discovery challenges

→ Challenge:

Design an energy-efficient car

Cars are responsible for one-third of the dangerous tiny particles in Sydney's air. They also consume natural resources more quickly than the Earth can replace them. Something must be done to reduce the damage to the environment by cars. Your challenge is to design an energy-efficient car.

→ Contents

Powerhouse discovery challenges are inquiry-based units of work that:

- begin and end in your classroom
- involve a structured discovery process with links to the classroom curriculum
- provide a deeper understanding of the Museum's collection
- promote team problem-solving skills, and
- are fun!

→ Teacher information

Before your visit

- Read the challenge to your students.
- Divide your class into groups of four or five students. Each group is a team and should work together to complete the challenge.
- Do the pre-visit activity. This activity is directly related to your challenge and will help your students focus on the issues, preparing them for their museum experience.
- Prepare your group leaders (a teacher, accompanying parent or older student) for the visit to the Powerhouse Museum. Photocopy and give them the challenge trail (pages 7–10) ahead of time. Group leaders are essential to the success of the *Powerhouse discovery challenges*. The more they know, the harder they will work to make your students' museum experience a success.
- Assign a group leader to each team.

At the Powerhouse Museum

- The challenge will take approximately two hours from the time of arrival to the time of departure.
- The challenge trail should only be given to your group leaders. Students may bring along a pad and pencil to jot down their ideas to help complete the challenge.
- On arrival, an education staff member will meet and escort your group to a briefing area, introducing the areas of the Museum that are included in your challenge. They will also remind you of the safety rules and assist with any other details of your visit.
- Apart from this orientation and welcome, staff members will not be available to guide your group through the Museum.
- The exhibitions listed in the challenge can be visited in any order.

After your visit

- Do the post-visit activity. This activity will draw on students' knowledge gained during their exploration of the Museum to complete the challenge.
- Go over the assessment tool which you will use to grade their work.
- Choose an extension activity for your students.
- Return the feedback page to the Powerhouse Museum.

Please note: the websites referred to in this *Discovery challenge* were available and suitable at the time of publication. We advise that teachers should check sites before recommending them to students.

Photo by Sue Stafford, Powerhouse Museum

→ Challenge outcomes

Powerhouse discovery challenges are structured for teachers to incorporate into their existing curriculum. This challenge has been written with upper primary classes in mind. A variety of learning processes are incorporated into the challenges as well as the 'values and attitudes' outcomes as indicated in the K–6 Science and Technology syllabus. Outcomes for this challenge and examples of how they might be achieved are included here:

1. Students are able to design and construct a machine.

   They show their ability by brainstorming, sketching, and discussing their plans and then constructing a balloon-powered car.

2. Students are aware that there is more than one way to design something.

   They show their awareness by comparing their designs with other students.

3. Students understand that the 'design-make-appraise' process may involve a number of trials, with frequent returns to the design phase.

   They show this by repeating the design-make-appraise stages a number of times in order to improve the car.

4. Students understand that machines have energy input in order to achieve their output.

   Students will identify that the air in the balloon is the input and the movement is the output.

5. Students understand that some of the energy in machines is wasted.

   Students identify where energy may be lost in their balloon-powered car.

6. Students understand that energy efficiency can be determined by a comparison of the relative amounts of useful and wasted energy that a machine consumes.

   Students show this by improving the energy efficiency of their balloon-powered car so that it travels further than the original model.

Clay and foam concept model. Lent by Holden Design for the exhibition *Success and innovation.* Photo by Jean-François Lanzarone, Powerhouse Museum

→ Pre-visit activity

Purpose: In this activity students will design and make a balloon-powered car.

Equipment

- An assortment of materials for constructing their balloon car (eg tissue boxes, cardboard tubes, wire, cardboard, polystyrene foam, reels and spools, dowel, lids from jars and bottles, flexible straws)
- An assortment of adhesive materials (eg sticky tape, glue, plasticine)
- One balloon per team
- Drawing material
- One tape measure

Teaching strategy

1. Outline the team challenge: How can we build a balloon-powered car?

   Explain that when the challenge is completed each team will measure the distance travelled by their car to see which one goes the furthest. You should not impose any rules on the use of the balloon and the only limitation on the size of the car should be the materials available to the students.

