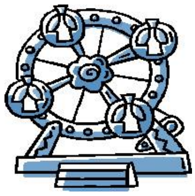
Build a Big Wheel



Provided by TryEngineering - www.tryengineering.org

Lesson Focus

Lesson focuses on the engineering behind big wheels (sometimes called Ferris wheels). Teams of students explore the engineering behind the "London Eye," explore the history of big wheels, and construct a working wheel model using pasta, glue, and teabags.

Lesson Synopsis

The Build a Big Wheel lesson explores how engineers have developed big wheels or Ferris wheels. Students explore the history of wheels, their design, and develop their own wheel using pasta, glue, and optionally, teabags. Student teams design their own wheels on paper, execute their plan, and evaluate the strategies employed all student teams.

Year Levels

Year 7 – Term 2; Year 8 – Term 2; Year 10 – Term 3

Objectives

- Learn about engineering design.
- Learn about motion, load, and construction.
- Learn about teamwork and working in groups.

Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- structural engineering and design
- problem solving
- teamwork

Lesson Activities

Students learn how big wheels have been designed throughout history, and then work in teams to develop a design for their own pasta wheel. Teams plan their wheel, execute construction, troubleshoot, evaluate their own work and that of other students, and present to the class.

Resources/Materials

- Teacher Resource Documents (attached)
- Student Worksheets (attached)
- Student Resource Sheets (attached)

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- TryEngineering (www.tryengineering.org)
- London Eye (United Kingdom) (www.londoneye.com)
- Build the London Eye Online (www.londoneye.com/LearningAndDiscovery/Education/TeacherResource/OnlineResource/refernce/refernce.html)
- Bellevue Ferris Wheel (Germany) (www.riesenrad-bellevue.de)
- Singapore Flyer (Singapore) (www.singaporeflyer.com.sg)
- Curriculum Links (www.acara.edu.au)

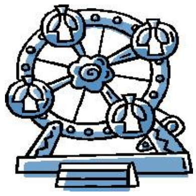
Recommended Reading

- Meet Me At The Ferris Wheel (ISBN: 1418438685)
- Ferris Wheels: An Illustrated History (ISBN: 087972532X)

Optional Writing Activity

- Write an essay or a paragraph about the engineering challenges faced during the construction of either the London Eye or the Singapore Flyer.

Build a Big Wheel



For Teachers:
Teacher Resource

◆ Lesson Goal
Explore engineering design through the construction of a pasta wheel. Students work in teams to design a functional wheel, request a planned quantity of different shapes of pasta from the project manager (you!), construct their wheel, and present their reflections on the project to the class.

◆ Lesson Objectives
- Learn about engineering design.
- Learn about motion, load, and construction.
- Learn about teamwork and working in groups.

◆ Materials
- Student Resource Sheet
- Student Worksheets
- Boxes of different shaped pasta
- One set of materials for each group of students:
  - Glue, string, paperclips, paper, cardboard, cardboard tubes (such as from paper towel rolls)
  - Quantity of pasta shapes as requested by each team based on their design (note: students will likely come back for more/different shaped pieces)
  - Four - eight dry tea bags (for optional weight challenge -- dry tea bags serve as the pods or benches for the model pasta wheels)

◆ Procedure
1. Show students the various Student Reference Sheets. These may be read in class, or provided as reading material for the prior night's homework. To get a feel for the construction, students may wish to visit Build the London Eye Online (www.londoneye.com/LearningAndDiscovery/Education/TeacherResource/OnlineResource/refernce/refernce.html) to explore the components of the London Eye. There are also lots of other educational resources at www.londoneye.com/LearningAndDiscovery/Education/TeacherResource/OnlineResource/Main.html.

2. Divide students into groups of 2-3 students, providing a set of materials per group.

3. Explain that students must develop a turning pasta wheel (you may wish to require "weights" such as tea bags which can be tied onto the wheel).

4. Students meet and develop a plan for their wheel. They agree on materials they will need, write or draw their plan, and then present their plan to the class. They should consider the stages of construction.

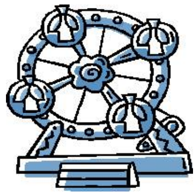
5. Student teams will request of the "project manager" (you!) the quantity of different pasta shapes they want for their design. They will likely come back and ask for different or additional shapes during construction.
6. Student groups next execute their plans. They may need to rethink their plan, add materials, or start over. This project may require overnight drying of wheel segments before final construction.

7. Each student group evaluates the results, completes an evaluation/reflection worksheet, and presents their findings to the class.

