SOFT LANDING

BIG IDEA:

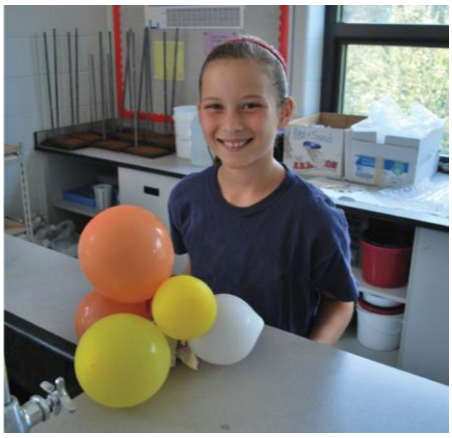
Due to the extraordinary distances and harshness of deep space, it's costly and hard to send humans to explore planets, moons, and asteroids. So NASA uses robotic spacecraft. Three recent missions to Mars used an airbag-landing system to land rovers safely on the surface. Participants will design and build an airbag system that can safely land an egg dropped onto the floor.

AUDIENCE:

- Families
- Students, 4th grade and up

WHAT YOU NEED:

- Materials quantities will vary depending on how participants design their landers. Many materials can be reused if landers are disassembled between participants. Approximate quantities per lander:
  - 2 hardboiled eggs
  - 10 9-inch balloons
  - 10 wooden craft sticks
  - 8 small (3/4 inch) binder clips
  - 20 rubber bands, assorted sizes
  - 2 small (3 oz.) paper cups
  - Tape
  - 3 ft. string
- Meter or yard stick
- (Optional) Computer or projection screen to show videos
- (Optional) Copies of Soft Landing handout



SET-UP:

- Providing inflated balloons with rubber bands pre-attached will save time and frustration. Blow up at least 10 balloons. Tie a small rubber band around each balloon's neck to help participants attach them to their frames. Use a "slip-through" knot—slip one end through the loop. Pull tight.

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- Cue up these two videos and be prepared to project them: Soft Landing Challenge, Erick Ordoñez, Materials Engineer. If you're unable to show videos, be prepared to review the activity's overview and steps with participants and tell them about the NASA work described in the videos and handout.
- (Optional) Pre-assemble some example frames to give participants starting points for how to use the materials. See the Soft Landing video for examples.

WHAT TO DO:

*See the Soft Landing: Leader Notes for additional information, participant handout, and photos.

Introduce the challenge:

1. Set the stage: 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)*
2. Explain the challenge: participants will design and build an airbag system that can safely land an egg dropped onto the floor. Show them the Soft Landing video.
3. Relate it to NASA missions: 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). Discuss the Pathfinder landing story on the second page of the handout.

Brainstorm and design:

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

Build, test, evaluate, and redesign:

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

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- If balloons pop: Have participants 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 participants can use to attach balloons (e.g., string, tape, and rubber bands).
- If their egg breaks: Have participants analyze why and improve the lander's ability to absorb shock.

Discuss what happened:

8. Emphasize key elements in today's challenge:
   - **Engineering**: How did testing help you decide what changes to make to your lander? (Point out that participants followed the engineering design process: they brainstormed an initial design, built an early version [i.e., a prototype]
   - **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 participants 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.

TIPS & TRICKS:

- If you are leading this activity in an out-of-school-time program or classroom setting, have students work in groups of two or three to design and build their landers. Provide enough materials for each group to have the quantities listed in the materials list.
- Extend the challenge:
  - Go higher. Drop the landers from bleachers, balconies, windows in a building, etc.

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    - 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?
- See the Mission2Mars Additional Resources document for related videos, printable resources, and other activities.

WHAT TO KNOW:

- Sending rovers to Mars is an important first step for eventually sending human missions there as well. Rovers collect information about what the planet is like to help scientists plan for how humans could live there. The process of sending spacecraft like rovers to Mars allows engineers to design and test technology, like the transportation and landing systems, that might eventually be used to bring humans and their supplies safely to Mars.
- Three rovers (Pathfinder, Spirit, and Opportunity) have used an airbag system like the one in this activity 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 and Perseverance rovers are currently on Mars, studying the Martian climate and geology and looking for substances associated with life. These rovers are the size of a small car—about five times larger than earlier rovers—so they were too heavy to use an airbag-landing system. Instead, they each used a rocket-propelled sky-crane that lowered them gently to the surface.

SOURCE: PBS Kids Design Squad, Mission: Solar System

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