CHALLENGE 1
LEADER NOTES
SOFT LANDING

CHALLENGE: Design and build an airbag system that can safely land an egg dropped onto the floor.

LEARNING GOALS: *Science:* Force, potential and kinetic energy, and the conservation of energy; *NASA:* Airbag-landing systems; *Engineering:* Design process

NASA CONNECTION: Due to the extraordinary distances and harshness of deep space, it's costly and hard to send humans to explore planets, moons, and asteroids. So NASA uses robotic spacecraft. Three recent missions to Mars used an airbag-landing system to land rovers safely on the surface.

GET READY AHEAD OF TIME

- **Inflate balloons.** Blow up ten balloons per team. Store them in a garbage bag.
- **Attach rubber bands.** Providing inflated balloons with rubber bands pre-attached will save time and frustration. Tie a small rubber band around each balloon's neck to help kids attach them to their frames. Use a "slip-through" knot—slip one end through the loop. Pull tight.
- **Get the videos.** Go to pbskids.org/designsquad/links/solarsystem. Download the *Soft Landing,* Erick Ordoñez, and NASA videos. Be prepared to project them. If you're unable to show videos, review the handout's overview and steps and tell kids about the NASA work described in the overview and in Step 1.
- **Photocopy.** Copy the handout and performance assessment rubric.

MATERIALS (per lander)

Soft Landing works well with teams of two.

- 2 hardboiled eggs (Have a few extra for the whole group.)
- 10 nine-inch balloons
- 10 craft sticks
- 8 small (i.e., ¾ inch) binder clips
- 20 assorted rubber bands
- 2 small paper cups (3-ounce)
- Tape (any kind)
- 1 meter (39 inches) string

1 INTRODUCE THE CHALLENGE (10 minutes)

Set the stage

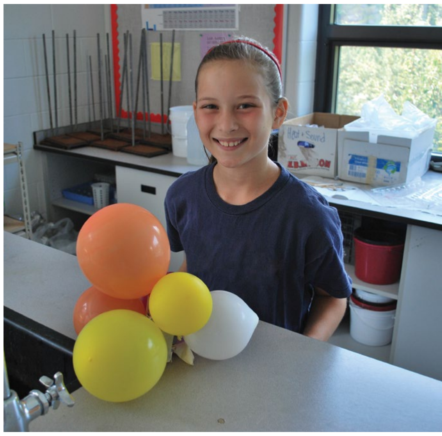
- Say: When you jump off something high, you absorb some of the energy by bending your knees and back. That's what shock absorbers do—absorb the energy of an impact. What materials absorb shock well? *(Soft, springy things, like balloons, marshmallows, cotton balls, foam, and air-filled packing material)*
- Tell kids the challenge and show them the *Soft Landing* video.

Relate it to NASA missions

Say: Because sending people into space is difficult, NASA uses rovers for many missions. To land safely on other worlds, the rovers must be protected. Three Mars missions used balloon-landing systems: *Mars Pathfinder* and the two Mars Exploration Rovers (*Spirit* and *Opportunity*). Today, you'll model this by protecting the egg. Show one of the NASA videos of airbags deploying. If you can't show a video, discuss the *Pathfinder* landing story on the handout.

2 BRAINSTORM AND DESIGN (10 minutes)

- **Identify the problem.** Have kids state the problem in their own words (e.g., keep the egg from breaking when it's dropped).
- **Show different kinds of frames.** Ask: How will you construct a frame to hold the egg firmly? Demonstrate how to connect the craft sticks with binder clips or with rubber bands.
- **Discuss the balloons.** Ask: How many balloons do you need to cushion the egg? (*Eight to ten work well.*) Show kids how the rubber bands can help them attach the balloons to the frame.



In *Soft Landing,* kids model three Mars missions that used airbag-landing systems.

3 BUILD, TEST, EVALUATE, AND REDESIGN (30 minutes)

If any of these issues come up, ask questions to get kids thinking about how they might solve them.

