotives from The Workshops Rail Museum's collection to:

- Explore energy transfers and transformations;
- Interpret Sankey diagrams; and,
- Calculate the energy efficiency of various locomotives.

Locomotives vs Trains

Locomotives and trains are the same thing, right? Not quite. A locomotive refers to the power unit of a train. It is usually the first part of the train that you see. A locomotive does not carry passengers or freight; it usually pulls the coaches, rail cars or wagons that contain the passengers and freight. A train refers to the series of interconnected coaches, rail cars or wagons that are usually pulled by the locomotive.

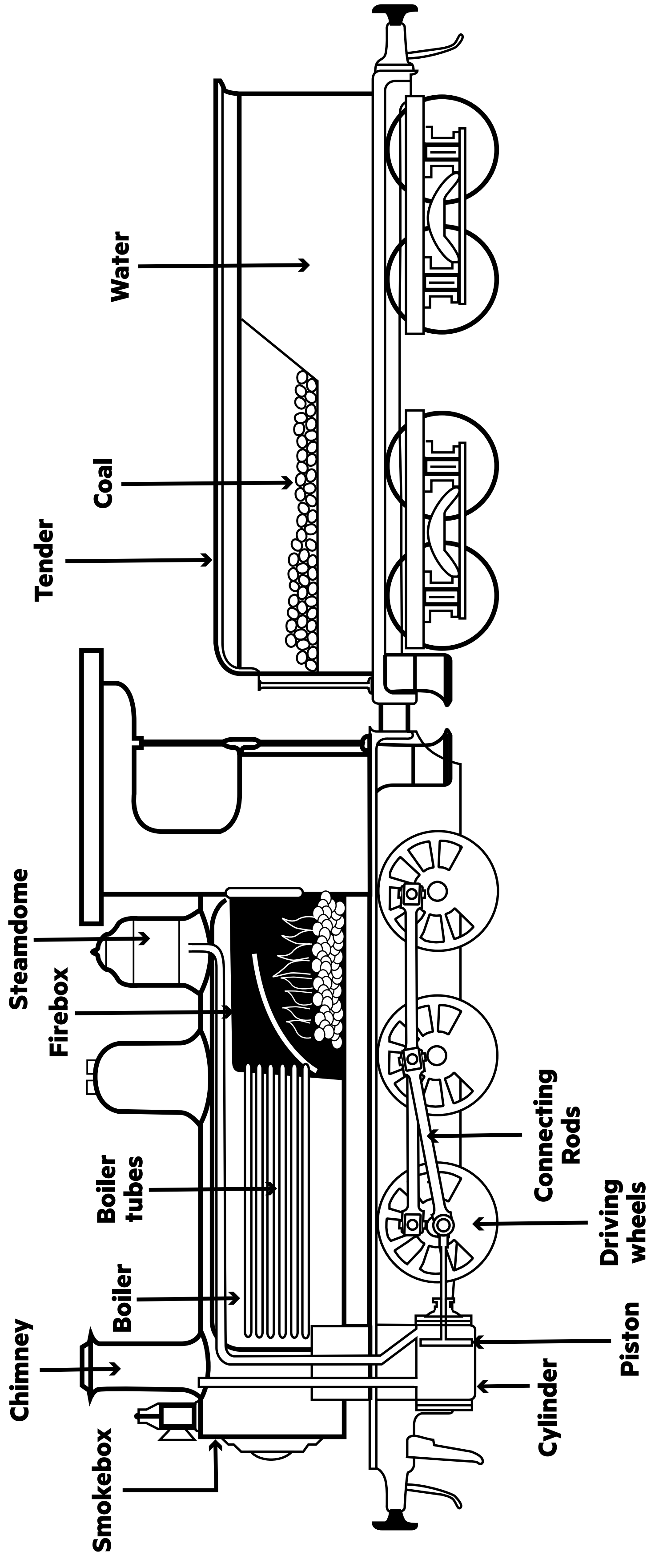
Steam Locomotives

A10 No.6 was one of twelve steam locomotives supplied to Queensland Railways (QR) in 1866. The locomotive was sold to the Bingera Sugar Mill in 1896, where it began a new life hauling sugar cane near Bundaberg. It remained in use until 1965, when the mill owner offered it back to QR as a 100th birthday present. The little locomotive was steamed all the way from Bundaberg to Brisbane and played a starring role in the centenary celebrations on 31 July 1965. A10 No.6 is the oldest working steam locomotive in Australia.

Image, left: A10 No.6 steam locomotive. QM, Peter Waddington.

View the diagram of the steam locomotive below. This is a general diagram of a steam locomotive and does not specifically represent A10 No.6 locomotive.

Steam Locomotive



Read the jumbled statements that describe how the steam locomotive works. Write the statements in the correct order in the flowchart below to show how energy moves through the system.
You could also cut out and rearrange the statements in the correct order.

Jumbled Statements

The pistons are connected to the driving wheels with rods. As the piston moves back and forth, it moves the rods, which then makes the wheels turn.
The steam rises to the steam dome, where it is forced through a series of tubes into the cylinder.
Fuel (usually coal) is burned in the firebox to make hot gases.
The gases heat the surrounding water and turns it into steam.
The steam drives the piston in the cylinder, pushing it forward.
The steam escapes through a one way opening, and the piston can slide back again.
The gases pass through boiler tubes that run the length of the water-filled boiler.

Flowchart – How a Steam Locomotive Works

Use your understanding of the states of matter to explain how the heating of water can drive an engine.

Draw a flow diagram to represent the energy transfers and transformations that occur in the steam locomotive.

Interpret the Sankey diagrams below. Justify which diagram best represents the transformation of energy in a steam locomotive.

Diagram 1

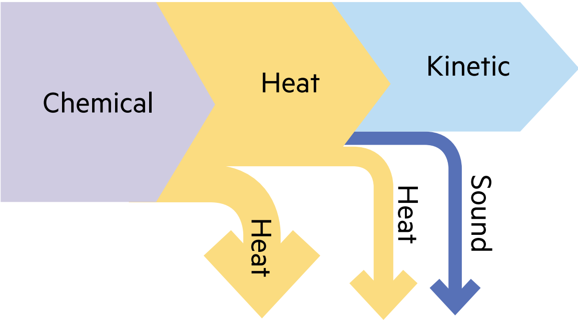


Diagram 2

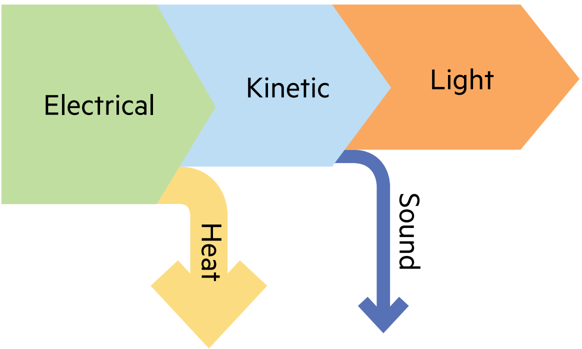
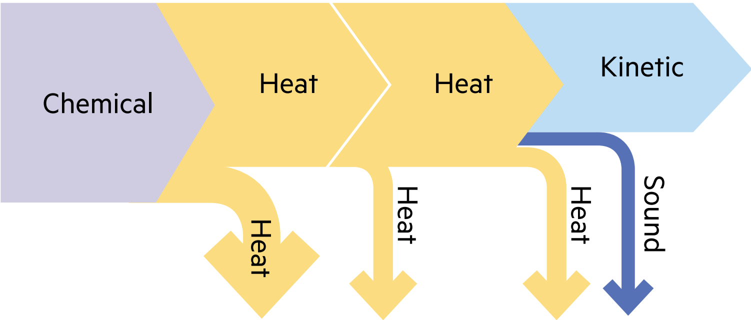


Diagram 3



The fireman's role on a steam locomotive was to stoke the fire and maintain steam pressure in the boiler. On average, a fireman could shift 4.53 kg of coal into the fire box in one shovel. If one gram of coal produces 34 kJ of energy, calculate much energy is in each shovel of coal.

