Rubber Band Racers

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Lesson Focus

The focus of this lesson is on rubber band powered car design. Teams of students construct rubber band powered cars from everyday materials. Students must design their cars to travel a distance of at least 3 meters within a 1 meter wide track.

Lesson Synopsis

The "Rubber Band Racers" lesson explores the design of rubber band powered cars. Students work in teams of "engineers" to design and build their own rubber band cars out of everyday items. They test their rubber band cars, evaluate their results, and present to the class.

Age Levels

8-18

Objectives

During this lesson, students will:

- Design and construct a rubber band car
- Measure distance and calculate speed
- Test and refine their designs
- Communicate their design process and results

Anticipated Learner Outcomes

As a result of this lesson, students will have:

- Designed and constructed a rubber band car
- Measured distance and calculated speed
- Tested and refined their designs
- Communicated their design process and results

Lesson Activities

In "Rubber Band Racers" lesson students explore rubber band car design. Students work in teams of "engineers" to design and build their own rubber band car out of everyday items. They test their rubber band cars, evaluate their results, 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

- International Federation of Automotive Engineering Societies: What do Automotive Engineers Do? (www.fisita.com/jobs/careers/do)
- TryEngineering (www.tryengineering.org)
- 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

- The New Way Things Work (ISBN: 978-0395938478)
- Masters of Car Design (ISBN: 978-8854403376)

Optional Writing Activity

- Write a paragraph or essay explaining what automotive engineers must take into consideration when designing safe vehicles today.

Rubber Band Racers

For Teachers:
Teacher Resources

◆ Lesson Goal

Students design rubber band cars out of simple materials. They then test their cars to determine if they can travel a distance of at least 3 meters within a 1 meter wide track. The car that can travel within the track for the greatest distance is the winner.

◆ Lesson Objectives

During this lesson, students will:

- Design and construct a rubber band car
- Measure distance and calculate speed
- Test and refine their designs
- Communicate their design process and results

◆ Materials

One set of materials for each group of students:

- 16 in. x 16 in. piece of corrugated cardboard (or a cereal box/smaller piece of cardboard) and 4: CDs, paper plates, or plastic coffee, yogurt, or takeout lids)
- 4 rubber bands
- 3 unsharpened pencils
- 4 metal paperclips
- package thumb tack
- scissors
- masking tape
- meterstick
- stopwatch

◆ 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.
2. Divide students into groups of 3-4 students, providing a set of materials per group.
3. Explain that students must develop a car powered by rubber bands from everyday items, and that the rubber band car must be able to travel a distance of at least 3 meters within a 1 meter wide track. Rubber bands cannot be used to slingshot the cars. The car that can travel within the track for the greatest distance is the winner.
4. Students meet and develop a plan for their rubber band car. They agree on materials they will need, write or draw their plan, and then present their plan to the class.
5. Student teams may trade unlimited materials with other teams to develop their ideal parts list.
6. Student groups next execute their plans. They may need to rethink their plan, request other materials, trade with other teams, or start over.
7. Next….teams will test their rubber band car. Students can create the 1 meter wide "track" using masking tape on the floor.
8. Teams then complete an evaluation/reflection worksheet, and present their findings to the class.

◆ Time Needed

- Two to three 45 minute class periods

Student Resource:
Automobiles and Automotive Engineering

◆ Brief History of the Automobile

The development of the automobile as we know it today has been an evolution over the past several hundred years. Both Leonardo da Vinci and Isaac Newton sketched ideas for vehicles during their lifetimes. The first steam-powered automobile was developed in the late 18th century by Nicolas Cugnot. Robert Anderson of Scotland developed the first electric vehicle sometime in the 1830s. In 1876 Nicolaus Otto developed the first effective gasoline motor engine which paved the way for the first gasoline powered vehicles. The first successful gasoline-powered vehicles were developed by Karl Benz and Gottleib Daimler in 1885. Some of the first mass-producers of gasoline powered automobiles included Rene Panhard and Emile Levassor and Peugeot in France; and Charles and Frank Duryea, Eli Olds and Henry Ford in the United States.

◆ Modern Automobiles

Even today, automobiles are constantly evolving. Today you can find automobiles in a wide array of colors, shapes and sizes. The vehicles of today possess innovative design features such as GPS, IPod Interfaces, rear video cameras and the ability to parallel park on their own!
In some markets, the size and efficiency of automobiles has become a priority. One of the smallest cars on the market, the smart car Fortwo, was introduced in 1998 by Nicholas Hayek the inventor of Swatch watches. The smart car is roughly 8 feet long 5 feet high and 5 feet wide making it ideal for crowded cities. The smart car Fortwo gets a reported 46.3 mpg in the city, and 68.9 mpg for highway driving.

Some of the greatest innovations in automotive engineering are occurring in the way cars are powered. The supply, cost, and environmental impact of fossil fuels are motivating many automakers to offer vehicles that use green technology or run on alternative energies. Hybrid cars use two systems of power including a gasoline powered engine and an electric motor. Some hybrid models need to be plugged in to recharge power and can even generate electricity. Electric cars run on electric battery powered motors. Some cars are designed to run on alternative fuels such as ethanol or biodiesel. Hydrogen powered cars and cars that run on hydrogen fuels are currently in development. Cars that run on compressed air are also being investigated by automakers around the world.

