Lander Egg Drop

Suggested Grade Level: 3–9

Summary

- Students will make a model of the Mars Exploration Mission (MER) planetary lander and its airbag technology.
- Students will test their model by dropping their lander from a height onto a Mars-like area.

Standards

- NM Science Content Standards: Strand I, Scientific Thinking and Practice; Strand III, Science and Society
- National Science Education Standards: Standard A, Science as Inquiry; Standard E, Science and Technology

Background Information

The Mars Exploration Rovers (MER) used the same airbag-cushioned landing that was successful for the Mars Pathfinder Mission in 1997. This style of landing using airbags was a new idea in landing technology for planetary missions; and it was less costly and required fewer components than a traditional soft landing on another planet. The airbags worked well for both Pathfinder and MER rover missions, but airbags can only be used with landing craft of a relatively low weight and small to moderate size.

For the MER rovers, there was no orbiting spacecraft. Instead, each spacecraft, consisting of a lander enclosing a rover within its folded tetrahedron shape, entered the Mars atmosphere and went directly to the previously selected landing site on the Mars surface. Each spacecraft hit the Mars atmosphere at a velocity of 5.4 km/ second (12,000 miles per hour). The craft first used a heat shield to protect it during its passage through the atmosphere, then a parachute to slow the descent. Eight seconds before landing, gas generators inflated the airbags and retro rockets fired to further slow the descent, the parachute was detached, and the lander fell the final 15 meters (50 feet). The first bounce took each lander up to as much as 15 meters (50 feet) above the surface and it is believed that Spirit bounced and rolled for as long as 6 minutes before it came to a rest.

The airbags were made of a fabric similar to that of bullet-proof vests, and were designed to survive vertical impacts; however, the bags could be ripped if wind carried them sideways against large rocks. The Spirit and Opportunity landings were difficult because the position of rocks at each of the landing sites and the wind speed during landing were parameters that were not able to be controlled. Twelve minutes after landing, motors began to retract the

airbags, and the protective lander petals enclosing the rover opened. Spirit came to rest on its base petal but Opportunity landed on one of the side petals; the tetrahedron design of the petals meant that regardless of which petal came to rest on the surface the lander would open with the rover in its proper upright configuration. In order to fit within the lander tetrahedron, the rover was folded up. Before it moved off the lander and began to explore the surface of Mars, each rover had to unfold its solar panels, Pancam mast, and wheels and stand up from its stooped position.

Materials For Each Team

- Student instruction sheet included in this activity
- Lander pattern included in this activity (can be shared by several teams)
- Parachute pattern included in this activity (can be shared by several teams)
- One cardboard square (can be part of an unfolded cereal box) that can be cut into an equilateral triangle 22 cm (8.5 inches) on a side
- Four 25 cm (10 in) balloons
- 5 meters (16.5 feet) of string
- One double page sheet from a newspaper
- One hard-boiled egg
- Tape, scissors, ruler, pencil, hole punch (can be shared by the teams)

Preparation

1. Print the lander and parachute patterns included in this activity. Both patterns are smaller than your final patterns will be, so they serve as guides to the final appearance. The lander pattern can be enlarged to 106% by photocopier so that each side of the triangle is 8.5 inches in length. Or you may simply use the pattern as a guide and draw a larger triangle around it, with each side 8.5 inches long. Use the final pattern to cut out the lander on sturdy cardboard.

   The parachute pattern included in this activity also is a guide for the much larger newspaper sheet. Take a double-page newspaper sheet and simply cut the corners off to make an eight-sided pattern. Use the pattern to cut out a large piece of paper or thin cardboard.

   One or two copies of each pattern are sufficient and can be used in turn by all of the student teams to produce their own landers and parachutes. Tape, scissors, and hole punch can also be shared by all teams.

2. Collect, or ask your students to collect, square pieces of thin cardboard. Unfolded cereal boxes work well.

3. Collect, or ask your students to collect, string and double page sheets from newspapers. You will need 5 meters (16.5 feet) of string and one sheet of newspaper for each team.