For every shovel of coal that is burned in the fire box, 50,826 kJ is lost as heat energy to the surrounding air. The remaining energy is used to heat the water in the boiler. Calculate the energy efficiency of this process.

Calculate how much useful energy is used to heat the water in the boiler, per shovel of coal.

Of the remaining energy used to heat the water in the boiler, 20% is lost as heat and 10% is lost as sound. Calculate the amount of energy that is used to drive the wheels of the train per shovel of coal, and then the overall efficiency of this process.

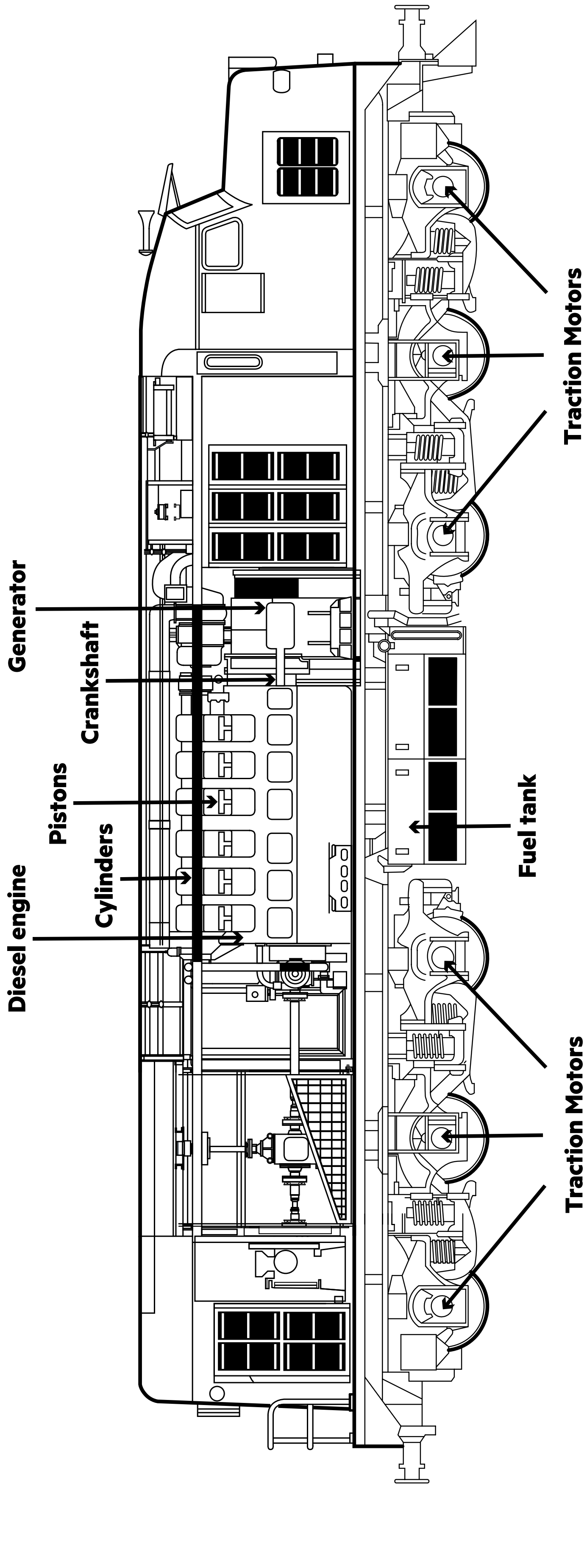
Diesel Electric Locomotives

The age of the diesel electric locomotive in Queensland began in October 1952, with the arrival of 10 new locomotives from the United States of America. Diesel electric locomotives were stronger and more efficient than their steam-driven cousins; each diesel locomotive could effectively do the work of two to three steam locomotives. They also needed less servicing, as they did not require extra stops for water and coal. This meant diesel electric locomotives could venture further west where water supplies were poor. Furthermore, diesel electric locomotives were lighter than steam locomotives; this allowed them to haul longer passenger and freight cars over lightly laid tracks where steam locomotives were too heavy to travel.

The diesel electric 1250 Class: No.1262, now on display at The Workshops Rail Museum, entered service on 27 October 1961. Locomotives in the 1250 Class transported ore on the Great Northern Line (Townsville to Mount Isa) and freight on the North Coast Line (Brisbane to Cairns) and Southern Line (Toowoomba to Wallangarra). Locomotive No.1262 retired from service on 4 November 1988. It travelled 2.7 million kilometres during its service.

1250 Class: No.1262 diesel electric locomotive. QM, Peter Waddington.

View the diagram of the diesel electric locomotive below. This diagram shows the diesel electric 1250 Class: No.1262.



Diesel Electric Locomotive

Read the jumbled statements that describe how the diesel electric locomotive works. Write the statements in the correct order in the flowchart below to show how energy moves through the system.

Jumbled Statements

The electricity is distributed to the electric traction motors, which drive the wheels.
Pistons are located inside the cylinders. This intake of air pushes the pistons down.
The heat of the compressed air ignites the fuel. These explosive bursts push the pistons back down. This movement turns a crankshaft.
The engine draws air into the cylinders.
The movement of the crankshaft drives a generator, which makes electricity.
Diesel fuel is injected directly into the cylinders. The fuel is delivered to the engine from the fuel tank by an electric pump.
As the pistons move back up, they compress the air inside the cylinders.

Flowchart – How a Diesel Electric Locomotive Works

Draw a Sankey diagram to represent the energy transformations that occur in a diesel electric locomotive.

1250 Class: No.1262 could hold 3,200 L of fuel in its tank and was capable of travelling 800 km per tank of fuel. Calculate the fuel consumption of the locomotive per 100 km.

Compare the fuel efficiency of 1250 Class: No.1262 to other modes of transport and assess the fuel efficiency of the locomotive.

The kinetic energy of an object can be calculated using the equation:

$$KE = \frac{1}{2}mv^2$$

$$(\text{Kinetic Energy} = \frac{1}{2} \text{x mass x velocity}^2)$$

For example, if a 60 kg person is running at a velocity of 2 m/s (equivalent to 7.2 km/h) we could calculate their kinetic energy in the following steps:

$m = 60, v = 2$

$KE = \frac{1}{2} mv^2$

$KE = \frac{1}{2} \times 60 \times 2^2$

$KE = \frac{1}{2} \times 60 \times 4$

$KE = 30 \times 4$

$KE = 120$ J

Calculate the kinetic energy of one point during your trip to school. (If you travel via car or bus you may need to research the mass of your vehicle and choose to calculate the kinetic energy using the approximate maximum velocity of your trip.)

1250 Class: No.1262 had a mass of nearly 80,000 kilograms. Calculate the kinetic energy of the locomotive if it was travelling at 60 km/h. (You will need to convert the velocity to m/s.)

Explain how the kinetic energy of the train would change if the locomotive was pulling 10 carriages loaded with freight.

Calculate the kinetic energy of 1250 Class: No.1262 while it is in The Workshops Rail Museum.

If a car and a train are both travelling at 60 km/h, examine which would have the longest stopping distance. Justify your answer by giving multiple reasons for your decision.

EXPLAIN – ELABORATE

Managing Collections at The Workshops Rail Museum

Teacher Resource

Queensland Museum has a responsibility to collect, research and promote Queensland's natural, cultural and technological heritage. Our collections provide evidence of changes occurring in our natural and cultural environments.

Cultural and historical collections are comprised of objects that are significant to the people of Queensland; some of these objects are small, such as a model electric locomotive (4.65 cm in length), while others can be as large as a diesel electric locomotive (16 m in length)! The people who research and acquire objects for a museum's collection are called curators.

