

ROVING ON THE MOON

LEADER NOTES

The Challenge

Build a rubber band-powered rover that can scramble across the room.

In this challenge, kids follow the engineering design process to: (1) design and build a rover out of cardboard; (2) figure out how to use rubber bands to spin the wheels; and (3) improve their design based on testing results.

1 Prepare ahead of time

- Read the challenge sheet and leader notes to become familiar with the activity.
- Gather the materials listed on the challenge sheet.
- Build a sample rover.

2 Introduce the challenge (5 minutes)

- **Tell kids some of the ways rovers will be used on the moon.**

NASA plans to land astronauts on the moon by the year 2020. The astronauts will need moon cars—called rovers—to drive across the moon’s surface, carry supplies, help build their outpost, and explore the area. Today you’ll build and test a rubber band-powered rover.

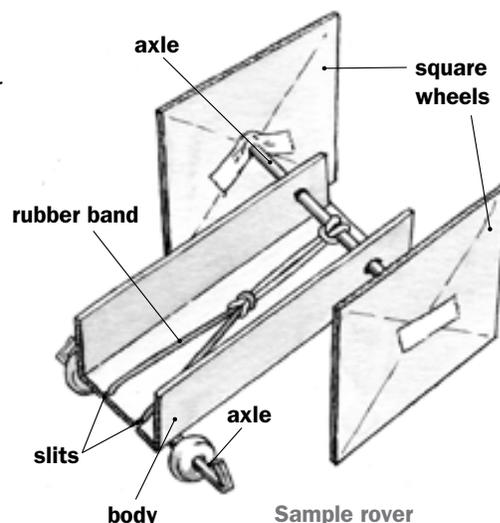
- **Show kids your sample rover. Tell them:**

This is a prototype of a rover, just like the one you are going to build. Prototypes are used all the time in engineering. They give you a basic design to build, test, and evaluate. Once you understand a design’s strengths and weaknesses, you can then find ways to improve it. Today, for example, as you test your rover prototype, you’ll find ways to make it work better. Improving a design based on testing is called the engineering design process.

3 Brainstorm and design (10 minutes)

Get kids thinking about the rover prototype. Ask:

- **What do we have to do to make the rover move?** (Turn the wheels to wind up the rubber band. Place the rover on the floor. Then let go. NOTE: Depending on the direction you wind the wheels, the rover can move either forward or backward.)
- **How can you make different kinds of wheels?** (Kids can make different-sized wheels by cutting larger or smaller squares or make different-shaped wheels by trimming the squares. NOTE: Square wheels offer two advantages: they’re quick to make, and it’s easy to find the exact center by drawing diagonal lines. The center is where the lines cross.)
- **How do you think square wheels affect how the rover moves across the floor?** (The points of the squares dig into soft surfaces, such as rugs, sand, or grass. This improves traction—the ability to grip a surface—and helps prevent the wheels from spinning out. Since the moon is covered in a thick layer of fine dust, good traction is essential, especially going up and down hills.)



- **What are different ways you can use rubber bands to power a rover?** (*Kids can change the number of rubber bands. Sometimes, a rubber-band chain works better than just one rubber band. Also, kids can cut open a rubber band and use the single strand of elastic.*)

4 **Build, test, evaluate, and redesign** (35 minutes)

Distribute the challenge sheet and have kids get started. Help them with any of the following issues. For example, if the rover:

- **wheels don't turn freely**—*Make sure they are firmly attached to the axles and are parallel to the sides. Also make sure the holes punched in the cardboard body are directly across from one another and are large enough to allow the pencil to turn easily.*
- **won't travel in a straight line**—*Make sure the axles are straight and the front wheels are the same size. If one wheel is smaller, the rover will turn in that direction.*
- **doesn't go far**—*Have kids wind up the wheels more. Also have them try using larger wheels. Bigger wheels have a larger perimeter (outer edge). As a result, one rotation of a large wheel will move the rover farther than one rotation of a small wheel.*
- **wheels spin out**—*Wheels spin in place when a rubber band delivers too much power at once or when there's not enough friction between the wheels and ground. To increase friction, have kids add weight over the drive wheels or add more wheels to each axle. To reduce how quickly a rubber band releases its power, kids can reduce tension by using a rubber-band chain or by cutting open a rubber band and using only a single strand of elastic.*

