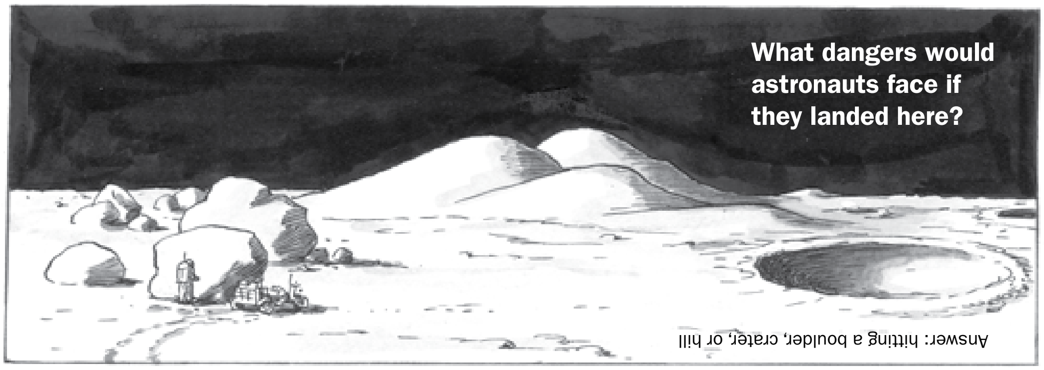
A NASA/DESIGN SQUAD CHALLENGE

TOUCHDOWN

Landing on the moon is tricky. First, since a spacecraft can go as fast as 18,000 miles per hour (29,000 km/hour) on its way to the moon, it needs to slow way down. Then it needs to land gently. That lander has astronauts inside, not crash-test dummies. Easy does it!



WE CHALLENGE YOU TO...

...design and build a shock-absorbing system that will protect two "astronauts" when they land.

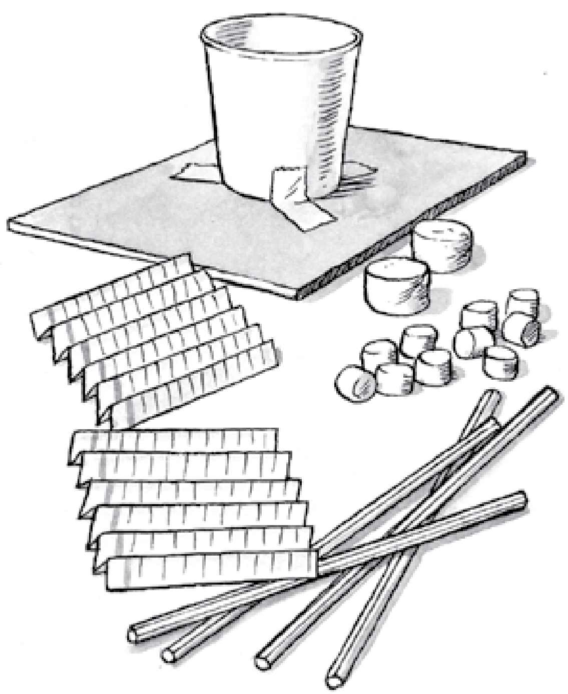
BRAINSTORM AND DESIGN

Think about how to build a spacecraft that can absorb the shock of a landing.

- What kind of shock absorber can you make from these materials that can help soften a landing?
- How will you make sure the lander doesn't tip over as it falls through the air?

BUILD

1. **First, design a shock-absorbing system.** Think springs and cushions.
2. **Then, put your spacecraft together.** Attach the shock absorbers to the cardboard platform.
3. **Finally, add a cabin for the astronauts.** Tape the cup to the platform. Put two astronauts (the large marshmallows) in it. (NOTE: The cup has to stay open—no lids!)



