Touchdown Challenge

DESCRIPTION
Students will design and build a shock-absorbing system that will protect two "astronauts" when they land.

OBJECTIVES
Students will follow the engineering design process to:
- Design and construct a shock-absorbing system out of paper, straws, and mini-marshmallows
- Construct a shock absorber to attach to a cardboard platform
- Evaluate and improve their design based on testing results

NASA SUMMER OF INNOVATION

UNIT
Engineering Challenges
Physical Science

GRADE LEVELS
4th -6th

CONNECTION TO CURRICULUM
Potential and Kinetic Energy, Acceleration due to gravity, Air Resistance, Measurement

TEACHER PREPARATION TIME
15-30 minutes

LESSON TIME NEEDED
60 Minutes *Level: Basic*

NATIONAL STANDARDS

National Science Education Standards (NSTA)
Physical Science
• Properties of Objects and Materials
• Position and Motion of Objects
• Motion and Forces
Science and Technology
• Abilities of Technological Design

Common Core State Standards for Mathematics (NCTM)
Measurement and Data
• Represent and interpret data

ISTE NET Performance Indicators for Students (ISTE)
Creativity and Innovation
Students:
- apply existing knowledge to generate new ideas, products, or processes
- create original works as a means of personal or group expression
- use models and simulations to explore complex systems and issues
- identify trends and forecast possibilities

Critical Thinking, Problem Solving, and Decision Making
Students:
- identify and define authentic problems and significant questions for investigation
- plan and manage activities to develop a solution or complete a project
- collect and analyze data to identify solutions and/or make informed decisions
- use multiple processes and diverse perspectives to explore alternative solutions

MANAGEMENT

Read the challenge sheet and leader notes to become familiar with the activity. Gather the materials ahead of time and set them up in a central location for student access. Fold an index card into a spring to demonstrate the use of springs as "shock absorbers."

CONTENT RESEARCH

Potential and kinetic energy—When the lander hits the surface, its motion (kinetic) energy is changed into stored (potential) energy, which gets stored in the shock absorbers.
Acceleration due to gravity—The lander accelerates (speeds up) as it falls due to Earth's gravitational pull.
Air resistance—Air exerts a force on the lander as it falls, slowing it down.
Measurement—Kids measure the various heights from which they drop the lander.
Misconceptions: Students may have difficulty recognizing the lack of air resistance on the moon due to the lack of an atmosphere. It is important to compare Earth and the moon to allow students to research how they might modify their designs for use on the moon or even other planets like Mars to account for different atmospheric conditions.

MATERIALS

- 1 Piece of stiff paper or cardboard (approximately 4 x 5 in/10 x 13 cm)
- 1 Small paper or plastic cup
- 3 Index cards (3 x 5 in/8 x 13 cm)
- 2 Regular marshmallows
- 10 Miniature marshmallows
- 3 Rubber bands
- 8 Plastic straws
- Scissors
- Tape

LESSON ACTIVITIES

- Introduce the challenge: Ask students why a spacecraft that can land gently is important for getting astronauts to and from the moon safely.
- Brainstorm and design: Students should be working in cooperative groups to develop a group design and using individual journals to record their decisions, design sketches, test results, etc.
- Build, test, evaluate, and redesign: Test data, solutions, modifications, etc should all be recorded in their journals individually.
- Discuss what happened: Have the students show each other their landers and talk about how they solved any problems that came up.
- Evaluation: Using the student's journals, assess their mastery of content, skills, and the engineering design process.

The "Touchdown" activity is located in the *On the Moon Educator Guide*, which contains engineering activities. http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/OTM_Touchdown.html

ADDITIONAL RESOURCES

- Lunar Reconnaissance Orbiter (LRO) Mission Page: http://www.nasa.gov/mission_pages/LRO/main/
- Lunar Crater Observation and Sensing Satellite (LCROSS) Mission Page: http://www.nasa.gov/mission_pages/LCROSS/main/

DISCUSSION QUESTIONS

- What kind of shock absorber can you make from these materials to help soften a landing? *Mini-marshmallows can serve as soft footpads. Cards can be folded into springs. Straws can provide a flexible structure. Rubber bands can flex and hold things together.*
- How will you make sure the lander doesn't tip over as it falls through the air? *Making the parts below the platform weigh more than the parts on the top helps the lander fall straight down. Also, it helps to evenly distribute the weight on top of the platform.*
- What forces affected your lander as it fell? *It accelerated [sped up] as it fell due to the pull of gravity. Air also pushed on it, and this air resistance slowed it down.*
- After testing, what changes did you make to your lander? Did your modifications improve the lander design and enable your design to meet the challenge? *Answers will vary.*
- Engineers' early ideas rarely work out perfectly. How does testing help them improve a design? *Testing helps you see what works and what doesn't. Knowing this lets you improve a design by fixing the things that aren't working well or could work even better.*

- What did you learn from watching others test their landers? *Answers will vary. But in general, kids will see that there are many ways to successfully tackle a challenge.*
- The moon is covered in a thick layer of fine dust. How might this be an advantage? A disadvantage? *If the dust layer is soft, it would help cushion a landing. However, if it is too soft, a lander could sink into it and get stuck. Also, the lander's rocket engine could send up clouds of dust, which could get into the machinery and cause it to jam or malfunction.*
- The moon has no atmosphere, how would you modify your lander to land softly on the moon's surface without the force of air resistance to slow your lander as it lands? *Answers will vary.*
- If astronauts visit the moon again in the future to stay for long periods of time what resources would they need to survive in the extreme environment? What invaluable resource were LRO and LCROSS able to find on the moon's surface? How would you assess the information gathered from LRO, LCROSS and other NASA moon missions to justify where astronauts should land? *Answers will vary.*

ASSESSMENT ACTIVITIES

Journaling is a valuable tool for engineers as they prepare and test designs to solve complex problems and meet challenges. Students should record their brainstorming session ideas, labeled and annotated sketches of their prototype designs, test results, modifications to their designs with sketches, photos, and group solutions that allow them to meet the challenge in a journal. They should also record any science, math, engineering, or technology content that is connected to their work or that they used to meet the challenge. The journal should be used as a formative and summative assessment tool.

ENRICHMENT

How high can you go contest: Students drop their landers from two feet. Eliminate all landers that bounce out their "astronauts." Next, raise the height to three feet. Continue in this fashion until a winner emerges. You can also increase the challenge by having kids add a third marshmallow "astronaut" to their cups.

Test springs of different sizes: Have kids see if the number of folds in an index card makes a difference in the amount of force the spring can absorb. Have them fold index cards with two, four, and six folds. Have them test to see how much of a difference these springs make in how softly a lander touches down.