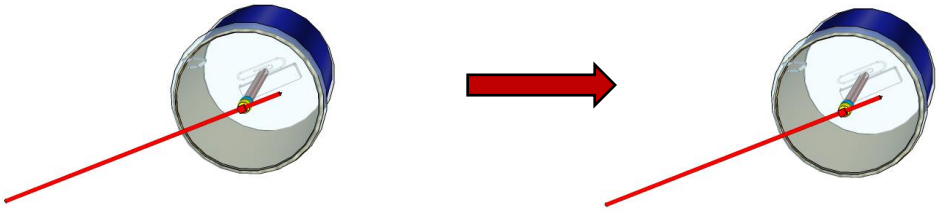
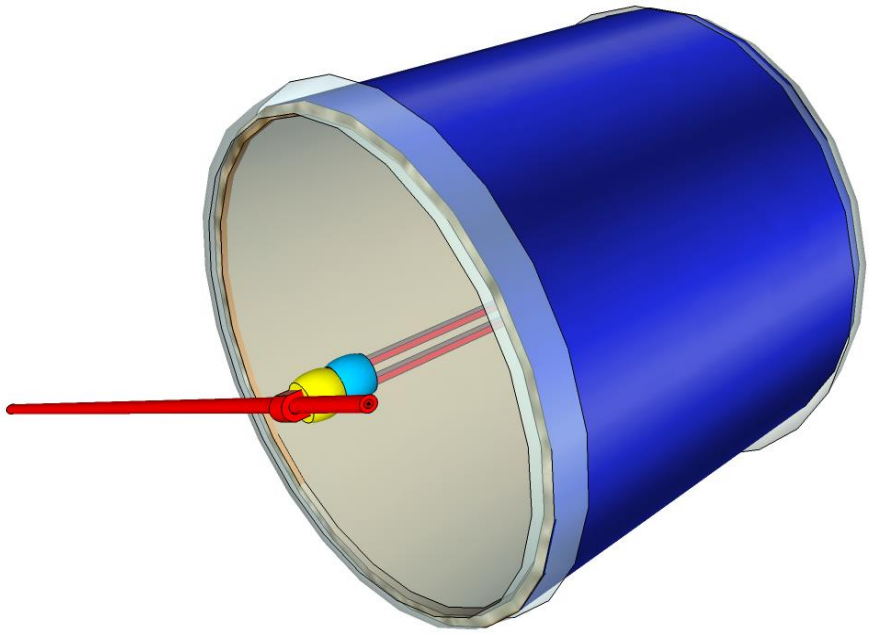
ROLLER RACER

Exploring energy conversion with a twist!



Enjoy the hands-on experience of building and using the Roller Racer, a modern variation of an old favorite. Explore the application of simple machines and energy conversion and investigate how changes in the amount of stored energy can affect the distance in which this device can roll!



Curriculum topics

- Air Pressure
- Friction
- Motion
- Inertia
- Engineering/Design

Subjects

- Engineering
- Physical Science

Grade range: 3 – 8

Who we are: Resource Area for Teaching (RAFT) helps transform the learning experience by inspiring joy through hands-on learning.

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Materials

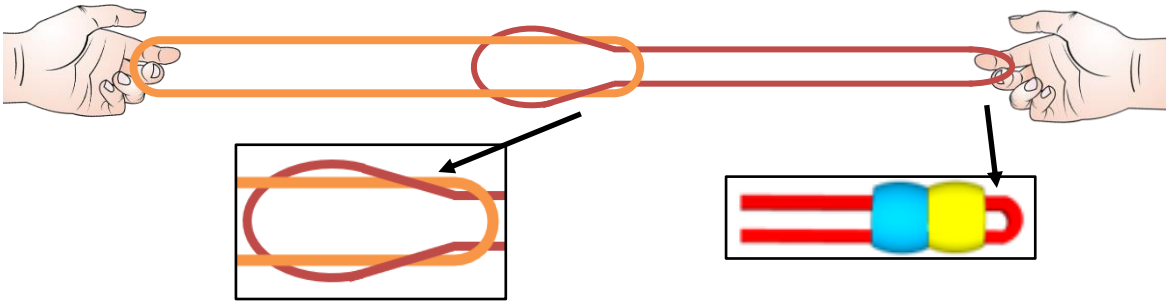
Materials in the kit may vary but generally, this kit contains the following:

- Plastic lids, circular, 3-5” diameter (2)
- Corrugated cardboard sheet, flutes parallel to short dimension (1)
- Rubber bands, non-latex (2)
- Pony beads, regular (2)
- Thin straw or coffee stirrer, 7” (1)
- Adhesive foam block (1)
- Paper clips (2)

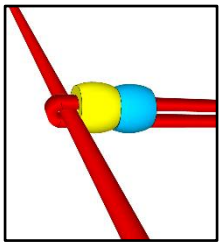
WARNING: Rubber bands contain natural rubber latex which can cause allergic reactions.