5 **Discuss what happened** (10 minutes)

Have the kids show each other their rovers and talk about how they solved any problems that came up. Emphasize the key ideas in today's challenge by asking:

- **What kinds of Earth vehicles are similar to rovers?** (*Snowmobiles, tanks, dune buggies, and all-terrain vehicles are similar. They all have good traction, are very stable, have powerful engines, and don't require a roadway.*)
- **The challenge sheet gave you a rover prototype to get started with. How did starting with a prototype help you end up with a rover that worked really well?** (*With a prototype, kids can quickly see what's working and what isn't. They then know where to make improvements.*)
- **How did friction affect your rover?** (*To be efficient, there needs to be minimal friction between the axle and the axle hole in the cardboard. To move, there needs to be lots of friction between the wheels and the ground.*)
- **How did the rover use potential and kinetic energy?** (*Potential energy is energy that is stored. Kinetic energy is the energy of motion. Winding the front wheels increased the amount of potential energy stored by the rubber band. When the wheels spin, this potential energy is turned into kinetic energy, and the axle and wheels turn.*)
- **How does the story about rover wheels on the back of the handout make you think about what it takes to design a wheel that can work on the moon?** (*Kids see that engineers face special design challenges when developing equipment to be used in space.*)

EXTEND THE CHALLENGE

- **Graph how increased potential energy affects distance traveled.** Kids can measure how far a rover travels as its rubber band is increasingly tightened. Have them turn the wheels 3, 6, 9, and 12 times and then measure the distance the rover travels each time. On a graph, have them plot the number of wheel rotations vs. the distance traveled. (*Winding the wheels more increases the potential energy, which should increase the distance.*)
- **Determine the effect of friction.** Have kids wind up the wheels a set number of times and measure the distance their rover travels. Then have them minimize friction in the wheel-axle system. For example, they can line the axle holes with a material such as aluminum foil, then wind up the wheels the same number of times and retest their rovers. Use the following formula to calculate the percent increase in distance traveled.

$$\text{Percent Increase} = \frac{(\text{Distance modified rover traveled}) - (\text{Distance basic rover traveled})}{\text{Distance basic rover traveled}} \times 100$$

- **Test the effect of wheel shape.** Starting with square wheels, have kids measure how far their rovers travel. Then have them snip off the corners of their wheels and test again. Make sure they wind up the wheels the same number of turns. How did the distance change? Did the wheels spin out? Test square, octagonal, and round wheels.

CURRICULUM CONNECTIONS

Roving on the Moon ties to the following concepts commonly covered in science, math, and technology curricula. For a list of education standards supported by the activity, see pages 39 and 40.

- **Friction**—To move, rovers need friction between the wheels and ground. To be efficient, rovers need minimal friction between the axle and rover body.
- **Newton's 2nd Law (Force = Mass x Acceleration)**—The more force the rubber band applies to the wheels and the less mass there is to move, the faster the rover will accelerate.
- **Potential and kinetic energy**—When kids wind up a rover's wheels, the rubber band stores energy as potential energy. As the wheels spin, the potential energy is changed to motion (kinetic) energy.
- **Measurement**—Kids measure how far their rovers traveled.

ROVING ON THE MOON



Can you imagine driving an all-terrain vehicle (ATV) on the moon? NASA can. It's building a fleet of ATVs (called rovers). Some can be driven by astronauts. Others are remote-controlled. All of them can handle the moon's dusty, rugged terrain. Talk about off-road adventure!

WE CHALLENGE YOU TO...

...design and build a rubber band-powered rover that can scramble across the floor.