Student Resource: Automobiles and Automotive Engineering

◆ Automotive Engineering

Automotive engineers design the vehicles that we use for life, work, and play. They are involved in aspects of engineering design ranging from the initial design concept all the way to production. They design, test and refine vehicles for safety, style, comfort, handling, practicality, and customer needs. The work of automotive engineers falls into three basic categories: design, development and production. The work of some engineers involves designing the basic part or systems of an automobile, such as brakes or engines. Research and development engineers devise solutions to various engineering challenges. Production engineers design the processes that will be used to manufacture the automobile.

Here are a few science concepts that will be helpful to keep in mind when designing and testing your rubber band car.

◆ Energy

Energy is the ability to do work. All forms of energy fall into two basic categories: potential energy and kinetic energy. Potential energy is mechanical energy which is due to a body's position. It is also known as stored energy. A car at rest has potential energy. Kinetic energy is mechanical energy that is due to a body's motion. For a car to move, potential energy must be transformed into kinetic energy.

◆ Newton's Laws of Motion

Sir Isaac Newton (1642 – 1727) was a brilliant mathematician, astronomer and physicist who is considered to be one of the most influential figures in human history. Newton studied a wide variety of phenomena during his lifetime, one of which included the motion of objects and systems. Based on his observations he formulated Three Laws of Motion which were presented in his masterwork Philosophiæ Naturalis Principia Mathematica in 1686.

Newton's First Law – An object at rest will remain at rest and an object in motion will remain in motion at a constant speed unless acted on by an unbalanced force (such as friction or gravity). This is also known as the law of inertia.

Newton's Second Law – An object's acceleration is directly proportional to the net force acting on it and inversely proportional to its mass. The direction of the acceleration is in the direction of the applied net force. Newton's Second Law can be expressed as: $F = ma$

Newton's Third Law – For every action there is an equal and opposite reaction.

Rubber Band Racers

Student Worksheet:
Design a Rubber Band Racer

You are a team of engineers who have been given the challenge to design your own rubber band car out of everyday items. The rubber band car needs to be able to travel a distance of at least 3 meters within a 1 meter wide track. The car that can travel the farthest distance within the track is the winner.

◆ Planning Stage

Meet as a team and discuss the problem you need to solve. Then develop and agree on a design for your rubber band car. You'll need to determine what materials you want to use.

Draw your design in the box below, and be sure to indicate the description and number of parts you plan to use. Present your design to the class.

You may choose to revise your teams' plan after you receive feedback from class.

Design:

Materials Needed:

Student Worksheet (continued):

◆ Construction Phase
Build your rubber band car. During construction you may decide you need additional materials or that your design needs to change. This is ok – just make a new sketch and revise your materials list.

◆ Testing Phase
Each team will test their rubber band car. Your rubber band car must travel 3 meters within a 1 meter wide track. Calculate your car's speed (distance traveled per unit of time; S = d/t). Be sure to watch the tests of the other teams and observe how their different designs worked.

Rubber Band Car Data			
	Distance Traveled within Track (m)	**Time Traveled within Track (s)**	**Speed (m/s)**
Test 1			
Test 2			
Test 3			
Average			

◆ Evaluation Phase
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 Rubber Band Racer Lesson:

1. Did you succeed in creating a rubber band car that traveled 3 meters within the track? If so, how far did it travel? If not, why did it fail?

Student Worksheet (continued):

2. Did you negotiate any material trades with other teams? How did that process work for you?

3. What is the average speed your car achieved?

4. Did you decide to revise your original design or request additional materials while in the construction phase? Why?

5. If you could have had access to materials that were different than those provided, what would your team have requested? Why?

6. Do you think that engineers have to adapt their original plans during the construction of systems or products? Why might they?

Student Worksheet (continued):

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

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

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

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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 A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

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

- Properties of objects and materials

CONTENT STANDARD G: History and Nature of Science

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

- Science as a human endeavor

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

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

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 F: Science in Personal and Social Perspectives

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

- Risks and benefits
- Science and technology in society

CONTENT STANDARD G: History and Nature of Science

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

- History of science

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

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

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

- Motions and forces

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, national, and global challenges

For Teachers: Alignment to Curriculum Frameworks (continued)

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

CONTENT STANDARD G: History and Nature of Science

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

- Historical perspectives

◆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.

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.

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)

Energy

Students who demonstrate understanding can:

- MS-PS3-5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

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.

For Teachers:
Alignment to Curriculum Frameworks (continued)

◆Principles and Standards for School Mathematics (ages 11 - 14)

Measurement Standard

-Apply appropriate techniques, tools, and formulas to determine measurements.

- solve simple problems involving rates and derived measurements for such attributes as velocity and density.

◆Principles and Standards for School Mathematics (ages 14 - 18)

Measurement Standard

- Apply appropriate techniques, tools, and formulas to determine measurements.

- analyze precision, accuracy, and approximate error in measurement situations.

◆ Common Core State Standards for School Mathematics Grades 2-8 (ages 7-14)

Measurement and data

- Measure and estimate lengths in standard units.

- CCSS.Math.Content.2.MD.A.1 Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes.
- CCSS.Math.Content.2.MD.A.3 Estimate lengths using units of inches, feet, centimeters, and meters.

Expressions & Equations

- Represent and analyze quantitative relationships between dependent and independent variables.

- CCSS.Math.Content.6.EE.C.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. For example, in a problem involving motion at constant speed, list and graph ordered pairs of distances and times, and write the equation d = 65t to represent the relationship between distance and time.

◆Standards for Technological Literacy - All Ages

Technology and Society

- Standard 5: Students will develop an understanding of the effects of technology on the environment.
- Standard 7: Students will develop an understanding of the influence of technology on history.

For Teachers: Alignment to Curriculum Frameworks (continued)

◆Standards for Technological Literacy - All Ages

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.