In this activity, students learn about the work of Rob Shiels, Curator of Transport at The Workshops Rail Museum (TWRM). During his time at TWRM, Rob has helped deliver a number of large object moves including locomotives, buses, cars, wagons and carriages, generators, tanks, rail motors and high voltage electrical material. Rob is also heavily involved in the development and delivery of exhibitions.

Following this activity, students could complete Generating Electricity: Past and Present. If visiting TWRM, students could also complete The Future of Rail: A Design Challenge.

Image, left: Rob Shiels, Curator of Transport at TWRM. Rob stands in the collection store, in front of models of locomotives, carriages and wagons from the T-House Collection. There are over 11,000 rail models in this collection!

Curriculum Links

Science

YEAR 6

Science as a Human Endeavour

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

Science Inquiry Skills

Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS110)

YEAR 8

Science as a Human Endeavour

Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE135)

Science Inquiry Skills

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

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Composing texts through speaking, writing and creating

Managing Collections at The Workshops Rail Museum

Student Activity

Queensland Museum has a responsibility to collect, research and promote Queensland's natural, cultural and technological heritage. Our collections provide evidence of changes occurring in our natural and cultural environments.

Cultural and historical collections are comprised of objects that are significant to the people of Queensland; these objects can be small, such as a model electric locomotive (4.65 cm in length) and as large a diesel electric locomotive (16 m in length)! The people who research and acquire objects for a museum's collection are called curators.

A Chat with Rob Shiels, Curator of Transport, The Workshops Rail Museum

Rob Shiels is the Curator of Transport at The Workshops Rail Museum (TWRM). Learn more about his work at the museum below.

- **How did you become interested in your field of work?**

  When I first went to university, I started a degree in town planning. I quickly realised town planning wasn't for me, and so I left the course. I then got a job for 12 months, but this wasn't a job I enjoyed, so I decided to go back to university. I didn't really know what I wanted to do there, but I knew that I wanted to study something that I was passionate about, so I decided to study history. After completing a Bachelor of Arts with a History Double Degree Major, I was lucky enough to get a job at TWRM. I worked at one of the Thomas the Tank Engine school holiday events and I quickly realised that I wanted to work in museums, so I enrolled in a Master of Museum Studies. I completed my Master's Degree part-time while I continued to work at TWRM. I have worked at TWRM for 15 years now, in a number of positions – currently I am the Curator of Transport.

Rob Shiels inspecting one of the locomotive models from the T-House Collection. There are over 11,000 individual models in this collection!

- **What do you enjoy most about your work?**

  For me, the best thing about working in a museum is learning about our past. Every object has a story to tell (often they have many stories to tell!), and we can learn so much about ourselves and our communities by looking over our shoulders to see where we have come from. The most rewarding part of my job is tracking down information about objects; sometimes it is like being a detective, trying to find clues and snippets of information about these objects from different sources. It is a great feeling when you start with an object you don't know much about and, through some hard work (and patience), discover its history and how people used it in the past.

- **Describe some of the objects you have worked with in the Queensland Museum collection. How do these objects function?**

  We have so many different types of objects at TWRM. It takes a lot of people and resources to run a railway, and our objects help us document this history. We have old uniforms, advertisements from stations, tools that were used to lay tracks, tickets, photographs, crockery that was used in railway refreshment rooms... in fact, we have thousands and thousands of different objects that help us tell stories about Queensland's railway history.

  Recently I have been working on many objects that have links to railway sporting teams, which I have found very interesting. Workplaces used to play a huge part in the social lives of workers and their families. Along with workplace sporting teams, there were also workplace brass bands and other workplace social clubs! These teams and clubs were started by railway workers at the Ipswich Railway Workshops. I have really enjoyed researching this other side of life as a railway worker over the last few years.

The Ipswich Railway Band was comprised of talented railway workers. They were very successful during the 1920s and won a number of competitions. QMN Collection.

TWRM however is most famous for its locomotives, and we are lucky enough have A10 No.6 locomotive in the collection. It is the oldest Queensland steam locomotive in existence. A10 No.6 was built in 1865, and although it may appear to be quite basic, its no-frills design allows visitors to see how external combustion engines were developed into steam locomotives.

After the era of steam, locomotives transitioned to diesel internal combustion engines. In Queensland, the 'dieselisation' of the fleet began in the 1950s. One early diesel locomotive purchased by Queensland Rail was the 1250 Class, built by English Electric of Rocklea, Brisbane. 1250 Class: No.1262 is on display in the *Diesel Revolution* zone of TWRM. The exterior panels of the locomotive were removed so visitors can see exactly how diesel electric locomotives work.

Image, left: A10 No.6 locomotive on display at TWRM. Image, right: Installing 1250 Class: No.1262 locomotive at TWRM in 2002. Image credit: David Mewes.

At TWRM, you can also learn about the electrification of railway networks and how overhead power lines (or third rails) power trains. Queensland has one of the largest electrified railway networks in Australia; passenger services and some freight services use this technology.

- **What has been the biggest impact of rail on Queensland?**

  The building of railways during the 19th and 20th centuries had a deep impact on the economic development of Queensland. Many of us live in places today that were created – or flourished – because a railway was built nearby or passed directly through our town or city. Even if the railway tracks were ripped up years ago, if you do enough research, you will probably be able to find out how an old railway line affected the past and present of sites across Queensland today.

- **What makes Queensland's railways unique?**

  The sheer size of Queensland influenced the design of our railways. Right from the very beginning, railway designers adopted a 3 foot 6 inch narrow railway gauge for Queensland in the 1860s. This narrow gauge size was cheaper to produce and install, meaning you could lay more for less. With about 70% of Queensland Government budgets between the 1860s – 1900s allocated to building, servicing and spreading the state's railway network, any savings to be found were appreciated. Despite this financial saving, the decision to use narrow gauge in the 1860s affected Queensland's ability to transport goods down to New South Wales and Victoria, who used different size rail gauges; this had a profound and long-lasting impact that is still experienced today. Despite gauge issues with other states, the railway network within Queensland was a resounding success with the network extending over 10,550 km at the start of the 1950s.

A map of Queensland railway network in 1950.

- **What would you recommend for students who would like to work in a similar field?**

  Museum jobs do not come up as often as some other industries, particularly in the capital cities, but there are often good opportunities in regional areas. If you are prepared to move away from the city for job opportunities, smaller regional museums and galleries are great places to work.

Hypothesise what rail will look like in 100 years' time. Consider the importance of sustainability, and the need to move toward a more sustainable future in your response.

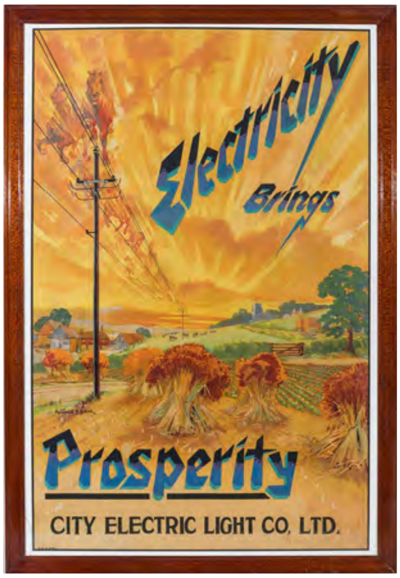
ENGAGE – EXPLORE

Electricity Brings Prosperity

Teacher Resource

In this activity, students use visual and written stimulus to imagine what life was like at the turn of the 20th century, when electricity was introduced into our lives for the very first time. Students firstly consider and reflect on an electrical advertisement from the early 20th century. They then develop an understanding of the history of electricity in Brisbane, and write a journal entry from the perspective of a member of the public witnessing electric lighting for the first time.