2. Show teams the range of materials available to choose from when they reach Step 5 of the challenge. Emphasise the need for each team to discuss plans and make a preliminary drawing before constructing their car.

3. Ask students to carry out the following steps:

   Step 1 As a team, brainstorm possible designs for your balloon-powered car.
   Step 2 Sketch some of your ideas on scrap paper.
   Step 3 Decide on one plan. Choose the one that you think will make the car travel the longest distance.
   Step 4 Draw your plan carefully so that all understand it, and show it to your teacher.
   Step 5 Collect the materials you need and use your plan to construct your balloon-powered car.
   Step 6 Demonstrate your car to the rest of the class and measure how far it travels.
   Step 7 Write how far it travels on your plans.
   Step 8 Display your car and your plans in the class.

4. Discuss the following designing question:

   What was the most difficult part of the job — getting ideas, choosing one idea, drawing plans, or constructing the car? Why was that part the most difficult?

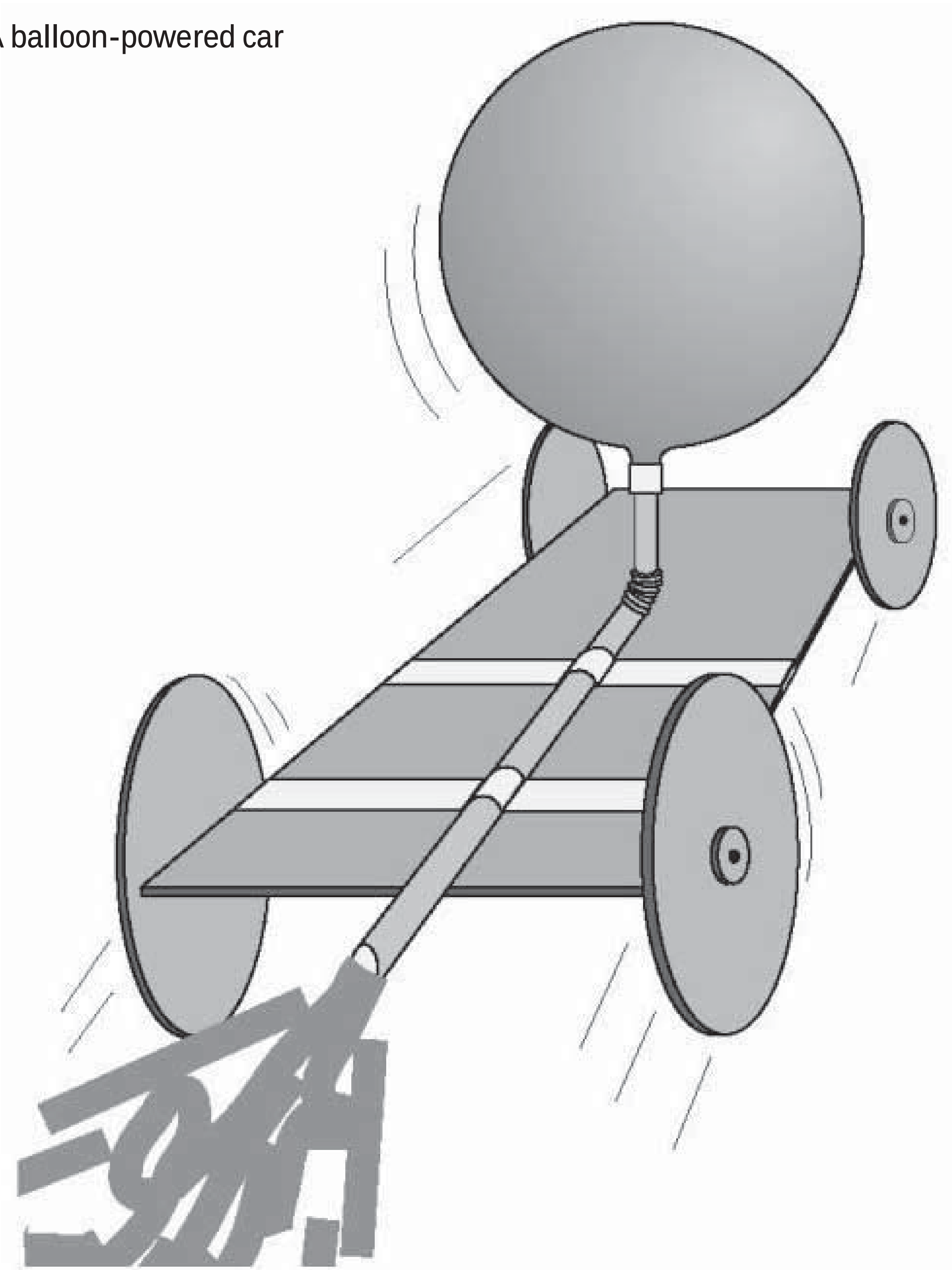
5. Discuss the energy inputs and outputs for the balloon-powered car by asking questions such as:

   - What was the energy input for the balloon-powered cars? (The energy input or source was a balloon full of air.)
   - What was the desired output? (The desired output was forward motion.)
   - Did all the vehicles travel the same distance?
   - How can you explain the different distances travelled in terms of energy use? (Some cars might have started with less stored energy or wasted more energy than others.)
   - Which car was the most energy efficient? (This is the car that travelled the furthest with the same amount of air as compared to another car.)

6. Discuss the term ‘energy efficient’ with your class. What do they know about it? What makes items in a house or on a car more energy efficient.

7. Using the trail (pages 7–10) as a guide, prepare the students for the visit to the Powerhouse Museum. Students will explore the concept of energy efficiency at the Museum and apply what they have discovered to improving their balloon-powered car. Ask questions about what they expect to see and what questions they might like to have answered by the visit.

A balloon-powered car



FOR GROUP LEADERS

discovery challenges

→ Challenge trail:

Design an energy-efficient car

Cars are responsible for one-third of the dangerous tiny particles in Sydney's air. They also consume natural resources more quickly than the Earth can replace them. Something must be done to reduce the damage to the environment by cars. Your challenge is to design an energy-efficient car.

Tips for the group leader

(a teacher, accompanying parent or student)

1. Know your group. Help them get excited about their visit.
2. Study the map of the exhibitions you will visit.
3. **Where to go** gives you brief directions on the location of your next exhibition stop. If you get lost, please ask a gallery officer for directions.
4. **All about** is designed to familiarise the group leader with the exhibitions they are about to visit.
5. **To say or do** gives the group leader ways to introduce the topic to the group. Explain the focus, activity or discussion point at each stop. Remember *Powerhouse discovery challenge* trails are guides not rules. If the students are restless or no longer interested, move to another part of the exhibition.
6. At each stop give your group time to look around the exhibition, listen to the audiovisual(s) and/or play the interactive(s).
7. Gather your group to talk, reflect or do an activity according to the stop.
8. Rest, debrief and allow time for each student to go back to his or her own exhibition highlight.
9. Have fun! The Powerhouse is a place of discovery. Be an adventurer with your group.

→ Challenge guide

Stop 1

■ Where to go

EcoLogic: creating a sustainable future exhibition, level 2. We recommend entering via the south end of the Turbine Hall and going around in an anticlockwise direction.

■ All about

EcoLogic looks at environmental problems facing Australia and the world. It also presents a positive picture of an ecologically sustainable future through case studies and real life stories of people and developments that are changing the way we live, manufacture, work and travel.

■ To say or do

Encourage your group to explore the different sections of this exhibition with a focus on the following sections:

a. The showcase containing the wind turbine looks at alternative energy sources. Ask students if any of the energy sources shown could be used in an energy-efficient car?

b. While passing through the 'house' area notice the energy efficient products on display. Why are they energy efficient?

c. Car manufacturers are developing cars that are less polluting. Find the Holden ECOmmodore. It is called a hybrid car because it runs on petrol and electricity. Look at the ECOmmodore, read the label and watch the video. Ask the group to explain to one another how a hybrid car works.

d. Opposite the ECOmmodore is a showcase of alternative transport. Does the group use any of these types of transport?

