RUBBERBAND POWERED CAR

Teacher Materials:

This program is focused on how energy can be stored in a rubberband chain and transformed into the energy of motion. With support, students can recognize variables that will affect either how much energy is stored in the rubber band or how much energy is lost to friction or non-forward motion.

Variables that students might notice and experiment with include:

- How straight the car's path is (how it is aimed, how the wheels are put on, how level the axles are)
- How much they wind up the back axle of the car
- How many rubber bands they use in a chain
- How many chains of two or three rubber bands they use
- The traction of the wheels – the effect of adding rubber bands to the outside of the wheel
- How much weight to add to the car

During the program, students will have the opportunity to make adjustments and test their ideas about what will make their car travel the farthest. Continuing to use and discuss the rubberband cars after the program provides opportunities for students to discuss and participate in systematic experimentation and to put their findings into words.

As a follow-up to the Rubberband Powered Car Program, you might:

- Have students share the variables that they think are important to the movement of the car and discuss why each one might matter (Student Sheet).
- Provide students with an opportunity to systematically test one variable that they are interested in (Student Investigation).
- Have students write a manual for building and using their car.

Rubberband Powered Car Student Investigation

We have designed the project below to provide an opportunity for students to develop inquiry thinking skills as they use their rubberband cars. In this investigation, students are asked to choose one variable to change and figure out how to vary it systematically to find out whether it matters for how far the car travels. We have based our investigation on the Curriculum-Embedded Performance Task model. Students have an opportunity to apply their understanding of energy and motion, test their ideas, and communicate their findings.

As with other investigation experiences, we expect that students will need support to structure their exploration, investigation, and writing. We encourage you to adapt the investigation below to fit your classroom routines and students' needs.

1. As a class, discuss the variables that students think might make a difference in how much energy you can store in a rubberband car or how efficiently you can transform the energy into motion.
   - Ask students to share what they found changed how far their cars traveled. You can model thinking about why these variables might make a difference and whether they affect how much energy is stored in the rubberbands or how the energy is transformed into motion.
   - You might have students complete the Student Sheet at this point.

2. Have students choose one variable that they are interested in exploring.
   - Students will most likely be convinced that one variable is the most important in how far the car goes; encourage them to focus on testing whether this one variable makes a difference.
   - Depending on the needs of your students, do a quick check to make sure that all students have chosen variables that they can change systematically (for example, it is easy to count the number of times that the back axle is turned to wrap the rubberband but much harder to measure whether the wheels are straight or crooked)
   - Have students predict how their variable will make a difference and why.

3. Have students plan their investigations and record a procedure. Depending on your focus and the needs of your students, this is an excellent opportunity to discuss and have students consider the following questions:
   - How much should you vary each variable; for example, when testing winding the rubber band is it better to try 1, 2, 3, 4, and 5 winds, 5, 10, 15, 20, and 25 winds, or 1, 2, 5, 10, and 20 winds?
   - Is it important to include more than one trial for each variable level (ie each number of winds or length of the rubber-band chain)? How many trials should be included?
   - How can variables not being tested be kept constant? Why is this important?

4. Provide students support in creating a data table that will help them record their data.
   - This sample table includes a column to describe the variable changed, columns for multiple trials, and a column for an average. Depending on the level of your students, you could simplify the table to include just one trial, in which case no average is needed.
   - Note that some variables will require fewer rows: testing rubberbands on the wheels might require just a test of no rubberbands vs. with rubberbands.

Variable:	**Distance Trial 1**	**Distance Trial 2**	**Distance Trial 3**	**Average I Will Use**
1 wind				
2 winds				
5 winds				
10 winds				
15 winds				

5. Have students carry out the investigations

   - Set up a 'track' for students to measure on. Mark distances of one foot if possible, or increments of five feet.
   - Check to make sure that students are measuring properly. You may need a class consensus on whether to record the farthest distance the car traveled or where it stopped (as the cars often move a foot or so backward at the end).
   - Make sure that students are keeping all variables constant except the variable being tested.
   - Note that students testing the number of rubber-bands in their chain may discover that they need to vary the number of winds as well – longer chains can be wound more times before they are completely tight. Students will need to find a way to determine a "tight" mark or feel.
   - You might encourage students to add other variable levels (ie number of winds around the axle or amount of weight added) after they finish their first five to see if the pattern they notice holds true.

6.Have students decide how to present their results.

- This is an excellent opportunity to use graphing to show results.
- If students have conducted more than one trial for each variable level, they will need to choose a way to average the results; calculating the mean distance and using the middle distance are two appropriate methods.
- You might want students to make posters or presentations to the class to share their findings.

7. Discuss why each variable made a difference or not, as well as whether there is an optimal level with best performance.

- Compare the shapes of students' graphs. It is interesting to note that with some variables, like the number of winds of the rubber-band, the car will continue to travel farther until the rubber-band breaks. Some variables, like the number of rubberbands in the chain, will make a difference at first but have a "best" level, after which more rubberbands won't improve the distance of the car and may decrease it as they start to drag on the ground.

Opportunity for Additional Challenge

Your students will notice that many cars move forward, then backward by a foot or so, then stop. Some students may be able to analyze the reasons for this backward motion and figure out how to solve it.

- Encourage these students to look closely at the motion of the car. (It may help to hold it upside down, wind it, and observe the wheels.
- Have students try to explain why the backwards motion occurs. (When the rubberband reaches its full length, the motion of the wheels wraps it around the axle in the forward direction, storing energy in the rubberband which then pulls the car backward.)
- Have students try out ways to solve the problem. (One easy solution is to not tie the rubberband chain to the back axle, instead wrapping it around. This way, the rubberband is pulled off the axle at the end, causing the car to continue to move forward until it is slowed by friction.)

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