BUILT YOUR OWN

EXPLORING INNOVATION THOUGH RUBBER BAND CARS

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SCIENCE TEACHER PROGRAM

Science supplies for Every Student Initiative Teachers

PEORIA RIVERFRONT MUSEUM

BUILT Your Own: Exploring Innovation Through Rubber Band Cars

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Lesson plan developed by the Peoria Riverfront Museum in conjunction with exhibitions *DURYEA: America's First Car Company* and *BUILT: American Custom Car Culture*.
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BUILT Your Own: Exploring Innovation Through Rubber Band Cars
Activity Overview

Student Objectives:
- Learn and gain comfortability with the engineering design process within a team environment
- Explore the difference between potential and kinetic energy and be able to identify when the model is using which
- Make a model and test it based on specific functional criteria

Learning Standards
4-PS3 Energy
3-5-ETS1 Engineering Design
MS-PS2 Motion and Stability: Forces and Interactions
MS-ETS1 Engineering Design

Customize to Classroom
1. This lesson encourages team learning and problem solving. For flow and material usage, we recommend dividing students into groups of 3-4 "engineers".
2. Ensure the student worksheet is accessible to all students participating.
3. This activity could be modified to fit into one day or stretched over multiple with time to take home ideas to refine the model to solve the problem at hand.
4. Note that there are two "Goals" with similar procedures. These are separated to promote specific learning for the age range. We encourage you to choose either or both activities based on what would work for your class and their abilities.
5. If utilizing both Goals: "Goal #1" and "Goal #2" can be combined when testing and refining, or each can be separated testing for distance on a flat surface and distance in terrain.

Lesson Activities
In this lesson, students will explore designing rubber band cars. Students will work in teams of "engineers" to design, problem-solve, and build a rubber band car from the provided kit. They will test run their cars under different questions based on interest and grade level, evaluate their results, and present their observations.

Resources
- Teacher Resource Document
- Three Student Resource Documents
- Duryea Brothers Automotive Engineering and Innovation Video
  https://www.youtube.com/watch?v=S1yMS_8fuVA

BUILT Your Own | Teacher Resource Document

Students design rubber band cars from kit materials. They then test the cars to determine if they can travel in a straight line for a distance of at least 3 meters within a 1-meter-wide boundary (Goal #1). They will be asked to refine their design to cross a difficult terrain to explore and predict outcomes about the changes in energy that occur when friction is applied to the terrain (Goal #2).

Lesson Objectives

During this lesson students will:

- Design and construct a rubber band car within their group
- Measure distance and calculate velocity
- Test and refine their designs to achieve different successes
- Communicate their engineering process and results

Time Needed

Can be split into one to three 45-minute class periods.

Lesson Process Overview

Part 1: Introduction as a class
Part 2: Design, Development, Production
Part 3: Reflection and Discussion

Materials

- Rubber band car kit
- Scissors
- Tape
- Meterstick
- Stopwatch

Specific for Goal #2:

- Smooth (tile/wood/pavement) surface
- Rough (carpet/ grass/ gravel) surface

Procedure

1. Discuss automotive engineering, energy, Newton's Law of Motion, and friction using the Background Information document and show class the materials provided. The Background Information document may be read in class or provided as reading material for the prior night's homework.

   Note: Attached here and under **Resources** is a Peoria Riverfront Museum video outlining an inspiring story of automotive engineering. Time allowed, utilize this video in your classroom's lesson to spark the spirit of innovation!

   (https://www.youtube.com/watch?v=S1yMS_8fuVA)

2. Divide students into their “engineering teams”.
3. Explain that students must develop a car powered by rubber bands, and that the rubber band car must achieve Goal #1: travel in a straight line for a distance of at least 3 meters within a 1-meter-wide track on a smooth surface. Rubber bands cannot be used to slingshot the cars. The car that can travel in a straight line for the greatest distance is the winner.
4. In teams, students design and present their engineering plan to achieve the objective.

   Note: Student Worksheet indicates design must be presented to the educator. To stretch the lesson and incorporate larger teamwork, classrooms can choose to present to all other groups and receive willing feedback about their design from their classmates.
5. Students build an initial model to achieve Goal #1.
6. Each engineering group tests their car for Goal #1 and calculates velocity using the provided table. To ensure that the rubber band cars travel in a straight line, students can create a 1 meter wide “track” using masking tape on the floor.

   Note: Student table allows space to conduct multiple tests and take an average. For a shorter lesson and/or younger classroom, test only once.
7. Students will change and improve the design if needed.

   Note: can be repeated or drawn out as much as time allows.
8. Repeat steps 5-7 for Goal #2 – car can travel in a straight line for a distance of at least 3 meters within a 1-meter-wide boundary on an unsmooth surface.

   Note: Classrooms can choose to only participate in Goal #1. Goal #2 encourages discussion of friction and motion on other surfaces. We encourage you to emphasize the team racing of step 9 if you exclude Goal #2.
9. Race cars against each other to announce the fastest car.
10. Use Student Discussion Handout to promote group and class discussion as well as engineer focused reflection. This handout can be worked on as a group worksheet to be turned in, an outline for an all-group discussion, or the outline for group presentations.

