Rubber Band Powered Vehicles

Lesson plans for grades 6-10

NGSS standards aligned along with DoD Critical Technologies

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Rubber Band Powered Vehicles

Grade Level: 6-10 **Time required: *45-70 minutes per lesson***

Activities included in lesson plan:

- Rubber Band Boat (45–70 minutes)
- Rubber Band Boat-Budget Challenge (45–70 minutes)
- Rubber Band Car (45–70 minutes)
- Rubber Band Car-Budget Challenge (45–70 minutes)

These lessons can be used in concordance with each other or used individually.

NGSS Learning Standards: Middle School

- **MS-PS2-2:** Plan and carry out an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
- **MS-PS3-1:** Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
- **MS-ETS1-4:** Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

NGSS Learning Standards: High School

- **HS-PS2-1:** Analyze data to support the claim that Newton's Second Law of Motion describes the mathematical relationship among net force, mass, and acceleration of objects.
- **HS-PS3-3:** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
- **HS-ETS1-3:** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics.

DoD Critical Technologies Connections:

- **Semiconductors and Microelectronics**
  Unmanned cars and boats in the real world rely on microchips to control movement, store energy data, and communicate. While your design is powered by rubber bands, it represents the mechanical side of systems that, in DoD vehicles, would be integrated with electronic sensors and controls.
- **Advanced Manufacturing**
  By selecting materials, building prototypes, and improving your design, you're practicing key skills in advanced manufacturing — the same field that creates real DoD vehicles using robotics, 3D printing, and automated assembly. Your hands-on work reflects how real engineers turn ideas into working technology.

Materials Needed:

Building Materials:

- Rubber bands (various sizes)
- Cardboard (various types)
- Skewers and straws
- Small wheels and items that can work as wheels **
- Balsa wood and/or craft sticks*
- Plastic bottles (various sizes) *
- Plastic spoons*
- Foam Pieces *

Fasteners and Adhesives:

- Various types of tape:
  - Duct tape
  - Masking tape*
  - Etc.*
- Various types of glue:
  - Hot glue
  - Super glue*
  - Etc.*
- Tub or water table for boat testing
- Towels for cleanup

Items marked with an asterisk (*) are optional.
****Required for Rubber Band Cars.***

Tools and Testing Supplies

- Scissors
- X-Acto knives, or box cutters
- Measurement:
  - Rulers
  - Tape Measures
  - Yard sticks
  - Etc.
- Stopwatches

Safety Gear:

- Heat-resistant gloves (for hot glue guns)
- Cutting resistant gloves (for sharp blades)
- Safety goggles

Note: Offering the optional materials gives students more opportunities to deepen their understanding of concepts such as force, mass, and propulsion, as students explore how different materials affect their vehicles performance, efficiency, and ability to travel.

Teacher Preparation:

- Prepare testing stations: Water table or tub
- Rubber Band Car: testing area
- Print out and fill in the price sheet (for budgeted activities)
- Place students into pairs or groups no bigger than three

Make sure to have enough copies of consumables for all students.

Note: *Testing areas should be equipped with stopwatches and measuring instruments.*
Designate a clear start and finish line for each testing area, and label them so students can easily identify where to begin and end.
Pre-measure the distance between the start and finish lines before student testing to establish a baseline measurement.

Rubber Band Boat (*45-70 minutes)*

Introduction: (5 minutes)

Say to students:
"Have you ever seen a boat move without a motor? Today, you'll design and build a boat powered only by a rubber band. Engineers working for the Department of Defense face similar challenges when creating new unmanned boats and ships. They look for ways to store energy, like in advanced batteries or spring systems, and release it efficiently to move a vehicle."

Show a short video clip or image of a rubber band boat or an unmanned DoD maritime vehicle to spark interest. *(Check page 8)*

Discussion prompts:

- Where does the boat's energy come from?
- What happens when the rubber band unwinds?

Briefly discuss student answers, then transition:
"Just like engineers, you'll need to plan your design carefully and think about which materials will help your boat travel."

Activity Directions (30–35 minutes)

Provide each pair of students with the following:

- **Student Direction Sheet for the Rubber Band Powered Boat.**
- **Recording sheet.**

Review the steps with students, then answer questions before they begin.

Say to students:
"Together we will read through the directions, and I will answer any questions you have before you begin working with your partners." Then read through the student direction sheet.

Teacher Actions:

- Keep a timer visible for students to manage their time.
- Announce the time remaining periodically (e.g., halfway and 10 minutes left).
- Circulate around the room to monitor safe tool use, ask guiding questions, and support groups as needed.
- Remind students to document materials and test results on their recording sheets.

