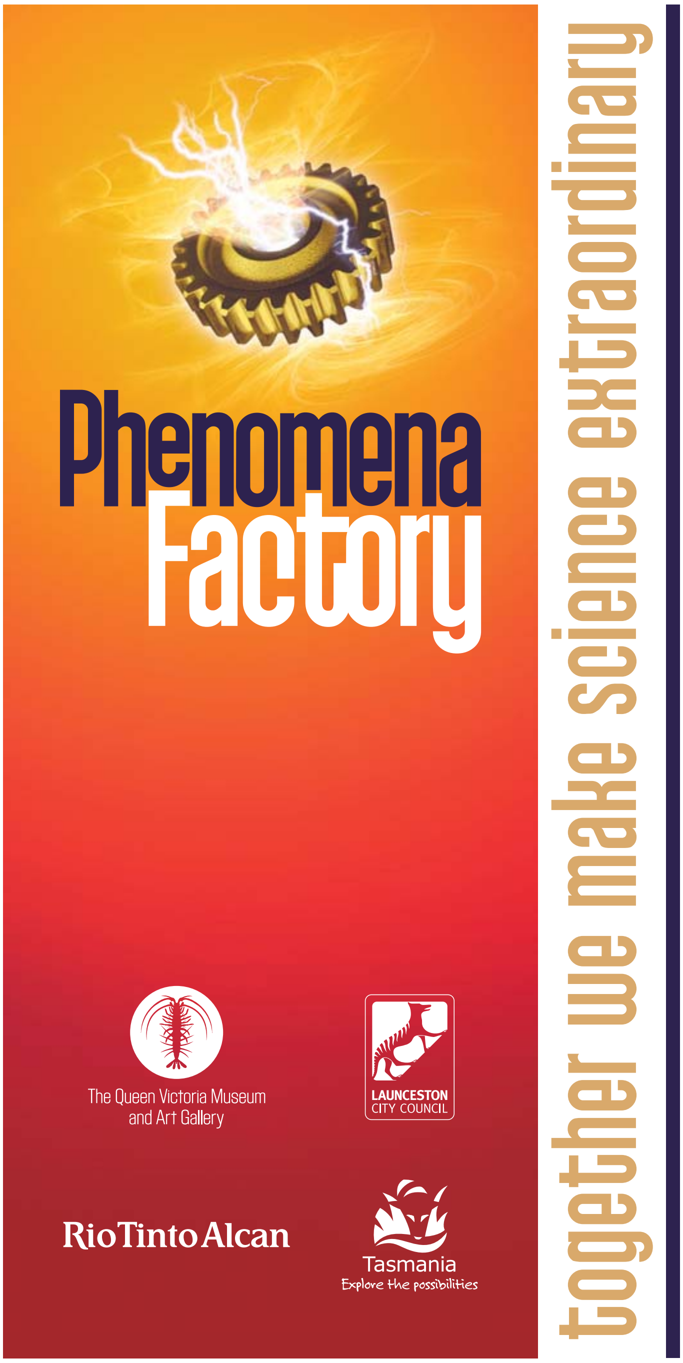

EDUCATION KIT

Part 1
Pre-visit Activities and Exhibit Information

Queen Victoria Museum and Art Gallery at Inveresk
Opening hours 10 am – 5 pm
www.qvmag.tas.gov.au

CONTENTS

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Edited by Ann Teesdale, graphics by Renée Singline and Philippa Steele, and text by Tammy Edmunds.

INTRODUCTION

What are phenomena?

Phenomenon noun (pl. **phenomena**) **1** a fact, occurrence, or circumstance observed or observable. **2** Something that impresses the observer as extraordinary; a remarkable person or thing.

Reference: Macquarie Concise Dictionary NSW: Macquarie Library 2004.

Phenomena Factory is the result of a successful partnership between Rio Tinto Alcan and the Queen Victoria Museum and Art Gallery, with generous support from the Tasmanian State Government and the Launceston City Council. The objective of the partnership is to encourage the community to explore and engage with science and technology.

Phenomena Factory provides free hands-on, minds-on, science education for kids of all ages, with over 30 permanent exhibits.

The exhibition covers various educational subject areas with strong emphases on science.

THE EXHIBITS AND THEMES

Electricity and Magnetism

Magnetic Sculpture
Lightning Tube
Pulse Rocket

Force and Motion

Catenary Arch
Eddies
Ex-1 Rocket
Gravity Well
The Cycloid
Water Vortex
Viscous Liquid

Renewable Energy

Wind Turbine
Solar Panels
Waterwheel

Eye Logic, Neurophysiology and Reflection

Spinners
Optical Illusions
Parabolic Mirrors
Perception Tunnel
Reaction Timer
Talking Vase

Mechanics, Dynamics and Motion

Bernoulli Blower
Robot Buzz

Sound, Wave and Resonance

Echo Tube
Giant 100-Metre Tube
Lissajou Figures
Resonant Pendulum
Thong-a-Phone
Tubular Resonance
Whisper Dishes

SPECIFIC LEARNING OPPORTUNITIES

Below is a guide to the exhibits and their link to stages in the Tasmanian Curriculum. Whilst students may not yet understand the science behind them it is recommended that all students have a turn experimenting with and exploring all exhibits. You are the best person to judge what your students can do and what science concepts they can understand.