Procedure Note:
Part 2 is divided into the three different steps of the automotive engineering design process: Design, Development, Production. To split this lesson into three days, run through Part 1: Introduction and Part 2: Design on day one, Part 2: Development and Production on day two, and Part 3: Discussion and Presentations on day three.

BUILT Your Own | Student Resource Document

Part One: Background Information

Automotive Engineering and Innovation

Automotive engineers focus on the application, design and manufacturing of many kinds of automotives. This type of engineering must look at everything from an initial design all the way to production, many times mass production. Their responsibilities can be broken down into three simple ideas: design, development, and production. They must test and refine their designs until their engineering problem is solved and their vehicle is ready for life, work, and play.

Let's think about our own backyard engineering innovators! Brothers Charles and Frank Duryea were both born and raised in Central Illinois near Peoria. In their youth, the Duryea Brothers were fascinated by motion and invention. Driven by this passion, they developed a gasoline engine that allowed a carriage to drive without horses. The brothers co-founded the Duryea Motor Company – the first American company to mass-produce, market and sell gas-powered automotives. This impressive work was not without challenges. Charles was inspired by a crude internal combustion engine he found at the 1886 Ohio State Fair. From then until 1893, Charles and Frank Duryea worked hard to create a gasoline engine light enough and reliable enough to power an automobile. Once they had a working model, their challenges did not disappear. They needed to both innovate to create a better engine, and work around manufacturing and financial disputes that came from mass-producing during the recession of 1900.

This all to say, their impact is revolutionary to automotive engineering and a great example of innovation at its purest form. Learn more about the Duryea Brothers on your next visit to the Peoria Riverfront Museum in the exhibit "Duryea: America's First Car Company"!

Energy

Energy can be defined as the ability to do work. In this case, energy is required for our vehicle to drive. All types of energy can be split up into two categories: potential energy and kinetic energy.

Potential energy is the stored energy of an object because of its position or state. Think about a bicycle on a hill. The gravity that would cause the bicycles wheels to roll down that hill has created potential energy, waiting to be used. Kinetic energy is energy that an object has because of its current motion. For a bicycle to move, potential energy must be transformed into kinetic energy. Force is used to transform potential to kinetic energy.

Laws of Motion

A scientist named Isaac Newton discovered three truths about motion we use today to describe how things move scientifically.

The First Law – An object at rest will remain at rest and an object in motion will remain in motion unless forces act on it.

The Second Law – The greater the mass of an object, the more force it takes to accelerate it. This also means the more force is applied the more acceleration results.

The Third Law- For every action, there is an equal and opposite reaction. The force of you kicking a ball is equal to the force the ball puts on your foot.

Friction

Friction is the resistance of motion when an object rubs against another. Friction works against motion and acts in the opposite direction.

<u>**BUILT Your Own | Student Resource Document**</u>

Part Two: Design, Development, Production

<u>Design</u>

You have been split into teams of engineers given the challenge to design and execute your own rubber band car. The car needs to travel in a straight line within the 1-meter-wide track for at least 3 meters in distance.

Meet as a team and identify the objective for your car. Develop and agree on a design for your rubber band car using the provided materials (you can use all materials, but you don't have to).

Draw your design in the box below including the description and number of parts you plan to use. Present your design to your teacher for approval.
You may choose to revise your team's plan after you receive feedback from your teacher.

Design:
Materials:

Development
Build your rubber band car! Durning construction you and your team may choose to pivot in your design and may need different materials than originally thought. This is okay, and all part of the engineering process.

Production
Each team will test their rubber band car. Your rubber band car must travel in a straight line for 3 meters within a 1-meter-wide track. Calculate your car's velocity (distance traveled in meters per second). Observe and note what is and is not working in your design. Be sure to watch the tests of the other teams and observe how their different designs worked.

Rubber Band Car on a Smooth Surface Data

	Distance Traveled (m)	Time Traveled (s)	Velocity (m/s)
Production Test 1			
Production Test 2			
Production Test 3			
Average			

Now take what you have observed about your car's performance and determine any redesign you may have to do to achieve success on a rough surface.

Your team will be given a short about of time to redesign before testing on a rough surface.

Rubber Band Car on a Rough Surface Data

	Distance Traveled (m)	Time Traveled (s)	Velocity (m/s)
Production Test 1			
Production Test 2			
Production Test 3			
Average			

BUILT Your Own | Student Resource Document

Part Three: Reflection and Discussion

Evaluate your team's results and answer the following questions.

1. What was the objective for your car?

2. Did your car succeed? If so, how far did it travel? If not, what could have been designed differently for it to succeed?

3. Explain the design process. How did your team know what materials were needed? Did you take inspiration from real cars?

4. If your group made changes to your car, what did/would you change? Did you take inspiration from other groups? If so, what?

5. What was your car's average speed?

6. Define Kinetic and Potential energy using your car as an example.

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

8. Do you think that engineers must change their original plans during development and production to succeed? Why might they?

9. If you could do it all again, would you change your initial design plan? Why or why not?

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

11. How would this project have been different if you were assigned to do it alone versus on a team? Do you think engineers work on teams often? Why or why not?