A lander under construction

MATERIALS (per lander)

- 1 piece of stiff paper or cardboard (approximately 4 x 5 in/10 x 13 cm)
- 1 small paper or plastic cup
- 3 index cards (3 x 5 in/8 x 13 cm)
- 2 regular marshmallows
- 10 miniature marshmallows
- 3 rubber bands
- 8 plastic straws
- scissors
- tape

as built on TV

TEST, EVALUATE, AND REDESIGN

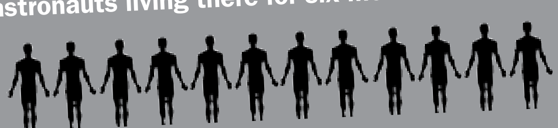
Ready to test? Drop your lander from a height of one foot (30 cm). If the "astronauts" bounce out, figure out ways to improve your design. Study any problems and redesign. For example, if your spacecraft:

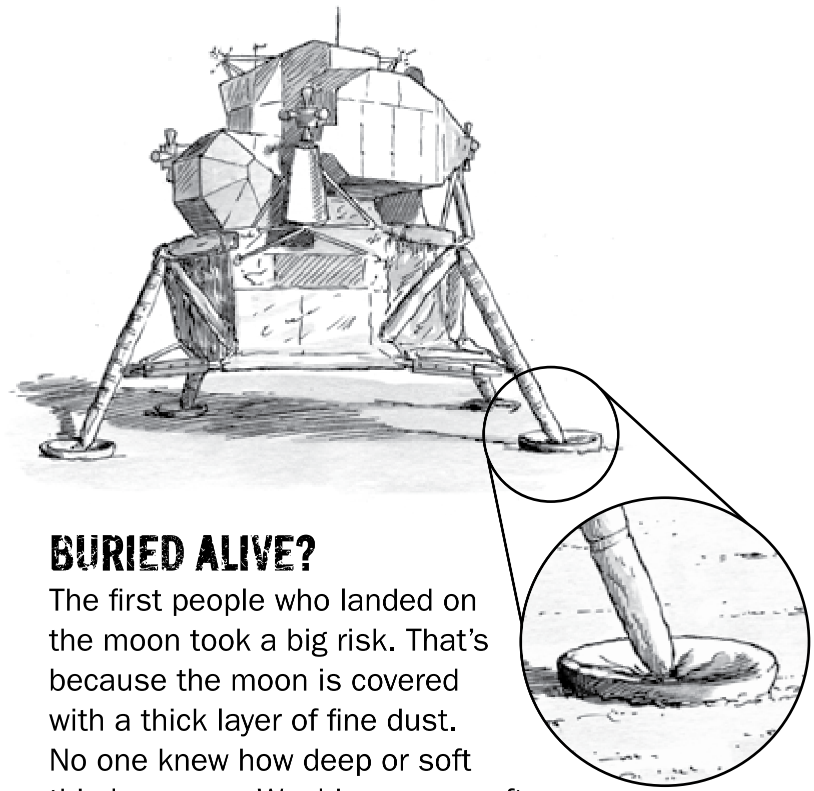
- **tips over as it falls through the air**—Make sure it's level when you release it. Also check that the cup is centered on the cardboard. Finally, check that the weight is evenly distributed.
- **bounces the astronauts out of the cup**—Add soft pads or change the number or position of the shock absorbers. Also, make the springs less springy so they don't bounce the astronauts out.

THE COOLEST JOB AT NASA

When people asked Cathy Peddie what she wanted to do when she grew up, she would point at the sky and say, "I want to work up there!" Now an engineer at NASA, she manages the Lunar Reconnaissance Orbiter (LRO) project. She calls it "the coolest job at NASA." LRO will orbit the moon for at least a year and collect information to help NASA prepare for having people live and work there. Hear her describe the mission at: **learners.gsfc.nasa.gov/mediaviewer/LRO**.

Only 12 people have ever visited the moon. But someday soon NASA plans to have teams of astronauts living there for six months at a time.





BURIED ALIVE?

The first people who landed on the moon took a big risk. That's because the moon is covered with a thick layer of fine dust. No one knew how deep or soft this layer was. Would a spacecraft sink out of sight when it landed? Now we know—the layer is firm. In the picture, you can see that Apollo 11's lander pads sank only about 2 inches (5 cm) into the dust. What a relief! This helped NASA figure out the kinds of shock absorbers and landing systems its spacecraft need.

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

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A NASA/DESIGN SQUAD CHALLENGE

HEAVY LIFTING

as built on TV

Living on the moon gets expensive fast. Shipping things from Earth costs about $25,000 a pound! No wonder NASA plans to use materials found on the moon, such as calcium compounds to make cement and nitrogen compounds to fertilize crops. To mine materials like these, astronauts use cranes for digging and moving heavy or bulky loads.