	Lower Primary **K–2** *Stages 1–5*	*Upper Primary* **3–4** *Stages 4–8*	*Middle School* **5–8** *Stages 6–12*	*Senior Secondary* **9–10** *Stages 10–15*
Electricity and Magnetism	Magnetic Sculpture Lightning Tube	Magnetic Sculpture Lightning Tube Pulse Rocket	Lightning Tube Pulse Rocket	Lightning Tube Pulse Rocket
Eye logic, Neurophysiology and Reflection	Spinners Optical Illusions Reaction Timer	Spinners Optical Illusions Perception Tunnel Reaction Timer Parabolic Mirrors	Spinners Optical Illusions Perception Tunnel Reaction Timer Talking Vase Parabolic Mirrors	Spinners Optical Illusions Perception Tunnel Reaction Timer Talking Vase Parabolic Mirrors
Force and Motion	Eddies Hover Table The Cycloid Viscous Liquid	Catenary Arch Eddies Ex-1 Rocket Hover Table The Cycloid Water Vortex Viscous Liquid	Catenary Arch Eddies Ex-1 Rocket Gravity Well Hover Table The Cycloid Water Vortex Viscous Liquid	Catenary Arch Eddies Ex-1 Rocket Hover Table
Mechanics, Dynamics and Motion	Bernoulli Blower Robot Buzz	Bernoulli Blower Robot Buzz	Bernoulli Blower Robot Buzz	Robot Buzz
Sound, Wave and Resonance	Echo Tube Giant 100-Metre Tube Resonant Pendulum Thong-a-Phone Tubular Resonance Whisper Dishes	Echo Tube Giant 100-Metre Tube Lissajou Figures Resonant Pendulum Thong-a-Phone Tubular Resonance Whisper Dishes	Echo Tube Giant 100-Metre Tube Lissajou Figures Resonant Pendulum Thong-a-Phone Tubular Resonance Whisper Dishes	Lissajou figures Resonant Pendulum Thong-a-Phone Tubular Resonance Whisper Dishes
Renewable Energy	Wind Turbine Solar Panels Waterwheel	Wind Turbine Solar Panels Waterwheel	Wind Turbine Solar Panels Waterwheel	Solar Panels Waterwheel

EXCURSION PLANNING

- *Phenomena Factory* – Queen Victoria Museum and Art Gallery at Inveresk

  Open from **May 1 2008**
- Queen Victoria Museum and Art Gallery is open from 10 am until 5 pm each day, (closed Good Friday and Christmas Day).
- Admission is free but bookings are essential to ensure that each visiting class receives the full exhibition experience.

  For bookings telephone (03) 6323 3798 or email *education@launceston.tas.gov.au*
- It is a good idea to familiarise yourself with the *Phenomena Factory* prior to the excursion if possible. You also need to remember that for the optimum learning experience ensure that your adult:child ratio is adequate for supervision.
- Online resources – *http://www.qvmag.tas.gov.au/education.html*

- *Essential Preparation*

  Research has shown that setting clear objectives for a museum visit and discussing them with students is extremely important. It makes the purpose of the visit clear and assists students to focus and work together during the visit.

  Creating interest in the subject of an exhibition is vital to a successful and enjoyable museum experience. Prior to your visit to *Phenomena Factory*, take some time in class to discuss your excursion and to assess your students' knowledge and understanding of what they will see.

BACKGROUND INFORMATION

The wonders of science

Almost all substances that exist are a solid, a liquid or a gas. What happens to these is sometimes amazing; they can change from one to the other by increasing or decreasing in energy. These substances are called states of matter. Matter is made up of tiny particles, atoms, and empty spaces between them. Atoms consist of a nucleus, at the centre, that is made up of equal numbers of protons and neutrons. Electrons zoom around the nucleus.

All substances are able to be broken down into smaller pieces until they convert to the chemical elements. Elements are individual in their own chemical and physical character. An element is made up of unique atoms with the same number of protons and other parts, but are different from the atoms of all other elements.

Pure elements are uncommon as most substances are made up of a couple, if not more, elements.

For example, citric acid found in lemon juice—a vital ingredient in sherbet—is made up of hydrogen, oxygen and carbon mixed with water. The same with eggs, you hardly look at them and say 'well, I can see that this chicken is smart and has created a compound of sulphur, carbon, nitrogen, phosphorus, hydrogen and oxygen'. We take it for granted that natural materials just are.

How all of these substances act in our world depends on many variables. Some of these include magnetism, electrical capability or whether force and motion interact with them. Other things to consider are; how the substance affects humans, whether it is man-made or natural, and how it reacts with its environment and ours.

Welcome to the *Phenomena Factory* where you can explore all of this and more.

Famous Faces

Archimedes	265 BCE	Discovered relative density.
Thales of Miletus	600 BCE	Discovered that rubbing amber produces an electrical charge.
Roger Bacon	1214–92	Showed that rays of light hit and bounce off a mirror at the same angle.
Galileo Galilei	1564–1642	Proved that nothing changes, stops, starts, goes faster or slower unless a force is applied.
Johannes Kepler	1571–1630	Developed several laws to describe his observations of the orbits of the planets.
Isaac Newton	1642–1727	Discovered gravity and the three laws of motion.
Benjamin Franklin	1706–90	Showed that lightning is electric.
Joseph Henry *Michael Faraday*	1797–1878 1791–1867	Discovered that moving a magnet could create an electric current.
Hans Christian Oersted	1820	Discovers the link between electricity and magnetism.
J.J. Thompson	1856–1940	Showed us that there are smaller parts of atoms called electrons.
Ernest Rutherford	1871–1973	Found that atoms are mainly empty space, except for the tiny dense blob at the centre called the nucleus.
Niels Bohr	1885–1965	With Rutherford, created a picture of what an atom consists of: tiny electrons circling the dense nucleus, which is made up of particles called protons and neutrons.

What other famous scientists can you find?

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PRE-VISIT ACTIVITIES

Electricity and Magnetism

One of the most useful forms of energy is electricity. Its uses vary from the basics of light and heat to the complicated working of a pace-maker. Electricity is linked to magnetism by the invisible force that runs between the materials. When electricity moves magnetism occurs, and likewise when magnets move, energy in the form of electricity is formed.

- How many times do you use electricity in a day? Ask the students to keep a tally of their daily electricity usage. What do you use in your classroom?
- Where does electricity come from? Look at different sources of power and see how they compare to hydro-electricity.
- Are there ways in which you could save electricity?
- What are the benefits of saving electricity?
- Rub a ruler on your hair or scuff your shoes on nylon carpet – see if your hair stands on end with the help of a ruler. This is static electricity.
- Magnets are great – get the children to make their own. See post-visit 'Electricity and Magnetism' activities for details.
- Children play with toys daily. Ask them to give you examples of toys which use electricity and/or magnetism.
- What happens when you push the ends of two magnets together? Turn one of the magnets around, what happens now?

