Curriculum topics:

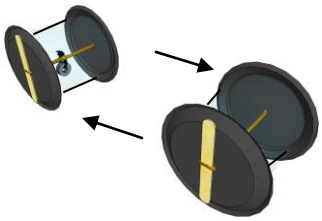
- Potential Energy
- Kinetic Energy
- Energy Conversion
- Motion

Subject:
Physical Science

Grade range: 2 – 12

ROLLBACK CAN

A clever way to demonstrate the transfer between potential energy and kinetic energy



A rolling can returns to its starting point on its own!? The Rollback Can provides an interesting example of energy transfer and storage.

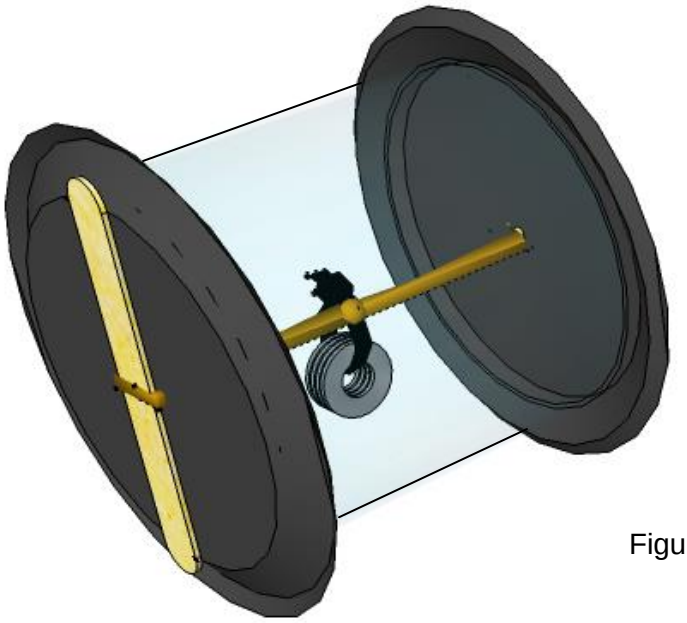


Figure 1

Teaching tip: Show learners the operations of the Rollback Can with a corrugated sheet wrapped around the clear cylinder hiding the inner workings **before** they make their own Rollback Cans. Discuss their observations and ask "What could be making the Rollback Can roll back?"

Who we are:

Resource Area for Teaching (RAFT) helps educators transform the learning experience through affordable "hands-on" activities that engage students and inspire the joy and discovery of learning.

For more ideas and to see RAFT Locations

www.raft.net/visit-raft-locations

Materials required

Per Rollback Can:

- 2 Plates, thin plastic (best) or paper, 17.5 cm (7”) diameter, which have a 5 mm (~1/4”) diameter center hole punched or poked
- One-sided corrugated sheet (best) or thin cardboard, 15 cm x 43 cm (6” x 17”)
- 2 Paperclips, jumbo
- 3 Rubber bands, number 64 (5 mm x 9 cm) ~ (1/4” x 3-1/2”)
- 4 flat metal washers with 1.5 cm (5/8”) inside diameter that **weigh** a total of about 60 grams (2 ounces)
- 2 Craft sticks, jumbo or regular (or jumbo paperclips)
- Releasable zip tie, chenille stem, or string about 10 cm (4”) long or longer

To make a demo version where the inner workings can be made visible:

- Clear, flexible plastic sheet 15 cm x 40 cm (6” x 16”)
- Adhesive tape (if the clear plastic sheet does not have an attached adhesive strip)

Rubber bands contain Natural Rubber Latex which may cause allergic reactions.

How to build it

These instructions are for the clear version of the Rollback Can.

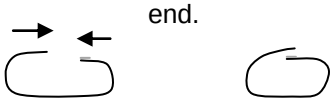
Tip for Student and Demo Versions: To make a student cardboard version, use a corrugated sheet instead of a clear sheet. Curl the single sided corrugated sheet into a cylinder (bumpy side out), overlapping the ends and then adding paperclips on either side of the overlap to keep the sheet from unrolling. To make a demo version, add a corrugated sheet **over** the clear sheet.

1 If a ~5 mm (¼”) hole is not already present in the center of each plate, poke, punch, or drill the hole.

2 If the plastic sheet has an attached adhesive strip, then peel off the “remove to expose adhesive” covering strip. Turn the sheet over so the adhesive is downward, hold the plastic sheet near the ends and bend the ends up and over so the adhesive is now upward as shown below. While still holding near the ends place the sheet on a flat surface, overlap the plain edge end over the adhesive covered end, and press down to secure the narrow ends of the plastic sheet together to form a cylinder, see below.

Exposed adhesive

Bend ends over each with the adhesive end under the other end.

