Activity 3 The Incredible Light Bulb / Egg Drop Challenge!

Background The Incredible Bouncing Spacecraft
(This introduction adapted, with thanks, from information to be found at
http://mars.jpl.nasa.gov/mer/mission/tl_entry.html)

MER's Entry, Descent, and Landing (EDL) phase begins when the spacecraft gets to about 3,522 kilometers (2,113 miles) from the center of Mars, and ends (we all hope!) with the lander safely on the surface. MER's EDL is an adaptation of the *Mars Pathfinder* method:

- An aeroshell and parachute decelerate the lander as it travels through the Martian atmosphere.
- Prior to impact, retro-rockets fire to slow the lander's descent speed, and airbags inflate to cushion the lander as it hits the surface.
- After impacting Mars, the lander bounces along, for perhaps a kilometer, until it rolls to a stop.
- The airbags deflate and retract, and the lander petals and rover egress aids (the "bat-wings") deploy.
- Once the petals open, the rover activates its solar arrays, and places the system in a safe state, waiting for instructions from Earth.

While there are many (in fact thousands!) of challenging moments for MER, the few minutes of EDL are some of the most "exciting", i.e. risky. In COUNTDOWN TO MARS and successor videos in "To Mars with MER" you can see just how hard the MER team worked to design airbags that would perform well on Mars, and how rigorously they tested them to ensure success under a wide range of conditions.

Objective
In this activity, participants will demonstrate an understanding of the challenges of *soft* landing a spacecraft on Mars, a *hard* planet, by designing, building and testing their own "interplanetary lander."

Vocabulary
atmosphere
deploy
descent
gravity
kilometer
payload
retro-rocket
simulation

Materials (For each team of 3-4 participants)
a square yard of tightly woven nylon material
a paper lunch bag
a plastic shopping bag

2 - 3 balloons
two paper clips
five feet of string
three 8 1/2 x 11 inch sheets of paper
masking tape
a raw egg (now you know it's going to be fun!) or a light bulb

Materials (For the entire group)
a scale sensitive to ounces (e.g. postal scale)

IMPORTANT SAFETY NOTE
In advance of this activity decide whether your "house", school or science center's policies (and your own prudence, and inclination to clean up a mess) permit you to use light-bulbs, or whether you will choose to use an egg, or other "fragile payload". Exercise caution: discourage youngsters from leaning off ladders or out of windows, or clambering up on roofs! We suggest enlisting help in the final "Drop Test."

Engage
From top of a ladder or table, drop a box of paper clips to the floor. It's noisy and messy, but nothing's broken. Ask participants to think of ways they might safely land a fragile spacecraft on another planet. Tell them that in this Activity, they are going to play the role of NASA engineers, and are going to design, build and test their own interplanetary landers.

Explore/Explain
In the above discussions, participants may suggest the use of retro-rockets as in the *Apollo* moon landings or as seen in many science fiction films. Some may even mention the *Viking* landings on Mars (1977.) Explain to participants that while retro-rockets do work, they add significant size and weight to a spacecraft and, if their thrust is applied too close to a planet's surface, they can seriously disturb or contaminate the very things which scientists wish to study. Thus, in this Activity, they will be challenged to come up with small, light-weight alternatives that don't use retro-rockets for safely landing a very fragile payload on the surface of Mars.

Procedure
Divide the group into "EDL Engineering Teams" and distribute a set of the above materials to each of the teams. Tell them they have exactly 30 (or 40?) minutes to design and build a lander out of some or all of the materials they have received. The fragile payload they will be challenged to land safely is the egg or light bulb which, when placed in their "descent module", must survive a fall of three stories (or whatever height is feasible for you) without breaking.

Tell participants that each team is in competition with the others for an all important NASA contract, and that the team which builds the lightest lander that successfully lands an unbroken egg or light bulb will be the winner. (You might also mention that this is a variant of an activity done, each year, by MIT undergrads: it's not just challenging for kids, but also for some of America's brightest and best engineers.)

If you have time, inclination, assistance and are brave enough, and the weather permits, go outside, record the weight of each lander and then, amid appropriate pomp and ceremony, have a colleague or other volunteer drop each entry, one by one, out of a third story window, or off your building's roof.

An exciting alternative (done by many schools during P2K's original LIVE FROM MARS project) >>>EB: LINK TO STUDENT WORK OR CLASSROOM CONNECTION, OR WHEREVER THIS MIGHT BE, AND ALSO, PERHAPS, TO THE DISCUSS-MARS ARCHIVE<<< is to invite your local fire department to take part using one of their big hook and ladder trucks. Invite the local news media to cover the event. Video tape the contest and send us a copy here at P2K. >>>LINK TO THE MAIL BOX ADRESS.<<<

Additional Alternatives
Give the EDL teams the additional challenge of keeping the overall size of their lander to a certain volume, e.g., no more than 12 cubic inches. If you're working in a science center or planetarium, you may also wish to use this Activity as a take home activity and invite visitors to work on this with their families and/or caregivers. (Be sure to include the IMPORTANT SAFETY NOTE in any hand-outs you create from this template!)

Expand/Adapt/Connect
In this Activity, participants tested their creations on home ground. As a follow up, challenge them to research relevant similarities and differences between Earth, the Moon and Mars and draw conclusions as to how these might affect the design of their lander. (I. e., the Moon has no atmosphere, so parachutes would be useless in slowing down lunar landers.) Mars does have an atmosphere, but it's very thin. Therefore, a descent device that relied solely on a parachute to slow it down would not work nearly as well on Mars as on Earth, unless it were much bigger. (See http://mars.jpl.nasa.gov/mer/gallery/spacecraft/meropen7_cropbrowse.html for an image of MER's parachute being tested in the world's largest wind tunnel, at NASA's Ames Research Center.) This, in turn, adds weight and volume to the spacecraft. Mars has only about one third of Earth's gravity. Therefore, objects fall more slowly on Mars. Dropping something from a relatively low height on Earth would cause the object to have the same speed on impact.

Participants of high school age studying physics will have ample opportunities to take this Activity further in formal studies. They can, for example, determine a lander's changing potential and kinetic energies as it falls. They can also study the rate of fall of the lander and compare final velocities, with and without parachutes, while learning about drag. Also, noting that the force of gravity on Mars is only 38% of that on Earth, they can calculate how high a drop on Mars would result in the same velocity upon impact as a drop from a three story building on Earth.

Write a news report January 2004, for the day the first MER is scheduled to land on Mars.

Research the descent and landing sequence (http://mars.jpl.nasa.gov/mer/mission/tl_entry.html) and what scientific data it will be collecting as it descends through the Martian atmosphere, and what "health and safety" data it will be sending back to Earth.

Suggested URLs
http://nssdc.gsfc.nasa.gov/planetary/mesur.html

Archived information about NASA's Mars *Pathfinder* spacecraft, the first American mission to use airbags.

http://www.nap.edu/readingroom/books/nses/html/egg6d.html
An example, taken from the National Science Education Standards, of how the classic "egg-drop" activity can be implemented in a classroom setting. Relating the underlying engineering challenge to an inherently exciting mission to Mars only adds to what's already an engaging and fun project.

http://www.ai.mit.edu/people/stauffer/Activities/Olympics/EggDrop/
The "raw" bones of the MIT egg-drop, with a more extensive Materials list.

http://www.amnh.org/rose/mars/eggdrop.html
The LIVE FROM MARS egg-drop activity implemented on camera by Neil DeGrasse Tyson, director of the Hayden Planetarium.