WE CHALLENGE YOU TO...

… design and build a crane and see how heavy a load it can lift.

BRAINSTORM AND DESIGN

Think about things that might affect how heavy a load your crane can lift.

- How will you keep the crane's arm from breaking off the box as it lifts a load?
- How will you stop a heavy load from pulling the arm to the left or right?
- How will you wind and unwind the cable so the hook can go up and down?

BUILD

1. **First, make the arm.** The arm holds the string up and away from the crane's body. Use one, two, or all three cardboard strips to design your arm. Then attach it to the box.
2. **Next, make a take-up reel.** Figure out how to make a take-up reel that lets you shorten and lengthen the cable. (Optional: add a crank to turn the take-up reel.)
3. **Finally, add the string, hook, and cup.** Run the string through the arm. Attach it to the take-up reel and hook. Poke holes in each side of the cup near the rim. Make a handle for the cup and slip it onto the hook.

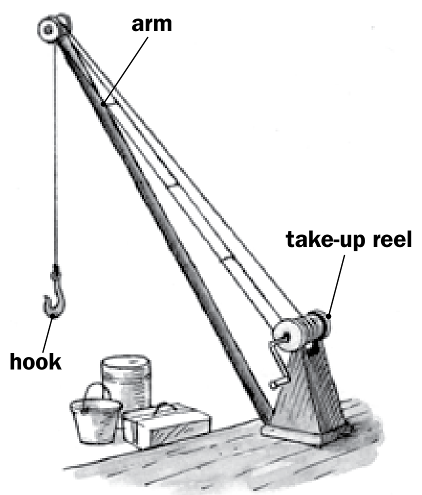
MATERIALS (per crane)

- cardboard box (shoebox size or bigger)
- 3 strips of corrugated cardboard (2 x 11 inches/5 x 28 cm)
- paper clip
- large paper cup
- 3 sharpened pencils
- scissors
- smooth string (e.g., fishing line or kite string)
- tape
- weights (e.g., batteries, pennies, marbles, or gravel)

TEST, EVALUATE, AND REDESIGN

Ready to test? Add weight to the cup. What's your crane's breaking point? Engineers improve their designs by testing them. The steps they follow are called the design process. Try some ideas and build an improved version. If:

- **the load rips the arm off the box**—*Reinforce how it attaches. Add cardboard supports. Or cut slits in the box to hold the arm. Also, add tape to the top and underside of the box.*
- **the arm crumples**—*Start over with new cardboard. Also, use several pieces of cardboard for an arm, either all together or spaced apart.*
- **the load pulls the arm to the side**—*Use extra cardboard or string to add support.*
- **the crank handle bends or slips**—*If it slips, tape it or attach it more firmly. If it bends, reinforce it.*