◆ Tips
Pre-glue long pasta strips for extra strength; have wheels rotate around tube from paper towel roll, or PVC pipe.

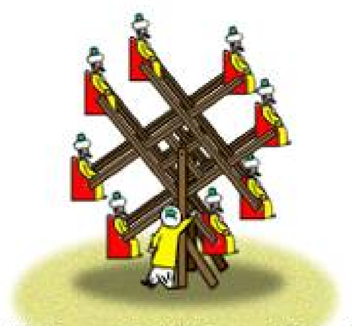
◆ Time Needed
Two to three 45 minute sessions

Build a Big Wheel



Student Resource: The History of Big Wheels

◆ Big Wheels Though Time



17th Century Turkish "Ups-and-Downs"

The earliest example of the Big Wheel is the Ups-and-Downs, a crude, hand-turned device, which dates back at least to the 17th century and is still in use in some parts of the world. The "Ferris" wheel was named after George Washington Gale Ferris, Jr., who designed an 80 metre wheel for the World's Columbian Exposition in Chicago, Illinois, USA in 1893. This first wheel weighed 2000 tonnes (2200 tons) and could carry 2,160 persons at a time; The Ferris wheel was the largest attraction at the Columbian Exposition standing over 76 metres tall and powered by two 1000 HP steam engines. There were 36 cars each the size of a school bus that accommodated 60 people each (40 seated, 20 standing). It took 20 minutes for the wheel to make two revolutions - the first to make six stops to allow passengers to exit and enter; the 2nd a single non-stop revolution - and for that, the ticket holder paid 50 cents. The wheel was moved twice after the 1893 Fair and was eventually destroyed (by controlled demolition) in 1904 after it was used at the St. Louis exposition of that year. At 70 tons, its axle was the largest steel forging of the time. It was 26 stories tall, only a quarter of the Eiffel Tower's height.

◆ London Eye

It took seven years and the skills of hundreds of people from five countries to make the British Airways London Eye a reality. The design is similar to an enormous bicycle wheel, with a central hub and spindle connected to outer and inner rims by cable spokes. It is over 200 times larger than the average bike wheel. The 80 spokes laid together would stretch for six kilometres. The spindle which holds the wheel structure is 23m long – the height of nine classic London red telephone boxes. The hub and spindle weigh in at 330 tonnes – equivalent to 49 double-decker buses, and 20 times heavier than Big Ben. Some 1,700 tonnes of steel were used in the construction of the London Eye. It was shipped up the River Thames by barge in sections and assembled at the South Bank. It took a week to lift it from a horizontal position to the fully vertical one. The technology employed had previously been used to erect North Sea oil rigs. The London Eye is often mistakenly called a Ferris wheel. This is not the case: first, the passenger capsules are completely enclosed and are climate controlled; secondly, the capsules are positioned on the outside of the wheel structure and are fully motorized; and third, the entire structure is supported by an A-frame on one side only.

Student Resource:
The History of Big Wheels (continued)

But, how does it work? The London Eye uses two types of cable, wheel cables and backstay cables. Wheel cables include 16 rim rotation cables, and 64 spoke cables, these are similar to bicycle spokes and stretch across the wheel. There are six backstay cables, which are located in the compression foundation. The compression foundation is situated underneath the A - frame legs; it required 2,200 tonnes of concrete and 44 concrete piles - each being 33 metres deep. The tension foundation, holding the backstay cables, used 1,200 tonnes of concrete. The main elements of the hub and spindle were manufactured in cast steel. The spindle was too large to cast as a single piece so instead was produced in eight smaller sections. Two further castings, in the form of great rings, form the main structural element of the hub. The hub is a rolled steel tube forming the spacer that holds them apart. All the casting was carried out by Skoda Steel. Find out more at www.londoneye.com/LearningAndDiscovery.

◆ **Singapore Flyer**

Completed in 2008, the Singapore Flyer is one of the world's largest man-made moving land objects at a height of 178 metres – equivalent to a 45-story building. It comprises of a giant observation wheel 150-metres in diameter sitting astride a 20-metre high, three storey terminal building. Once aboard, passengers are enthralled by sweeping, epic views – from the historic Singapore River and modern skyline, to the grand vista of ships on the horizon, and on a clear day, right out to Malaysia and Indonesia. From each of the 28 air-conditioned, UV-protected capsules, visitors enjoy the fascinating sensation of flight, while afloat in the sky during the 37-minute ride.