The advertisement used in this activity, titled *Electricity Brings Prosperity*, is from Queensland Museum's Cultures and Histories collection. Private entrepreneurs conducted the first experiments in electricity production and supply in Queensland.[3] Their experiments resulted in Brisbane being the first city in the southern hemisphere to provide the public with a supply of electricity.[4] The introduction and relatively quick expansion of electricity generation across the state meant that its promotion was an important undertaking. The imagery and symbolism used in the advertisement highlights the wonder and awe of electricity; the advertisement also promotes important ideals of the time, including prosperity, technological development, innovation and infrastructure. You can find further information about this advertisement in its Queensland Museum blog post, written by Dr Geraldine Mate, Principal Curator of History, Industry and Technology at the Queensland Museum.

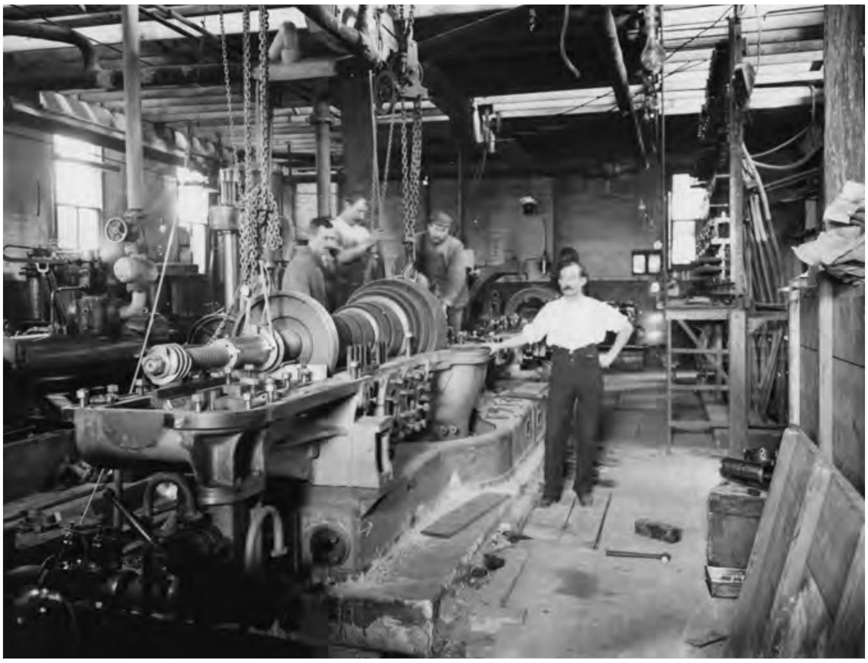


Image, left: Advertising poster for the City Electric Light Company Limited. Queensland Museum. Image, right: City Electric Light Company Power House, corner of William and Margaret Streets, Brisbane, circa 1910. State Library of Queensland.

3 Queensland State Archives, Agency ID A401. (n.d.). *City Electric Light Company Limited.* https://www.archivessearch.qld.gov.au/agencies/A401
4 King, J. & Queensland Energy Museum. (2003). *Power for the people: Brisbane's electrical heritage 1880s-1950s.* Queensland Energy Museum, Brisbane.

The advertisement was produced for the City Electric Light Company Limited (CEL) which operated in Brisbane from 1904 to 1952. CEL supplied electricity to Brisbane, becoming the dominant supplier for the city in 1925, and to regional areas in Queensland.[4,5] In 1952, the state government converted CEL from a privately owned company to a public authority, and it was acquired by the Southern Electric Authority of Queensland (SEAQ).[4] The SEAQ became the South East Queensland Electricity Board in 1977, which then became Energex in 1997.

You may also wish to investigate the life and achievements of CEL founder Edward Barton with your students; the Australian Dictionary of Biography provides a detailed overview of his life. Barton is widely renowned as a pioneer of electricity supply in Queensland. Barton, along with his previous business partner, C.F. White, established the first public electricity supply in Australia, and their business, Barton, White & Co., became the first electricity supplier in Australia.[6]



Image, left: Portrait of Edward Barton, circa 1910. State Library of Queensland. Image, right: Inside the City Electric Light Company, circa 1910. Workers repair a generator or turbine using overhead chains, pulleys and other mechanical apparatus. State Library of Queensland.

5 Egeherg, H.F. (1959). The development of electricity supply in Queensland. Journal of the Royal Historical Society of Queensland, 6(1), 60-72. https://www.textqueensland.com.au/item/article/f8af2b8c2f4a34e7354f3220506ef85c

6 John Oxley Library. (2016). Edward Gustavus Campbell Barton, electricity pioneer. https://www.slq.qld.gov.au/blog/edward-gustavus-campbell-barton-electricity-pioneer

Curriculum Links

Science

YEAR 6

Science Understanding

Electrical energy can be transferred and transformed in electrical circuits and can be generated from a range of sources (ACSSU097)

Science as a Human Endeavour

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE098)

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

Science Inquiry Skills

Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS110)

HASS: History

YEAR 6

Knowledge and Understanding

The contribution of individuals and groups to the development of Australian society since Federation (ACHASSK137)

Inquiry and Skills

Develop appropriate questions to guide an inquiry about people, events, developments, places, systems and challenges (ACHASSI122)

Locate and collect relevant information and data from primary sources and secondary sources (ACHASSI123)

Sequence information about people's lives, events, developments and phenomena using a variety of methods including timelines (ACHASSI125)

Present ideas, findings, viewpoints and conclusions in a range of texts and modes that incorporate source materials, digital and non-digital representations and discipline-specific terms and conventions (ACHASSI133)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Composing texts through speaking, writing and creating

Information and Communication Technology

Investigating with ICT

Critical and Creative Thinking

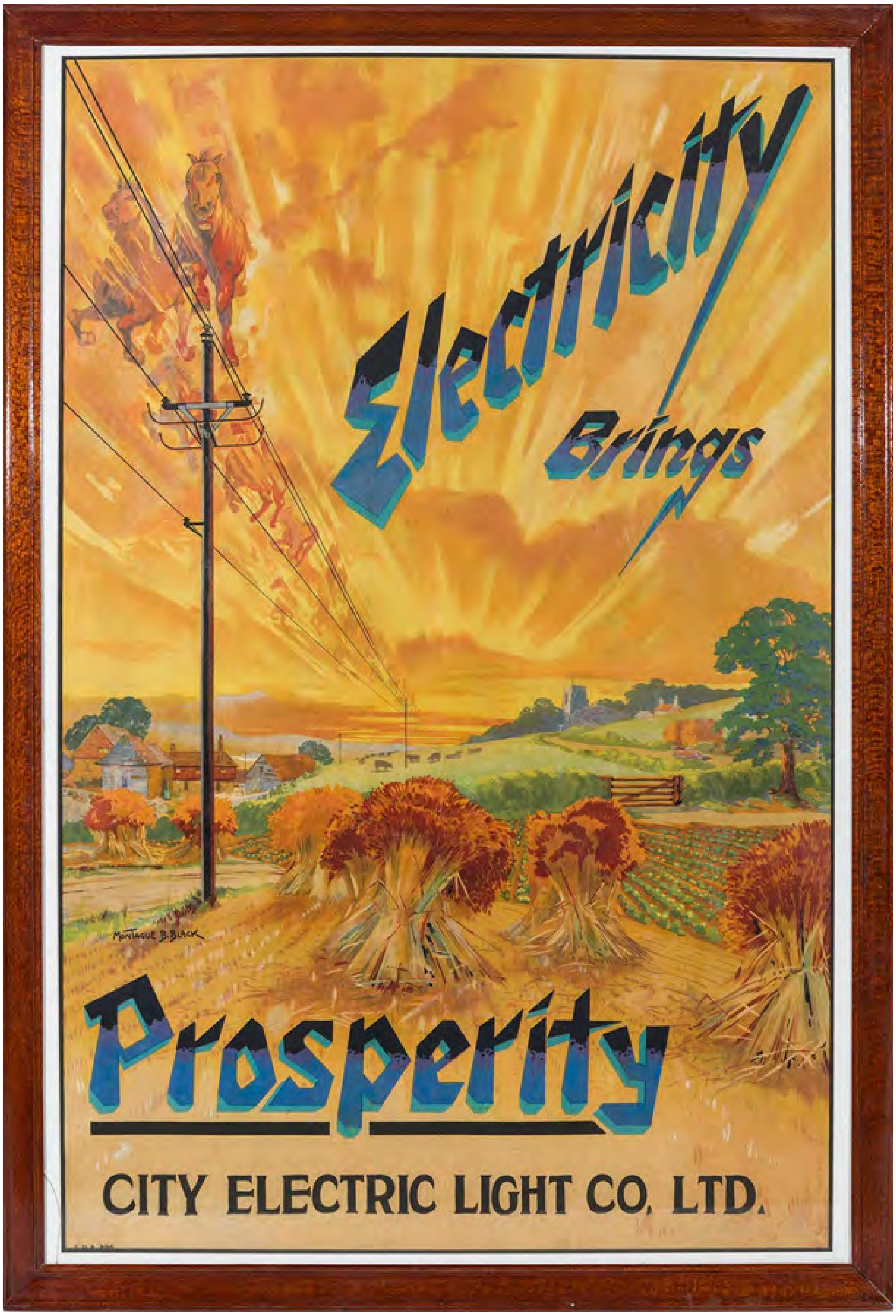
Inquiring – identifying, exploring and organising information and ideas