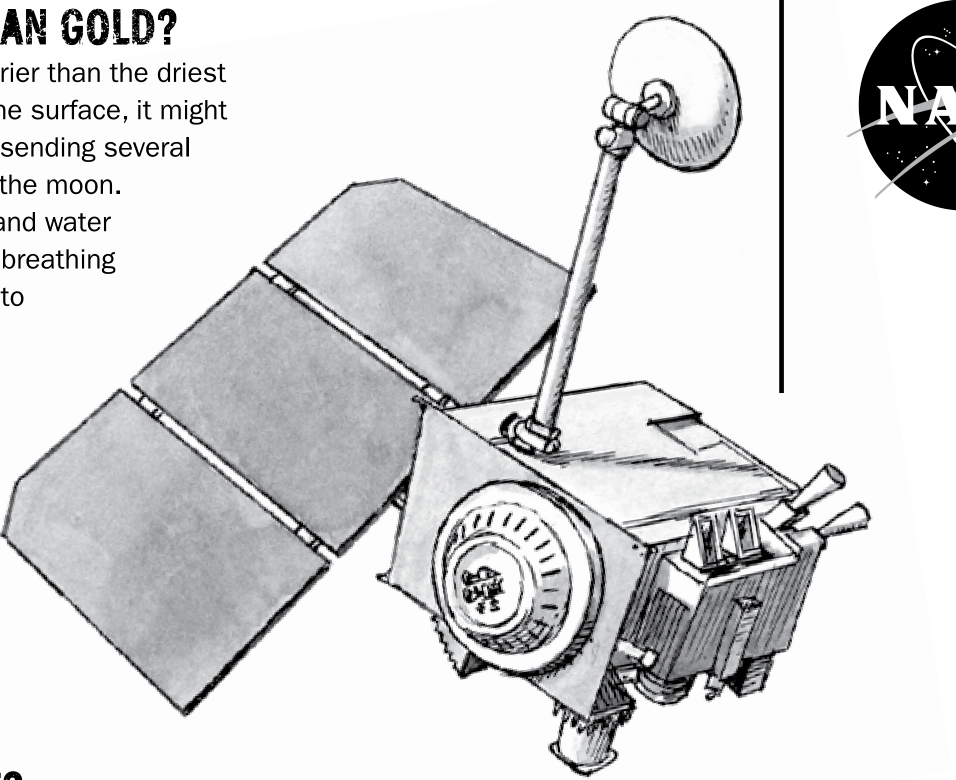


This hand-operated crane shows you the parts you'll need to include on your crane.

MORE PRECIOUS THAN GOLD?

The surface of the moon is drier than the driest desert on Earth. But under the surface, it might be a different story. NASA is sending several spacecraft to look for ice on the moon. Ice can be made into water, and water can be made into oxygen for breathing and fuel for the return home to Earth. If the spacecrafts find ice, one way to extract it is to use cranes.

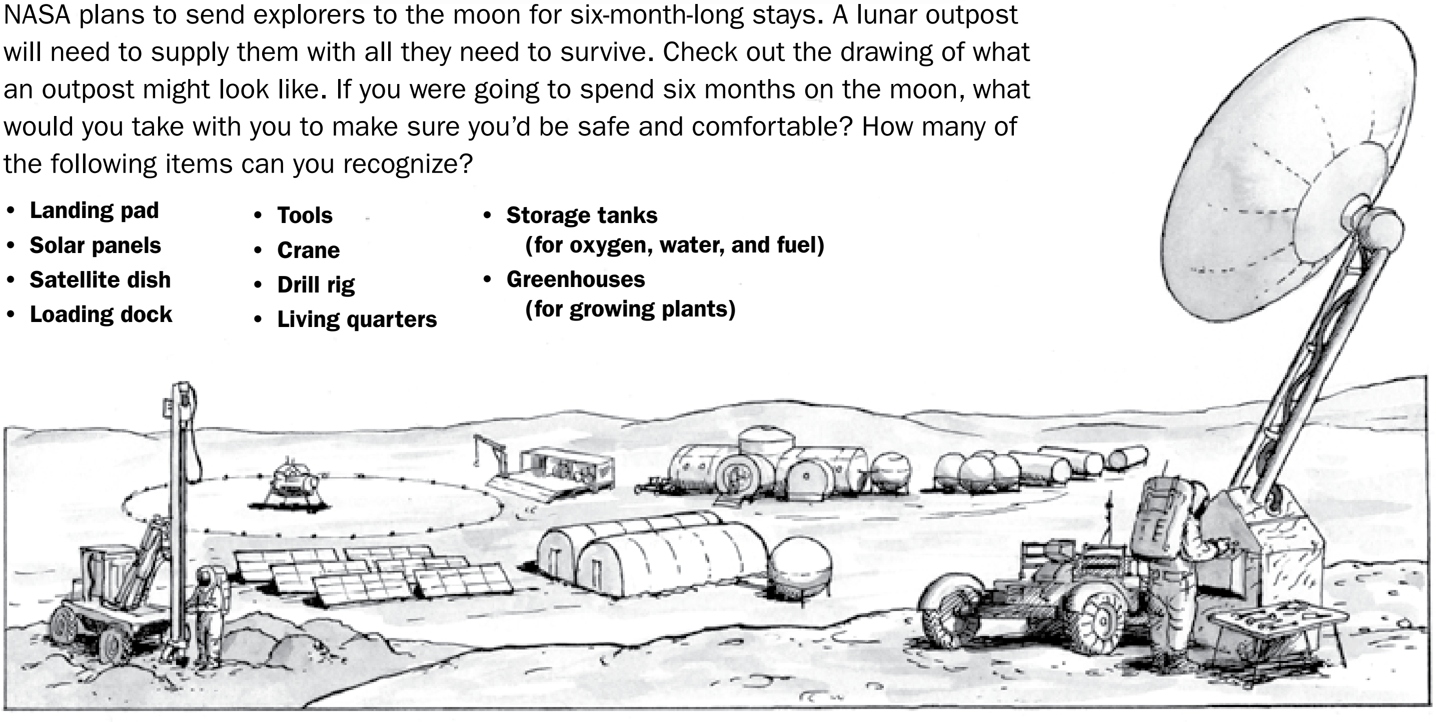
NASA's Lunar Reconnaissance Orbiter (right) will study the moon's surface to find ice. If there's ice, cranes will help astronauts mine it.



