Give Me a Brake

Provided by TryEngineering - www.tryengineering.org

Lesson Focus

Lesson focuses on brakes, force, and friction, using bicycle rim brakes to demonstrate basic braking mechanisms to stop, slow, or prevent motion.

Lesson Synopsis

The Give Me a Brake activity explores the concept of how brakes can stop or slow mechanical motion. Students examine the operation of a bicycle brake and use low cost materials to devise a simple braking system, then work as a team to suggest improvements to current bicycle brake designs.

Year Levels

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

Objectives

- Learn about braking systems.
- Learn about force and friction.
- Learn about the interaction between different materials.
- Learn about teamwork and the engineering problem solving/design process.

Anticipated Learner Outcomes

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

- force and friction
- brakes
- impact of engineering and technology on society
- engineering problem solving
- teamwork

Lesson Activities

Students learn about how basic rim bicycle brakes work, and discuss force and friction. Students work in teams to experience a simple braking system using three different materials, they discuss advantages of each, develop recommend changes to improve bicycle braking systems, and present to class.

Resources / Materials

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

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- TryEngineering (www.tryengineering.org)
- Bicycle Brake Systems (http://en.wikipedia.org/wiki/Bicycle_brake)
- A Short Course on Brakes (www.familycar.com/brakes.htm)
- Curriculum Links (www.acara.edu.au)

Recommended Reading

- How Cars Work by Tom Newton (ISBN: 0966862309)
- Automotive Brakes and Antilock Braking Systems by Kalton C. Lahue (ISBN: 0314028382)
- Brake Systems by L. Carley (ISBN: 1557882819)

Optional Writing Activities

- Write an essay or a paragraph describing how the brakes operate on another machine to slow, stop, or prevent motion. Choose from the following products: motorised wheelchair, basic wheelchair, car, airport luggage cart, walker.

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For Teachers:
Teacher Resources

◆ Lesson Goal

Explore how simple rim brake systems work for bicycles. Student teams explore how three different materials react when used in a braking system to stop the motion of a marble. Then student teams evaluate the design and materials used in standard bicycle brakes, and develop or improve the current design for improved safety using words and sketches. The teams then present their ideas to the class.

◆ Lesson Objectives

- Students learn about braking systems.
- Students learn about force and friction.
- Students learn about the interaction between different materials.
- Students learn about teamwork and the engineering problem solving/design process.

◆ Materials

- Student Resource Sheets
- Student Worksheets
- One set of materials for each group of students:
  - marble or ball less than 2.5cm in diameter
  - 2.5cm foam pipe insulation (foam) (about 30 cm) (available at hardware stores)
  - cardboard tube from paper towels
  - PVC pipe (about 30cm)…similar diameter to towel tube
  - string, rubber bands
- Optional material - bicycle with working rim brake for examination

◆ 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. They may also be directed to look at the brake systems on their own or a friend's bicycle in advance of the activity.
2. Divide students into groups of 3-4 students; provide one set of materials per group.
3. Ask students to complete the student worksheet. As part of the process, the students work in teams as "engineers" to consider improvements to bicycle brake designs.
4. Each student group presents their vision of improved features for bicycle brakes to the class.

◆ Time Needed

One 45 minute session.

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Student Resource: All About Brakes

◆ The Basics

Brakes are used to slow, stop, or prevent the motion of a machine, such as a car or bicycle. A bicycle brake applies force to both sides of a wheel rim. In the process the energy of the moving part -- such as the wheel of a bicycle -- is frequently converted to heat through friction. In most cars, the heat generated through the braking process is stored in a rotating drum or disc and then gradually released to the air.

◆ Key Words

Force: By pushing or pulling on an object we give it energy and cause it to move, stop moving, or change direction. For example, when we apply a bicycle brake, we exert force on the wheel causing it to slow or stop rotating. The force produced may cause the body to deform -- in bicycles, the wheel is compressed.

Kinetic Energy: energy that a machine or material possesses, caused by its motion.

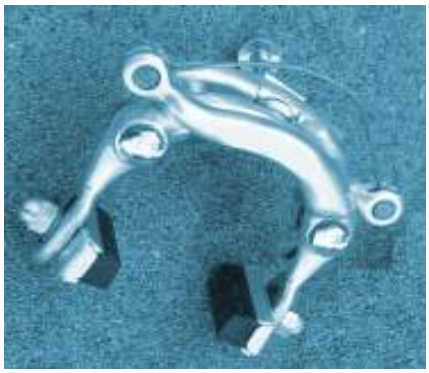
Friction: a term that describes how much resistance there is for two objects to move over another. The greater the friction, the more difficult it is for the two objects to move smoothly. With less friction, objects move easily and smoothly against one another.