BUILD

- 1. First, you have to make the body.** Fold the cardboard into thirds. Each part will be about 2 inches (5 cm) across. Fold along (not across) the corrugation (the tubes inside a piece of cardboard).
- 2. Then, make the front wheels.** On the two 5-inch (13-cm) cardboard squares, draw diagonal lines from corner to corner. Poke a small hole in the center (that's where the lines cross). On the body, poke one hole close to the end of each side for the axle. Make sure the holes are directly across from each other and are big enough for the pencil to spin freely.
- 3. Now attach the front wheels.** Slide the pencil through the body's axle holes. Push a wheel onto each end. Secure with tape.
- 4. Next, make the rear wheels.** Tape the straw under the back end of the rover. Slip a candy onto each end. Bend and tape the axle to stop the candies from coming off.
- 5. Finally, attach the rubber band.** Loop one end around the pencil. Cut small slits into the back end of the body. Slide the free end of the rubber bands into the slits.

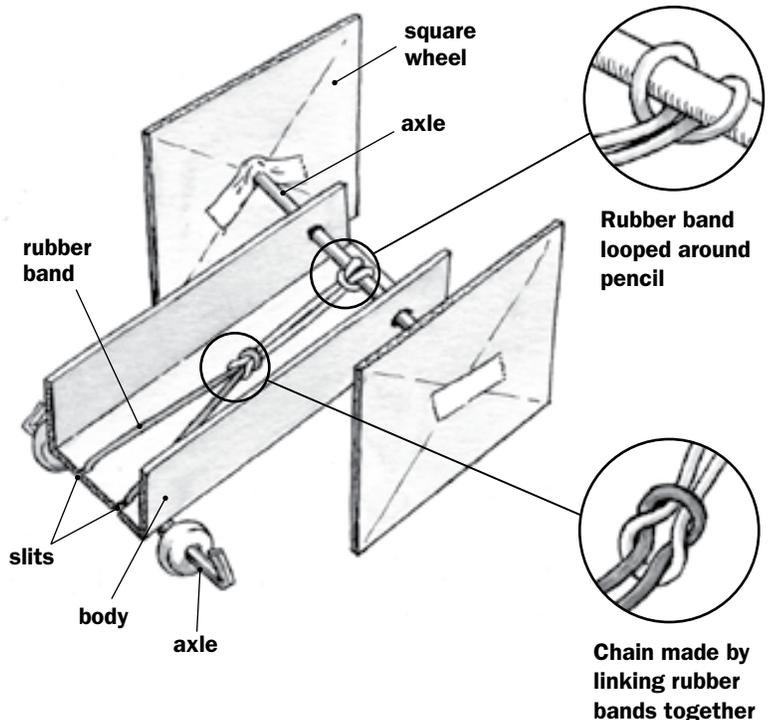
MATERIALS (per rover)

- corrugated cardboard body (6-inch/15-cm square)
- 2 corrugated cardboard wheels (5-inch/13-cm square)
- 1 sharpened round pencil
- 2 rubber bands
- ruler
- tape
- 2 round candies (the hard, white, mint ones with a hole in the middle)
- 1 plastic drinking straw
- scissors

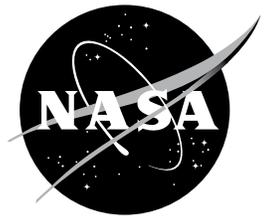
TEST, EVALUATE, AND REDESIGN

Test your rover. Wind up the wheels, set the rover down, and let it go. Did everything work? Can you make your rover go farther? Engineers improve their designs by testing them. This is called the design process. Try redesigning the wheel setup or rubber band system. For example, if:

- **the wheels don't turn freely**—
Check that the pencil turns freely in the holes. Also, make sure the wheels are firmly attached and are parallel to the sides.



- **the rover doesn't go far**—Wind up the wheels more. Try wheels of different sizes or shapes. Or, add another rubber band or use a rubber-band chain.
- **the wheels spin out**—Add weight above the square wheels; put more wheels on the pencil; use bigger wheels; or cut open a rubber band and use only a single strand of elastic.
- **the rover won't travel in a straight line**—Check that the pencil is straight and the front wheels are the same size.