Stop 2

■ Where to go

Experimentations, level 2. You can enter this exhibition via the northern end of the Turbine Hall.

■ All about

Experimentations is all about the science behind familiar things. Students can make their own discoveries with over 30 hands-on exhibits that demonstrate a variety of principles of science.

■ To say or do

The sections to focus on are the electricity and magnetism exhibits in the back left-hand corner of the exhibition, but feel free to explore the other exhibits. Who knows, perhaps a student will come up with an idea for using chocolate in their design! Have the team try out the fire engine. See who can get the radio, wipers, lights and sirens to activate. What are the energy inputs and what are the energy outputs (legs → electrical → sound/light/movement)? While exploring the other exhibits in the area ask students to think about what other ways they can make electricity? Could they incorporate any of these ideas into their design?

The ECOmmodore. Lent by Holden Ltd for the exhibition *EcoLogic: creating a sustainable future*. Photo by Marinco Kojdanovski, Powerhouse Museum

Stop 3

■ Where to go

Transport exhibition, level 2. If you are in *EcoLogic* walk past the ECOmmodore or enter via the North end of the Turbine Hall.

■ All about

The *Transport* exhibition contains vehicles that have brought people together. Your team will see the enormous Catalina flying boat, 'drive' Locomotive 1243 and catch a C-Class electric tram.

■ To say or do

The *Transport* exhibition is full of different types of vehicles for getting around. Like the balloon-powered cars, the energy output for all these vehicles is movement. What are the energy inputs? For example:

- C-Class electric tram — electricity
- penny-farthing — human
- Locomotive 1243 — coal
- Dick Smith balloon gondola — gas
- 1912 spring cart — horse
- motorcycles — petrol.

This rickshaw required a runner to provide the energy input. What other forms of energy input can you find in the *Transport* exhibition?

Stop 4

■ Where to go

Success and innovation: achieving for Australia, level 4. To get to level 4, take the stairs, escalators or ramp. The exhibition is opposite Locomotive No 1.

■ All about

Explore the risks and triumphs of Australia's manufacturing industries. Specially designed computer interactives add to an appreciation of the people, products and processes involved in Australian manufacturing. A display area called *Simply the best* features excellence in Australian engineering and design.

