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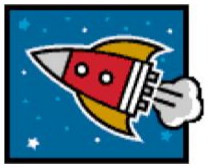

How to Land Softly on A Hard Planet

Math

Goal: Students design, build and drop a landing system.

Objectives: Students will…

- Use team work to meet a goal
- Incorporate as many geometric shapes as possible in design
- Measure square area when designing
- Predict what will happen for each change of the design
- Compare the rate of fall of different drops by changing a variable each time
- Determine mass of their device

Materials (for a class of 30):

- 1 Cereal box or cardstock
- Small balloons, marshmallows or Styrofoam peanuts
- 5 m of string
- 1 sheet of newspaper
- 1 egg
- tape, scissors, pencil, hole punch
- stopwatch
- record sheet
- 6 digital scales or balances
- 6 large envelopes or shoe boxes
- 30 copies of How to Land Softly on A Hard Planet-Student Direction Sheet
- 30 copies of How to Land Softly on A Hard Planet-Student Sheet
- 30 copies of How to Land Softly on A Hard Planet-Spirit and Opportunity Lander Information

Time Required: 2, 45-60 minute periods

Next Generation Sunshine State Standards Met:

SC.6.N.1.1: Define a problem from the sixth grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

SC.6.N.1.2: Explain why scientific investigations should be replicable.

SC.6.N.1.4: Discuss, compare, and negotiate methods used, results obtained, and explanations among groups of students conducting the same investigation.

SC.6.N.1.5: Recognize that science involves creativity, not just in designing experiments, but also in creating explanations that fit evidence.

SC.6.P.11.1: Explore the Law of Conservation of Energy by differentiating between potential and kinetic energy. Identify situations where kinetic energy is transformed into potential energy and vice versa.

SC.6.P.12.1: Measure and graph distance versus time for an object moving at a constant speed. Interpret this relationship.

SC.6.P.13.1: Investigate and describe types of forces including contact forces and forces acting at a distance, such as electrical, magnetic, and gravitational. Summer 2008 Space Week Teacher's Guide Addendum 11

SC.6.P.13.2: Explore the Law of Gravity by recognizing that every object exerts gravitational force on every other object and that the force depends on how much mass the objects have and how far apart they are.

SC.6.P.13.3: Investigate and describe that an unbalanced force acting on an object changes its speed, or direction of motion, or both.

Procedure:

DAY ONE

- Explain that students will be working to determine the best way to get their rover from the rocket to the surface of Mars. There are many factors they will need to consider, height of drop, speed, mass, and risk.
- You might want to review the animated video shown Day 1, Mission to Mars. Show the segment where the rover drops onto the planet's surface.
- Review the various parts of the landing system: lander, parachute, and airbags.
- Tell students that they will not be practicing with their real rover because they do not want to incur damage. Headquarters has determined that if they can safely land an egg, their rover should be fine.
- Students should work in mission teams to design, construct and drop a rover.
- Give each student a copy of How to Land Softly on A Hard Planet-Student Direction Sheet.
- Review the directions and expectations.
- Give students materials to start constructing.
- Give each group a balance or access to a balance to determine mass.
- At the end of class, have each group put their design and materials in an envelope or shoe box with their names on the outside.

OPTION 2– You may want to guarantee student lander success by giving them a prescribed system that definitely works.

See the How to Land Softly on A Hard Planet-Option 2 Specific Lander Directions .

DAY TWO

PREP

- Set up your drop zone. This should be the place from which you intend to drop the rovers. If possible, consider dropping outside! Be sure to drop onto a tarp for easier clean-up. Prepare the tarp to look like a large scale of the map students have used throughout the unit. Students will need to place a marker where they hope to land and then see how close they actually get to the location.
- Cut out Fate Cards.

IN CLASS

- Students should work in their mission teams. Hand out the How to Land Softly on A Hard Planet-Student Sheet.
- Ask students to get their landers and take them to the drop zone.
- Measure the drop zone height and have students record this on their How to Land Softly on A Hard Planet-Student Sheets.
- Designate a timer and give that student a stop watch.
- Students should hypothesize the outcome of their first drop and record this on their How to Land Softly on A Hard Planet-Student Sheet.
- Drop the landers one at a time. Depending on your drop zone, you probably want to be the designated dropper.
- Be sure to time each drop.
- After all six have been dropped, walk students through the process to calculate the speed in meters/second using this formula; Speed=distance/time.
- Allow each team to choose a fate card.
- Give the teams a short period of time to redesign their lander.
- Have students hypothesize the outcome for their second drop.
- Repeat the procedure from the first drop
- Have students help you clean up the drop zone.
- Return to the classroom and give each student a copy of How to Land Softly on A Hard Planet-Spirit and Opportunity Lander Information.
- Review the actual data from the current rovers' landing systems.

Teacher Suggestions:

1. Your local fire department may bring a truck and drop your models for you.
2. A member of staff may be willing to drop models from the roof of your school.
3. Make the construction of the "Lander" a homework assignment. Option 2 on pg. 44 of the "MISSION: KSC Space Week Teacher's for Launch Specialists Guide 2007-2008" could be given to the students to complete at home. Completion of the parachute and air bags could be completed in the classroom. Or let the students come up with their own designs. Have extra eggs on hand for those who can't get their egg to school without breaking it.
4. Remember that raw eggs cause illness, so take the proper safety precautions.