Testing and Wrap-Up (10–15 minutes)

When time is up, have students do the following:

- Perform final tests on their boats.
- Clean up their workstations.
- Return any unused or reuseable materials to the material area.

Discussion Questions:

- Which designs went farthest, and why?
- What materials seemed most effective?
- How might you change your design if you could start over?

Rubber Band Boat-Budget Challenge (*45-70 minutes)*

Introduction (5 min)

Say to students:

"Today you will design a boat while staying under a set budget. This is what engineers often face, especially those working for the Department of Defense. They must create the best designs they can while staying within a strict budget for materials."

Show students the price list and pass out student budget sheets. The instructor will need to fill out the price sheet ahead of time with the materials and prices that are available. Along with creating a budget for students.

Discussion Prompts:

- How do you think a budget will change the way you plan your design?
- What materials might be worth spending more on?
- How could you reuse materials to save money?

Briefly discuss student answers, then transition:

"Now, you and your partner will plan and build your boat design. Just like engineers, you'll need to carefully track what materials you use and make decisions that help you stay within your budget."

Activity Directions (30–35 minutes)

Provide each pair of students with the following:

- **Student Direction Sheet for the Budget Boat Challenge**
- **Budget sheet**.
- **Recording sheet.**

Review the steps with students, then answer questions before they begin.

Say to students:

"Together we will read through the directions, and I will answer any questions you have before you begin working with your partners." Then read through the student direction sheet.

Teacher Actions:

- Keep a timer visible for students to manage their time.
- Announce the time remaining periodically (e.g., halfway and 10 minutes left).
- Circulate around the room to monitor budget sheets, safe tool use, ask guiding questions, and support groups as needed.
- Remind students to document materials and test results on their recording sheets.

Testing and Wrap-Up (10–15 minutes)

When time is up, have students do the following:

- Perform final tests on their boats.
- Clean up their workstations.
- Return any unused or reuseable materials to the material area.

Discussion Questions:

- How did working with a budget affect your design?
- Did you trade certain materials for others?
- How does that compare to engineers who balance performance and cost?

Rubber Band Car (*45-70 minutes)*

Introduction (5 minutes)

Say to students:
"Have you ever seen a car move without a motor? Today, you'll design and build a car powered only by a rubber band. Engineers working for the Department of Defense face similar challenges when creating new unmanned vehicles. They look for ways to store energy, like in advanced batteries or spring systems, and release it efficiently to move a vehicle."

Show or sketch a simple rubber band powered car to spark ideas. (Check page 8)

Discussion Prompts:

- How will a car be different from a boat?
- What new challenges might you face on land compared to water?
- How might wheels, friction, or weight affect your design?

Briefly discuss student answers, then transition:
"Just like engineers, you'll need to plan your design carefully and think about which materials will help your car travel."

Activity Directions (30–35 minutes)

Provide each pair of students with the following:

- **Student Direction Sheet for the Rubber Band Powered Car**
- **Recording sheet.**

Review the steps with students, then answer questions before they begin.

Say to students:
"Together we will read through the directions, and I will answer any questions you have before you begin working with your partners." Then read through the student direction sheet.

Teacher Actions:

- Keep a timer visible for students to manage their time.
- Announce the time remaining periodically (e.g., halfway and 10 minutes left).
- Circulate around the room to monitor safe tool use, ask guiding questions, and support groups as needed.
- Remind students to document materials and test results on their recording sheets.

Testing and Wrap-Up (10–15 minutes)

When time is up, have students do the following:

- Perform final tests on their cars.
- Clean up their workstations.
- Return any unused or reuseable materials to the material area.

Discussion questions:

- What materials or designs might you try next time?
- How is designing a car compared to designing a boat?

Special note: Most of the car ideas will require a way to cut or drill a hole into a bottle cap (if not using CD's, cardboard, or small wheels with predrilled holes). Keep that in mind when preparing for this lesson.

Rubber Band Car-Budget Challenge (*45-70 minutes)*

Introduction (5 minutes)

Say to students:
"Today you will design a rubber band car while staying under a set budget. This is what engineers often face, especially those working for the Department of Defense. They must create the best designs they can while staying within a strict budget for materials."

Show students the price list and pass out student budget sheets. The instructor will need to fill out the price sheet ahead of time with the materials and prices that are available. Along with creating a budget for students.