Eye Logic, Neurophysiology and Reflections

Neurophysiology is the study of nervous system function. The brain and the spinal cord are part of this. The brain is located in the head, protected by the skull and close to the primary sensory apparatus of vision, hearing, equilibrioception (balance), taste and olfaction (smell) (http://en.wikipedia.org/wiki/Nervous_system).

- Visit the library and seek out the *Where's Wally?* books created by the British illustrator Martin Handford and other similar books.
- Visit the internet, particularly *http://www.ritsumei.ac.jp/kic/~akitaoka/index-e.html*
- Set up an activity station with balance being the focus, find physical activities that require balance.
- Ask the students to colour in tessellations. Find some examples at *http://gwydir.demon.co.uk/jo/tess/index.htm*
- Brainstorm mind tricks as a class. What can students come up with?

For a reflection to occur light needs to strike a surface at an angle. Anything from a tiny spec to the full amount may be bounced back at exactly the same angle. The way the reflection reacts depends on the surface it hits. On a mirror or shiny surface every ray may leave in the exact same pattern it arrived, a perfect reflection of the light.

- Look for reflections in tin foil, cans, bottles and spoons. Which surface shows the best reflection of you?
- Wave at yourself in a mirror with your left hand. Which hand does your reflection seem to be using? What do mirrors do? They reverse images so it appears that your right side is waving back.
- In pairs, ask students to mirror image each other in movements.

Force and Motion

The four main types of forces in nature are gravitational, electrical, magnetic and nuclear. The forces always act in pairs; for every action there is a reaction. Thanks to these forces humans are able to stay upright. The forces also turn the earth on its axis.

- Everywhere we look things are in motion. Standing in the playground at lunchtime you can see; planes in the air, children running, teachers walking around on duty and trees swaying in the breeze. Research Sir Isaac Newton's laws, and force and motion, on the internet.
- Children play with toys every day. Ask them to give you examples of toys which involve particular aspects of science such as balancing, bouncing, stored energy, pressure and motion.
- Ask students to describe types of force and motion in the playground. They should be able to come up with things like pushing or pulling, friction, gravity, simple machines, levers, gears, pulleys and so on.

Mechanics, Dynamics and Motion

- What machines exist in your daily life? What machines do you have in your classroom? What about the class next door?
- As a class make a list of machines you might find at home? For homework, ask students to make a list of the machines their family uses. The next day make up a graph tallying the machines. What is the most common machine? For older children, work out the percentage of homes that have three televisions in their house, etc.
- Create a machine out of boxes. What is its purpose?
- Create a timeline of the history of machines and their inventors.
- Many children are interested in space. Perhaps your class could investigate some of the science and technology associated with space travel. Some possible concepts to consider include: how vertical thrust is achieved by rocket engines; whether the launch would be better from a spot at one of the poles or at the equator; why a satellite is able to remain in its orbit above the earth; and what causes the space shuttle to speed up upon re-entry into earth's atmosphere.

Sound, Waves and Resonance

Travelling through water and many hard solids, sound waves radiate in all directions from the source. The waves carry energy—all waves do. Once they hit something they lose part of, or all of, their energy. When an aerial is hit by radio waves, the energy changes into electrical currents that the radio then converts into sound.

- In the playground ask students to push a classmate on the swing at regular intervals. The swing will go higher and higher. If they push the swing at odd intervals and varying speeds it will swing in smaller arcs. The natural regular interval is the resonance frequency, showing efficient use of energy. When the pattern is irregular, energy is not utilised to its full effect.

- Describe some of the 'physical science' experiences that would apply if the students belonged to a musical group (e.g. a band, an orchestra or similar). If musical instruments are available, these could be used to explore vibrations, sound, motion, force, frequency (pitch), amplitude (loudness), etc.
- Children play with toys daily. Ask them to give you examples of toys which involve particular aspects of science such as sound and/or light.

Renewable Energy

Renewable energy effectively uses natural resources—sunlight, wind, rain, tides and geothermal heat—which are naturally replenished. Renewable energy technologies range through solar power, wind power, hydro-electricity/micro hydro, biomass and biofuels for transportation. Renewable energy sources are naturally replenished in a relatively short period of time.

Non-renewable energy is energy taken from finite resources that will eventually dwindle, becoming too expensive or too environmentally damaging to retrieve. Non-renewable energy is non-reusable fuel—it can only be used once.

- Explore renewable energy. Talk about the sun, wind and water etc. What are the differences between these and non-renewable energy? What are the definitions of each of the renewable energies? How do they work?
- What are the renewable and non-renewable resources we use daily? As a class make a graph to show what you use the most?
- How can we save energy? Have students draw a map of their classroom, house, bedroom, etc; indicate on the map where energy could be saved.
- Ask students to make a list of activities they engage in that use energy. Ask them to consider going on holidays to a destination without electricity (for example to a tropical island). Predict what daily activities may change, and what effects this may cause. Suggest possible alternatives to provide for their needs at the holiday destination.
- What are the renewable energy sources that are used in Tasmania? Research these.
- As an educator look through websites such as *http://www.sustainableenergy.qld.edu.au/*

PHENOMENA FACTORY EXHIBIT INFORMATION AND SELECTED CURRICULUM LINKS

This exhibition covers a wide range of topics related to the physical sciences and various technology strands with potential for mathematics and social skills.

Included below are brief descriptions of the exhibits and the science behind them. These statements are by no means exhaustive but do give essential concepts in each case.

Electricity and Magnetism

Magnetic Sculpture

Lightning Tube

Pulse Rocket

Magnetic Sculpture

Description:

A powerful magnet attracts hundreds of steel washers to itself. The washers can be shaped and drawn into a variety of complicated arrangements, loops, piles etc. Each washer is behaving like another magnet.

Science behind the exhibit:

There are various forms of magnetism and magnetic repulsion. This arrangement, with a large iron magnet and iron (or steel) washers, is one of the simplest. Each washer appears to be itself magnetic, yet if you take two away from the main magnet they lose their apparent magnetism and no longer attract each other (or shouldn't, depending on how long they have been in the display).