Assessment:

- Participation in activity
- Completion of student sheet

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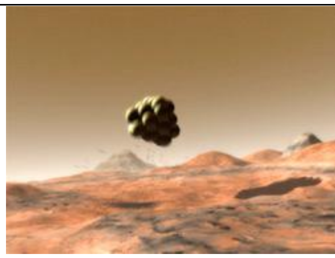
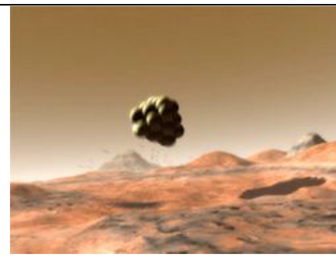
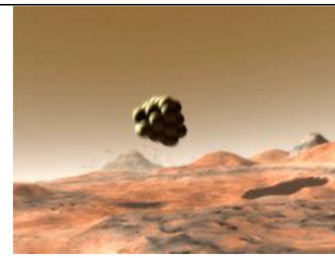
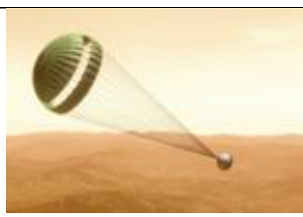
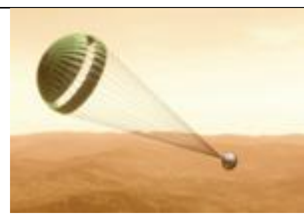
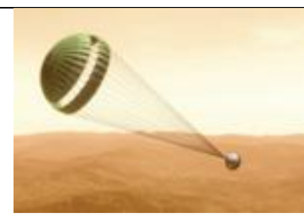
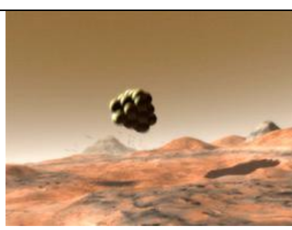
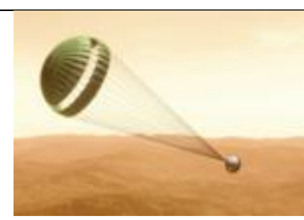
How to Land Softly on A Hard Planet- Fate Cards

 **FATE** One half of your airbags failed to deploy, but your parachute is intact.	 **FATE** One fourth of your airbags failed to deploy, but your parachute is intact.	 **FATE** All of your airbags failed to deploy, but your parachute is intact.
 **FATE** Your parachute and one half of your airbags failed to deploy.	 **FATE** Your parachute and one fourth of your air bags failed to deploy.	 **FATE** Your parachute is in a tangle and all air bags failed to deploy.
 **FATE** Your parachute failed to deploy but all airbags are inflated.	 **FATE** Your parachute deployed but it has a huge hole in it, all airbags are inflated.	 **FATE** Your parachute is a tangled mess but all airbags are inflated.

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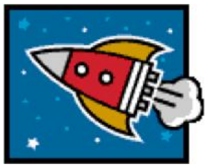

How to Land Softly on A Hard Planet– Student Direction Sheet

Directions: Your mission team must create a landing system that will allow your rover to land safely on Mars. In order to complete this phase of your mission, you need to practice using something other than your rover. Using your rover could lead to extensive damage during the practice phase. Headquarters has determined that if you can drop and land an egg without smashing it, your rover will be safe.

LANDER (the object that cradles your rover safely to Mars)-

1. Design a lander to carry your rover (egg) safely to the surface of Mars using the following materials:
    - Cardboard
    - Tape
    - Scissors
    - Egg
2. Before you place your egg in the lander, measure the lander's area and mass. Record this information on your How to Land Softly on A Hard Planet-Student Sheet.
3. Measure the mass of the egg. Record data.

Spirit and *Opportunity* include the following elements to land safely. You may use any design that you feel will be most successful!

PARACHUTE

1. Design a parachute to slow your descent using ONLY the materials in your envelope.
2. Measure the mass and area (L x W) of your parachute and record on your student sheet.

AIR BAGS

1. Design a cushioned landing for your rover using ONLY the materials in your envelope.
2. Measure the total mass of the cushioning you plan to use on your lander and record.
3. Once your lander is completed and the egg loaded, measure the total mass and record on your student sheet.

DROP

1. Measure and record the height of the drop to the floor/landing.
2. Predict the outcome and time for your first drop and record on your student sheet.
3. Time the drop using a stopwatch.
4. Give your lander to the teacher to drop. Hope your payload survives!
5. Calculate the speed in meters/second using this formula; Speed=distance/time. Record the speed on your student sheet.
6. Draw a fate card from your teacher.
7. By following your fate card, change your lander's design and don't forget to predict the outcome and time before you drop it. Calculate the speed and record it on the student sheet.
8. If your egg survives, design your last test. Predict the outcome and time and then compare the rate and outcome. Calculate the speed and record it on the student sheet.