- **If balloons pop…** Have kids see if there are any sharp edges on their frames that need to be covered or eliminated. Check if they taped their balloons together. Tape is so inflexible that it can rip a balloon as it stretches upon impact. Have them remove some tape.
- **If balloons fall off the frame…** Point out the different materials kids can use to attach balloons (e.g., string, tape, and rubber bands).
- **If their egg breaks…** Have kids analyze why and improve the lander's ability to absorb shock.

Kids use the engineering design process to build landers that will protect an egg dropped onto the floor.

4 DISCUSS WHAT HAPPENED (10 minutes)

Emphasize key elements in today's challenge by asking:

- **Engineering:** How did testing help you decide what changes to make to your lander? (*Point out that kids followed the engineering design process: they brainstormed an initial design, built an early version [i.e., a prototype], and then revised it based on testing.*)
- **Engineering:** What design features did today's successful landers have? (*Typically, they have an effective way to absorb shock, stay intact upon impact, and protect the egg on all sides.*)
- **Science:** Why is it more likely for an egg to break when you drop it from a greater height? (*Due to the acceleration of gravity, a lander gains more energy when released from a greater height than from a lower height. The greater the energy, the greater the force of impact.*)
- **NASA:** What are some advantages of an airbag-cushioned landing? (*It can land in a variety of terrains and is lighter compared to a controlled landing, which requires fuel, engines, and a control system.*)
- **Career:** Show kids the engineer profile featuring Erick Ordoñez. As a materials engineer, he makes sure that the materials that go into space do the job and won't cause problems, like catching fire or failing at a crucial moment like during an airbag landing. Download the profile sheet for fun facts, discussion prompts, and extension ideas.

EXTEND THE CHALLENGE

- **Go higher.** Drop the landers from bleachers, balconies, windows in a building, etc.
- **Go lighter.** It costs $25,000 to send 0.5 kilos (1 pound) of material into space. That's why NASA engineers build the lightest spacecraft possible. Have teams optimize for weight. Divide the drop height by the weight. The successful mission with the lowest ratio of weight to drop height wins.
- **Rolling test.** Go bowling! Whose lander can protect the egg as it rolls across the floor?

CURRICULUM CONNECTIONS

Use *Soft Landing* to engage, explain, and extend student understanding of the following topics:

- **Force.** The airbags absorb energy from the collision between the ground and lander. The increased pressure in the airbag exerts a force in the opposite direction of the "push" from the ground (Newton's 3rd Law). Since heavy objects hit the ground with more force than lighter ones, you can discuss Newton's 2nd Law (force = mass x acceleration). Air also exerts a force on the lander as it falls.
- **Potential, kinetic, and mechanical energy.** Kids increase the potential (stored) energy of their landers when they lift them up. Once they let go, this potential energy changes to kinetic (motion) energy. When a lander hits the surface, some of its kinetic energy changes into mechanical energy (i.e., it does work by exerting a force on the airbag over a distance). Some of it also changes back into potential energy, as the air pressure inside the airbag increases. Ask kids to identify all the places one kind of energy changes into another kind.
- **Conservation of energy.** Drop a ball to the floor. Ask kids how high it bounces each time. (The ball bounces highest on the first bounce, getting successively lower with each additional bounce.) The law of conservation of energy says that energy cannot be lost or gained in a system. Ask kids why the ball doesn't bounce to the same height each time. (Each time the ball bounces, it loses energy to the work involved in compressing the ball and to friction with the ground and air. The cycle repeats until the ball—and lander—ultimately distributes its energy and stops.)

SOFT LANDING

Spacecraft use airbags. Cars use airbags. Packages use airbags. Air makes a great cushion. Three rovers have landed safely on Mars using an airbag system.

WE CHALLENGE YOU TO...