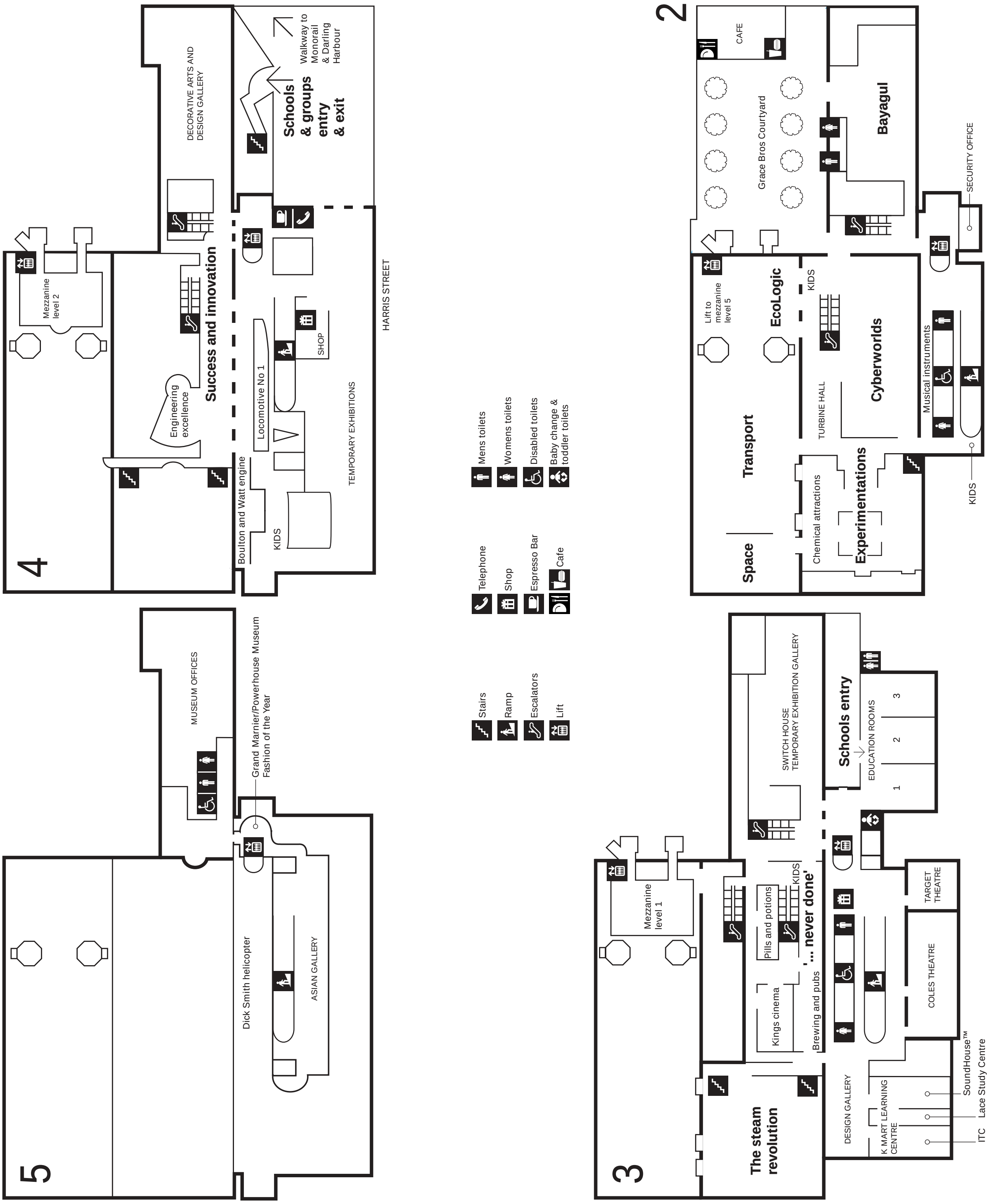
■ To say or do

Designers have a major influence on the final look of a product and the way it works. How do you think designers have influenced some of the items in the showcases?

Find the scaled-down concept car model in one of the red pods. How is it similar and different to the balloon cars that students made in class (eg both smaller than a real car, this one is made of clay and foam and is only half a model, in class students are testing energy efficiency, this is a model of how a car will look)?

Find the Leyland P76 (it is the green car hidden behind the showcases!). In its time it won the *Wheels* Car of the Year Award and was the most economical for its size. However it didn't sell well. Discuss this with your group. What other factors could influence the final design of their balloon-powered car (eg availability of materials, number of balloons allowed, cost, environmental laws, fads of the day)?

Map



2
CAFE
Grace Bros Courtyard
Bayagul
SECURITY OFFICE
Lift to mezzanine level 5
EcoLogic
KIDS
Cyberworlds
Musical instruments
TURBINE HALL
Transport
Chemical attractions
Experimentations
KIDS
Space
4
DECORATIVE ARTS AND DESIGN GALLERY
Walkway to Monorail & Darling Harbour
Schools & groups entry & exit
Mezzanine level 2
Success and innovation
SHOP
HARRIS STREET
Engineering excellence
Locomotive No 1
TEMPORARY EXHIBITIONS
Boulton and Watt engine
KIDS
Mens toilets
Womens toilets
Disabled toilets
Baby change & toddler toilets
Telephone
Shop
Espresso Bar
Cafe
Stairs
Ramp
Escalators
Lift
5
MUSEUM OFFICES
Grand Marnier/Powerhouse Museum Fashion of the Year
Dick Smith helicopter
ASIAN GALLERY
3
SWITCH HOUSE TEMPORARY EXHIBITION GALLERY
Schools entry
EDUCATION ROOMS
1
2
3
Mezzanine level 1
Pills and potions
KIDS
'... never done'
TARGET THEATRE
COLES THEATRE
Kings cinema
Brewing and pubs
SoundHouse™
Lace Study Centre
ITC
DESIGN GALLERY
K MART LEARNING CENTRE
The steam revolution

→ Post-visit activity

Post-visit activity

Purpose: How can we change our balloon-powered car so that it is more energy efficient?

