EDUCATION ON TRACK

SIMPLE MACHINES

Purpose
This program of work aims to provide opportunity to explore simple machines in the context of home, school and the railway. Students will be able to apply what they learn about simple machines to everyday life.

The primary objectives of the program are for students to gain an understanding of:

- Simple machines, why we use them, what they are (the six types) and how they work.
- How simple machines are combined to make compound machines such as the locomotives and rail-related machinery.

Activities in this program assist students to investigate how machines we use everyday help make our work easier.

Students are provided with primary and secondary *Railway Resources* including:

- Photographs
- Schematic drawings of locomotives

Key concepts
Simple machines are used to assist in making work easier. Simple machines help lift, pull, increase elevation of heavy things, change the direction of the force, increase the force, split things, fasten things, and cut things. With the Industrial Revolution, which in Great Britain in the 1700s was sparked by the invention of the Steam Engine, people began to see the value in combining simple machines to make more complex machines to ease work loads and increase the availability of goods and products.

QR (Queensland Rail) has utilised simple machines throughout its history, from the wheels and axles of a locomotive to the tools used to lay the tracks. By the end of this program of work students will be able to understand how simple machines work in the context of home, school and the railways.

Learning outcomes

SCIENCE	**E&C 4.1**	Students design and perform investigations into relationships between forces, motion and energy.
ENG	**OP 4.3**	Students, when writing and shaping organise and link ideas using generic structure, paragraphs, topic sentences and theme, elaborate ideas and support a position, extended noun groups, phrases, words and visual resources, use sound, visual and meaning patterns and knowledge of word function to spell.
TECH	**MAT 4.1**	Students explain how characteristics of materials affect ways they can be manipulated.
TECH	**MAT 4.2**	Students employ their own and others' practical knowledge about equipment and techniques for manipulating and processing materials in order to enhance their products.
TECH	**TP 4.2**	Students generate design ideas through consultation and communicate these in detailed design proposals.

Inventors Log and KWL Chart
Students are asked to complete tasks which encourage active participation and maximum engagement. These include tasked activities such as:

- Inventors log which challenges students to plan, design and build a simple machine that is able to help solve a posed problem.
- KWL Chart provides a way for the student and teacher to track the met-cognitive development throughout the program.

Student task sheets are available from the website as a downloadable PDF.

Program outline

Total time: This program could be run over a term.
Previous knowledge: An understanding of ratio. Additionally, an understanding of the different forms and sources of energy could be of benefit.
Description: • Pre-visit ➢ Students participate in the introductory lessons **Stimulating Interest in Simple Machines, lessons 1 & 2**. Students are asked to fill out a **KWL Chart** and complete a take home **Observational Exercise** related to simple machines (**Part A**). ➢ Students participate in a **Simple Machines Scavenger Hunt**. • Visit to The Workshops Rail Museum ➢ Students participate in a two-day hands-on "Simple Machines" workshop at The Workshops Rail Museum. During these workshops students use Lego to build simple machines and explore how simple machines can be found in complex machines such as locomotives and other rail-related machinery. • Post-visit ➢ Students are asked to invent a machine to solve a given problem. This invention activity provides students with an opportunity to apply what they have learned about simple machines in a problem solving context. ➢ Students are asked to fill out a **KWL Chart** and complete a take home **Observational Exercise** related to simple machines (**Part A**).

Support materials and references

Teacher Resources:

Merrell, Jo Ann (2003). **Hands-on Minds-on Science: Simple Machines**. Hawker Brownlow Education: VIC.

Queensland Studies Authority, Science Module **Force and Motion**

Queensland Studies Authority, Mathematics Module **A visit to a museum**

Internet sites:

Simple machines, on-line construction site:
http://home.earthlink.net/%7Ekandyhig/sm/index.htm
MYKIDS.COM: http://sirinet.net/~jgjohnso/simple.html
Egheads: http://edheads.org/activities/simple-machines/
Thinkquest: http://library.thinkquest.org/J002079F/sub3.htm
A comprehensive list of possible sites on simple machines:
http://www.teachers.ash.org.au/jduke/jnrscience/JR3websites.html
The Workshops Rail Museum: http://www.theworkshops.qm.qld.gov.au

Introducing the program: Lesson 1

Stimulating Interest in Simple Machines

Introduce the terms gravity, friction, and force on the board to provide a vocabulary base for the playground activity that follows. Briefly discuss as a class the meaning of each term and encourage students to fill out the **KWL Chart** as a means of evaluating their existing knowledge and monitoring their learning progress.