The big permanent magnet is surrounded by an invisible magnetic field. The presence of the field effectively turns each of the washers into a tiny magnet in its own right and, in turn, any other washer that comes into contact with the first and so on. Magnets attract each other and so the washers can be shaped into various unlikely forms. Only material that can itself be turned into a magnet can be attracted to another magnet. Are all metals magnetic? Can material other than a metal respond to a magnetic field?

Tasmanian Curriculum links:

Science:	**Energy and Force:**	Standards 2–5, particularly stages 5–7
	Matter:	Standards 1–5, particularly stages 1–3

Lightning Tube

Description:

In this exhibit visitors are able to interact with streaks of lightning contained within a long glass tube. Placing a volt stick near the tube causes the lightning streaks to stop their random flowing movements and concentrate their movements under where the stick is situated.

Science behind the exhibit:

The lightning tube is similar to a large neon tube but the gases and power supply are different. Here there is a mixture of the inert gases neon, krypton and xenon as well as traces of other non-inert, dopant, gases. Passing an electric current (a flow of electrons) through the tube excites the gas atoms and causes them to ionise (glow) in thin streams of light.

Gases at higher pressures are used with high voltages (10 000 V) to produce the bright filaments of light seen. Placing a volt stick near the tube allows small amounts of current to flow away at that point. This causes the lightning streaks to follow pathways under the hand.

Tasmanian Curriculum links:

Science:	**Energy and Force:**	Standards 3–5, particularly stages 4–11
	Earth and Space:.	Standards 1–5, particularly stages 2–12

Pulse Rocket

Description:

The object of this exhibit is to use magnetic repulsion to initially 'launch' and then subsequently safely 'land' a rocket. After undertaking a pre-launch briefing session, the visitor presses a 'launch' button. This causes a main coil in the exhibit to energise. In response to this, a rocket rapidly rises vertically along a long pipe high into the air. If the visitor presses the 'land' button at the correct time the rocket will land safely, having been prevented from crashing by magnetic repulsion. The level of success (or failure) of the mission is governed by the correct timing of the button-pressing process and is displayed at the end of the mission.

Science behind the exhibit:

Pressing the launch button sends an intense pulse of alternating current (AC) electricity through the coil surrounding an iron core. This generates a strong (and changing) magnetic field in the coil, which induces powerful eddy currents in the ring 'rocket'. By Lenz's Law, these eddy currents produce changing magnetic fields in the rocket that repel those in the core. Hence, because of magnetic repulsion, the rocket flies skyward!

Pressing the 'landing' button at the right time creates a gentle magnetic repulsion pulse that prevents the rocket from crashing upon landing.

Tasmanian Curriculum links:

Science:	**Energy and Force:**	Standards 2–5, particularly stage 5
	Earth and Space:.	Standards 3–5, particularly stages 7–11

Eye Logic, Neurophysiology and Reflection

Spinners

Optical Illusions

Perception Tunnel

Reaction Timer

Talking Vase

Parabola

Spinners

Description:

Three rotating disks can be spun to produce different effects, some on the spinning disk, and others when the viewer looks away at stationary and distant objects. Try them all.

Science behind the exhibit:

Two of the disks produce their strongest effects when the viewer looks away after having watched them for a while. The dotted disk should be spun slowly at about one revolution every three seconds. Watch it for a while and then look at the palm of your hand. It should appear to behave very strangely.

Spin the spiral disk much faster, say three rotations per second and watch it for colour and distortion effects. Enjoy those then look away at a distant object. It should appear to move towards you, or away depending on the direction in which you spun the spiral.

Both these disks work by saturating the brains motion detectors, an effect that persists for a while even when the stimulus has ceased.

Benham's Disk (half black) should produce the illusion of colour if spun at about three rotations per second. Why this works is a bit of a mystery. The spinning black and white pattern should only produce a perception of shades of grey. The probable answer lies in the persistence of vision and the response time of the red, green and blue sensitive cells in our retina, which respond at slightly different rates and may somehow be 'fooled' into firing by the spinning pattern.

Tasmanian Curriculum links:

Science:	**Energy and Force:**	Standards 1–5, particularly stages 2– 4
	Living Things:	Standards 3–5, particularly stages 7–11

Optical Illusions

Description:

Optical Illusions tell us important things about perception. Our eyes are important, but our brains are vital when it comes to making sense of the external world. Our brain sorts out how to interpret the neural signals that come from our eyes and makes sense of them—puts them into a consistent context. Optical Illusions explore the ambiguities of our visual software and highlight the extreme complexity of visual signal processing.

Science behind the exhibit:

The large spiral is not a spiral at all, it is a series of concentric rings each of which has a 'twist' that forces the brain to interpret the whole as a spiral. Try tracing out the spiral (warning: this illusion is powerful enough to draw the finger into the apparent spiral). This is a variation of the twisted cord illusion. If you cover half the pattern, its circular nature is much easier to see, which suggests that this illusion is having its effect on the 'global field' part of the brain's image processing network.

The grouped circular patterns appear to shimmer and, for some viewers, the circles towards the edge of their vision appear to actively rotate. This effect is due to the minute but constant movement of our eyes which is like a retinal 'screen saver' and is referred to as saccadic shimmer.

The Striped Panel (The Chevreul Illusion) shows five colour steps from bright to dark with the edges perfectly distinguishable. Cover the margin between any two stripes though and what happens? Our ability to differentiate between the shades disappears! Our perception of brightness is subjective. It depends as much on the visual context as it does on the actual level of luminance and reflectivity of the observed surfaces. We rank the brightness of an object according to the objects around it.

The Coloured Words puzzle illustrates the Stroop Effect, named after its discoverer. When you look at the words you see both their colour and their meaning. If those two things are in conflict, you have to make a choice between the output from two different parts of your brain. Because words are so important to us we tend to give them priority.

The next two puzzles play on the way our eyes work to help our brains concentrate on the thing in the centre of our field of view. Things that we are looking at directly get made a little brighter, while things just around the edge are darkened a touch. This is called Receptive Field Inhibition.

When we look at the Hermann Grid, pale dots appear at the intersection of the squares towards the edges of our vision, but not at the intersection we may be looking at directly. That is because our eyes have slightly dimmed the white lines between the squares around where we are looking, thus the white appears faintly grey. What happens if you step right back? Do you see a dot in the intersections.