Equipment

- An assortment of materials for constructing their balloon car.
- An assortment of adhesive materials
- Extra balloons
- Drawing material
- One tape measure

Teaching strategy

1. Since each team may have explored different exhibits at the Powerhouse Museum, we suggest the teams share their information and ideas for completing the challenge.

2. Reintroduce the term 'energy efficiency' from the pre-visit activity.

3. Outline the team challenge: How can we change our balloon-powered car so that it is more energy efficient? (Can the students make the cars travel further with the same energy inputs?)

4. Show teams the range of materials available to choose from when they reach Step 3 of the challenge.

5. Ask students to carry out the following steps:

   Step 1 Test your car and make sure it still works.

   Step 2 Talk with your team-mates about how to improve its energy efficiency. Discuss:

   - Where is energy wasted in the design?
   - How could we change the design so we don't waste energy at those places (eg change nose design, size of wheels, number of balloons)?

   Redraw your design to show the changes you could make.

   Step 3 Collect the materials you need and change your car to match the changes in your design.

   Step 4 Test how far your car travels now. Does it go further?

   Step 5 Go back to Steps 2, 3 and 4 and see if you can improve your car even more. You can keep repeating these steps until you run out of time. This is called the 'design-make-appraise' (DMA) process.

   Step 6 Demonstrate your car to the rest of the class and measure how far it travels.

   Step 7 Write how far it travels on your plans.

   Step 8 Display your car and your plans in the class.

6. Discuss the energy efficiency for the balloon-powered car by asking questions such as:

   - Some of the cars are more energy efficient now than they were before. How can you tell? (They can travel further than they did before.)
   - Could you compare the energy efficiency of your car with other teams? (We could compare their energy outputs by comparing how far they travel, but we would have to take into account the fact that there may be different amounts of energy put in. For example, a balloon car with three balloons may travel further than a car with two balloons, but it doesn't mean it is more energy efficient. It is easier to compare efficiencies when the energy inputs are the same.)

7. Discuss the 'design-make-appraise' process by asking questions such as:

   - When you appraised (tested) your model, what did you decide to improve?
   - How did you change your design to achieve this improvement?
   - Are you happy with the final model or will you continue with the DMA process?

→ ECOmmodore fact sheet

Object: Automobile, ECOmmodore
Object No: On loan from Holden Limited
Designer: Holden Limited, CSIRO
Maker: Holden Limited
Place: Melbourne
Date: 2000
Size: Family-sized sedan
Materials: Metal, plastic, fibreglass, polycarbonate, fabric, rubber

What is it?

ECOmmodore, the first hybrid petrol-electric prototype vehicle to be made in Australia, was developed by Holden Limited and the CSIRO to reduce exhaust emissions and maximise fuel economy.

How was it made?

Based on the Holden Commodore, the ECOmmodore is a parallel hybrid using a largely conventional internal combustion engine and an electric motor to drive the front wheels.

The weight of the car has been minimised by Holden using lightweight aluminium in the four-cylinder engine and floor, carbon fibre and fibreglass panels, and polycarbonate side and rear windows.

The compact CSIRO-developed electric motor doubles as an electricity generator when powering the car and when it brakes. Five CSIRO lead-acid batteries and super-capacitors in the boot provide power to the electric motor. In combination these weigh only 200 kg, much less than the batteries that power other electric vehicles. The super-capacitors are larger than a car battery, store large amounts of energy and can absorb and deliver energy very quickly. The petrol engine and electric motor are able to power the car either together or alone.

How does it work?

The decision as to whether the car should be powered by electricity, petrol or both is made by the Energy Management Computer (EMC). During acceleration, both electricity and petrol provide power for high performance with the initial burst of power supplied by the super-capacitors. When cruising, the electric motor alone powers the car. When the battery charge becomes low, the petrol engine takes over. The electric motor then acts as a generator charging the batteries and superconductors for later use. Extra electricity is generated by the electric motor which converts the kinetic energy of braking into electric power and stores it in the batteries and super-capacitors.