Electricity Brings Prosperity

Student Activity

Image Analysis

Imagine you have never seen or used electricity before… and then take a look at the poster below.



Electricity Brings Prosperity. Advertising poster for the City Electric Light Company Limited. Artwork by Montague Birrell Black. Queensland Museum.

What do you think about when you look at the poster? (You may like to consider colours, symbols, words, font style and other objects and images shown in the poster.)

Describe how the poster makes you feel. Identify the parts of the poster that make you feel this way.

Describe what the poster makes you wonder. You may like to conduct research to answer these questions.

Brisbane's Electric Past

Take a moment to look around. How many objects can you see that are powered by electricity? What other objects have you used today that are powered by electricity?

Electricity plays an integral role in our lives, and we often take this form of energy for granted. Yet, our ability to use electricity is still relatively new!

Scientists and engineers made the greatest progress in electrical engineering in the late 1800s - only about 140 years ago! Their progress enabled electricity, firstly in the form of electric lighting, to be introduced to factories, the streets and finally our homes.

The first place in the world to have a commercial supply of electricity was Godalming, England in September 1881. A water-powered generator was used to generate electrical energy, and the resulting electricity was used to power lighting in houses and streets.

Just over one year later, the first public demonstration of electricity in Australia occurred in Brisbane, Queensland on 9 December 1882. This was a significant event for the city, and it was well documented by journalists at the time. We can find a number of newspaper articles detailing the introduction of the electric light in Brisbane, including the article on the next page.

Read the article (you can also view the article online here: https://trove.nla.gov.au/newspaper/article/97518345), and then respond to the questions that follow.

This image was taken on Queen Street, from the corner of Edward Street, looking south. Today, we would see a very different sight! The image shows what Brisbane looked like in 1883, just one year after electric lighting was introduced to the city. State Library of Queensland.

THE ELECTRIC LIGHT IN BRISBANE.

In spite of the very unpleasant weather of Saturday evening the streets were thronged with people who had come out to see the eleccric light. The brightness of Queen-street was a great contrast upon its usual appearance, and the effect was very generally admired. After the first sensation of surprise was over, numbers of the people stood in groups at the foot of the lamp-posts, apparently enjoying the beautiful light, and there was but one expression—that of unqualified admiration—to be heard on all sides, the high expectations formed by those who hitherto had only read of the electric light being fully met. To those who watched closely there was apparent a very sensible variation in the intensity of the light, although there was nothing approaching to the flickering motion so noticeable in some forms of electric light. The variation to which we allude was owing to the fact that the belt which drives the "governor" of the steam-engine broke early in the evening, and the engine had to be run during the remainder of the time without the aid of the governor to maintain an equal rate of speed. Every effort was made to keep the steam at an even pressure, but whenever water had to be pumped into the boiler it fell off slightly and the strength of the current was at once reduced. This accident also accounts for the slight interruption immediately after the current had been turned on. In spite of this drawback the exhibition may be regarded as a success, and the immense superiority of the electric light over our ordinary system of street-lighting became very apparent, in spite of the glare of gas from a number of shops which were open. As previously stated, there are eight lamps extending the whole length of Queen-street from the corner of Eagle-street to the Bridge, a distance of a little over half-a-mile. We learn that a second exhibition of the light will be given in Queen-street, this evening from half-past 7 till 10 o'clock. This will form an attractive feature in the Separation Day celebrations, and it is interesting to note that it is just seventeen years ago since a former anniversary was made the ocoassion of the first display of illuminating gas in Brisbane. On Monday 11th December, 1865 the Brisbane Gas Company, then just beginning operations, erected an arce studded with burners across Queen-street, in front of the whole Supreme Court. The unusual sight when the whole was lit up gathered one of the largest crowds which, up to that time had been seen in Queen-street. There was a central arch with two smaller ones over the footpaths, the central ornament consisting of the words "Advance Brisbane," in jets of gas. Brisbane and the whole colony have truly advanced with immense strides since that time, and it seems that in the matter of artificial lighting we are not likely to be behind the age.—*Courier.*

The Electric Light in Brisbane. (1882, December 13). Western Star and Roma Advertiser (Toowoomba, Queensland: 1875 - 1948), p. 3. Retrieved from http://nla.gov.au/nla.news-article97518345.

Comment on the parts of the article surprised you, and why.

Imagine you were one of the people who attended this event. You just witnessed electric lighting for the very first time! Write a journal entry about the event from this perspective.

Remember to include factual information, as well as your own thoughts and feelings, about the event. You may even like to reflect on how this event may change the way you live and contribute to the development of your community.

Use the article to compare and contrast your life today with life in 1882, when the first public demonstration of electricity occurred.

Edward Barton: Electricity Pioneer

Electricity was quickly installed throughout Queensland following its first public demonstration in Brisbane in 1882. In 1883, electric lighting was installed in the Government Printing Office. In 1886, electric lighting was installed in the Queensland Parliament House - most likely the first government building in the Commonwealth to use electricity.[7] In 1888, electric lighting was installed in the General Post Office – this was the first public supply of electricity in Australia, not just Brisbane. The supply of electricity to the General Post Office was soon extended via a system of overhead wires to nearby shops.

Portrait of Edward Barton, circa 1910. State Library of Queensland.

One of the key people involved in the production and supply of electricity throughout Brisbane and Queensland was Edward Barton. Barton, an electrical engineer, is widely considered a pioneer of electricity supply in Queensland. In fact, it was Barton and his colleague, C.F. White, who installed the electric lighting in the General Post Office. Their business, Barton, White & Co., was the first electricity supplier in Australia!

You will now conduct research to investigate the life and achievements of Edward Barton. Use a timeline to sequence and record your findings.

Date	Describe the Event

7 King, J. (2003). *Power for the People: Brisbane's Electric Heritage. 1880s – 1950s*. Queensland Energy Museum Inc.

EXPLORE – EXPLAIN – ELABORATE – EVALUATE

Electrifying Vehicles

Teacher Resource

We use electrical energy to power many things. In this activity, students explore vehicles powered by electricity. They explore the story of the Lucas Bedford electric van, make a battery-powered car in a hands-on design challenge, and then use the specifications of different electric vehicles to plan a road trip in Queensland. You can find additional information about these activities on the following pages.

The Lucas Bedford Electric Van

The Lucas Bedford electric van is part of Queensland Museum's Cultures and Histories collection. It was one of two vans used during the 1982 Commonwealth Games in Brisbane.

One of the Lucas Bedford electric vans used in the 1982 Commonwealth Games. It is now part of Queensland Museum's collection and is stored at The Workshops Rail Museum, Ipswich Queensland Museum.