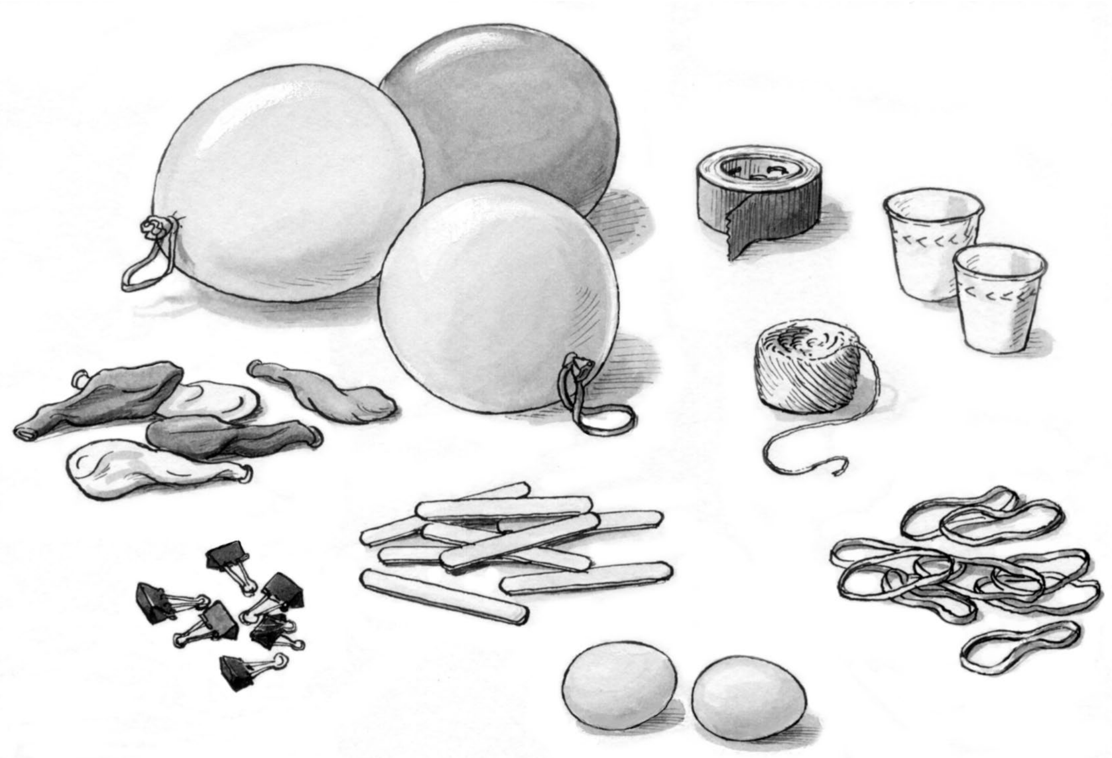
...design and build an airbag system that can safely land an egg dropped onto the floor.

1. IDENTIFY THE PROBLEM AND BRAINSTORM

- How will you make a frame that holds the egg?
- How will you attach balloons to your frame?
- How should you arrange the airbags to absorb shock?

2. DESIGN AND BUILD

Use the materials to invent your own design.



3. TEST

- Drop your lander from a height of 1 meter (39 inches).
- Watch how it bounces and rolls. Did the egg break?

MATERIALS (per lander)

- 2 hardboiled eggs
- 10 nine-inch balloons
- 10 craft sticks
- 8 small (i.e., ¾ inch) binder clips
- 20 assorted rubber bands
- 2 small paper cups (3-ounce)
- Tape (any kind)
- 1 meter (39 inches) string

WORDS TO USE

- **force:** *A push or a pull*
- **shock absorber:** *Absorbs the energy of an impact*

4. EVALUATE AND REDESIGN

- How well did the egg stay in the frame?
- How well do the balloons stay together to protect the egg on all sides?