Playground Activity:

- Take the entire class outside for whole group activity.
- Select a few students to demonstrate gravity on the monkey bars.
- Ask them to climb halfway across the bars. Then, ask them to hang and let go of bars.
- Discuss what caused the students to drop to the ground.
- Take the students to the slide for a demonstration of friction.
- Have students predict if students would travel faster down the slide with or without a towel.
- Allow several students to go down the slide with and without the use of a towel.
- Note the difference and briefly discuss the use of friction.
- Reinforce the function of gravity to enable the students to go down the slide.
- Take the students to the swings to demonstrate the concepts of force, work, and inertia.
- Discuss the terms as the students demonstrate as they swing.
- Take the class back to the classroom to discuss their learning.

Discuss as a large group what transpired on the playground. Brainstorm as a group and write the group responses on chart paper. Circle conceptual terms for a word bank. Include gravity, inertia, force, and friction.

KWL Chart

K	W	L
What I **K**now	What I **W**ant to know	What I **L**earned

Introducing the program: Lesson 2

Stimulating Interest in Simple Machines

Begin this program with a number of exhibits to arouse interest. Include rulers, wedges, nails, screws, nuts and bolts, small wheels, prisms, egg beaters, a pencil sharpener, and even meccano if it is available. See if students can identify similar attributes of the objects. Allow time for students to handle materials. In small groups, encourage students to handle the items collected and discuss how they fit into categories. Promote discussion about why they feel the items need to be grouped in such ways.

This is likely the first opportunity the students have had to study simple machines. Introduce new vocabulary: levers, pulleys, screws, wheel and axle, inclined plane, wedge, simple machine, compound machine, energy, friction, motion, force, push, pull, gravity, etc. Write these words onto card and post them the board. Allow time for students to share what they think each word means.

Pose questions to students to start discussion about simple machines.

- Why do we use machines?
- What are simple machines?
- What are complex machines?
- Why do we use simple machines?
- How many different types of simple machines are there and what are they?
- How can the different types of simple machines be grouped?

Provide students with the **Explanation of the different types of Simple Machines** to read through. Encourage students to write definitions to the words posted on the board earlier.

To reinforce learning use railway photos for the conclusion of the lesson.

Divide students into cooperative groups. Ask students to carefully examine the photos provided. Ask them to locate the simple machines demonstrated in each photo.

Explanation of the different types of simple machines

Scientists recognise four different types of simple machines.

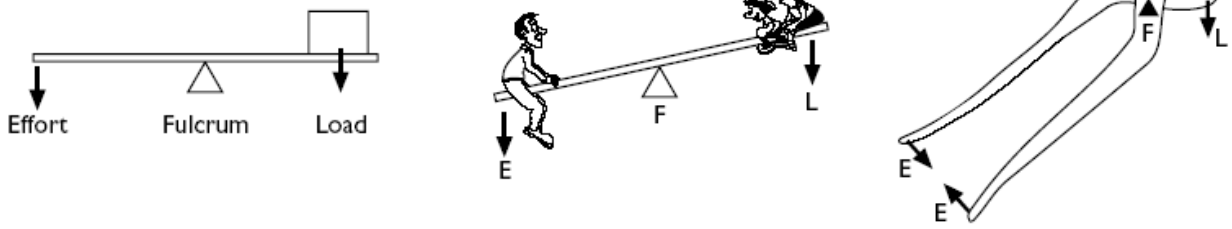
1. The lever

A lever is usually a rigid bar or rod which can rotate about a fixed point, called the **fulcrum**. A force, called the **effort**, is applied to the lever with the intention of causing the bar to rotate about the fulcrum thus causing the **load**, located at some other point on the bar, to move.