Although the Lucas Bedford electric van was not the first electric vehicle on Australian roads, it is significant because it is an example of how the automotive and electrical manufacturing industries responded to the oil crisis of the mid-1970s. The goal of these industries was to mass-produce electric commercial vehicles as an alternative to oil-powered vehicles. The use of the van at major gatherings and events, such as the Commonwealth Games, was intended to promote the benefits of owning and using electric vehicles to the general public. However, as the oil crisis resolved, the high purchase cost of electric vehicles became a significant barrier to their widespread use and adoption.

Electric Vehicle Design Challenge

In this challenge, students design, create and test a battery-powered toy car that should be able to travel a distance of at least five metres. Students use recyclable materials and electrical components to create and test their designs. While the students may source some of these materials themselves, other materials will need to be provided by the teacher. Suggested materials for this design challenge are provided on the following pages.

Curriculum Links

Science

YEAR 6

Science Understanding

Electrical energy can be transferred and transformed in electrical circuits and can be generated from a range of sources (ACSSU097)

Science as a Human Endeavour

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE098)

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

Science Inquiry Skills

With guidance, pose clarifying questions and make predictions about scientific investigations (ACSIS232)

Identify, plan and apply the elements of scientific investigations to answer questions and solve problems using equipment and materials safely and identifying potential risks (ACSIS103)

Decide variables to be changed and measured in fair tests, and observe, measure and record data with accuracy using digital technologies as appropriate (ACSIS104)

Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data using digital technologies as appropriate (ACSIS107)

Compare data with predictions and use as evidence in developing explanations (ACSIS221)

Reflect on and suggest improvements to scientific investigations (ACSIS108)

Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS110)

Design and Technologies

YEAR 5 AND 6

Design and Technologies Knowledge and Understanding

Investigate how electrical energy can control movement, sound or light in a designed product or system (ACTDEK020)

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

Design and Technologies Knowledge and Understanding

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

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

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

Mathematics

YEAR 6

Number and Algebra

Select and apply efficient mental and written strategies and appropriate digital technologies to solve problems involving all four operations with whole numbers (ACMNA123)

Find a simple fraction of a quantity where the result is a whole number, with and without digital technologies (ACMNA127)

Add and subtract decimals, with and without digital technologies, and use estimation and rounding to check the reasonableness of answers (ACMNA128)

Measurement and Geometry

Convert between common metric units of length, mass and capacity (ACMMG136)

Solve problems involving the comparison of lengths and areas using appropriate units (ACMMG137)

HASS: Economics and Business

YEAR 6

Knowledge and Understanding

How the concept of opportunity cost involves choices about the alternative use of resources and the need to consider trade-offs (ACHASSK149)

The effect that consumer and financial decisions can have on the individual, the broader community and the environment (ACHASSK150)

The reasons businesses exist and the different ways they provide goods and services (ACHASSK151)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Composing texts through speaking, writing and creating

Numeracy

Estimating and calculating with whole numbers

Using fractions, decimals, percentages, ratios and rates

Using spatial reasoning

Using measurement

Information and Communication Technology

Investigating with ICT

Creating with ICT

Critical and Creative Thinking

Inquiring – identifying, exploring and organising information and ideas

Generating ideas, possibilities and actions

Reflecting on thinking and processes

Analysing, synthesising and evaluating reasoning and procedures

Personal and Social Capability

Social management

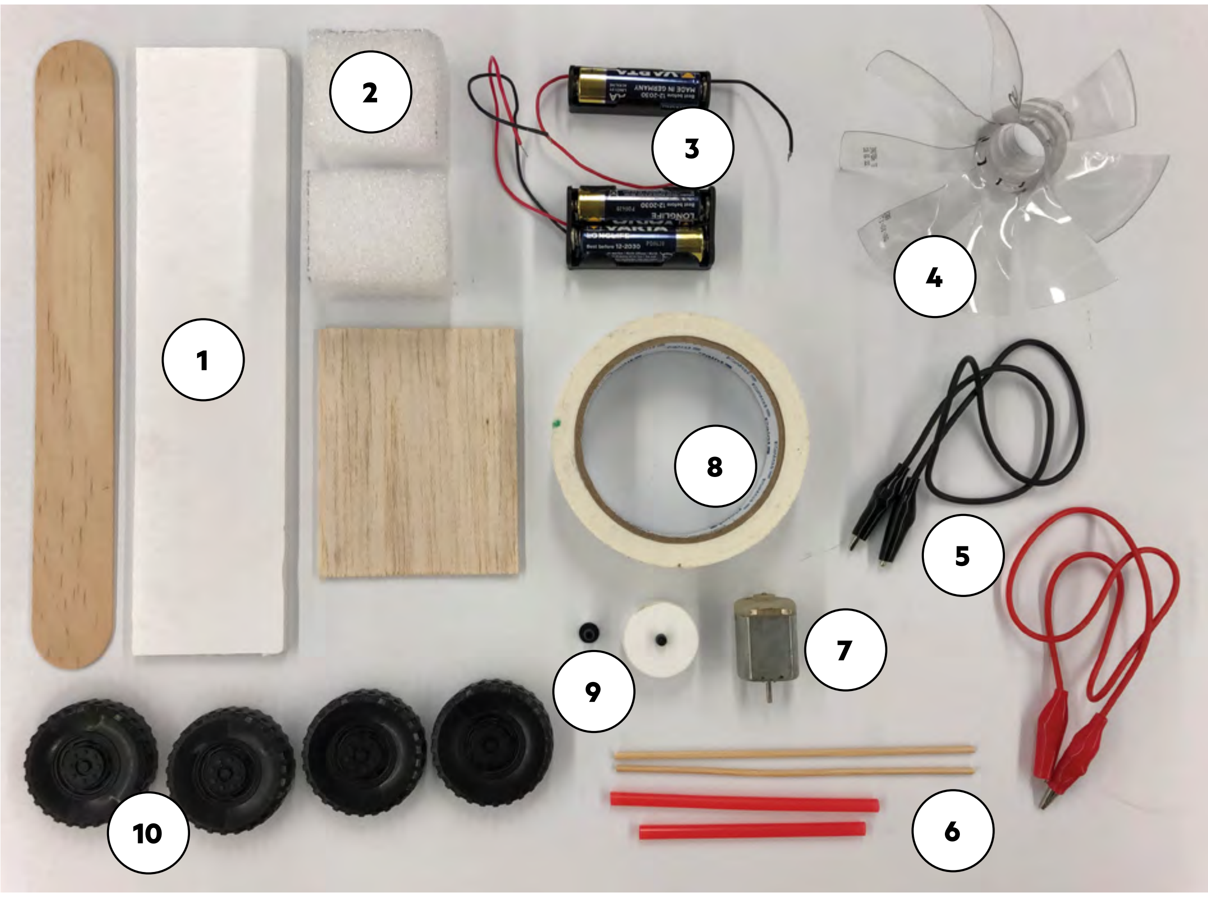
Electrifying Vehicles

Teacher Resource

Material Suggestions

We recommend the following materials for the *Electrifying Vehicles Design Challenge*. You can substitute some materials for others or provide additional materials that are not listed below. Ensure students know how to work safely with electrical components before they create their designed solutions.

Materials to Construct a Battery Powered Car



1 Chassis materials, such as large tongue depressors, corflute and balsawood.

2 Booster materials, such as foam blocks. The foam blocks raise the motor and fan, so that there is more space between the fan and the ground. Lighter materials will allow the fan to propel the vehicle further.

3 Batteries and battery holders. We recommend providing single and double AA battery holders for students to choose from, as well as the corresponding number of AA batteries. Students could also experiment with different battery sizes, including AAA, C, D or 9V batteries.

4 A fan, made from the top of a plastic bottle. The fan is attached to the motor. When the fan is connected to the circuit, it provides the force needed to move the car along the ground. Note: Teacher assistance will be required to construct the fan.