HOME SWEET HOME?

NASA plans to send explorers to the moon for six-month-long stays. A lunar outpost will need to supply them with all they need to survive. Check out the drawing of what an outpost might look like. If you were going to spend six months on the moon, what would you take with you to make sure you'd be safe and comfortable? How many of the following items can you recognize?

- **Landing pad**
- **Solar panels**
- **Satellite dish**
- **Loading dock**
- **Tools**
- **Crane**
- **Drill rig**
- **Living quarters**
- **Storage tanks (for oxygen, water, and fuel)**
- **Greenhouses (for growing plants)**



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A NASA/DESIGN SQUAD CHALLENGE

FEEL THE HEAT

Colder than Antarctica? Welcome to the moon! To survive on the moon, astronauts will need buildings that can protect them from temperatures as low as –250º Fahrenheit (–157º Celsius). One way to heat these buildings is to use sunlight to heat water and pump it through the rooms.

WE CHALLENGE YOU TO...

…design and build a solar hot water heater and see how big a temperature change you can get.

BRAINSTORM AND DESIGN

To heat water with your heater:

- What color should you make the tube and background?
- Being exposed to light is what heats water. How fast do you want water to flow through the tube?
- How can the way you zigzag the tube across the cardboard help the water in the tube absorb heat from the sun or light bulb?

BUILD

1. **First, get water to flow through the tube.** Poke a small hole near the bottom of a cup. Put the tube into the hole. Set a second cup under the tube's other end. Test your system with water. Seal any leaks.
2. **Then, build your hot water heater.** Use the materials to design a system that can help the water absorb a lot of heat energy.

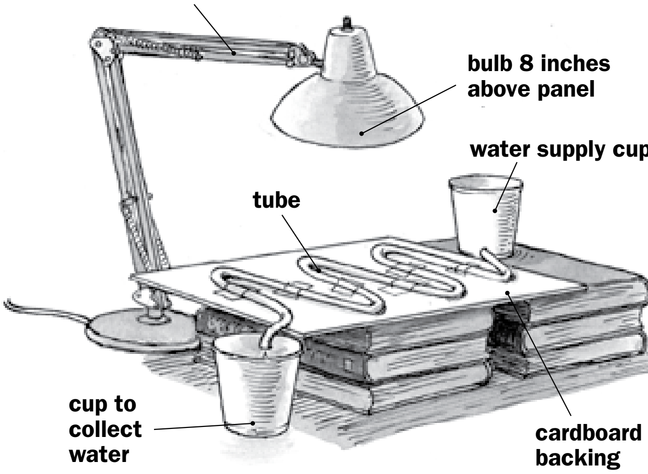
TEST, EVALUATE, AND REDESIGN

- Put your heater in strong sunlight or 8 inches (20 cm) below the lamp. (SAFETY NOTE: Keep water away from the outlet, lamp, and bulb.)
- Measure and record the temperature of the water in the pitcher.
- Pour water from the pitcher into the supply cup.
- Record the temperature of the water as it comes out of the lower end of the tube.