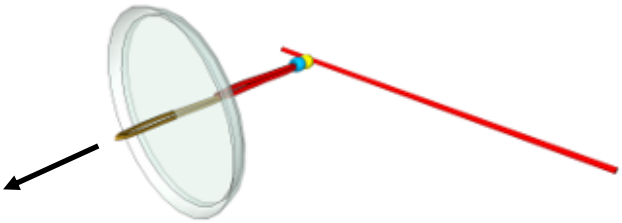
To Do and Notice

1 **Assembly:** Interlock the two **non-latex** rubber bands as shown below. Insert the end of one rubber band through both pony beads until a small rubber loop sticks out (below, right).



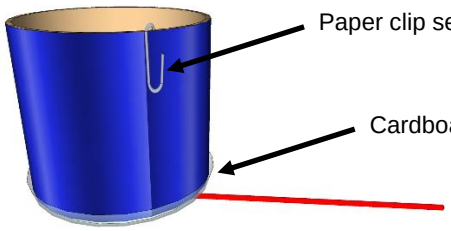
2 Insert the thin straw through the small loop in the rubber band (see below, left). Slide the beads towards the straw and pull on the rubber band to sinch the straw in place.



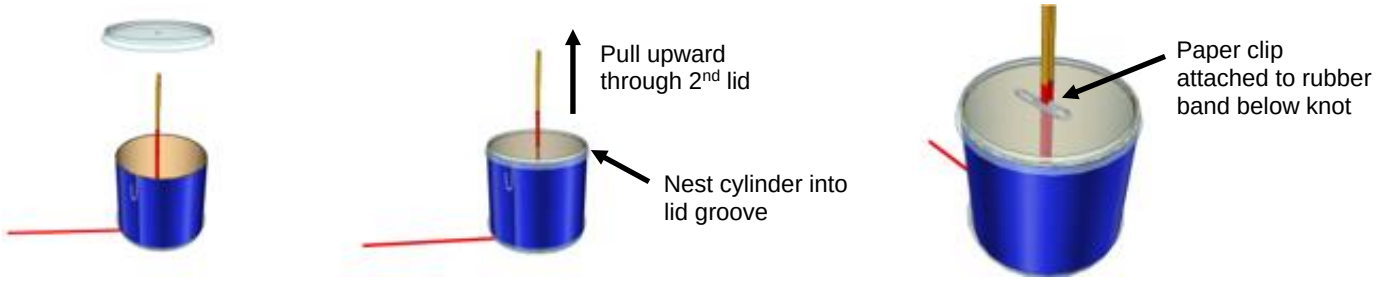


3 Insert the free end of the rubber bands into the center hole of a lid starting from the top side of the lid (open groove is on the other side) (see above, right). Pull the rubber band through until the beads are snug against the lid.

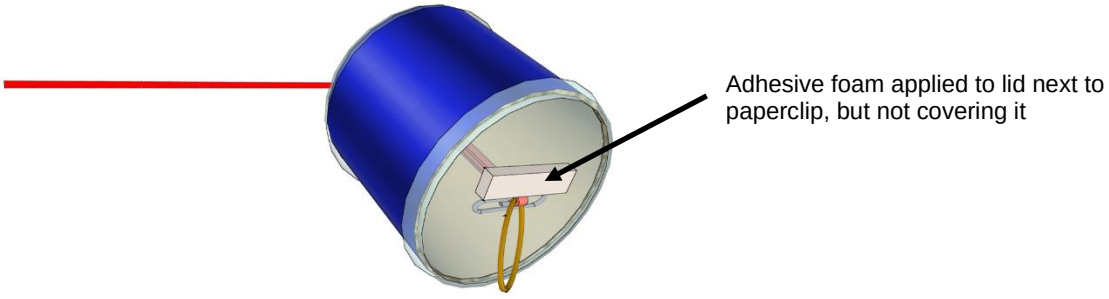
4 Place the lid on a flat surface with groove facing upward. Insert the long edge of the corrugated cardboard sheet into the groove of the lid, forming a cylinder. Overlap the ends and secure with a paperclip (see below).



5 Pull the end of the rubber band up and out of the cardboard cylinder (see below, left). Insert the rubber band through the second lid with groove side facing downward. Fit the cylinder into the lid groove (below, middle). Hold the lid in place while pulling the rubber band up until the knot between the rubber bands comes through the lid. Attach a paperclip to the rubber band below the knot (below, right).