Why is it important?

Because the petrol engine does not power the car all the time, the ECOmmodore has the potential to reduce fuel consumption by up to 50 per cent, dramatically reducing hydrocarbon emission levels. It is an important practical learning tool for future manufacture of cars.

The engine of the ECOmmodore, the first hybrid petrol-electric car to be built in Australia. Lent by Holden Ltd for the exhibition *EcoLogic: creating a sustainable future*. Photo by Marinco Kojdanovski, Powerhouse Museum

→ Extension activities

Ask students to:

1. Create a spreadsheet showing the data collected. Analyse it to determine which design was most efficient for that element. Create a graph.

2. Draw detailed plans of their car from many perspectives.

3. Investigate whether the relative performance of the balloon-powered cars are the same if they are tested on a different surface.

4. Make a balloon-powered pinwheel by taping another balloon to a flexible straw. Push a pin through the straw and into the eraser of a pencil. Inflate the balloon and watch it go. (See diagram opposite.)

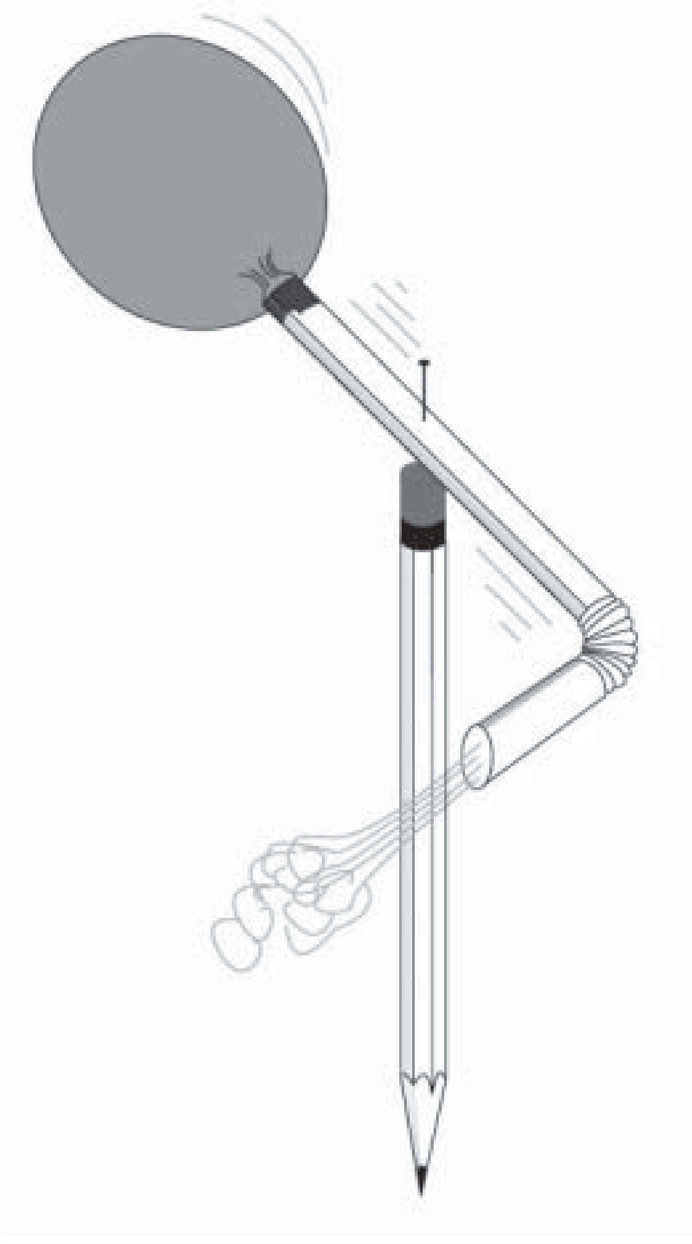
5. Design an energy-efficient car of the future.

6. Write a letter to car manufacturers and a local member of parliament to lobby for the implementation of an energy-efficient transport system.

7. Use the internet to research the most recent concept cars being created by major automobile manufacturers such as Holden's ECOmmodore (see http://www.holden.com.au/ecommodore and the fact sheet on page 12). Are they energy efficient vehicles? How?

