TOUCHDOWN

LEADER NOTES

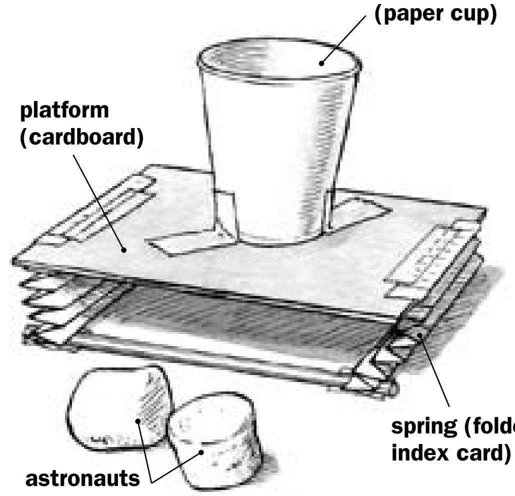
The Challenge

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

In this challenge, kids follow the engineering design process to: (1) design and build a shock-absorbing system out of paper, straws, and mini-marshmallows; (2) attach their shock absorber to a cardboard platform; 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.
- Fold an index card into a spring (see illustration).



Sample lander

2 Introduce the challenge (5 minutes)

- **Tell kids why a spacecraft that can land gently is important for getting astronauts to and from the moon safely.**

  NASA is looking for safe landing sites on the moon. Once they find one, they need to design and build a spacecraft that can land there without injuring astronauts or damaging the spacecraft. Today you'll make a lander—a spacecraft that can land safely when you drop it on the floor. As you test, you'll find ways to make it work better. Improving a design based on testing is called the engineering design process.

- **Show kids the spring made out of an index card.**

  When you jump off a high step, you bend your back and knees to absorb some of the energy and break your fall. That's what a shock absorber does—absorbs the energy of an impact. Soft things, like marshmallows, cotton balls, foam, and bubble wrap absorb shock well. You can also use paper, like this index card made into a spring by folding it like an accordion.

3 Brainstorm and design (10 minutes)

Distribute the challenge sheet. Discuss the questions in the Brainstorm and Design section.

- **What kind of shock absorber can you make from these materials to help soften a landing?** *(Mini-marshmallows can serve as soft footpads. Cards can be folded into springs. Straws can provide a flexible structure. Rubber bands can flex and hold things together.)*

- **How will you make sure the lander doesn't tip over as it falls through the air?** *(Making the parts below the platform weigh more than the parts on the top helps the lander fall straight down. Also, it helps to evenly distribute the weight on top of the platform.)*

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

Help kids with any of the following issues. For example, if the lander:

- **tips over when it drops**—Move the cup slightly away from the side that's tipping. Or, reposition the parts of the shock-absorbing system to better balance the weight.

- **bounces instead of landing softly**—Change the size, position, or the number of shock-absorbing parts. Kids can also add mini-marshmallows for landing-pad feet. Or, they can use marshmallows at key junctions in the lander's frame to help absorb energy.

5 Discuss what happened (10 minutes)

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

- **What forces affected your lander as it fell?** *(It accelerated [sped up] as it fell due to the pull of gravity. Air also pushed on it, and this air resistance slowed it down.)*
- **After testing, what changes did you make to your lander?** *(Answers will vary.)*
- **Engineers' early ideas rarely work out perfectly. How does testing help them improve a design?** *(Testing helps you see what works and what doesn't. Knowing this lets you improve a design by fixing the things that aren't working well or could work even better.)*
- **What did you learn from watching others test their landers?** *(Answers will vary. But in general, kids will see that there are many ways to successfully tackle a challenge.)*
- **The moon is covered in a thick layer of fine dust. How might this be an advantage? A disadvantage?** *(If the dust layer is soft, it would help cushion a landing. However, if it is too soft, a lander could sink into it and get stuck. Also, the lander's rocket engine could send up clouds of dust, which could get into the machinery and cause it to jam or malfunction.)*

EXTEND THE CHALLENGE

- **Hold a "How High Can You Go?" contest.** Have kids drop their landers from two feet. Eliminate all landers that bounce out their "astronauts." Next, raise the height to three feet. Continue in this fashion until a winner emerges. You can also increase the challenge by having kids add a third marshmallow "astronaut" to their cups.
- **Test springs of different sizes.** Have kids see if the number of folds in an index card makes a difference in the amount of force the spring can absorb. Have them fold index cards with two, four, and six folds. Have them test to see how much of a difference these different springs make in how softly a lander touches down.

CURRICULUM CONNECTIONS

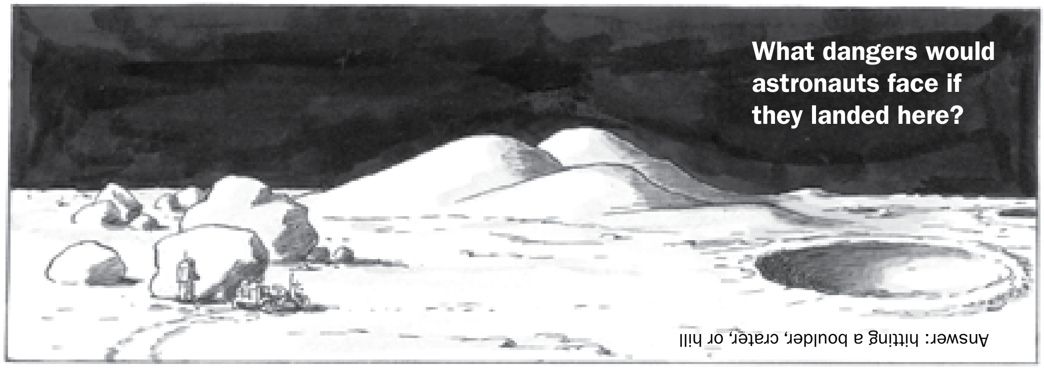
Touchdown ties to the following concepts commonly covered in science, math, and technology curricula. For a list of education standards supported by the activity, see pages 38 and 39.