4. Purchase a large package of balloons.

5. Hard-boil eggs so that each team has at least two eggs.

6. Prior to the testing of the models, you should locate and prepare a Mars landing site and drop point.

Introduction for Students

Do you know how the Mars Exploration Rover mission landed on Mars? It was designed to use airbags, similar to the ones in your family's car, but much larger and stronger. With the materials provided, your team will make a lander, a parachute, and air bags, and model the landing of the Mars Exploration Rovers. Will your lander survive landing? Why do you think this type of landing technology was used for the rovers? What other type of landing technology could have been used? What do you think the engineers and scientists worried about with this airbag landing? What do you think the problems are with landing using airbags?

Procedure

In order to model the landing of the Mars Exploration Rover mission, each team must construct a lander, a parachute, and airbags—and then test their landing technology in a prepared landing site and drop area.

Making the Lander

1. Starting with a cardboard square, trace the lander pattern provided by your teacher onto the square and cut on the solid lines. Note: if the lander pattern is unavailable, just draw an equilateral triangle 22 cm (8.5 inches) on a side on the cardboard square and cut it out.

2. Punch a single hole near each point.

3. Fold the triangle along the dotted lines into a tetrahedron to form a lander.

4. Place the egg inside the tetrahedron and tape it closed along each seam.

5. Tie a single 1 m (40 in) piece of string through the holes.

Making the Parachute

1. Unfold a large (double page) piece of newspaper.

2. Trace the parachute pattern provided by your teacher and cut out. Note: if the pattern is unavailable, simply cut off the edge of the sheet to form a square and then cut across the corners of the square to form an octagon.

3. Using four 1 m (40 in) pieces of string, tape each end of each string to adjacent corners of the octagon parachute (each string is looped and taped at each end to each side of the octagon in order to make a series of four loops).

Making the Air Bags

1. Inflate four 25 cm (10 in) balloons.

2. Using tape rolled back on itself, tape each balloon to each face of the lander.

3. Gather the four strings on the parachute and tie them to the lander string.

Preparing the Landing Site and Drop Point

1. Choose an area about 6 feet square that is beneath a height where the landers can be safely dropped. A mezzanine within a building is ideal. A second floor window or balcony on the outside of a building can be used if it is not a windy day.

2. Cordon off the landing site area. Randomly scatter a few rocks of different sizes (or blocks or boxes) in the area. The student teams should gather around the landing site and observe the landing.

3. Use raw eggs! Prepare a landing site that will not be damaged if the eggs break. Count and map the location of the bounces.

Entry, Descent and Landing (EDL) of the Landers

Drop each lander from the high area onto the prepared landing site and see if your payload rover (egg) survives. A teacher or assistant can drop all of the landers so that conditions are similar for each lander. Each lander can be counted down (10-9-8....1) and then dropped. The lander should drop vertically and should not be thrown out sideways; if necessary, the parachute can be looped over a yardstick and dropped over a railing or window sill by allowing it to slide down the yardstick.

Process/Closure

This activity models the final few seconds before impact with the surface of the Mars Exploration Rovers. Eight seconds before hitting the surface, the airbags were inflated and the lander fell the final 15 meters (50 feet) to the surface, with the airbags cushioning the shock of landing and causing the lander to bounce and roll several times before reaching a stable position.

What is not modeled here? We cannot reproduce the distance that the lander actually drops or the true weight of the lander, or the number of bounces that Spirit and Opportunity actually survived. The real landers fired deceleration rockets and cut their parachutes loose just before landing. The model retains the parachute in order to slow its impact.

Extension/Enrichment

Vary the number of balloons. Attach the balloons to the sides of the lander rather than the points.

Change the number and size of rocks in the landing site to reproduce the Viking 1, Viking 2, Pathfinder, Spirit, and Opportunity sites and discuss what is needed to make this landing technology work.