The Café Wall illusion (offset tiles) uses the same effect, except the slight greying of the line between the tiles runs at an angle due to the off-setting of the tiles. Our brain reads this as a grey line converging towards where we are looking, hiding the real symmetry of the figure and making the straight lines look strangely bent.

Tasmanian Curriculum links:

Science:	**Energy and Force:**	Standards 1–5, particularly stages 2–4
	Living Things:	Standards 3–5, particularly stages 7–11

Perception Tunnel

Description:

The Perception Tunnel is a 3-metre-diameter tube, some 4-metre-diametre in length that rolls through 30 degrees. The wall of the tube is decorated with a familiar Launceston landscape repeated infinitely by the positioning of two large mirrors at either end. Visitors walk through the tunnel and experience a powerful illusion that the outside world is turning while they remain stationary. There is a lot of stumbling as a result, as the visitor's brain struggles to reconcile two completely contradictory and powerful sensory inputs.

Science behind the exhibit:

We rely on our senses for information about the outside world. Streams of input from our eyes, ears, muscles and other systems are collated by our brain to picture the outside world. In normal circumstances the senses agree with one another closely enough for us to move around safely. In this case the moving tunnel presents a paradox. Our eyes tell us that the world around us is rolling but our inner ear, that senses gravity and acceleration (movement), tells us that we are stable. The resulting contradiction sets the outside world spinning (look out through the exit and entry doors) and can cause massive disorientation (including nausea) as our brain and body fights to reconcile the contradictory inputs.

We commonly assume that it is the role of the inner ear's semi-circular canals to tell us which way is up. This exhibit clearly demonstrates that sight has an important role in doing so as well. People who suffer from Méniére's Disease and who lose the use of their semi-circular canals can learn to walk safely and remain upright by relying on their eyes alone.

Tasmanian Curriculum links:

Science:	**Energy and Force:**	Standards 3–5, particularly stages 7–14
	Living Things:	Standards 3–5, particularly stages 7–11

Reaction Timer

Description:

Our ability to react to external events depends on a complex chain of detection, analysis, and reaction, all of which takes time as nerves carry signals around our body. In this exhibit a ruler falls under the force of gravity and the user attempts to catch it as soon as possible. The distance the ruler falls is proportional to the time taken to catch it.

Science behind the exhibit:

The falling ruler is accelerated by gravity at 10 m/sec and because of that we can measure the time elapsed between the release of the ruler and its stopping, in distance! The main purpose though is to explore the limits of our capacity to react to even simple and predictable external stimuli. Nerve impulses travel quite slowly. This applies not only to detecting the falling ruler, but also in analysing the input, deciding what to do about it and then reacting physically. We experience the external world through our senses and always after a delay! We are always slightly behind the external world!

Try the reaction timer normally on your own, then have someone distract you by talking to you, or try doing a mental task such as reciting a poem or saying the seven times table. Notice how your reactions slow. This is because we only have a certain amount of available computing power and multi-tasking (doing more than one thing at a time) slows down everything. That is why concentrating on a single task at a time, without distraction, is more efficient than doing several things at once.

Explore the effects of practice. Notice how users get faster and faster, but only to a certain point. Plot the 'learning curve' as it flattens out. The user is up against physiological limits and can improve no more.

An average good reaction time by the way, is about one-tenth of a second.

Tasmanian Curriculum links:

Science: **Energy and Force:** . . . . Standards 2–5, particularly stages 3–9

Living Things: . . . . Standards 3–5, particularly stages 7–11

Earth and Space: . . . . Standards 3–5, particularly stage 8

Talking Vase

Description:

This is a three-dimensional illusion that explores how an object can be defined and interpreted, not only in its own right but in terms of the space around it.

Science behind the exhibit:

At first sight the white vase is just that, but once it is set spinning an illusion of movement causes the brain to reinterpret the vase altogether. Instead of being a solid object it becomes a negative space between two profiles engaged in conversation.

The dominant signal has ceased to be the vase itself. It has become the recently detected movement of the 'lips' on what becomes the right profile. Being very sensitive to movement, the brain rapidly reinterprets what it had initially interpreted as information-free black space as two profiles facing one another.

Tasmanian Curriculum links:

Science: **Energy and Force:** . . . . Standards 3–5, particularly stages 8–9

Living Things: . . . . Standards 3–5, particularly stages 7–11

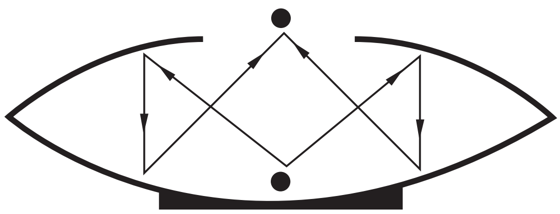
Parabolic Mirrors

Description:

An apparently solid object is projected above the plane of two opposing parabolic concave mirrors. The 'real' image is arranged to appear in focus on the back of the top mirror which has been cut away. The image can be inspected from all sides and appears to be a solid three-dimensional object.

Science behind the exhibit:

The diagram below explains the optics in terms of ray paths within the paired parabolic reflectors. The effect works because the projected object lies close to the focal point of the upper mirror.



Tasmanian Curriculum links:

Science: **Energy and Force:** . . . . Standards 1–5, particularly stages 8–13

Force and Motion

Catenary Arch

Eddies

Ex-1 Rocket

Gravity Well

The Cycloid

Water Vortex

Viscous Liquid

Catenary Arch

Description:

This module introduces visitors to the catenary shape, a shape widely found in nature that has certain physical properties useful to engineers. The catenary curve can assume a variety of patterns and is produced most easily by holding a loop of material between two hands. The curve of the material between the hands is determined by its weight, length and the distance apart of the hands (anchoring points). All the forms produced by this exercise are catenary curves. If the curve is inverted to point upwards, a catenary arch is produced.

Science behind the exhibit:

The arrangement of the blocks in the catenary arch is the strongest in terms of capacity to carry weight that can be arranged. This is because the blocks convert all borne load into compression. Further, the mating faces of the blocks fit against one another without a shearing (slipping) component and without significant bending forces inside each block. Compare this sort of arrangement with the square lintel of a window or door frame where the horizontal element is most likely to fail.

