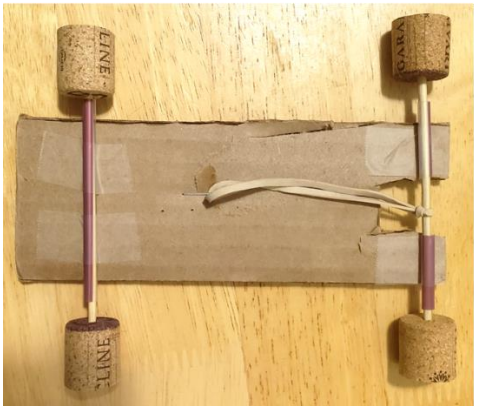
Did you know that when you stretch a rubber band, you are turning your *physical energy* into *elastic potential energy*? The stored energy of a stretched rubber band can be turned into *mechanical energy* used to fuel a model car. This handout will provide you with instructions on how to make your very own rubber band car and challenge you to innovate your design for speed or distance!

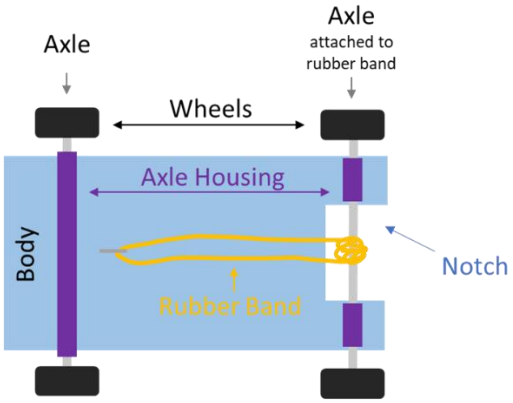
Objectives

- Build a rubber band car, using a rubber band as the energy source.
- Learn more about the engineering that impacts a car's performance – either speed or distance.
- Understand the innovation cycle – design, prototype, test, and iterate

What is a rubber band car?

A rubber band car is a model car that uses the energy in a wound-up rubber band to drive it forward. There are many ways to design a rubber band car, but they are usually made of a body and two pairs of wheels connected by an axle. One axle will be connected to a rubber band, and the other connected to the body.





Materials

You can use lots of different materials to get the job done! Try looking in your recycling to make an environmentally friendly car. Here are some ideas for car parts:

- Wheels: bottle tops, cardboard circles, CDs (ask your parents what they are)
- Axles: straws, pencils, dowels, chopsticks
- Car Body: plastic bottle (recycled, of course!), cardboard, popsicle sticks glued together
- Adhesive: glue, tape, yarn

Today we will be using the following:

- Wheels: Corks cut in half

- Axels: wooden skewers
- Axle housing: paper or plastic straw
- Car Body: Cardboard
- Adhesive: tape, glue, stapler

Building the car

Before you start building, it is important to develop a ***design*** for your car. Draw out how you will assemble the pieces, and what their relative sizes are. Make note of what materials you have and what you might need to get or change. For your first car, check out the photos above. After you have built this model, change it up by trying different sizes and materials!

Once you have a sketch in hand, now's the time to start building!

1) Check sizes: the axles should fit through the axle housing and be able to rotate. The axle should be long enough to cross the width of the car and secure into wheels without too much wiggle room.
2) Create the body – use sturdy cardboard to make a rectangle. Cut a notch on one short end (see photo above).
3) Make axles: using wooden or bamboo skewers, trim them so they will span the width of the car.
4) Make wheels: cut corks in half. Poke the wheels in the center with the sharp end of the bamboo skewer to make a hole that will allow you to connect the wheels to the axles. Do not glue them together yet!
5) Make axle housing: cut straws to the appropriate size:
    a. One straw will span the entire width of the model.
    b. Two shorter straws will cover each side of the notch.
6) Secure the axle housing: tape or glue the straws to the cardboard.
7) Attach one wheel to the axle –press firmly to attach the cork to the skewer, then seal with glue.
8) Place the wheel + axle through the axle housing.
9) Attach the second wheel – use the hole you created in step 4, attach the wheel and seal with glue.
10) Attach the rubber band – in the area of the notch where the bare axle is exposed, wrapping a loop of the rubber band over the skewer, then feed the rubber band through the loop created. Sounds weird, but watch this short video to see it in action: https://youtu.be/EbYuhdwknbs
Hint: this is also a way to string smaller rubber bands together!
11) Anchor the rubber band – pull it so it is attached to the body of the car, and secure with a staple.

12) Pull the car backwards – as you do so, the rubber band should wrap itself around the axle. This is converting the energy of motion from you into the potential kinetic energy of the rubber band.
13) Release the car and watch it move forward!

Innovation – From Troubleshooting to Optimizing

You've just built a **prototype**, which is an early version of your car. Prototypes help engineers understand the strengths and weaknesses of a build, and allow you to identify ways that you could improve your design. Oftentimes, our first draft doesn't work quite right. For some common problems, see the list below. Tweaking a design to make it work is a classic step in the engineering cycle. If you have a particular goal in mind – like making the car go *faster* or go a *further distance* – then you can further optimize your design to reach your goal. All you need to do is come up with ideas to make your prototype perform better, revise your design, and then run your next experiment! Remember to only change one thing at a time, or you won't know which idea was the most effective.

Common Problems and Potential Solutions

Problem: My car winds up, but when I let it go it just spins in place! Potential Solution: Add weight to the vehicle – sometimes we need more downward force to allow the wheels to grip and move forward. Potential Solution: Add rubber bands to the outside of the wheels – this creates more traction for the wheels and may help propel the vehicle forward.

Problem: My rubber band gets caught in the notch! Potential Solution: use a thinner rubber band, so the bulk is smaller. Potential Solution: Make the notch deeper to accommodate the rubber band and allow free rotation.

Research Questions

1. What effect does wheel size have on speed? On distance travelled?
2. What effect does wheel size placement have on your car's performance? For example, does having larger wheels in the back with smaller wheels in front make the car faster?
3. How much weight can your car carry?

Terms and Concepts to Start Background Research

- **Potential energy** – Energy stored in an object at rest.
- **Kinetic energy** – Energy of an object in motion
- **Conservation of energy** – Energy can not be created or destroyed – it just changes form!
- **A Simple Machine** – A mechanical device that can change the direction or amount of force. A wheel and axle is an example of a simple machine.

Rubber bands around wheels to increase friction

Added weight to increase down-force. Despite the fact that batteries help the car perform, it is not battery powered!

Bibliography

1. PBS Rubber Band Car: https://pbskids.org/designsquad/parentseducators/resources/rubber_band_car.html
2. Scientific American Rubber Band Car: https://www.scientificamerican.com/article/build-a-rubber-band-powered-car
3. Kinetic and Potential Energy: https://www.nasa.gov/sites/default/files/atoms/files/stemonstrations_kinetic-potential-energy.pdf

Saturday Academy, October 2020