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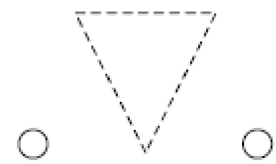
How to Land Softly on A Hard Planet-
Option 2 Specific Lander Directions

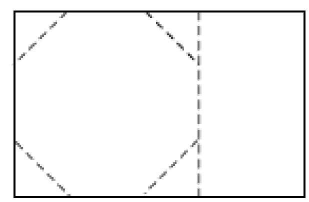
Directions: Your mission team must create a landing system that will allow your rover to land safely on Mars. In order to complete this phase of your mission, you need to practice using something other than your rover. Using your rover could lead to extensive damage during the practice phase. Headquarters has determined that if you can drop and land an egg without dropping it, your rover will be safe.

LANDER

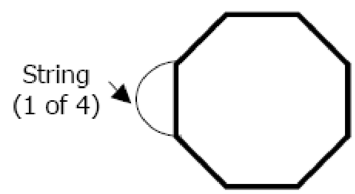


1. Unfold the cereal box.
2. Trace an equilateral triangle (22cm) on a side.
3. Cut out triangle and punch a single hole near each vertex.
4. Fold the triangle (dotted lines) into a tetrahedron to form the lander.
5. Place the egg inside the tetrahedron and tape it closed along each seam.
6. Tie a 1m piece of string through the holes at the vertices.
7. Measure the mass and area of the lander.

PARACHUTE



1. Unfold a large piece of newspaper.
2 Cut off one side of the newspaper form a square (dotted line).
3 Cut off each corner of the square to form an octagon 4(dotted lines).
4. Using four 1m pieces of string, tape each end of each string to the sides of the octagon.
5. Measure the mass and area of the parachute.



AIR BAGS
1. Evenly inflate four 25cm balloons.
2. Tape each balloon to each face of the lander.
3. Tie the four strings on the parachute to the string on the lander.
4. Measure the mass of the airbag system.

DROP
1. Measure and record the height of the drop to the floor/landing
2. Predict the outcome and time for your first drop.
3. Time the drop using a stopwatch
4. Drop your lander to see if your payload survives!
5. Calculate the speed in meters/second using this formula; S=d/t. Record the speed on your student sheet.
6. By following your fate card, change your lander's design and don't forget to predict the outcome and time before you drop it. Calculate the speed and record it on the student sheet.
7. If your egg survives, then you design your last test. Predict the outcome and time and then compare the rate and outcome. Calculate the speed and record it on the student sheet.

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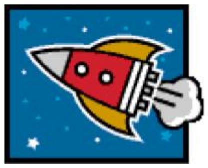

How to Land Softly on A Hard Planet-Student Sheet

Names of team members: ____

____

Directions: Record all data below.

Mass of lander=__________

Mass of egg=__________

Mass of parachute=__________

Mass of cushioning material=__________

Total mass of lander=__________ (add together the mass of lander, egg, parachute, and cushioning material)

Area of parachute=_____________

Circle = 3.14 x radius2
Rectangle or square = base x height
Triangle = 1/2 base x height

Drop Height=______________________

As each team drops their landing system, complete the information in the chart below. To find the speed of each landing system, you will need to multiply the distance dropped by the number of seconds it takes to fall. You might want to **bring a calculator**!

Group	Predicted Time	Actual Time	Sketch of Lander **(Label Geometric Shapes)**	Total Mass of Lander	Speed Calculation **(distance x time)**	+\- Did it survive?
1						
2						

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Group	Predicted Time	Actual Time	Sketch of Lander **(Label Geometric Shapes)**	Total Mass of Lander	Speed Calculation **(distance x time)**	+\- Did it survive?
3						
4						
5						
6						
7						
8						

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Respond to the following:

1. Describe your fate card. How did you change your design in response?

2. If you were able to make a third design, what did you change? Why? Were you successful?

3. Comparing the rate of fall for each of your tests, what did you discover?

4. Using the information about the actual lander, what would/could you recommend to improve your design to better ensure a "safe" landing?

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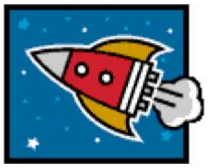

How to Land Softly on A Hard Planet-
Spirit and Opportunity Lander Information

- It takes only 6 minutes from the time the rover enters the Martian atmosphere at 19,300km/h and is slowed to 0km/h for a safe landing.

- Lander parachute is 40% larger than Pathfinder's due to the increased weight of the Rovers. (10.6kg=23lbs) vs. (174kg=384lbs) Deployed at 9000 meters.

- The parachute alone could not slow it down enough to ensure a safe landing. It slows it from 400m/sec to 85m/sec.

- Rovers must have RAD rockets (Rocket assisted descent) to further slow the descent to the Martian surface due to atmospheric density being **less than 1%** of Earth's.

- These RAD rockets will virtually bring the spacecraft to a dead stop 10-15 meters above the Martian surface so that it then is in free-fall and breaks from the tether.

- Gravity and the airbags will do the rest. The rover could bounce/roll up to 1km