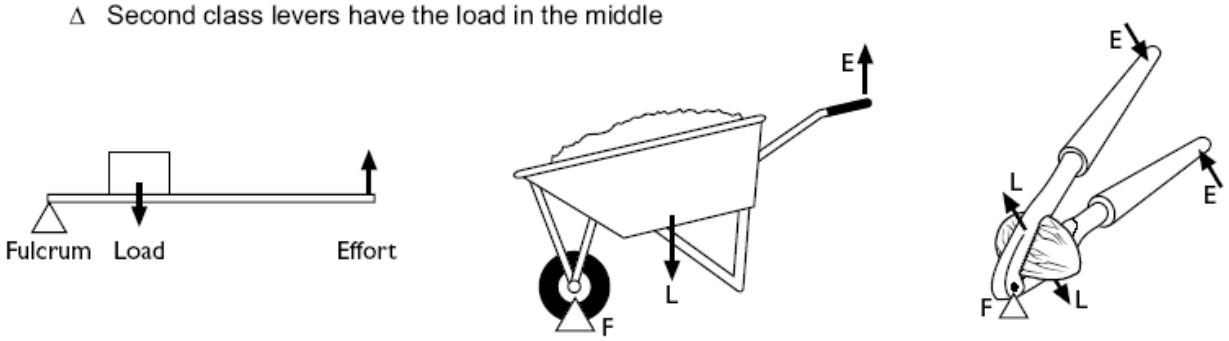
Levers can either magnify a force or magnify the distance moved by a force.

There are three types of lever determined by the position of the three elements:

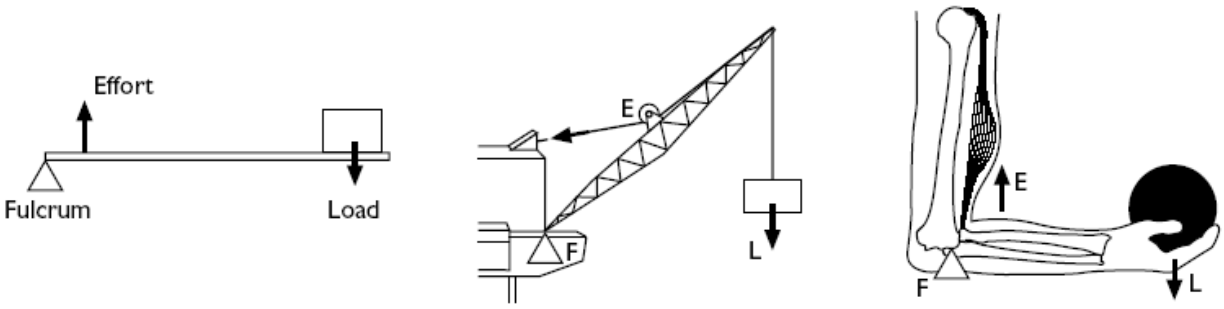
- First class levers have the fulcrum in the middle



- Second class levers have the load in the middle



- Third class levers have the effort in the middle

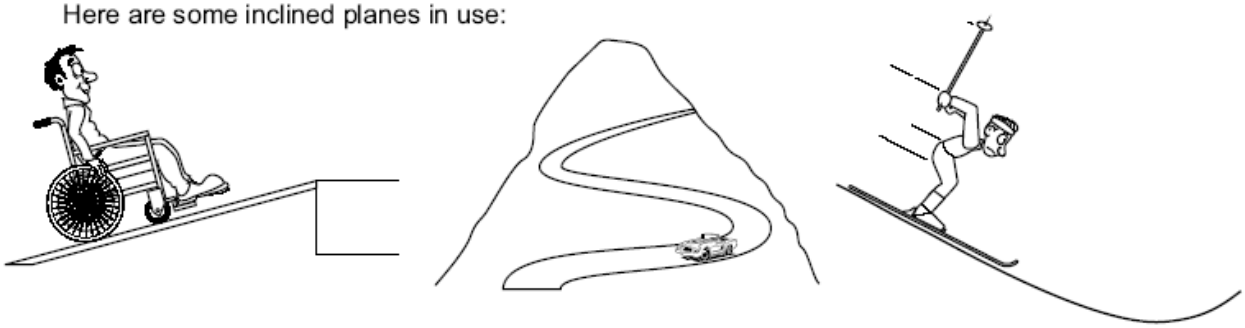


Courtesy of the Curriculum Exchange site
http://education.qld.gov.au/tal/curriculum_exchange/teachers/science/unit_1/ref_pdf/ref_s01.pdf