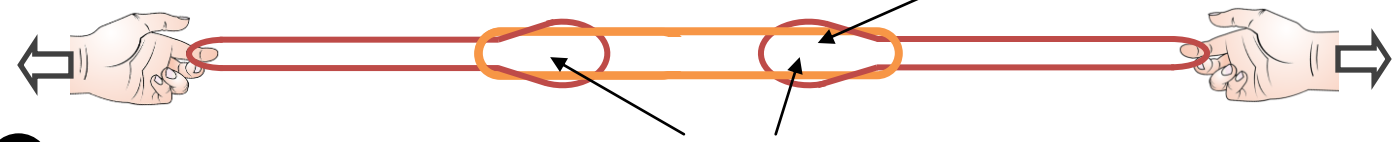


Align the top end edge over the adhesive and press down. If a dent is created, pop it out.

If the plastic sheet has no adhesive strip, then overlap the ends and tape together.

3 Interlock the 3 rubber bands as shown below. Knot the first two together, then add the third. Wait to pull the knots tight in Step 5.

Thin end of zip tie goes through knot in step 5



4 Insert the thin end of the zip tie into one of the 2 knots created.

5 Pull the ends of the 3 interlinked rubber bands in opposite directions to tighten the 2 knots. Slide the zip tie around until the thick part of the zip tie is right next to the rubber band, as shown in figure 2.

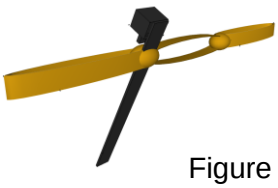


Figure 2

6 Insert the thin end of the zip tie into the center hole in 4 metal washers. Next insert the thin end of the zip tie into the appropriate slot in the thick end of the zip tie. Push and then pull the thin end through and out the slot until about 2 cm (1”) of the zip tie has been pulled through. This hangs the washers from the rubber bands on the zip tie. See figure 3.

Figure 3

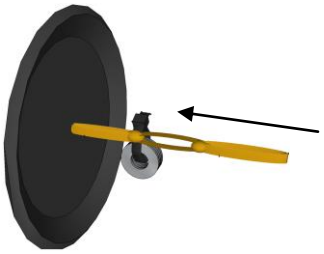


Figure 4

7 Push the loose end of the joined rubber bands that is closest to the zip tie through the hole in a plate, starting from the food side of the plate. See figure 4.

8 Pull the rubber band through the hole until there is a loop large enough to be able to insert a craft stick halfway through the loop. Pull the rest of the rubber band back through the hole to tighten the loop and pull the craft stick tightly against the bottom of the plate. See figure 5.

Figure 5

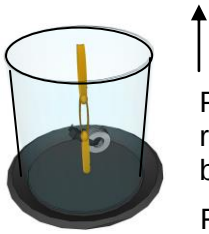


Figure 6

9 Place the plate down, craft stick side first, on a flat surface. Place the cylinder onto the food side of the plate, with the washers and rubber bands inside the cylinder. Reach into the cylinder and grab the loose end of the rubber bands. Pull the end up high enough to insert into the hole in the second plate, starting from the food side of the plate. See figure 6.

10 Place the second plate over the plastic cylinder as shown in figure 7. Hold the second plate food side downward and pull the loose end of the rubber bands upward tightly enough to pull the end of the middle rubber band through the hole.

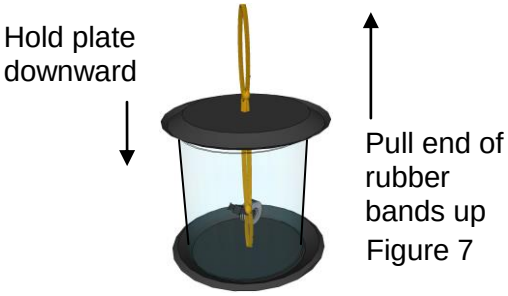


Figure 7

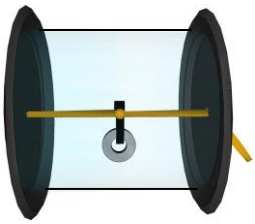


Figure 8

11 Pull the middle rubber band through the hole until the second craft stick can be inserted into the middle rubber band. This secures the end of the rubber band on the outside of the plate. Check to make sure the craft stick is centered on the plate. Tuck the loose end of the third rubber band under one end of the craft stick.

12 Hold the Rollback Can horizontally so that the washers hang down at a right angle to the rubber bands. Check that the washers do not touch the cylinder. See figure 8.

Note: Over time or if stored in a warm environment, the rubber bands may stretch and prevent the Rollback Can from working. The rubber bands can be shortened or replaced, as needed.

13 If the washers are hanging too low, then remove the last inserted craft stick and move the plate aside until the zip tie can be reached. Tighten the zip tie a little to shorten the zip tie loop. Reassemble and check to see if the weight is hanging high enough, as far from the middle of the rubber band as possible without dragging on the plastic cylinder. If the end of the zip tie drags, check to make sure the zip tie is oriented correctly (see step 6), trim zip tie end if needed.

Curriculum Standards:

Forces & Motion (Next Generation Science Standards: Grade 3, Physical Science, 2-1 & 2-2; Middle School, Physical Science, 2-2; High School, Physical Science, 2-1)

Kinetic and Potential Energy (Next Generation Science Standards: Grade 4, Physical Science 3-1; Middle School, Physical Science, 3-2 & 3-5,)

Compare Multiple solutions (Next Generation Science Standards: Grades K-2, Engineering Design 1-3; Grades 3-5, Engineering Design 1-2; Middle School, Engineering Design, 1-2 & 1-4)

Science & Engineering Practices (Next Generation Science Standards: Grades 2-12)

Additional standards at: http://www.raft.net/raft-idea?isid=357

To do and notice

1 Place the Rollback Can on a smooth, level surface at least 3 m (~10 feet) long. A carpeted surface might work, but only if the carpet is tightly woven.