Student Worksheet: Build Your Own Wheel

You are a team of engineers who have been given the challenge of building a "big wheel."

◆ Research/Preparation Phase

1. Review the various Student Reference Sheets.

◆ Planning as a Team

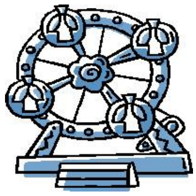
2. Your team has been provided with some "building materials" by your teacher. You have dried pasta, glue, paper, cardboard, string, paperclips, and other resources.

3. Start by meeting with your team and devising a plan to build your structure. You'll need to figure out how many pieces of each shape of pasta you'll require, how much string you require, and develop a sketch of your plan for review by your teacher. You should consider the stages or steps that will be needed in construction to make sure the wheel stays together.

4. Write or draw your plan in the box below, including your projection for the materials you'll require to complete the construction. Present your design to the class, and explain your choice of glue. You may choose to revise your teams' plan after you receive feedback from class.

Stages of Construction: Materials Needed:

Build a Big Wheel



Student Worksheet: Evaluation

◆ Construction Phase

5. Build your big wheel! You may need to let glue dry overnight before the wheel is completed. You may also need to build and connect certain parts before others. Consider how the London Eye was constructed in stages (www.londoneye.com/LearningAndDiscovery).

6. Evaluate your teams' results, complete the evaluation worksheet, and present your findings to the class.

◆ Use this worksheet to evaluate your team's results in the Build a Big Wheel lesson:

1. Did you succeed in creating a "big wheel" that could turn? If not, why did it fail?

2. Did you need to request additional or different shapes of pasta while building the wheel? If so, what happened between the design (drawing) and the actual construction that changed your material needs?

3. Do you think that engineers have to adapt their original plans during the manufacturing process? Why might they?

4. If you had to do it all over again, how would your planned design change? Why?

5. What designs or methods did you see other teams try that you thought worked well?

Student Worksheet: Evaluation (continued)

6. Did you find that there were many designs in your classroom that met the project goal? What does this tell you about engineering plans?

7. Do you think you would have been able to complete this project easier if you were working alone? Explain…

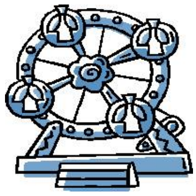
8. How do you think the engineering designs for "big wheels" have changed over time? What impact has the development of new materials had on the engineering plans for "big wheels?"

9. How have these engineering improvements changed the experience of those riding on the "big wheels?"

10. What engineering considerations are needed in big wheel design to accommodate riders in wheelchairs?

11. Do you think that the expectations of riders have impacted the designs of "big wheels." How have "big wheels" changed to meet these expectations?

Build a Big Wheel



For Teachers:
Alignment to Curriculum Frameworks

Note: All lesson plans in this series are aligned to the Australian Curriculum for both Science and Mathematics.

	Year Level					
	5	**6**	**7**	**8**	**9**	**10**
Science Understandings			Change to an object's motion is caused by unbalanced forces acting on the object **(ACSSU117)** *Investigating the effects of applying different forces to familiar objects*	Energy appears in different forms including movement, heat and potential energy, and causes changes within systems **(ACSSU155)** *Using flow diagrams to illustrate changes between different forms of energy*		Energy conservation in a system can be explained be describing energy transfers and transformations **(ACSSU 190)** *Using models to describe how energy is transferred and transformed within systems* The motion of objects can be described and predicted using the laws of Physics **(ACSSU229)**
Science as a human endeavour			Scientific knowledge changes as new evidence becomes available **(ACSHE119 – Yr 7); (ACSHE134 – Yr 8)** Science knowledge can be developed through collaboration and connecting ideas across the disciplines of Science **(ACSHE223 – Yr 7); (ACSHE226 – Yr 8)**		Advances in scientific understandings often rely on developments in technology and technological advances are often linked to scientific discoveries **(ACSHE195)**	

Science Inquiry Skills			Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge **(ACSIS124 – Yr7); (ACSIS139 – Yr 8)** Summarise data and use scientific understanding to identify relationships and draw conclusions **(ACSIS130 – Yr 7); (ACSIS145 – Yr8)** Reflect on the method used to investigate a question or solve a problem, evaluate quality of data collected and identify improvements to the method **(ACSIS131 – Yr7); (ACSIS146 – Yr8)** Use scientific knowledge and findings from investigations to evaluate claims **(ACSIS132 – Yr7); (ACSIS234 –Yr8)** Communicate scientific ideas and information for a particular purpose **(ACSIS133 – Yr7); (ACSIS148 – Yr8)**	Formulate questions or hypothesis that can be investigated scientifically **(ACSIS198)** Use knowledge of scientific concepts to draw conclusions that are consistent with evidence **(ACSIS204)** Evaluate conclusions and describe specific ways to improve quality of data **(ACSIS205)** Communicate scientific ideas and information for a particular purpose **(ACSIS208)**