Tasmanian Curriculum links:

Science: **Energy and Force:** . . . . Standards 3–5, particularly stages 4–12

Eddies

Description:

This exhibit allows visitors to create and observe (from above) various enticing vortex and peripheral eddy patterns in a water-based medium. This is achieved by spinning the top portion of the exhibit in either direction at various speeds.

Science behind the exhibit:

Eddies form whenever water currents are redirected for some reason. For example, eddies often form behind rocks in rapidly flowing rivers. Behind the rock the water current is slowed and this causes the water to circle around and form an eddy.

In this exhibit, the eddy current patterns creep into the overall swirling vortex pattern. This is primarily because of frictional effects between the moving fluid and the container within which it is enclosed.

Tasmanian Curriculum links:

Science:	**Energy and Force:**	Standards 2–5, particularly stages 6–10
	Earth and Space:	Standards 1–5, particularly stages 3–9
	Matter:	Standards 2–5, particularly stages 4–5

EX-1 Rocket

Description:

This exhibit allows the visitor to fire some actual working rockets! The rockets are in the form of upturned plastic bottles that are propelled skyward along vertical wires by compressed air escaping from their lower nozzles.

Visitors secure one of the bottles to an air hose outlet inside a launch tower, close the tower door and then proceed to the launch panel of the control centre to undertake the launch process. A 'fuel' button on the launch panel is used to fill the rocket to any desired pressure, up to a preset limit (the fill pressure achieved is shown on a dial on the panel).

Pressing the 'launch' button commences the countdown sequence and causes the rocket to be released at its conclusion. Built-in safety devices prevent the rocket from being filled or fired if the tower door is open.

Science behind the exhibit:

Air pressure in the filled bottle rocket is higher than in the room around it. As the rocket is launched trapped air is allowed to rapidly escape from its base. By Newton's third law of motion— 'For every action there is an equal and opposite reaction'—air moving rapidly downwards causes the bottle to move quickly upwards. The bottle returns to the ground again under the action of gravity when the flow of downward moving air from the bottle becomes insufficient to continue moving it up the wire (i.e. the air runs out!). The bottle undergoes various energy changes (potential energy [PE] to kinetic energy [KE] to PE to KE to heat/sound etc.) as it fills, flies upwards, stops momentarily, drops backward and finally crashes into the landing pad again.

Tasmanian Curriculum links:

Science:	**Energy and Force:**	Standards 3–5, particularly stages 7–14
	Earth and Space:	Standards 3–5, particularly stages 8–7

Gravity Well

Description:

Here visitors can see what happens when they commence a ball rolling around the edges of this exhibit.

Because of the hyperbolic shape of the well, the ball will roll ever more slowly around the outside edge until it finally spirals (ever faster) into and around the central hole.

Eventually (after an unusually long time) the ball finally drops through the hole and rolls to the edge of a lower platform to enable the process to be repeated again.

Science behind the exhibit:

Gravity wells of this type are designed so that the ball acts like planets orbiting around the sun. Planets closer to the sun have a faster orbit than those further away. In the same way (and for the same reason; conservation of angular momentum) the rolling ball gets faster as it gets closer to the centre.

Friction initially removes some of the energy of the rolling ball causing it to drop down into the gravity well. When the ball drops into the well some of its gravitational potential energy is converted into kinetic energy, which increases the speed of the ball.

Tasmanian Curriculum links:

Science: **Energy and Force:** . . . . Standards 3–5, particularly stages 9–14

Earth and Space: . . . . Standards 3–5, particularly stages 8–13

The Cycloid

Description:

The fastest path between two points is not always along the shortest distance or in a straight line. Neither is it always the steepest!

In this case, the visitor presses a button (causing three solenoids to open) that allows balls to roll down three different (but fixed) pathways to equivalent finish spots.

One pathway is the shortest, another the steepest and the third, along a track known as the cycloid (which is neither the shortest, nor the steepest), proves to be the fastest of the three!

Science behind the exhibit:

The cycloid is the locus of a point on the rim of a circle rolling along a straight line, or a circular gear rolling along a toothed rack.

The straight-line shortest path never allows the ball to build up speed, the steepest path allows speed to quickly build up but involves the longest distance. In contrast, the cycloid is the best compromise between slope and distance thereby enabling the fastest travel times.

Tasmanian Curriculum links:

Science: **Energy and Force:** . . . . Standards 1–5, particularly stages 2–9

Water Vortex

Description:

In this exhibit visitors are able to control a large whirlpool and directly observe (from the side) changes in its behaviour.

Rotating a wheel on the front of the exhibit one way opens a valve under a central drain hole in the base of the water column. Opening the valve allows water to be pumped away from that region. The pressure is then lowered at that point and Water Vortex extends further down toward the base as a result.

Turning the wheel the other way closes the valve again, thus enabling the pressure to be restored and Water Vortex length to diminish once more.

Science behind the exhibit:

This exhibit is a giant version of the whirlpool that forms in a bath or sink when the water is draining and low. Water Vortex forms because the 'downdraft' created in the water begins to rotate and gather speed.

In this exhibit the drain holes allow water to be pumped from the tank and returned via the horizontal pipe. This inflowing water provides the energy to keep Water Vortex spinning. Turning the wheel clockwise opens the middle drain hole causing Water Vortex to deepen and sometimes allowing air into the water column producing bubbles (this is known as 'cavitation').

Several factors contribute to the funnel shape of the whirlpool. Gravity acts downward trying to maintain an overall flat surface on the water. 'Inertial tendency' from the rotation (sometimes described as the fictitious 'centrifugal' force) acts outwards causing the spinning water to build up towards the sides. Water pressure is the other major factor. It increases rapidly with water depth. This pushes the water back towards the central spin axis with ever-increasing force as a function of depth in the water column.

Tasmanian Curriculum links:

Science:	**Energy and Force:**	Standards 1–5, particularly stages 4–9
	Earth and Space:	Standards 1–5, particularly stage 6

Viscous Liquid Demonstration

Description:

Here three vertical perspex tubes contain oils of different viscosities. Viscosity is a measure of internal friction, or resistance to flow, in liquid. The different viscosities are demonstrated as the visitor pumps bubbles of air into the base of each tube.