Discussion Prompts:

- What materials are most important for a fast, efficient car?
- How might you save money by reusing or sharing materials?
- How will you make trade-offs between speed and cost?

Briefly discuss student answers, then transition:
"Now, you and your partner will plan and build your car design. Just like engineers, you'll need to carefully track what materials you use and make decisions that help you stay within your budget."

Activity Directions (30–35 minutes)

Provide each pair of students with the following:

- **Student Direction Sheet for the Budget Car challenge**
- **Budget sheet**
- **Recording sheet.**

Review the steps with students, then answer questions before they begin.

Say to students:
"Together we will read through the directions, and I will answer any questions you have before you begin working with your partners." Then read through the student direction sheet.

Teacher Actions:

- Keep a timer visible for students to manage their time.
- Announce the time remaining periodically (e.g., halfway and 10 minutes left).
- Circulate around the room to monitor budget sheets, safe tool use, ask guiding questions, and support groups as needed.
- Remind students to document materials and test results on their recording sheets.

Testing and Wrap-Up (10–15 minutes)

When time is up, have students do the following:

- Perform final tests on their cars.
- Clean up their workstations.
- Return any unused or reuseable materials to the material area.

Discussion questions:

- How did working with a budget affect your design?
- Did you trade certain materials for others?
- How does that compare to engineers who balance performance and cost?

Special note: Most of the car ideas will require a way to cut or drill a hole into a bottle cap (if not using CD's, cardboard, or small wheels with predrilled holes). Keep that in mind when preparing for this lesson.

Assessment Ideas:

1. Collect and review student recording sheets.
2. Observe teamwork, problem-solving, and safe tool use during activities.
3. Optionally, take a grade based on completion of data tables and reflections.

Optional Extensions:

- **Design Presentations:**
  - Have each team present their final design to the class, explaining their design choices, challenges, and trade-offs. Encourage students to highlight how they balanced performance, cost, and creativity.

- **Competition Challenges:** Add a fun, competitive element by awarding categories such as:
  - Farthest Distance
  - Fastest Time
  - Most Cost-Effective Design
  - Most Creative Use of Materials

- **Math Connections:** Integrate math standards by having students:
  - Graph their distance over time results. (Graph sheet on page 15)
  - Use the formula $speed = \frac{distance}{time}$ to calculate the speed of their vehicle.
  - Compare results across teams and analyze trends.

- **Creative Engineering Extensions:**
  - Ask students: "*What else could you design with rubber bands as the energy source?*" ***NOTE: remind students to be school appropriate with their answers***. Allow them to brainstorm other possible vehicles, machines, or everyday tools that could use stored energy for movement.

- **Entrepreneurship and Public Speaking Activity:**
  Challenge students to "Sell" their creations to the class. Each team should:
  - Develop a short sales pitch and simple marketing plan (posters, slogans, or features).
  - Present their pitch in 2 minutes.
  - Answer questions from classmates for another 2 minutes.
  - They may describe their design using the real materials they built with or invent "fictional upgrades" to boost their pitch

Goal: Build public speaking, persuasion, and teamwork skills while reinforcing the engineering design process.

Links for information on unmanned vehicles

U.S Navy ship: Mantas T12
https://martacsystems.com/products/t12/
**This webpage has information and images for other autonomous vehicles as well.

U.S Navy ship: Sea Hunter
https://en.wikipedia.org/wiki/Sea_Hunter

Links for idea inspiration for the Rubber Band Powered Boats

Make an Elastic Band Paddle Boat:
https://youtu.be/YVInLcZUcFA?si=LG7TOSUn0orVY4x-
** This one is very advanced and requires the use of a drill and sandpaper

Self-Paddle Boat | STEM Project:
https://youtu.be/mlzjfjk3ta8?si=aVKcJa0o8JkY8cMG
** This one is very simple

How to Make an Elastic Band Paddle Boat:
https://youtu.be/IwQJaY-wQuY?si=VFwU2lGkPtud5xZF

How to Make a Rubber Band Powered Boat - Simple Elastic Band Paddle Boat:
https://youtu.be/LDNgV_RVPO0?si=Fdyv-RFEi4mstu1W
**Simple but requires foam

Links for ideas and inspiration for the Rubber Band Powered Cars

How to Make Rubber Band Car (Simple and Easy)
https://www.youtube.com/watch?v=rUVL9dxqkz8

Science Buddies: Build a Rubber Band Powered Car:
https://www.sciencebuddies.org/stem-activities/rubber-band-car
**requires CD's or DVD's.