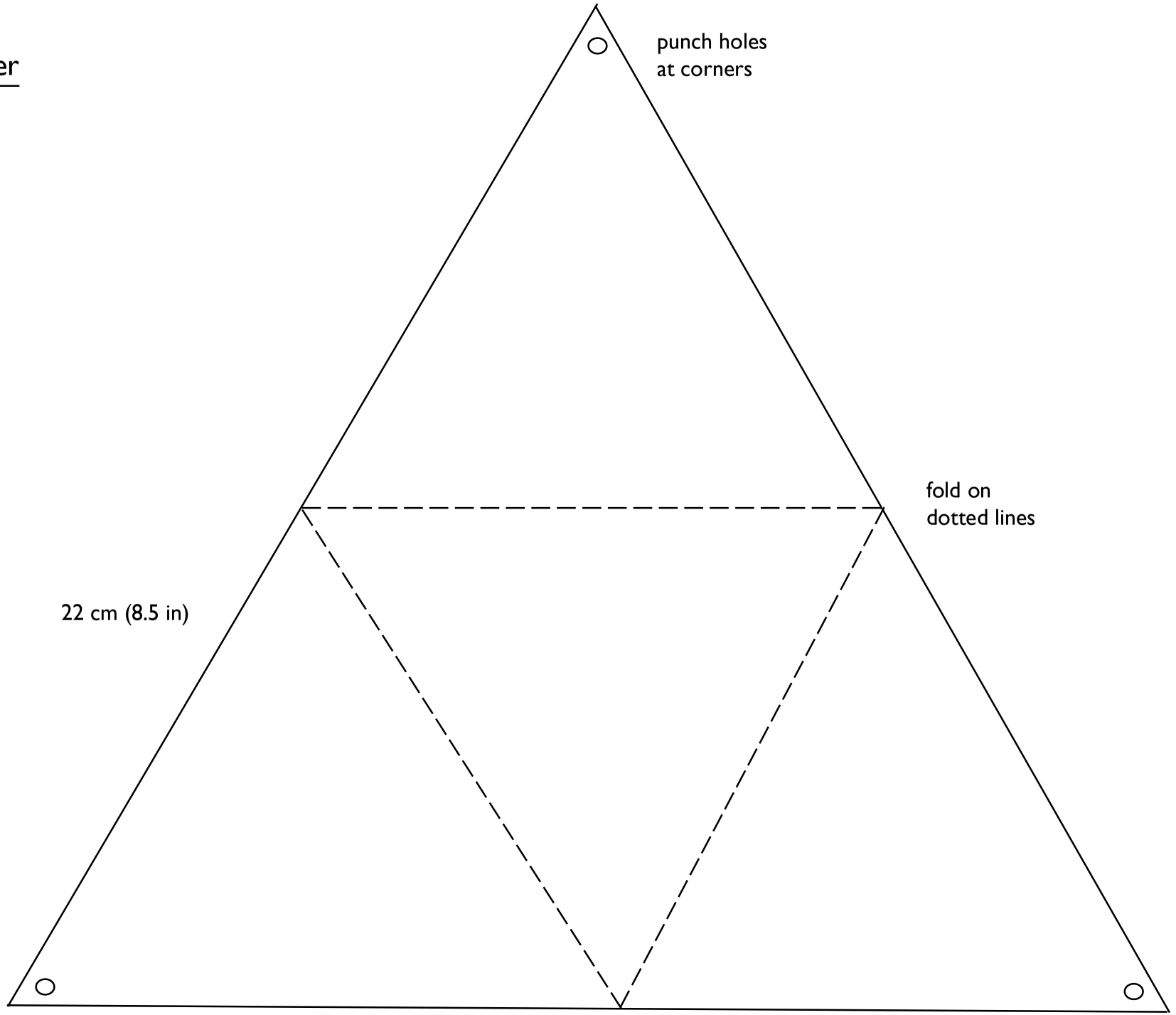
Use raw eggs! Prepare a landing site that will not be damaged if the eggs break.

Count and map the location of the bounces.