8. Design a vehicle to travel as fast as possible using another source of energy. Heat, solar, wind, electrical, nuclear, mechanical and chemical are just some forms of energy to consider.

9. Survey the class to discover the different kinds of transport used to get to school, eg foot, bus, car, skateboard, bicycle. Record results as a pictogram. Suggest reasons for these choices. Evaluate what makes a good way to come to school. Consider things such as safety, keeping dry, enjoyment etc. Is this the same for everyone? Which type of transport is the most energy efficient?



→ Assessment tool

A Likert scale can be used by the teacher as an evaluation of the *Discovery challenges* program or by students as a self-assessment tool. Teams can use this to evaluate themselves or other teams. Below are some suggestions for creating your own Likert scale.

A sample Likert scale might look like this:

Name: ____________________ Date: ____________________

Challenge name: ____________________

Who is assessing? (circle one) Student Team Teacher

1. Criterion: Quality and accuracy of information gathered at PHM

|———|———|———|———|———|

Quickly put together — Shows some thought — Accurate & detailed

2. Criterion: Completed challenge project

|———|———|———|———|———|

Incomplete — Meets criteria — Exceeds criteria

3. Criterion: Creativity

|———|———|———|———|———|

Lacks originality — Shows some thinking — Museum-worthy

Comments:

____

____

____

Grading Scale:

4.5 – 5 = A 3.8 – 4.4 = B 2.8 – 3.7 = C 2 – 2.7 = D below 2 = not yet

This is one scale that works with the 1————2————3————4————5 scale.

You would add the total points and divide by the number of criteria for final number grade.

← 1. At the top of your scale include a place for name, date and challenge name.

← 2. Also include a 'Who is assessing?' line with choices to circle.

← 3. Establish criteria for assessment. The three criteria shown here are some examples. Objective statements may also be used for evaluation, such as, 'Students demonstrated the ability to…'

← 4. Decide on a scale. Scores are placed on the scale by marking an 'X' where the score falls. You can use a verbal scale like the ones shown left, or a variety of others. Some additional scales might be:

1___2___3___4___5
A___B___C___D___F
Wow___Okay___Needs Work

← 5. Leave room for comments at the bottom of the page.

← 6. Include a scale if grades are used.

→ Feedback form

Your feedback will help us modify and improve the *Discovery challenges* program. Please complete this evaluation with your students and return it to the address below or fax to (02) 9217 0441. When we receive your completed form we will send you a free family pass to the Museum.

School name:

Teacher in charge:

School phone:

School address:

Year level(s):

Total group size:

Day and date of visit:

Name of challenge:

Did you do the pre-visit activity?	Yes ☐	No ☐
Was the pre-visit activity useful?	Yes ☐	No ☐
Were the ‘Where to go’ directions helpful?	Yes ☐	No ☐
Was the ‘All about’ information helpful?	Yes ☐	No ☐
Were the ‘To say or do’ questions relevant?	Yes ☐	No ☐
Did your group do the post-visit activity?	Yes ☐	No ☐
Did the challenge trail assist in completing the post-visit activity?	Yes ☐	No ☐
Did you attempt an extension activity?	Yes ☐	No ☐
Would you like to do a challenge again in the future?	Yes ☐	No ☐

How did you incorporate the challenge into your curriculum?

Comments:

Thank you for taking the time to fill out this form!

Please return to:
Powerhouse Discovery Challenge Program
Education & Visitor Services
Powerhouse Museum
PO Box K346
Haymarket NSW 1238

EcoLogic: creating a sustainable future
sponsored by

HOLDEN

For other challenges visit:
http://www.phm.gov.au/education/challenges.html

For more information about *Powerhouse discovery challenges* or to make a booking, contact:

Education and Visitor Services, Powerhouse Museum
Telephone: (02) 9217 0222
Fax: (02) 9217 0441
Email: edserv@phm.gov.au
Post: PO Box K346, Haymarket, NSW 1238

Get regular updates about Museum programs delivered directly to your computer by joining our listserv. Email: edserv@phm.gov.au

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