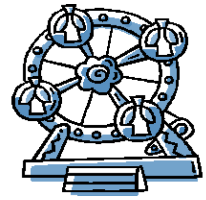
Build a Big Wheel



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.

Age Levels
8-18.

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)
- ITEA Standards for Technological Literacy: Content for the Study of Technology (www.iteaconnect.org/TAA)
- National Science Education Standards (www.nsta.org/publications/nses.aspx)

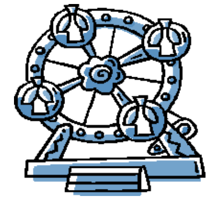
Recommended Reading

- 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 or toilet paper 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.

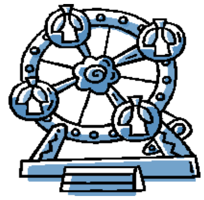
6. Student groups next execute their plans. They may need to rethink their plan, add materials, or start over. This project may require overnight drying of wheel segments before final construction.

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 or toilet paper roll, or PVC pipe.

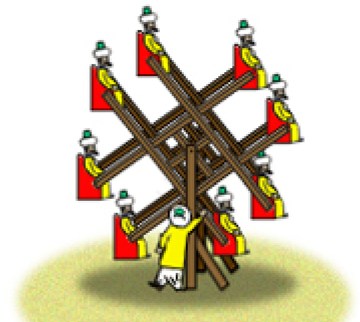
◆ Time Needed
Two to three 45 minute sessions

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 meter (264 foot) 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 250' 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

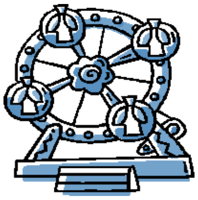
It took seven years and the skills of hundreds of people from five countries to make the British Airways London Eye a reality. The design is similar to an enormous bicycle wheel, with a central hub and spindle connected to outer and inner rims by cable spokes. It is over 200 times larger than the average bike wheel. The 80 spokes laid together would stretch for six kilometers. 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.

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

When it is completed in 2008, the Singapore Flyer will be one of the world's largest man-made moving land objects at a height of 178 metres – equivalent to a 45-story building. It will comprise a giant observation wheel 150-metres in diameter sitting astride a 20-metre high, three storey terminal building. Once aboard, passengers will be 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 can enjoy the fascinating sensation of flight, while afloat in the sky during the 37-minute ride. The artist's impression on the right shows what the Singapore Flyer will look like. Find out more at www.singaporeflyer.com.sg.

Build a Big Wheel



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

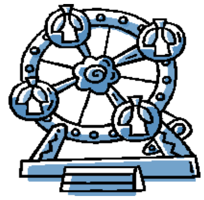
2. Your team has been provided with some "building materials" by your teacher. You have dried pasta, glue, paper, cardboard, string, paperclips, and other resources.

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?

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?

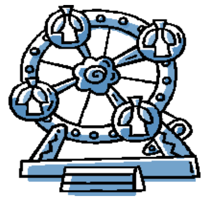
7. Do you think you would have been able to complete this project easier if you were working alone? Explain…

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?

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



For Teachers:
Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

◆National Science Education Standards Grades K-4 (ages 4 - 9)

CONTENT STANDARD B: Physical Science

As a result of the activities, all students should develop an understanding of

- ✦ Properties of objects and materials
- ✦ Position and motion of objects

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- ✦ Abilities of technological design

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- ✦ Science and technology in local challenges

◆National Science Education Standards Grades 5-8 (ages 10 - 14)

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop an understanding of

- ✦ Properties and changes of properties in matter
- ✦ Motions and forces
- ✦ Transfer of energy

CONTENT STANDARD E: Science and Technology

As a result of activities in grades 5-8, all students should develop

- ✦ Abilities of technological design
- ✦ Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- ✦ Science and technology in society

◆National Science Education Standards Grades 9-12 (ages 14-18)

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop understanding of

- ✦ Structure and properties of matter
- ✦ Motions and forces

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- ✦ Abilities of technological design
- ✦ Understandings about science and technology

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- ✦ Historical perspectives

For Teachers:
Alignment to Curriculum Frameworks (continued)

◆Next Generation Science Standards – Grades 3-5 (Ages 8-11)

Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

- 3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

Engineering Design

Students who demonstrate understanding can:

- 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

◆Next Generation Science Standards - Grades 6-8 (Ages 11-14)

Engineering Design

Students who demonstrate understanding can:

- MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

◆Next Generation Science Standards - Grades 9-12 (Ages 11-14)

Engineering Design

- MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

◆Standards for Technological Literacy - All Ages

The Nature of Technology

- Standard 1: Students will develop an understanding of the characteristics and scope of technology.
- Standard 2: Students will develop an understanding of the core concepts of technology.

For Teachers:
Alignment to Curriculum Frameworks (continued)

◆Standards for Technological Literacy - All Ages

The Nature of Technology

- Standard 1: Students will develop an understanding of the characteristics and scope of technology.
- Standard 2: Students will develop an understanding of the core concepts of technology.

Technology and Society

- Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.
- Standard 5: Students will develop an understanding of the effects of technology on the environment.
- Standard 6: Students will develop an understanding of the role of society in the development and use of technology.
- Standard 7: Students will develop an understanding of the influence of technology on history.

Design

- Standard 8: Students will develop an understanding of the attributes of design.
- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

- Standard 11: Students will develop abilities to apply the design process.

The Designed World

- Standard 18: Students will develop an understanding of and be able to select and use transportation technologies.