Special note: Most of the car ideas will require a way to cut or drill a hole into a bottle cap (if not using CD's, cardboard, or small wheels with predrilled holes). Keep that in mind when preparing for this lesson.

Price Sheet

Item	Price per unit
	$
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	$
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Rubber Band Powered Vehicle Budget Sheet

Team Members: _____

Project: ☐ Boat ☐ Car

Date: _____

Total Budget Allowed: _____

Material	Quantity	Cost per Unit	Total Cost

***Reminder: You must stay within the total budget. Anything you bought but did not use will still count towards your budget. You may share supplies you've already bought with other teams.*

Total Spent: _____

Remaining Budget: _____

Rubber Band Vehicle Recording Sheet

Challenge Type (circle one): Boat Car Budget Boat Budget Car

Team Members: _____

Date: _____

Design Sketch:

Draw and label your design below.

(include key parts: frame, rubber band mechanism, wheels or paddles, etc.)

Testing Log:

Record your test results. Include distance, time, or notes about what changed between tests.

Test #	Distance	Time	What Worked? What Changed?
1			
2			
3			

Rubber Band Vehicle Recording Sheet

Team Members: _____

Date: _____

Extra Testing Log:
Record your test results. Include distance, time, or notes about what changed between tests.

Test #	Distance	Time	What Worked? What Changed?
4			
5			
6			

Any Other Notes:

Rubber Band Vehicle Reflection Sheet

Name: _____

Date: _____

Directions: Answer each of the following questions using **complete sentences**. Be sure to **support your responses with specific details and evidence** from your project, including your design process, testing results, and any observations you made.

1. Did your vehicle successfully complete the challenge (reach the end of the test area)? If yes, what do you think made it successful? If not, what do you think prevented it from working as expected?

2. What design features or materials contributed most to your vehicle's performance, and how did they affect speed, distance, or stability?

3. If you were to redesign your vehicle, what specific changes would you make to improve its performance, and why?

Rubber Band Vehicle Reflection Sheet

Name: _____

Date: _____

Directions: Answer each of the following questions using **complete sentences**. Be sure to **support your responses with specific details and evidence** from your project, including your design process, testing results, and any observations you made.

4. What did you learn about how your vehicle stored and released energy (e.g., elastic, gravitational, etc.) to move?

5. What was your favorite part of this activity and why?

6. How did you and your team work together during the project? What strategies helped you collaborate effectively?

Team Members: _____

Title: _____

Rubber Band Powered Boat

Challenge: Build a boat that moves across water using only rubber band power—no pushing allowed!

Steps: Record your work using the **Rubber Band Vehicle Recording Sheet.**

1. Research rubber band boat designs.
2. Sketch your boat and rubber band mechanism.
3. Plan materials that you will be using.
4. Gather materials.
5. Build your boat while wearing safety gear as necessary.
6. Test your boat. Measure distance and time.
7. Improve your design and retest.

Remember: *Use the recording sheet!*

Budget Boat Challenge

Challenge: Build a boat that moves across water using only rubber band power—no pushing allowed! You must also stay within your material budget.

Steps: Record your work using the **Rubber Band Vehicle Recording Sheet.**

1. Research rubber band boat designs.
2. Sketch your boat and rubber band mechanism.
3. Plan materials using the price list and budget.
4. Gather materials and track costs.
5. Build your boat while wearing safety gear as necessary.
6. Test your boat. Measure distance and time.
7. Improve your design and retest.

Remember: *Use the recording sheet and don't go over budget!*

Rubber Band Powered Car

Challenge: Build a car that moves using only rubber band power—no pushing allowed!

Steps: Record your work using the **Rubber Band Vehicle Recording Sheet.**

1. Research rubber band boat designs.
2. Sketch your boat and rubber band mechanism.
3. Plan materials that you will be using.
4. Gather materials.
5. Build your boat while wearing safety gear as necessary.
6. Test your boat. Measure distance and time.
7. Improve your design and retest.

Remember: *Use the recording sheet!*

Budget Car Challenge

Challenge: Build a car that moves using only rubber band power—no pushing allowed! You must also stay within your material budget.

Steps: Record your work using the **Rubber Band Vehicle Recording Sheet.**

1. Research rubber band car designs.
2. Sketch your car and rubber band mechanism.
3. Plan materials that you will be using.
4. Gather materials and track costs.
5. Build your boat while wearing safety gear as necessary.
6. Test your car. Measure distance and time.
7. Improve your design and retest.

Remember: *Use the recording sheet and don't go over budget!*