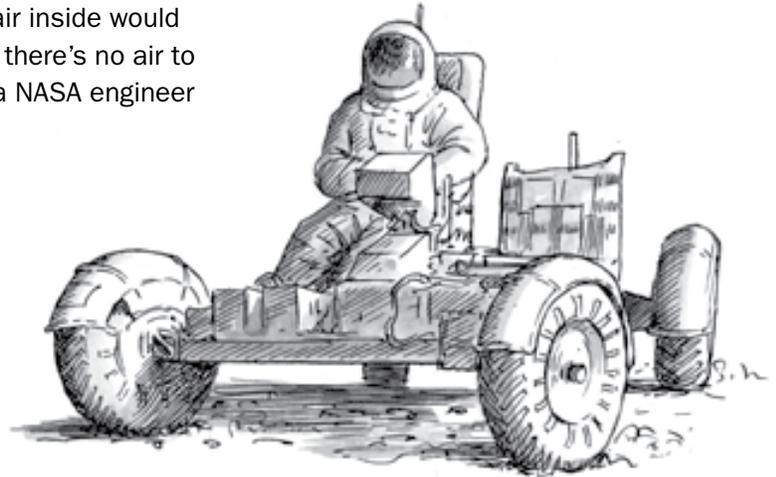


Check out NASA's moon missions at moon.msfc.nasa.gov.

CUSTOM WHEELS

The moon doesn't have an atmosphere—there's no air there! So air-filled tires like the ones on a bike or car would explode—the air inside would push through the tire to escape into outer space (where there's no air to push back against the walls of the tire). Imagine you're a NASA engineer who has to design a tire that:

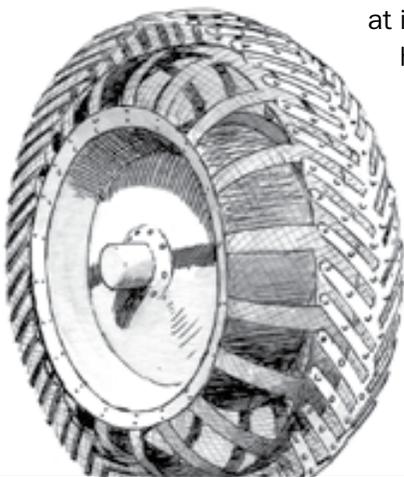
- works in space, where there's no atmosphere
- withstands extreme hot and cold temperatures—on the moon, they range from roughly 250° to -250° Fahrenheit (121° to -157° Celsius)
- weighs 12 pounds (5.5 kg), which is half the weight of an average car tire
- won't get clogged with the fine dust that covers the moon



Despite these challenges, engineers designed a tire that worked perfectly when it was used on the moon. It's made of thin bands of springy metal. That helps it be lightweight, have good traction, and work at any temperature the moon can throw

at it. Plus, it flexes when it hits a rock, and it doesn't need to be pumped up.

Dependability is important. There's no roadside service when you're on the moon, 250,000 miles (400,000 km) from home.



RIDE IN "STYLE"?

A rover may not be the hottest-looking vehicle around, but with a price tag of over ten million dollars, it's one of the most expensive. And it sure is convenient to bring along. Rovers can be folded and stored in a landing module the size of a small room. Look at the picture of the rover. Which features are also found on cars designed for use on Earth?

Answers: Chassis, wheels, fenders, motor, seats, seat belts, antenna, battery, camera (some cars), and steering controls.

The farthest trip anyone has ever taken on the moon with a rover is 2.8 miles (4.5 km).

Watch **DESIGN SQUAD** on PBS or online at pbs.org/designsquad.



Major funding for *Design Squad* provided by



Additional funding for *Design Squad* provided by



Design Squad is produced by WGBH Boston. *Design Squad*, AS BUILT ON TV, and associated logos are trademarks of WGBH. All rights reserved. This NASA/*Design Squad* challenge was produced through the support of the National Aeronautics and Space Administration (NASA).



For more information about NASA missions and educational programs, visit nasa.gov.