2 Give the Rollback Can a firm push in a direction that is clear of obstacles. Watch as the Rollback Can rolls away, slows down, stops, and then returns, stopping close to or even past the starting point!

3 If a dragging sound is heard, then repeat step 13 of **How to build it.**

4 If the Rollback Can rolls away and then a rapid rattling sound is heard, then the weights are too close to the rubber band. To prevent the weights from being lifted up and over the rubber band (unwinding the rubber band), follow the instructions in step 13 of **How to build it** but loosen the zip tie instead by pressing on the release lever and making the zip tie loop a little larger. Or, increase the weight.

Learn more

- The Rollback Can may be pre-wound by turning while holding or by shaking in a circular motion. The Rollback Can will then roll away when it is placed on a flat surface without needing to be pushed. The Rollback Can will seem to move unaided, if students do not know the rubber band has been pre-wound! A pre-wound Rollback Can may be able to roll up a slight incline.
- Using a clear tube for the Rollback Can to create an "x-ray" version allows seeing how the weight and rubber band interact when the can rolls along.
- Vary the weight hanging from the zip tie. Use more or fewer washers.
- Also try different thicknesses of rubber band while keeping the length of the rubber bands the same.
- Try 4 rubber bands instead of 2 in the middle. Or try 2 rubber bands on each side instead of just 1.

Related activities: See RAFT Idea Sheets:

Roller Racer -
http://www.raft.net/ideas/Roller Racer.pdf

Retractor a Go-Go Car -
http://www.raft.net/ideas/Retractor a Go-Go Car.pdf

Resources

Visit www.raft.net/raft-idea?isid=357 for "how-to" video demos & more ideas!

See these websites for more information on the following topics:

- **The science of elastic energy storage** – http://www.ftexploring.com/lifetech/flsbws2.html
- **How much energy can a stretched elastic band supply?** – http://www.practicalphysics.org/go/Experiment_475.html
- **Videos on Balanced and unbalanced forces from the Khan Academy:** https://www.khanacademy.org/science/physics/forces-newtons-laws/balanced-unbalanced-forces/v/balanced-and-unbalanced-forces

The science behind the activity

The Rollback Can is an example of energy being stored in one form and then transformed into another form. Much of the **kinetic energy** (moving energy) provided by pushing the Rollback Can is stored as **potential energy** in the stretched rubber band as the rubber band twists. Some of the kinetic energy from the push is lost to the friction between the plate edges and the surface below. Some energy is also lost to the friction of the Rollback Can moving through the air. Later, the potential energy is converted back into kinetic energy. Some of the potential energy is also lost to friction as the Rollback Can moves along a surface and through the air. The narrow edges of the plates minimize the rolling friction so that the Rollback Can will come back almost to (or even past) the starting point when rolled on a surface that is level.

The “secret” to the Rollback Can is in the weight that hangs from the rubber band. This weight is pulled down by gravity while also receiving an increasing turning force from the twisted rubber band as the Rollback Can rolls from being pushed. As long as the weight does not lift over and around the rubber band, the rubber band will become twisted tighter and tighter as the Rollback Can’s ends rotate. The twisting rubber band stores elastic potential energy. The force needed to further twist the rubber band increases as the rubber band’s twisting becomes tighter. At some point all the kinetic energy of motion has been changed into the potential energy stored in the tightly twisted rubber band and friction. When all the kinetic energy has been changed, the Rollback Can will stop moving forward. The twisted rubber band will then unwind. The rubber band applies a twisting (torsional) force to the ends of the can and the weight in the middle. Only the ends, and thus the Rollback Can, are free to rotate as long as the weight cannot be lifted over and round the rubber band. The potential energy in the twisted rubber band is released as the Rollback Can rotates in the opposite direction, moving back towards the starting point.

A weight with its center of gravity farther from the attachment point to the rubber band will require more energy to lift. A weight with more mass will also require more energy to lift. Both of these conditions can allow more energy to be stored in the rubber band. Changing these variables will alter the performance of the Rollback Can. For example, sometimes the rubber band can become so tightly wound that the weight is lifted up and then rotates around the rubber band in the opposite direction, unwinding the rubber band. Some of the stored elastic potential energy is then converted into the kinetic energy of the rotating weight. This reduces the total amount of stored energy available to rotate the Rollback Can. In this situation the Rollback Can will not return as closely to the starting point as when the weight stays below the twisting rubber band.

Over time, or in a warmer environment, a stretched rubber band can become weaker, allowing the weight to drop lower. A weight that is too low can drag on the inside of the rolling can, which will greatly increase the friction losses when the can is pushed. The losses can be enough to significantly reduce the distance the Rollback Can will travel back toward the starting point.