Give Me a Brake

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.

Age Levels

8-11.

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)

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: motorized wheelchair, basic wheelchair, car, airport luggage cart, walker.

For Teachers: Teacher Resource

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 1" in diameter
  - 1" foam pipe insulation (foam) (about 12") (available at hardware stores for less than $6 for whole class)
  - cardboard tube from paper towels
  - PVC pipe (about 12")…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.

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.

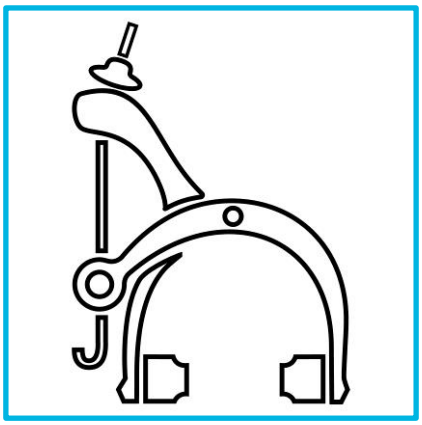
Kinetic Energy: energy that a machine or material possesses, caused by its motion.

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 tire 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 tire as it rotates. The more pressure applied to the rim, the slower the wheel can turn.

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, tire, 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

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 traveling 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?

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.

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 5-8 (ages 10-14)

CONTENT STANDARD B: Physical Science

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

- 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

◆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

- Motions and forces
- Interactions of energy and matter

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design

◆Next Generation Science Standards Grades 2-5 (Ages 7-11)

Matter and its Interactions

Students who demonstrate understanding can:

- 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

Energy

Students who demonstrate understanding can:

- 4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.

For Teachers: Alignment to Curriculum Frameworks

◆Next Generation Science Standards Grades 2-5 (Ages 7-11)

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-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

◆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 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Technology and Society

- Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects 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.

The Designed World

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