Credits

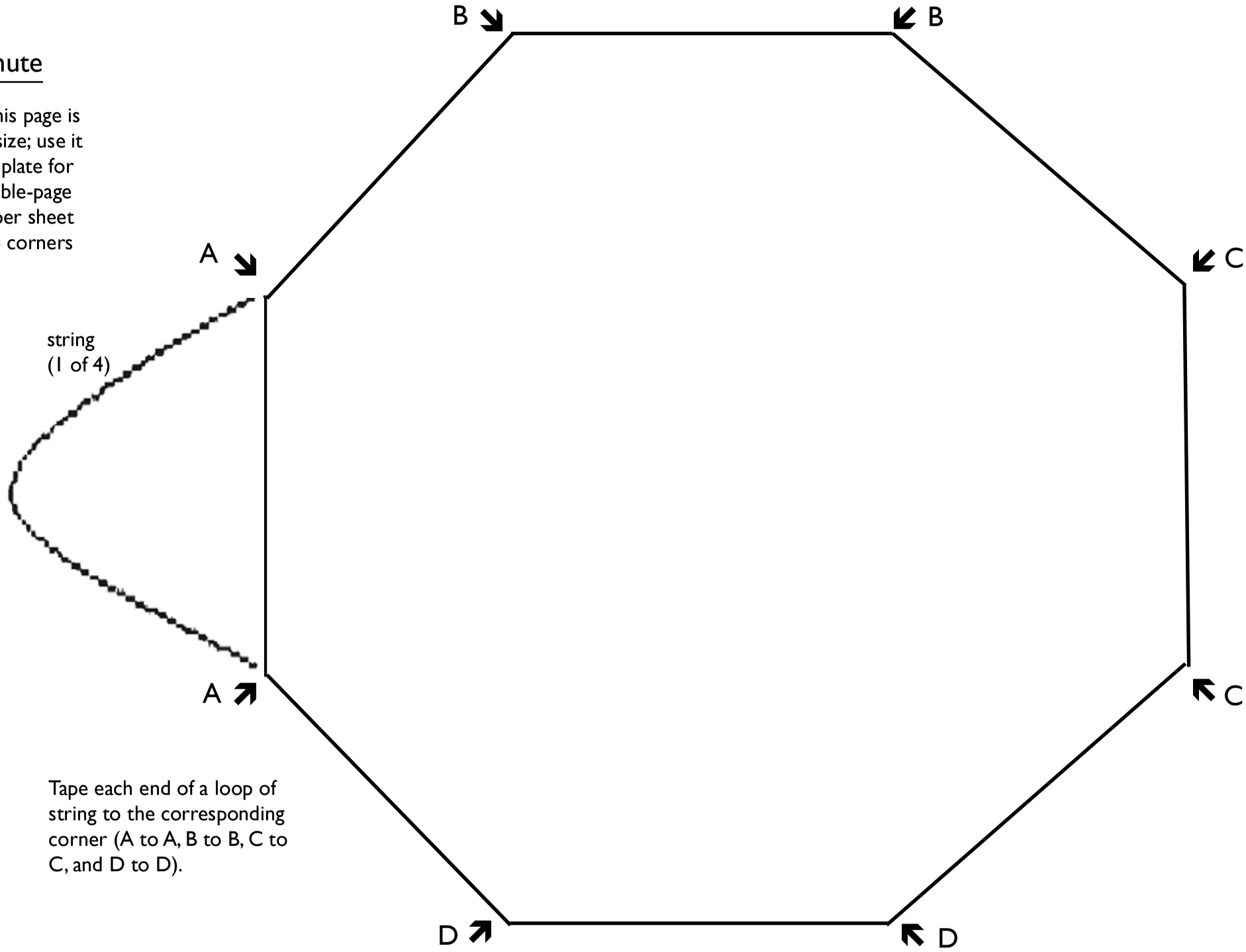
This activity was adapted by Amy Grochowski and Jayne Aubele, New Mexico Museum of Natural History & Science, from the Mars Pathfinder Egg Drop and Landing Activity in NASA's Mars Activities: Teacher Resources and Classroom Activities.

Lander



Parachute

Note: This page is not full size; use it as a template for one double-page newspaper sheet with the corners cut off.



Tape each end of a loop of string to the corresponding corner (A to A, B to B, C to C, and D to D).