6 Remove the release paper from the piece of adhesive foam. Adhere the foam on the lid next to and against the paperclip. The foam prevents the paperclip from rotating.



7 **Investigate potential (stored) energy:** (STUDENT PROCEDURE, PART 1) Lay the Roller Racer on a flat surface with foam side facing downward and straw on top. Rotate (twist) the straw around the pivot point a set number of times (for example, 10 to 20 times). This winds the rubber band. Release the straw and measure and record the time in seconds for the straw to stop moving (come to rest). Repeat this multiple times for the same number of twists to confirm results. Is the measured time consistent for each number of twists? (STUDENT PROCEDURE, PART 2) Increase the number of twists in the rubber band beyond the number previously tested and repeat the investigation across multiple trials. **How is the number of twists related to the amount of time for the straw to stop? What does that tell you about the amount of potential energy stored in the rubber band?**

8 **Investigate energy conversion(potential energy to kinetic energy):** (TEACHER NOTE) Set up a "rolling alley" about 3' x 10' on a flat surface. Mark a start and finish line with tape or another visible marker at the ends of the rolling alley. Students line up behind the starting line, wind up their devices, set them on the ground sideways at start line, and release the Roller Racers. They may need 1-2 practice rolls. (STUDENT PROCEDURE) Use your time measurement data from before to estimate how many twists might be needed to roll your cylindrical racer from start to finish line. Keep trying until you succeed! **What happens to the potential energy in the rubber band? How does this relate to the Roller Racer's motion? What is the evidence supporting your claim(s)?**

9 **Investigate lever arm effects:** (TEACHER NOTE) Discuss the straw as a type of lever arm that can push on the ground opposite the direction of twist. Demonstrate how to adjust the straw length by changing its position in the rubber band. (STUDENT PROCEDURE) Adjust the straw as shown by your teacher. Repeat step 8 above when the straw's end is near the beads and again when it's centered over the lid, noting any differences in performance. **How does the straw/lever affect the motion of the Roller Racer?**

10 **Share** student learning with RAFT! Submit photos/video via email at education@raft.net or on social media (Facebook, Twitter, Instagram).

Core Content Skills:

Science & Engineering (NGSS)

Developing and Using Models, Planning and Conducting Investigations, Generating and Comparing Design Solutions, Properties of Matter, Forces and Motion, Definitions of Energy, Conservation of Energy, Types of Interactions, Cause and Effect, Systems

Social Emotional Learning

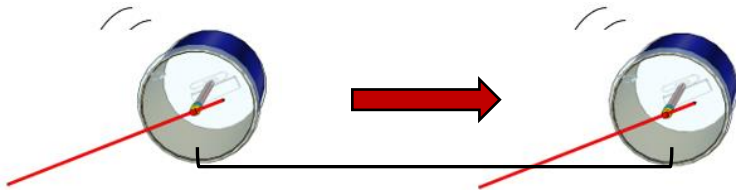
- Self-awareness
- Self-management
- Responsible decision-making

The Content Behind the Activity

Turning the straw, which acts as a **lever**, winds up the rubber band and stores elastic potential energy. This energy is the result of the mechanical work done by a moving finger as it applies a force over a certain distance. When the rubber band is allowed to unwind, the **potential energy** (stored energy) is converted into **kinetic energy** (energy of motion), and a small amount of heat that is generated by friction. The more twists in the rubber band, the more potential energy is stored, resulting in more kinetic energy being available to move the Roller Racer through a greater distance.

If distance and time data are measured, these data can be graphed to reveal patterns in relation to the number of twists in the rubber band. For example, a simple graph can be made with the number of twists along the x-axis (independent variable) and the distance traveled along the y-axis (dependent variable). Similarly, one can graph the time of each traveled distance vs the number of twists. In addition to this graphical analysis, it is possible to calculate the average speed of the Roller Racer by taking the average distance traveled and dividing that value by the average time measured for each number of twists in the rubber band (see Resources below).

Roller Racer travels a distance **D** in a certain amount of time **t** for **X** number of twists



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Reuse

This kit uses 100% reusable materials designed for other uses. To continue making a positive impact in reducing waste, reuse these materials in other projects. Additionally, any unused materials can be collected and delivered back to RAFT.

Feedback

Please comment on this kit by taking this short survey: http://bit.ly/RAFTkitsurvey. Let us know of any material concerns (missing, broken, or poorly fitting parts) as well as any suggestions for improvement.

Visit https://raft.net to view related activities!

Car on a Roll
Racing Cups
Rollback Can
Retractor Car

Resources

- Difference between potential and kinetic energy – https://bit.ly/3Cm7kfo
- Relations between speed, distance, & time - https://bit.ly/30tX8o9