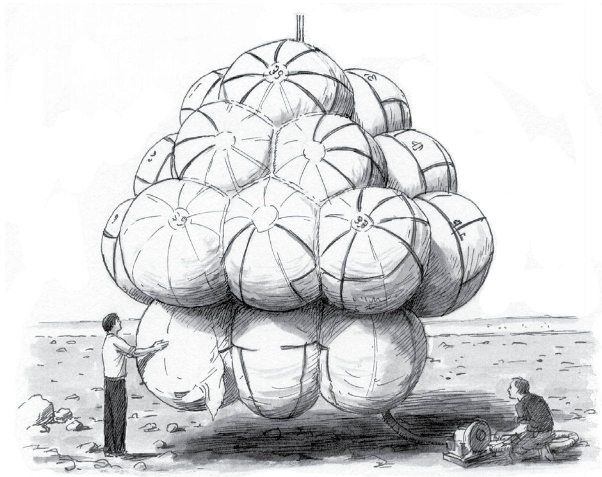
5. TRY THIS NEXT!

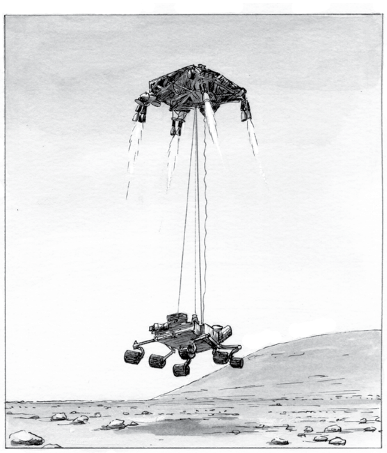
- Drop the lander from 2 meters (78 inches). How high can you go?
- Add a parachute or other system to slow the lander before it hits the ground.

Check out NASA's missions at nasa.gov

NASA EXPLORES SPACE

This picture shows NASA engineers testing an airbag-landing system on Earth. Three rovers have used this system to land safely on Mars. As they approach Mars, they're going about 20,000 kilometers (12,000 miles) per hour. Thanks to a parachute, heat shield, and rockets, the airbag-wrapped rovers hit the surface going about 80 kilometers (50 miles) per hour. One bounced as high as a five-story building. Then after 15 bounces, it stopped rolling, the airbags deflated, and the mission began.





The *Curiosity* rover is on Mars, studying the Martian climate and geology and looking for substances associated with life. *Curiosity* is the size of a small car. It is so big and heavy—about five times larger than earlier rovers—that it couldn't use an airbag-landing system. Instead, it used a rocket-propelled sky-crane that lowered it gently to the surface.

Visit the *Design Squad Nation* website at pbskids.org/designsquad.

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DESIGN CHALLENGE PERFORMANCE ASSESSMENT RUBRIC

DESIGN squad Nation

Challenge name:

Names of team members:

Identifying the problem(s) and brainstorming solutions	Showed a clear understanding of the problem(s) to solve. Independently brainstormed solutions.	Needed some teacher direction to define the problem(s) and brainstorm possible solutions.	Needed lots of teacher direction to define the problem(s). Little if any independent brainstorming.	**Points:**
Working as a team member	Worked well together. All team members participated and stayed on task.	Some team members were occasionally off task.	Most team members were often off task and not cooperating or participating fully.	**Points:**
Using the design process	Team brainstormed many design ideas and tested and improved the design. Final design complete or nearly complete and shows creative problem solving.	Some team members were occasionally off task.	Team brainstormed few design ideas and did little testing or redesigning. Final design lacks clear design idea(s).	**Points:**
Processing the science and engineering	Team gave a strong presentation of its solution to the challenge and showed clear understanding of the science concepts and design process.	Team gave a basic presentation of its solution to the challenge and showed basic understanding of the science concepts and design process.	Team gave a weak presentation of its solution to the challenge and showed little understanding of the science concepts and design process.	**Points:**
				Total Points:

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