Science behind the exhibit:

Viscosity is very important in the behaviour of liquids from sticky 'explosive' lavas, to blood in our veins and arteries or liquids being pumped through a pipeline. Liquids have various levels of resistance to internal flow or displacement which is measured as their viscosity. Low viscosity liquids flow easily while high viscosity liquids (like honey or thick oils) flow slowly. Viscosity can be measured by the rate at which a ball of known weight and density sinks through a liquid, or the rate at which a liquid will flow through a hole of fixed size.

The rate and manner in which identical volumes of air rise through the various columns demonstrate the nature, and some of the effects, of varying viscosity.

Gasses are liquids too and also have viscosity.

Tasmanian Curriculum links:

Science:	**Energy and Force:**	Standards 1–5, particularly stages 4–10
	Earth and space:.	Standards 1–5, particularly stages 4–9

Mechanics, Dynamics and Motion

Bernoulli Blower

Robot Buzz

Bernoulli Blower

Description:

Here a light ball can be made to float in the air-stream of a hose at the front of the exhibit. If the air stream is slightly deflected to the side the ball can be suspended in space off to the side of the exhibit or made to pass through several hoops on top of the exhibit.

If the ball is pulled slowly out of the stream of air when vertical, a force is felt trying to pull the ball back into the air-stream.

Science behind the exhibit:

When the ball is suspended in the air-stream, the air flowing upward hits the bottom of the ball and slows down. This creates a region of high-pressure air which holds the ball up against the pull of gravity.

When the ball is pulled partly out of the air-stream the air rushes around one side of the ball. The fast moving air creates a region of low-pressure on that side of the ball. The normal pressure of the calm air on the other side of the ball pushes it back into the air-stream, even when the blower is tilted at a slight angle.

Tasmanian Curriculum links:

Science: **Energy and Force:** . . . . Standards 1–5, particularly stages 2–9

Robot Buzz

Description:

This 'robot' is actually a remotely controlled operating vehicle (ROV) that the visitor controls by pushing buttons on the control panel. Radio signals, sent from the control panel, cause the robot to commence moving, change direction, stop and emit half a dozen pre-recorded sounds from built-in speakers. To further enhance the experience, the visitor is able to see what it is that the robot is 'looking' at via returning signals (from a camera in the robot's head), which are displayed on a screen at the control panel.

Science behind the exhibit:

The robot is controlled in the FM frequency range. It is driven by two 12-volt direct current (DC) motors running off four 12-volt batteries. The video picture from the robot camera is sent using high frequency waves (similar to microwaves). The pre-recorded sounds are generated by a computer and transmitted by waves in the AM frequency range.

Tasmanian Curriculum links:

Science: **Science as a Human Endeavour:** . . . Standards 1–5

Sound, Wave and Resonance

Echo Tube

Description:

The long black tube suspended at an angle is capped at the far end. A noise (shout or clap) at the mouth bounces back strangely distorted, having travelled at least twice the length of the tube (66-metre) and perhaps a lot further.

Science behind the exhibit:

Echoes are not necessarily straight forward! The sound entering the tube radiates out from the source (clapping hands, mouth) as a series of concentric spheres of pressure variation. Only the small proportion of the original wave that moves absolutely perpendicular to the plane of the opening is reflected directly back. The rest follows a more complicated path bouncing from side to side in the tube as it travels. The resultant echo is 'smeared out', starting at a higher pitch and ending in a deeper 'growl'. The diameter of the tube and the wavelength of the original sound interact to cause the effect.

Tasmanian Curriculum links:

Science: **Energy and Force:** . . . . Standards 2–4, particularly stages 3–9

Giant 100-Metre Tube

Description:

This simple tube, about 100 m long, demonstrates the speed of sound in air. The ear pieces receive the sound about one-third of a second after it enters the mouth-piece.

Science behind the exhibit:

Sound travels at about 331 m/sec in air at sea level. The delay between making the sound and hearing it is due to the measurable speed sound takes to travel the 100 m between the mouth and ear pieces.

A second effect concerns the importance of audible feedback in speech. We listen to ourselves when we speak and modify our diction accordingly, too fast for us to be aware of. The delay makes it very difficult for some people to talk coherently. Try reading the exhibit label or reciting a rhyme while listening to the delay.

Tasmanian Curriculum links:

Science: **Energy and Force:** . . . . Standards 2– 4, particularly stages 3–9

Lissajou Figures

Description:

A projected laser show of varying patterns is the main feature of this exhibit. Visitors use control knobs to adjust the frequencies of two signals, each of which is causing a speaker to vibrate.

Mirrors connected to the speakers respond to the vibrations accordingly and cause laser light that strikes them to form a pattern on a wall behind the exhibit. For certain frequency ratios simple patterns are produced, whilst for others more complex displays occur.

Science behind exhibit:

Frequency oscillators are used to make two speakers vibrate. Attached to each of these speakers is a mirror, with the two mirrors being at right angles to each other. A beam of laser light bounces from these two mirrors in turn before hitting the screen.

When the frequencies of vibration of the two speakers are the same, a circle is produced. When the two frequencies are multiples of each other, simple patterns emerge (eg. a 'figure-8' occurs when one frequency is twice the other one). At other times complicated patterns occur.

Tasmanian Curriculum links:

Science: **Energy and Force:** . . . . Standards 2–5, particularly stages 8–14

Resonant Pendulum

Description:

A large heavy weight is suspended within reach of smaller weak magnets on chains. These are placed at 90 degrees to one another. Careful use of the smaller magnets can induce the heavy weight to swing freely and collaboration between two magnet users can make it happen faster, though that is very difficult.

Science behind exhibit:

Physical systems often have 'resonant frequencies'. This is a frequency which, when applied to the system, results in constructive re-enforcement and induces movement apparently out of proportion to the force applied. Essentially, once the weight begins to move, the visitor must pull and release in careful step with the growing swing or risk losing their magnetic grip.