5 Alligator clips.

6 Straws and skewers, used to make the front and rear axles.

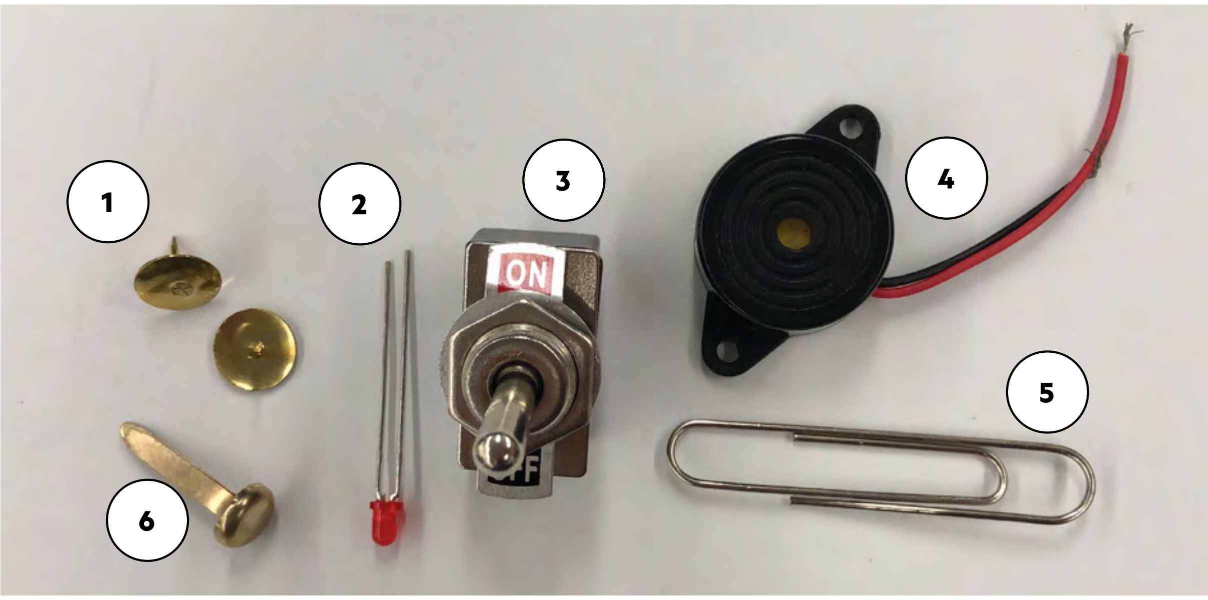
7 9V motor.

8 Masking tape.

9 A bottle lid and motor adaptor pin. A small hole is drilled into the centre of the lid. The motor adaptor pin is inserted into the lid and secured in place with hot glue. The motor adaptor pin is attached to the motor, and the lid is attached to the fan. Note: Teacher assistance will be required to make a hole in the lid of the bottle top and to secure the motor adaptor pin with hot glue.

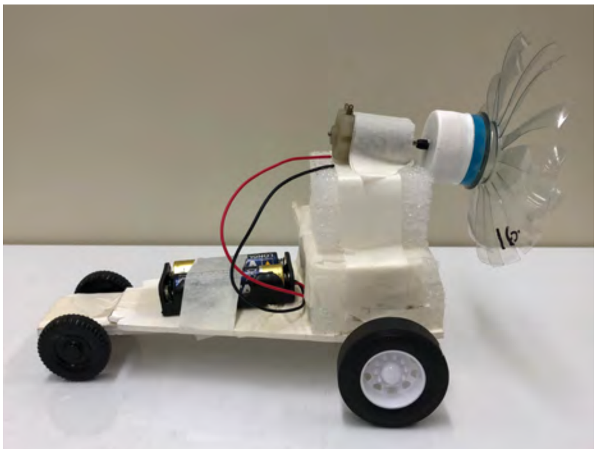
10 Plastic wheels.

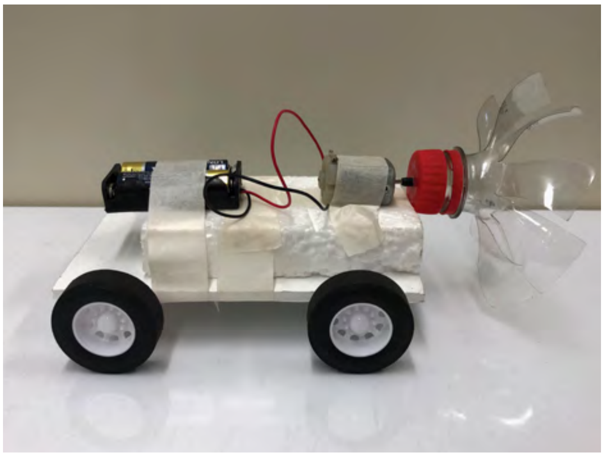
Optional Materials



1 Thumb tacks	**2** LED lights	**3** Switch
4 Buzzer	**5** Paperclip	**6** Split pins

Battery Powered Car Examples





Electrifying Vehicles

Student Activity

The Lucas Bedford Van

We use electrical energy to power many things, including vehicles. Electric vehicles have actually been around for a lot longer than you might think! The first electric car is believed to have been built by English inventor, Thomas Parker, in 1844. Around this time, the world was experiencing the rapid development of electricity, and many other inventors, engineers and scientists were also exploring how electrical energy could be used to power different vehicles and machines.

An electric vehicle that has an important place in Queensland's history is the Lucas Bedford electric van. Two Lucas Bedford electric vans were used during the 1982 Brisbane Commonwealth Games, and one of these vans is now part of Queensland Museum's collection.

Image, top: One of Thomas Parker's electric cars, circa 1895. Parker sits in the middle of the photograph.
Image, bottom: One of the Lucas Bedford electric vans used in the 1982 Commonwealth Games. Queensland Museum.

The vans were used during the road walk event and the men's marathon. One van led the competitors and carried a digital clock, which showed the race time and distance covered. The other van drove behind the competitors; this van transported crew and equipment and picked up exhausted or injured runners and walkers.

The vans travelled almost silently, could cover a distance of 100 kilometres and had a top speed of 80 kilometres/hour. A lightweight rechargeable battery was used to power the vehicles.

When a battery is connected to a circuit, a chemical reaction occurs within the battery. This reaction transforms chemical energy to electrical energy. The electrical energy then flows through the wires of the circuit, where it can be transformed into other types of energy, from light to sound to movement (kinetic energy), similar to the electrical energy travelling through your home or school. Over time, the materials in the battery no longer react and eventually the battery 'goes flat'.

Image, right: Runners competing in the 1982 Commonwealth Games marathon. The Lucas Bedford electric vans, used as lead and field vehicles, are seen in the bottom right corner and the middle of the image. Image courtesy of Mimag, retrieved from http://nla.gov.au/nla.obj-306125746.

For some batteries (like the ones you might find in a television remote), this chemical change is irreversible and a brand new battery is needed as a power source when the old battery goes flat. For other batteries (like the ones you might find in a mobile phone, laptop, or the Lucas Bedford van), this change is reversible and the battery can be recharged. This is because rechargeable batteries can be connected to an external source of electricity – say through a charger that is connected to mains power – and the flow of electricity into the battery can reverse the chemical reaction, restoring the battery's charge. The battery can then be reused as a power source.

Despite the benefits of the Lucas Bedford electric van, its high purchase and servicing costs, heavy mass and limited driving range meant that it was not widely used by people after the Commonwealth Games. Today, electric vehicles are comparable in cost, mass and driving range to most fuel-powered cars, and we are now seeing greater numbers of electric vehicles on the roads.