2. The inclined plane

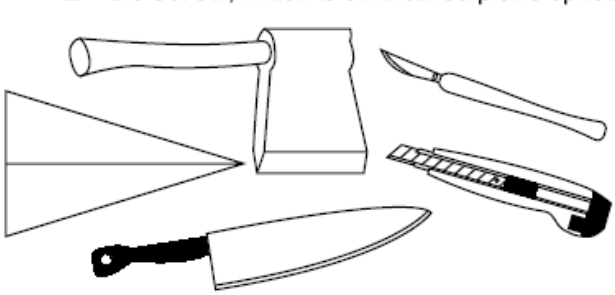
The inclined plane is any inclined (or sloping) surface, track or ramp. Inclined planes make it easier to raise objects, but a longer distance must be travelled in order to raise the object with a smaller force.

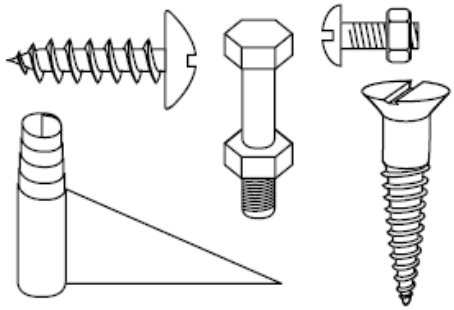
Here are some inclined planes in use:



Two important adaptations of the inclined plane are sometimes treated as separate machines. They are:

- the **wedge**, which is composed of two inclined planes back to back
- the **screw**, which is an inclined plane spirally wound.

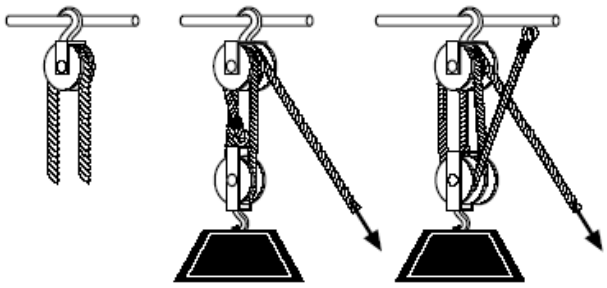




3. The pulley

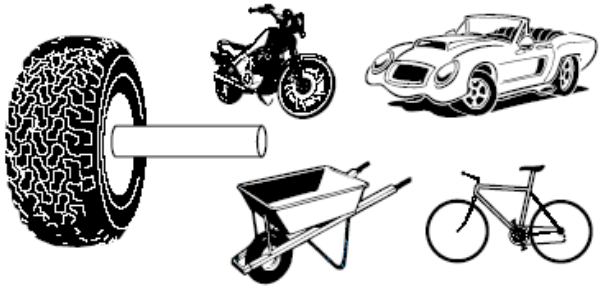
A pulling or lifting device consisting of a mounted wheel with a rope passing over the circumference of the wheel.

A single pulley changes the direction of a force. When a number of moveable pulleys are linked into a system, a larger load can be lifted with a smaller effort.



4. The wheel and axle

This machine consists of two concentric wheels of different sizes. The smaller wheel is usually called the axle. The wheel and axle can magnify a force or distance moved by a force. It is a common component of many complex machines.



Photographs:

1.

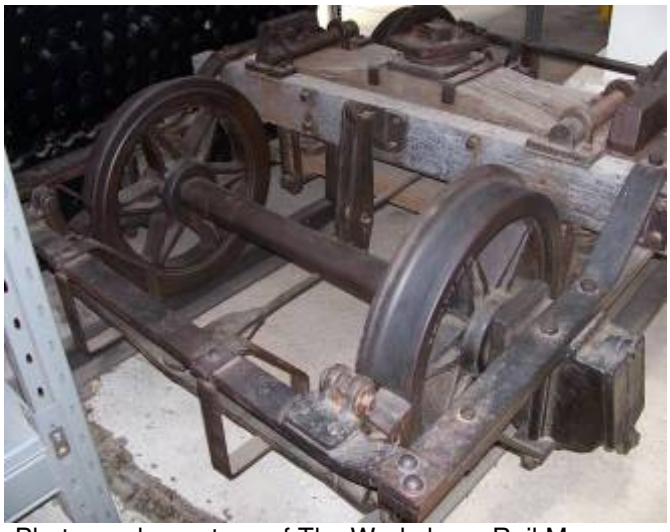
Photograph courtesy of The Workshops Rail Museum

2.