Tasmanian Curriculum links:

Science: **Energy and Force:** . . . . Standards 1–5, particularly stages 4–10

Thong-a-Phone

Description:

This collection of tubes of different length demonstrates a resonance effect that favours the transmission or production of certain frequencies of sound.

Science behind the exhibit:

The pipes are the same width but different lengths. The lengths are proportional to the wavelengths of the sound that can be heard through the pipe (or the sound produced when the open end is 'slapped' with a thong). The air in each pipe resonates at the frequency of the sound wave that most closely matches the length. Waves of other lengths may suffer destructive interference and do not induce resonance in the pipes—they are therefore only more weakly heard. The pipes are acting as filters for particular sound frequencies.

Tasmanian Curriculum links:

Science: **Energy and Force:** . . . . Standards 1–5, particularly stages 3–9

Tubular Resonance

Description:

This exhibit makes use of a horizontal, clear perspex tube which is partially filled with polystyrene beads.

Sound from a speaker housed at one end of the tube causes the polystyrene beads to form 'vertical clusters' along the tube. The bead clusters may be moved to various sections of the tube by adjusting the frequency of the sound coming from the speaker. Frequency variation from tens to hundreds of hertz is possible.

Science behind the exhibit:

This exhibit graphically demonstrates 'resonant frequencies' in a tube.

Essentially, this exhibit contains a sine wave generator (of variable frequency) connected through an amplifier to a powerful speaker in the tube. Vibrating the speaker at one of the 'resonant frequencies' causes significant air pressure differentials to occur along the length of the tube. The polystyrene beads (coated with graphite so they do not stick together by electrostatic charge) are light enough that these pressure differentials force the beads to group together at particular spots (producing standing wave patterns) within the tube.

Resonance occurs at the frequencies where the beads form these standing waves.

Tasmanian Curriculum links:

Science: **Energy and Force:** . . . . Standards 2–5, particularly stages 3–9

Whisper Dishes

Description:

Whisper Dishes consists of two large parabolic reflectors, set far apart and facing each other, that act as mirrors reflecting sound to each other. Two people situate themselves at approximately the focal point for each reflector, so that the sound coming from each reflector is focused at this point. Each visitor can then clearly hear the other's voice, even at very low decibel levels, in spite of the distance separating the dishes.

Science behind the exhibit:

The parabolic shape of each dish causes sound waves, from different specific directions in the listening field of the dish, to become focussed at slightly different spots in the region directly in front of the dish. The indicated spot (where the speaker's/listener's head is normally placed) causes sound from the speaker to be defocused at one dish into parallel waves that travel through the air until they strike the other dish. There they are refocused onto the listener's ear. The focussing of many sound waves from primarily only one source (the speaker at the other dish) causes great amplification of those sounds to occur in comparison to other background sounds. This makes the low decibel whispers detectable.

Tasmanian Curriculum links:

Science: **Energy and Force:** . . . . Standards 1–5, particularly stages 3–9

Renewable Energy

Wind Turbine

Solar Panels

Waterwheel

Wind Turbine

Description:

Two wind turbines are suspended at different heights from the steel frame in the courtyard. They are free to rotate to face the wind and generate electrical power as the wind turns their blades, which inturn run a generator. Beside them is a weather station measuring wind speed. The power output and local wind speed are displayed at ground level.

Science behind the exhibit:

Wind can be a useful source of power. Mass in motion contains harvestable energy. Water weighs 1000 kg/m^3, air weighs about 1.3 kg/m^3. A strong wind therefore represents a lot of power. The energy of the moving air is converted by the wing-shaped blades into mechanical energy turning the armature of a generator and thus producing electrical power.

In general, the higher the turbine the faster the wind speed and the greater the amount of electricity produced. This can be tested by comparing wind speed, estimated rate of turbine rotation and power output at each turbine. Is the speed/output linear?

It may happen that neither of the turbines is turning. What are the implications of this for renewable energy generation?

Tasmanian Curriculum links:

Science:	**Energy and Force:**	Standards 1–5, particularly stages 2–7
	Earth and Space:	Standards 1–5, particularly stages 5–7

Solar Panels

Description:

Two silicon solar photo-voltaic panels, one steerable and the other fixed, are linked to output meters measuring the amount of electricity each produces. The aim is to show the importance of strong direct illumination in power generation by this means.

Science behind the exhibit:

Photo-voltaics works because incident photons (light from the sun) effectively ‘knock’ electrons into free flow generating current. Efficiency is low, typically 10% or less, and power output is strongly dependent on good illumination. This is sometimes achieved by steering solar arrays so that they face the sun. Shadowing or misdirecting the cells dramatically cuts their output.

On the positive side, each 1 m^2 of the ground receives about 1000 watts of solar power and 10,000 times more solar power reaches the earth than we currently use from all energy sources. How many watts/m^2 does our array produce?

Tasmanian Curriculum links:

Science: **Energy and Force:** . . . . Standards 1–5, particularly stages 2–7

Earth and Space: . . . . Standards 2–5, particularly stages 5–7

Waterwheel

Description:

Until about 200 years ago the only sources of energy were natural—the work of human or animal muscle, wind or water power. Windmills and waterwheels were the main sources of mechanical power. They were all what we now call renewable energy.

The Industrial Revolution gave us mechanical power derived from engines of various types which, while they consume resources (such as coal, wood or oil), were more reliable in terms of output and reliability. The windmill at Ross was superseded by a steam engine and one of the major infrastructure projects at Port Arthur was the development of a waterwheel to replace convicts working a treadmill to grind flour.

Science behind the exhibit:

Moving mass contains energy, or force, so flowing water or wind, if they can be harnessed, can provide power to do work. Getting power out of wind and water depends on slowing the flow of the medium and extracting that energy to be applied to some task. There is no such thing as a free lunch! The water flows more slowly after it has passed the wheel than it did before entering it. The difference in speed is a measure of how much energy has been extracted from the flowing water by the wheel.

Waterwheels became highly developed, and were widely used, before being replaced by steam power. This one, which worked in Tasmania, is an undershot wheel where the moving water hits blades on the lower surface of the wheel; a very efficient design.

Tasmanian Curriculum links:

Science: **Energy and Force:** . . . . Standards 1–5, particularly stages 4–10