Electrifying Vehicles

Student Activity

Electric Vehicle Design Challenge

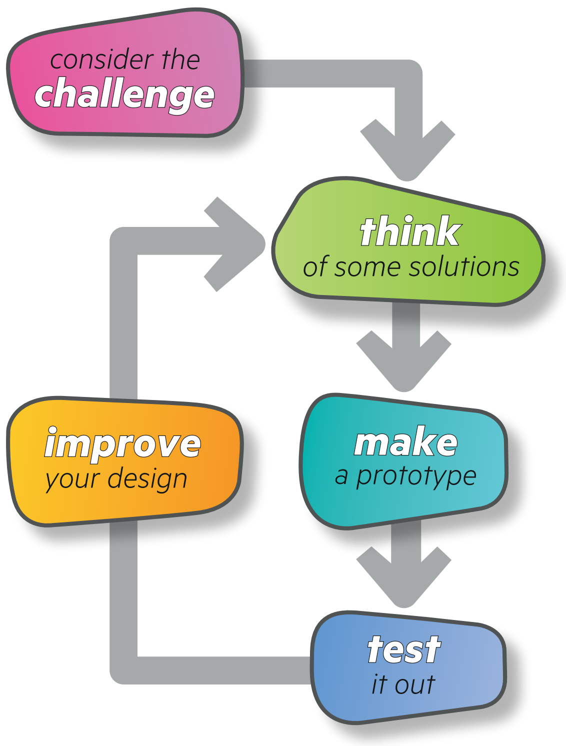
Task:

Design, create and test a battery-powered toy car. The car should be able to travel a distance of at least five metres.

You must:

- **Consider the challenge.** What are the requirements of the design challenge?

  Think of some solutions. Investigate the components that a car needs to move. What materials and electrical components could you use to replicate these parts? What other ideas do you have for a design?
- **Make a prototype.** What materials and components will you use? How will you work safely? Create a labelled diagram of your design, and then construct your prototype.
- **Test it out.** Test the prototype. What did you notice? Did the prototype operate as you intended? You may also like to explore the effect of different variables, such as the number of batteries used in your design.
- **Improve your design.** You may like to introduce new features to the car, such as light or sound. Keep testing and refining until you are satisfied with your design.
- **Evaluate your design.** What aspects of your design are you very satisfied with, and why? What challenges did you experience during the design process, and how did you overcome them?



Consider the Challenge

What are the requirements of the design challenge? Identify and record these requirements, and any criteria for success, below.

Think of Some Solutions

A car uses the following parts to move:

Wheels	Axle	Battery	Engine

Research what these parts do and where they are found in a car. Draw a labelled diagram of a car, showing the location of these important parts on your diagram.

Consider the materials and electrical components you could use to replicate these parts of the car, as well as other major car parts like the car body. Mark these ideas on your diagram above.

Make a Prototype

Design your battery-powered car. Consider the characteristics and properties of materials and how you will use electrical energy to control movement.

Draw a labelled diagram of your battery-powered toy car. Make sure you identify and justify the materials and electrical components you will use in your design.

Draw a circuit diagram of your battery-powered toy car.

Construct your prototype.

Explain any changes that were made to the design as you created the prototype.

Test It Out

Test your design and record your observations below.

Explain your observations. Consider what you already know about electrical energy and the properties of different materials. Make sure you include scientific language in your explanation.

If you are completing the Electric Vehicle Investigation, please do so now. Move ahead two pages to find the investigation.

Improve Your Design

Explain how you will improve your design. You may also like to introduce new features to the car, such as light or sound.

Draw a revised circuit diagram to show these modifications.

Re-test your design. Explain and evaluate the effect of these modifications.

Continue testing and refining until you are satisfied with your design.

Evaluate Your Design

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

- Explain how your knowledge of science helped you to make decisions about your design.
- Evaluate your final design. Which aspects are you most satisfied with? Which aspects would you further improve on? How would you make these improvements?
- Describe the main challenges you experienced during the design process. Explain how you overcame these challenges.
- Explain what you have learnt about electrical energy and/or the design process from this activity.

Electrifying Vehicles

Student Activity

Electric Vehicle Investigation

Explore the effect of changing one variable (the independent variable) on the design of your electric vehicle. You could investigate the effect of the number of batteries, voltage of batteries, mass of the car or another variable of your choice. Remember, for a fair experiment you should change only one variable.

Aim

State the purpose of your investigation.

Hypothesis

Make a prediction about the outcome of the investigation, giving reasons for your response.

Variables

Identify the variables you are going to change, measure or observe and keep the same.

Change? (Independent Variable)	Measure/Observe? (Dependent Variable)	Keep the same? (Control Variables)

Materials

List all of the equipment you will use in the investigation. Remember to include numbers and amounts.

Method

List all of the steps you will take to conduct the investigation.

Risk Assessment

What safety considerations must be made before, during and after the investigation? Identify at least five risks and how to minimise them.

Risk	How to manage the risk

Recording Results

Draw a table and record your results.

Represent this data as a graph. You could use Excel to create the graph.

Discussing Results

Summarise the results.

Explain the results.

Explain if your original prediction was supported by the data collected.

Discuss how you could use these results to improve your battery-powered toy car.

Describe any challenges you experienced during the investigation.

Explain how you could improve the investigation.

Conclusion

Summarise the experiment and the results. Was your prediction supported or refuted?

Electrifying Vehicles

Student Activity

Planning a Road Trip - EV Style

In this activity, you will plan a Queensland road trip in an electric vehicle. You must choose your vehicle, and then identify the approximate road trip route you would like to take. Identify where you would like to go, and then identify where you will need to stop to recharge.

You may use Queensland's Super Electric Highway and PlugShare charging points (focussed on Queensland) to plan your journey. You may also plan to charge using normal household 240 V power points, for example, while staying in overnight accommodation, however recharging using household power is significantly slower than most public charging points.

Electric Vehicle Specifications

Research an electric vehicle. Identify how far the vehicle can travel in a single charge (its range) and its top speed. Record this information in the table below.

	Electric Vehicle:
Range (km)	
Top speed (km/h)	

Plan Your Journey

Think about where you would like to travel on a road trip. Use Queensland's Super Electric Highway and PlugShare charging points in Queensland to plan your journey. If there are any parts of the journey where you will not have public charging stations, you may need to charge overnight at your accommodation.

Create a Map of Your Journey

Draw your trip on a map of Queensland, and record the distances between your major stops/points of interest.

Add the public charging stations along your route. Are there any long stretches of driving where you do not have a public charging station? Can you modify your journey slightly to travel via public charging stations, or will you need to charge at private accommodation?

Identify where you will need to charge along your journey. How many stops will you need to make? How many times will you need to stop to specifically charge your vehicle (rather than stopping at a destination or point of interest)?

Calculate how long it will take you to complete your journey. How much time do you spend at each destination? How long does it take to charge the vehicle along the way?

You may need to investigate charge time specific to your vehicle, because charging an electric vehicle can take anywhere from 20 minutes using a fast charger to over 24 hours using a regular household plug, depending on battery size and type of charger. The chargers along Queensland's Electric Super Highway generally have 22 kW AC charging points and 50 kW DC fast charging points. You can identify approximately how long it will take to charge your vehicle by searching the specifications of your vehicle. The Fleets Charge Together Vehicle Guide also has charging information for electric vehicles in Australia and the Electric Vehicle Database contains information on electric vehicles in the USA, UK and Germany.

Record your answers in the table below.

	Electric Vehicle:	
Explain why you chose your route. Were you required to make any trade-offs?		
How many stops will you need to make to complete your road trip?		
Which locations will you stop at to recharge? How did you choose these locations?		
How long will your road trip take? You may like to use the space here to record working out.		

Evaluate the strengths and limitations of long distance travel in these vehicles. What trade-offs do you need to consider?

Imagine the Queensland Government is selecting the location of 10 new fast-speed charging sites. Write a letter of recommendation to the government, detailing where you believe these sites should be located and why.

Examine how your road trip may change if the government accepts your proposal and builds your recommended charging stations.

Some private businesses have their own charging stations, such as the Birdsville Roadhouse and Cunnamulla Tourist Park. How did/could the decision of these businesses to provide charging stations affect your travel? Additionally, how could the decision affect the business, broader community and the environment?

If you were to complete your road trip in the Lucas Bedford van, discuss how your journey would change. Include data in your answer.