Starting temperature: _______________

Ending temperature: _______________

Temperature change: _______________



MATERIALS (per heater)

- aluminum foil
- large sheet of cardboard (e.g., 11 x 17 inches/ 28 x 43 cm)
- gooseneck lamp with an indoor 100-watt floodlight light bulb (optional if using sunlight)
- black marker
- black paper
- 2 paper cups (medium-sized)
- 3 feet (0.9 m) clear plastic tubing (Outside diameter: ¼ inch/6 mm)
- pitcher of water
- ruler
- scissors
- straws
- duct tape
- an indoor-outdoor digital thermometer that can read tenths of a degree

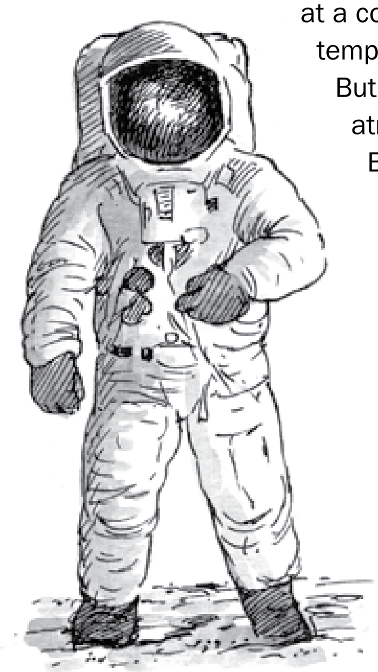
TEST, EVALUATE, AND REDESIGN (CONTINUED)

Can you get an even bigger change? Engineers test a design and improve it based on what they learn. This is called the design process. See how big a change you get.

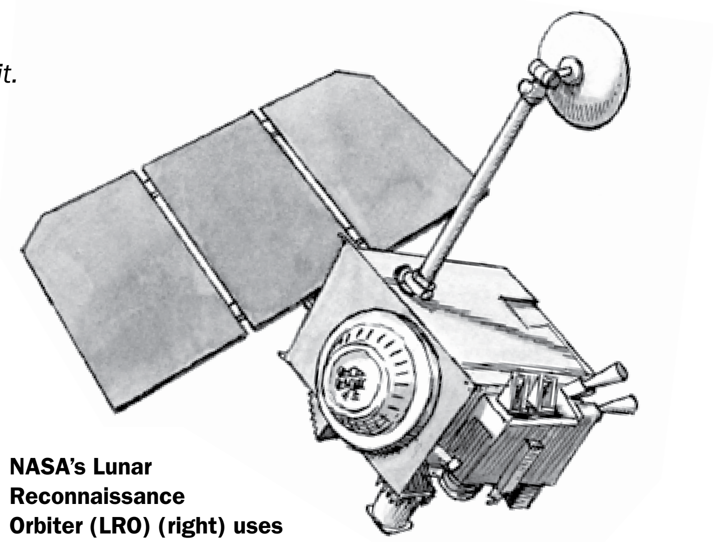
- **Help the water absorb more heat**—*Add materials above, below, or around the tube to focus more heat energy on the water. Also think how you can use color to help heat the water.*
- **Slow the flow**—*The longer the water stays in the light, the more it will heat up. Figure out how to make the water flow slowly through the tube.*
- **Make your tube longer**—*A longer tube can help water stay in the light for a longer time. Tape two tubes together.*
- **Air bubbles clog the tube**—*Blow into the tube to clear it.*

WHAT SHALL I WEAR?

Ever have trouble deciding what to wear? Try packing for the moon! On the moon, daily temperatures can swing about 500° Fahrenheit (260° Celsius). It can get up to 250° F (121° C) during the day, and at night, it can drop to –250° F (–157° C). Earth's blanket of air—the atmosphere—keeps us at a comfortable average temperature of 60° F (16° C). But the moon has no atmosphere to hold heat. Better bring a well-insulated space suit when you visit!



Buzz Aldrin wore a million dollar spacesuit (left) designed to protect him from the moon's extreme hot and cold temperatures.



NASA's Lunar Reconnaissance Orbiter (LRO) (right) uses a large solar panel to turn sunlight into electricity.

RUN BY THE SUN

Make your own electricity? In space, NASA's LRO spacecraft uses large solar panels to turn sunlight into electricity. They can produce about 1850 watts—enough to run a large microwave oven. But on average, LRO only uses 800 watts—enough to run a small toaster. The extra electricity is stored in batteries on board the LRO. When LRO goes into the shadow behind the moon, the darkness there prevents it from using the energy from the solar panels. So it powers itself with the batteries.