Heat: a form of energy associated with the motion of matter. Heat can be generated in many ways, such as chemical or nuclear reactions, and friction.

◆ Look Ma, No Brakes

Early bicycles had no brakes. Riders could reverse their motion to slow down, but then had to jump off quickly to stop. Clearly this resulted in numerous injuries and required the engineering of a new, safer system. Now there are many different type of brake systems. This lesson focuses on the "rim brake" which was introduced in the 1890's.

◆ Rim Brakes



There are several variations of rim brakes designs, but in all of them, the force is applied to the tyre by the bicyclist squeezing a level on the handlebar. This causes pads that are usually made of plastic or some synthetic material (but have also been made of leather) to rub against the metal rim holding the tyre as it rotates. The more pressure applied to the rim, the slower the wheel can turn.

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Student Worksheet: Brake Operation

Optional Advance Step: Have students examine the operation of standard rim brakes on a bicycle. This may be done as a group in the classroom if a bicycle is available, or students could be directed to examine the operations of the rim brake on their own or a friend's bicycle outside of class. Have students draw a sketch that illustrates how the brake operates (showing pads, tyre, and rim in both the "released" and "braking" positions.

Step One:
As a team, you will examine the braking process using the materials provided to you. Consider the marble or small ball to be the object in motion which you need to slow, stop, or prevent from moving. Roll the ball through the three tubes provided. One is a stiff PVC pipe, the second is a paper towel roll, and the third is a foam tube used to insulate water pipes. Using your hand, a rubber band, string, or other materials, see if you can prevent the ball from going all the way through the tubes. If you succeed, you'll have applied a brake within the tube. Try to simply slow it down using the materials provided.

Step Two: Answer the questions below

Questions:

1. What advantages did the foam tube have over the other two materials in terms of the ability to slow or stop the rolling ball/marble?

2. Which material do you think would hold up best over time? Why?

3. Which material gave you the greatest control over the speed of the ball travelling through the tube? Why do you think this was?

4. What provides the "force" in your tube experiments? Where is the friction?

5. Which tube material required the least amount of friction to stop the ball/marble? Why do you think this was true?

6. Bicycle rim brake pads are made of a moderately hard rubber or plastic, and are sometimes made of leather. Why do you think these materials are preferred?

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Student Worksheet:
You are the Engineering Team!

Your challenge is to work as a team to devise an improvement in design for a bicycle braking system that will make it brake more smoothly, and therefore more safely. You may work to improve the rim brake, or come up with a completely new design. Propose your ideas and theories as a group. Then, as a team, develop a proposal which you will present to your class.

Step One: Observation

1. Examine how the common rim brake operates…if possible look at one on a working bicycle.

2. Decide as a team what you want to change in the design. Discuss materials you might use (metals, plastics, foam, leather), whether you think the size of the pads, or the number of pads might impact the performance of the brake, and finally how easy your new brake will be to operate for someone new to bicycling.

3. Draw a sketch of your new braking system and be sure to include a list of the type of materials you'll use in construction. Call out the areas of the design you have changed and explain why your team came up with these ideas.

Materials to be used in manufacture/Why selected?

What is unique about this design? (two sentences maximum)

4. Present your ideas to your class….pretend they are individuals who are considering funding the manufacture of your new brake system.

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For Teachers:
Alignment to Curriculum Frameworks

Note: All lesson plans in this series are aligned to the Australian Curriculum in Science

	Year Level					
	5	**6**	**7**	**8**	**9**	**10**
Science Understandings			Changes to an object's motion is caused by unbalanced forces acting on a object **(ACSSU117)**	Energy appears in different forms including movement (kinetic energy), heat and potential energy, and causes change within a system **(ACSSU115)**		The motion of objects can be described and predicted using the laws of physics **(ACSSU229)**
Science as a human endeavour			Science knowledge can develop 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 **(ACSHE192 – Yr 10)**	
Science Inquiry Skills			Summarise data, from student's own investigations and secondary sources, and use scientific understandings to identify relationships and draw conclusions **(ACSIS130 – Yr 7); (ACSIS145 – Yr – 8)** Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of the data collected, and identify improvements to the methods **(ACSIS131 – Yr 7); (ACSIS146 – Yr 8)** Communicate ideas, findings and solutions to problems using scientific language and representations using digital technologies as appropriate **(ACSIS133 – Yr 7); (ACSIS148 – Yr 8)**		Use knowledge of scientific concepts to draw conclusions that are consistent with evidence **(ACSIS204 – Yr 10)** Evaluate conclusions and describe specific ways to improve **(ACSIS205 – Yr 10)** Communicate scientific ideas and information for a particular purpose **(ACSIS208 – Yr 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***.