Mathematics Links

Activity	**Concept / Year Level**							
	Number and Algebra				**Measurement and Geometry**		**Statistics and Probability**	
	Number and place value	**Real numbers**	**Money and financial maths**	**Linear and non-linear relationships**	**Using units of measurement**	**Geometric reasoning**	**Data and representation and interpretation**	**Shape**
Build a big wheel	Yr 5 - 10	Yr 7 - 10	Yr 8 (budget)		Yr 5 - 10		Yr 5 - 10	

Mathematics Links with Science Curriculum (Skills used in this activity)	General Capabilities	Cross-Curriculum Priorities
• Process data using simple tables • Data analysis skills (graphs) • Analysis of patterns and trends • Use of metric units	• Literacy • Numeracy • Critical and creative thinking • Personal and social capacity • ICT capability	• Sustainability

Science Achievement Standards

Year 7

By the end of Year 7, students *describe techniques to separate pure substances from mixtures*. They represent and predict the effects of unbalanced forces, including Earth's gravity, on motion. They explain how the relative positions of the Earth, sun and moon affect phenomena on Earth. They analyse how the sustainable use of resources depends on the way they are formed and cycled through Earth systems. They predict the effect of environmental changes on feeding relationships and classify and organise diverse organisms based on observable differences. Students ***describe situations where scientific knowledge from different science disciplines has been used to solve a real-world problem. They explain how the solution was viewed by, and impacted on, different groups in society***.

Students identify questions that can be investigated scientifically. They ***plan fair experimental methods, identify variables to be changed and measured***. They ***select equipment that improves fairness and accuracy and describe how they considered safety***. ***Students draw on evidence to support their conclusions. They summarise data from different sources, describe trends and refer to the quality of their data when suggesting improvements to their methods. They communicate their ideas, methods and findings using scientific language and appropriate representations.***

Year 8

By the end of Year 8, students compare physical and chemical changes and *use the particle model to explain and predict the properties and behaviours of substances*. They ***identify different forms of energy and describe how energy transfers and transformations cause change in simple systems***. They compare processes of rock formation, including the time scales involved. They analyse the relationship between structure and function at cell, organ and body system levels. Students examine the different science knowledge used in occupations. They ***explain how evidence has led to an improved understanding of a scientific idea and describe situations in which scientists collaborate to generate solutions to contemporary problems***.

Students identify and construct questions and problems that they can investigate scientifically. They ***consider safety and ethics when planning investigations, including designing field or experimental methods. They identify variables to be changed, measured and controlled. Students construct representations of their data to reveal and analyse patterns and trends, and use these when justifying their conclusions. They explain how modifications to methods could improve the quality of their data and apply their own scientific knowledge and investigation findings to evaluate claims made by others. They use appropriate language and representations to communicate science ideas, methods and findings in a range of texts types.***

Year 10
By the end of Year 10, students analyse how the periodic table organises elements and use it to make predictions about the properties of elements. **They *explain how chemical reactions are used to produce particular products*** and how different factors influence the rate of reactions. They explain the concept of energy conservation and represent energy transfer and transformation within systems. ***They apply relationships between force, mass and acceleration to predict changes in the motions of objects.*** Students describe and analyse interactions and cycles within and between Earth's spheres. They evaluate the evidence for scientific theories that explain the origin of the universe and the diversity of life on Earth. They explain the processes that underpin heredity and evolution. Students analyse how the models and theories they use have developed over time and discuss the factors that prompted their view.

Students develop questions and hypotheses and independently design and improve appropriate methods of investigation, including field work and laboratory experimentation. They explain how they have considered reliability, safety, fairness and ethical actions in their methods and identify where digital technologies can be used to enhance the quality of their data. ***When analysing data, selecting evidence and developing and justifying conclusions, they identify alternative explanations for findings and explain any sources of uncertainty***. Students ***evaluate the validity and reliability of claims made in secondary sources with reference to currently held scientific views***, the quality of methodology and the evidence cited. They ***construct evidence-based arguments and select appropriate representations and text types to communicate science ideas for specific purposes***.