Photograph courtesy of The Workshops Rail Museum

Photographs:

3.



Photograph courtesy of The Workshops Rail Museum

4.

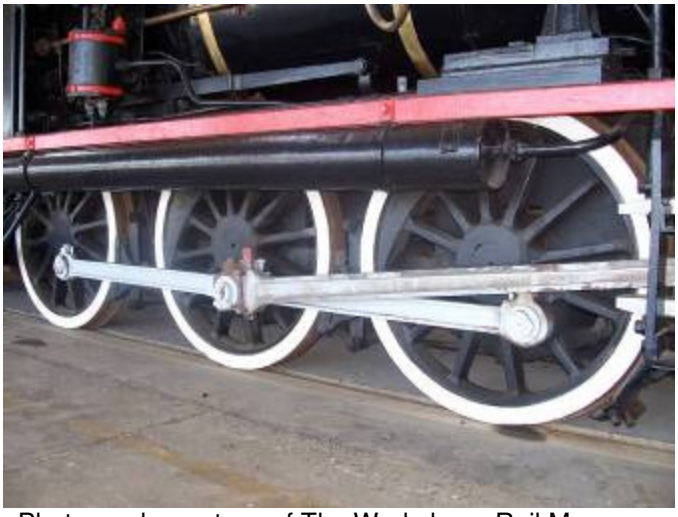
Photograph courtesy of The Workshops Rail Museum

5.

Photograph courtesy of The Workshops Rail Museum

Photographs:

6.



Photograph courtesy of The Workshops Rail Museum

7.

Photograph courtesy of The Workshops Rail Museum

8.

Photograph courtesy of The Workshops Rail Museum

Photographs:

9.

Photograph courtesy of The Workshops Rail Museum

10.

Photograph courtesy of The Workshops Rail Museum

Photograph interpretation key for teachers:

1. This is the firebox door of a 1948 Perry steam locomotive. It is an example of a third class lever.
2. These are sanding levers on a 1948 Perry steam locomotive. They are also examples of third class levers.
3. This is a wooden archbar bogie from a goods wagon built around the 1800's. It is an example of wheels and axles.
4. This is a C17 tender boggie (four wheel truck). It is an example of a wheel and axle.
5. This is a whip crane used in a goods yard for loading and unloading heavy items (up to 3 tonne). It is an example of a working gear.
6. These are driving wheels (or coupled wheels) on a steam locomotive. It is an example of wheels and axles.
7. This is an overhead travelling crane used in the workshops. It is an example of compound gears.
8. This is a water crane used for putting water into a steam locomotive. It is an example of third class lever.
9. This is a pulley system used to raise and lower the hook on a travelling crane. It is an example of a pulley system.
10. This is a pulley and hook used to make lifting easier in the workshops. It is an example of a pulley system.

Glossary of terms:

- Archbar Bogies: An older bogie constructed from bar steel and timber. Wagons fitted with archbar bogies were usually limited to lower speeds on goods trains unless they were fitted with larger journals and wheels, when they could be run at passenger train speeds. Wagons restricted to goods trains had 660mm diameter wheels, while those fitted for passenger train speeds had 838mm diameter wheels.

- Sanding Levers:

- Tender Bogie:

Observation Exercise: Part A

Simple Machines

Take a walk around your **home** and answer the following questions:

1. What object did you find?

   _____

2. Draw the object:

3. Name the type of simple machine that your object is? (If your object is made up of more than one simple machine, make a list of them all).

   _____

4. How can you tell what type of simple machine your object is?

   _____

   _____

5. How does this simple machine make work easier?

   _____

   _____

Take a walk around your **school** and answer the following questions:

6. What object did you find?

   _____

7. Draw the object:

8. Name the type of simple machine that your object is? (If your object is made up of more than one simple machine, make a list of them all).

   _____

9. How can you tell what type of simple machine your object is?

   _____

   _____

10. How does this simple machine make work easier?

    _____

    _____

Observation Exercise: Part B

Simple Machines

Take a walk around **The Workshops Rail Museum** and answer the following questions:

11. What object did you find?

    _____

12. Draw the object:

13. Name the type of simple machine that your object is? (If your object is made up of more than one simple machine, make a list of them all).