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A NASA/DESIGN SQUAD CHALLENGE

ROVING ON THE MOON

NASA

DESIGN SQUAD as built on TV

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

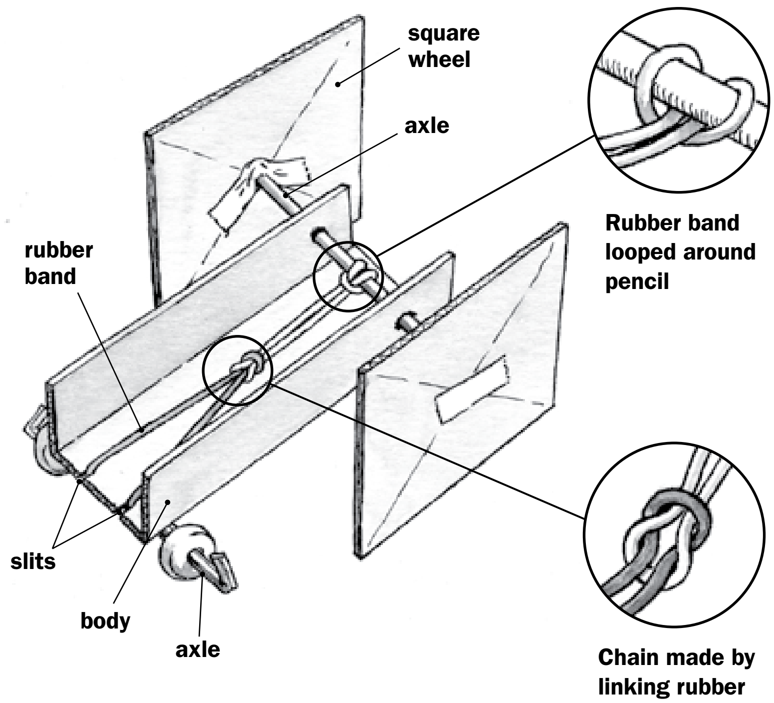
1. **First, you have to make the body.** Fold the cardboard into thirds. Each part will be about 2 inches (5 cm) across. Fold along (not across) the corrugation (the tubes inside a piece of cardboard).
2. **Then, make the front wheels.** On the two 5-inch (13-cm) cardboard squares, draw diagonal lines 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:

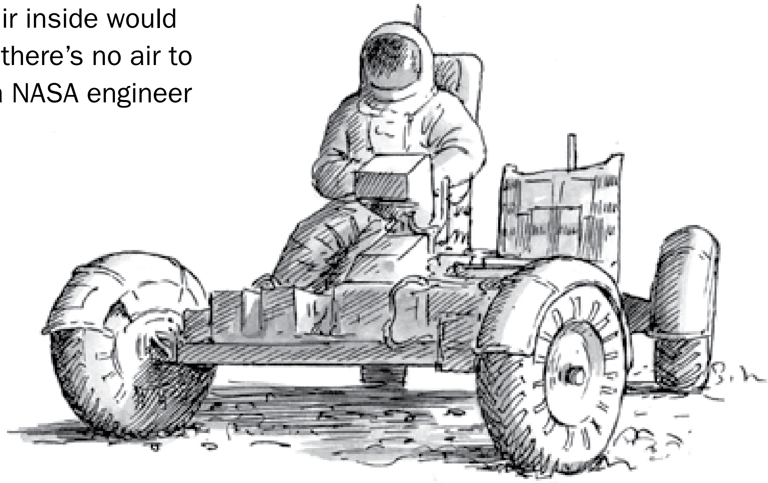
- **the wheels don't turn freely**—
  Check that the pencil turns freely in the holes. Also, make sure the wheels are firmly attached and are parallel to the sides.



- **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.*

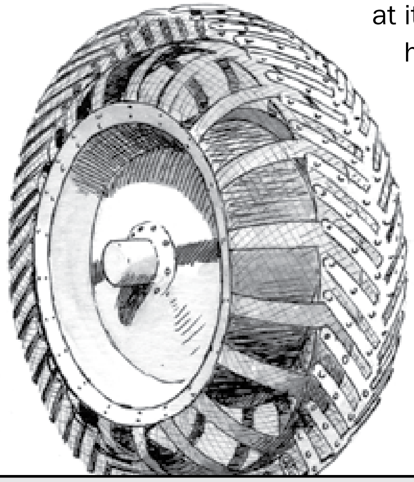
CUSTOM WHEELS

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).

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