- **Potential and kinetic energy**—When the lander hits the surface, its motion (kinetic) energy is changed into stored (potential) energy, which gets stored in the shock absorbers.
- **Acceleration due to gravity**—The lander accelerates (speeds up) as it falls due to Earth's gravitational pull.
- **Air resistance**—Air exerts a force on the lander as it falls, slowing it down.
- **Measurement**—Kids measure the various heights from which they drop the lander.

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.

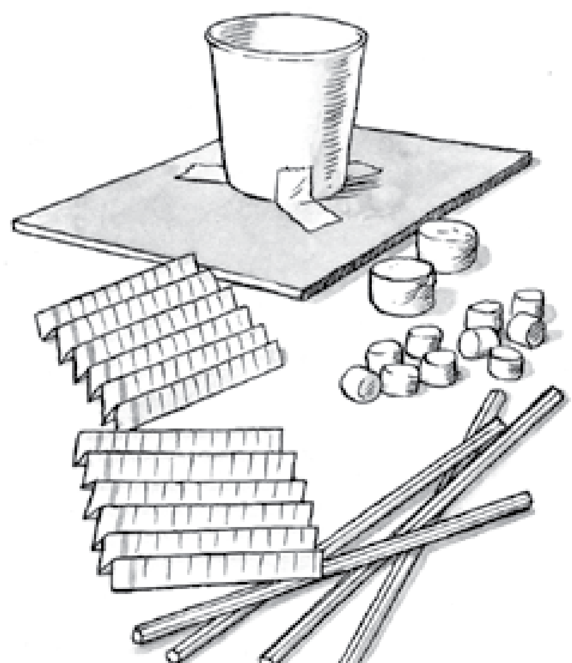
BRAINSTORM AND DESIGN

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

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:

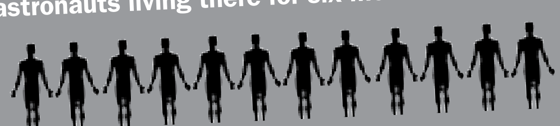
- **tips over as it falls through the air**—Make sure it's level when you release it. Also check that the cup is centered on the cardboard. Finally, check that the weight is evenly distributed.
- **bounces the astronauts out of the cup**—Add soft pads or change the number or position of the shock absorbers.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

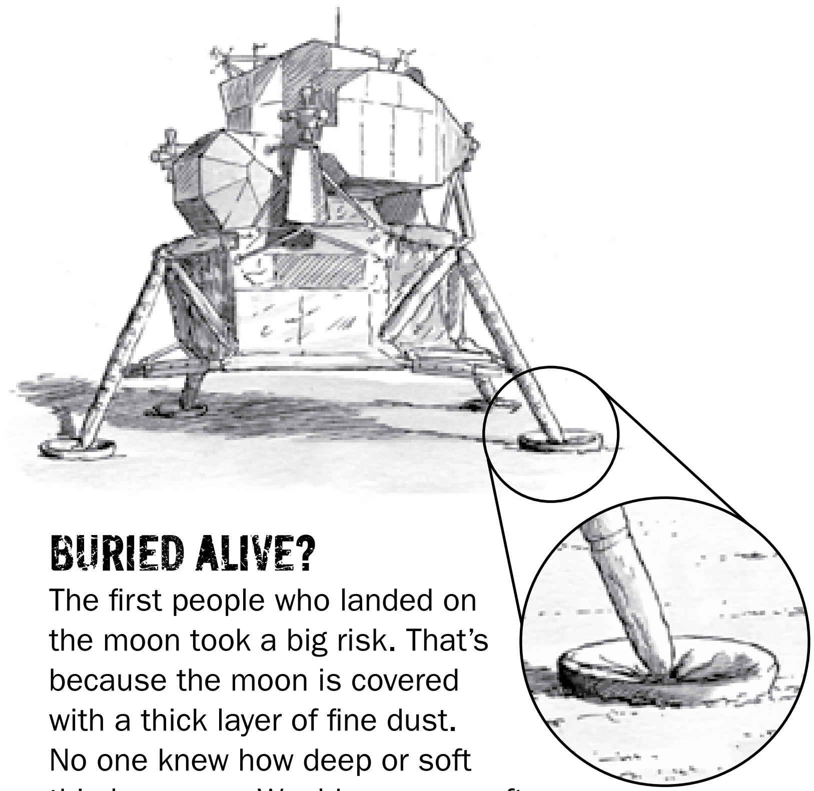
Check out NASA's moon missions at moon.msfc.nasa.gov.

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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