    _____

14. How can you tell what type of simple machine your object is?

    _____

    _____

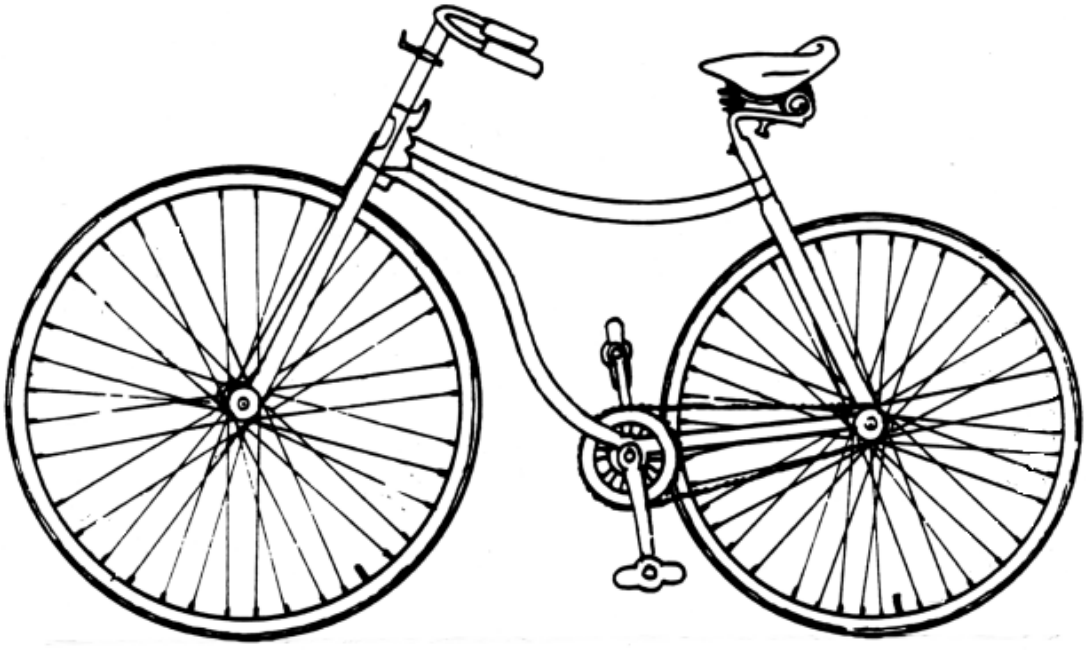
15. How does this simple machine make work easier?

    _____

    _____

Assessment:

16. Examine the bicycle below and find as many simple machines as you can. Circle each part and give it an appropriate label (i.e. wheel, lever, pulley…).



Student's Names: _____

Simple Machines Scavenger Hunt

Your school and its grounds are great places to find examples of every type of simple machine. Work with a small group of no more than 3 students to locate at least two examples of each simple machine listed in the table below. Draw the machine and label its parts. Write where you find each example.

Simple Machine	Examples		Location
Lever			
Wheel and Axle			
Pulley			
Inclined Plane			
Wedge			
Screw			

Inventors Log

Student's Name: _____

Date work commenced:_____ Date work was completed:_____

Problem
Examine the following problem carefully and then view the station photos of the station before working on a solution.

At a remote railway station in North Queensland a mimic panel is delivered by rail for instalment in a three story signal cabin. Using only simple machines, workers need to lift the 200kg mimic panel up into the signal box. The stairway is too narrow to pass the mimic panel up but there is a heavy lifting point above the third storey balcony. Your task is to design and build a model of a machine that can easily lift the mimic panel from the ground to the third storey balcony for installation.

Task 1: Outline a possible solution(s)

_____

_____

_____

Task 2:

Design 1: Design and label your first simple machine drawing

List the materials you will need to build your simple machine:

_____

_____

_____

Build and test your first design. How could you improve your design?

_____

_____

_____

Task 3:

Design 2: Design and label your second modified simple machine drawing

List the additional materials you will need to build your second modified simple machine:

_____

_____

_____

Build and test your second design. How well did your improvements to your design work?

_____

_____

_____

Teacher's comments:

_____

_____

_____

_____

Photographs:

A: Three storey station from a side view.

B: Three storey station from a front view.

Photographs:

C: The mimic panel.

D: The station stairs.