On Target Challenge

LESSON THEME
Students will modify a paper cup so it can zip down a line and drop a marble onto a target.

OBJECTIVES
Students will
- Apply the engineering design process
- Modify a cup to carry a marble down a zip line
- Test their cup by sliding it down the zip line, releasing the marble, and trying to hit a target on the floor
- Improve their system based on testing results

NASA SUMMER OF INNOVATION

UNIT
Engineering—Challenges

GRADE LEVELS
7 – 9

CONNECTION TO CURRICULUM
Newton's First Law, Potential and Kinetic Energy, Acceleration Due to Gravity, Vectors, Trajectory, and Measurement

TEACHER PREPARATION TIME
15 to 30 minutes

LESSON TIME NEEDED
1 hour *Level: Basic*

NATIONAL STANDARDS

National Science Education Standards (NSTA)
Science as Inquiry
- Understanding of scientific concepts
- Understanding of the nature of science
- Skills necessary to become independent inquirers about the natural world
- The dispositions to use the skills, abilities, and attitudes associated with science

Physical Science Standards
- Position and motion of objects

Common Core State Standards for Mathematics (NCTM)
Expressions and Equations
- Apply and extend previous understandings of arithmetic to algebraic expressions
- Solve real-life and mathematical problems using numerical and algebraic expressions and equations
- Understand the connections between proportional relationships, lines, and linear equations

ISTE NETS and 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. Set up a sample zip line. Put a handle and paper clip on a cup, that is, do not make a door or platform for the marble.

CONTENT RESEARCH

Newton's First Law—As it travels down the zip line, the marble builds up a forward speed. Once launched, it will keep going at that speed until a force acts on it, such as hitting the ground.
Acceleration—Due to Earth's gravitational pull, the marble's speed increases as it falls.
Vectors—Marble's motion has both a horizontal and a vertical component, and these motions can be represented in a vector diagram.
Trajectory—When an object that is already moving horizontally is dropped (like a marble dropped from a cup moving down a zip line), it travels in a curved path, called a trajectory.
Potential and kinetic energy—Marble's stored (potential) energy changes to motion (kinetic) energy as it falls.
Measurement—Students measure to make the zip line. They also measure the height from which their marble is dropped and how far it lands from the target.

Misconceptions: The most common misconception of Newton's First Law is the idea that sustaining motion requires a continued force. Students should have opportunities to investigate the effects of net forces on objects prior to or after the challenge. A net force (an unbalanced force) causes an acceleration of an object; the acceleration is in the same direction as the net force. For example, slide a book across a table and watch it slide to a rest position. The book in motion on the table top does not come to a rest position because of the *absence* of a force; rather it is the *presence* of a force—that force being the force of friction—that brings the book to a rest position. In the absence of a force of friction, the book would continue in motion with the same speed and direction forever (or at least to the end of the table top).

MATERIALS
(per zip line)

- 9 feet (3 m) of smooth line (e.g., fishing line or kite string)
- Index card
- Marble
- Masking tape
- Paper clip
- 1 medium-sized paper cup
- Scissors
- Target drawn on a piece of paper

LESSON ACTIVITIES

- Introduce the challenge: Tell kids how NASA will use the LCROSS spacecraft to search for water on the Moon (scripted in the Leader Notes).
- 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: Ask the students to show each other their modified cups and talk about how they solved any problems that came up.
- Evaluation: Using the students' journaling, assess their mastery of content, skills, and the engineering design process.

http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/OTM_On_Target.html

ADDITIONAL RESOURCES

Print a picture of the Lunar Crater Observation and Sensing Satellite (LCROSS) from the LCROSS Web site at https://www.lcross.arc.nasa.gov/

Lunar Reconnaissance Orbiter (LRO) Mission Page
http://www.nasa.gov/mission_pages/LRO/main/

LCROSS Mission Page
http://www.nasa.gov/mission_pages/LCROSS/main/

DISCUSSION QUESTIONS

- How will you modify the cup so it can carry a marble down a zip line and also drop it onto a target*? If the marble rides inside the cup, students need to cut a door. If it rides outside the cup, students need to make a platform, shelf, or holder. All systems need a way to tip the cup at the right instant.*
- How will you remotely release the marble from the cup? *Attaching a string on the uphill side of the cup, opposite the door or platform, will enable the students to tip the cup effectively.*
- When do you need to launch the marble so that it will hit the target? *Kids should stand near the top of the zip line, holding one end of the string. When the cup reaches the "drop zone," students should jerk the string. The marble will be ejected and fall toward the target. NOTE: When dropped, the marble keeps moving forward as it falls. Students will need to factor in this forward motion as they decide when to release the marble.*
- What parts of your design were most important in getting the marble to hit the target? *Getting the marble to eject cleanly from the cup and the timing of release are important.*
- After testing, what changes did you make to your cup? *Answers will vary.*
- Describe the way your marble moved after you ejected it. *It moved both downward and forward. This combination produced a curved path called a trajectory.*
- Newton's First Law states that an object in motion continues in straight-line motion until acted on by a force. How did today's activity demonstrate Newton's First Law? *As it traveled down the zip line, the marble built up speed. Once launched, it kept going at that speed until a force, such as gravity pulling it down or the floor stopping it, acted on the marble.*
- How is your challenge similar to NASA's LCROSS mission to the Moon? *Both you and NASA devised a system that caused something to crash into a surface. Also, both setups have a remote triggering device, although LCROSS's is radio controlled. Finally, both the marble and the spacecraft have a forward and downward component to their motion.*
- If astronauts visit the Moon for long periods of time, what resources would they need to survive in the extreme environment? *Water, oxygen, food, and shelter.*
- What invaluable resource were LRO and LCROSS able to find on the Moon's surface? *Water.*
- 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

Watch a video about LCROSS. The LCROSS Web site has a 4-minute-long video that describes the mission and uses animation to show what happens when LCROSS strikes the Moon's surface. Watch it online at http://lcross.arc.nasa.gov/.

Analyze an object's motion as it follows a trajectory. To show that an object's speed is constant as it follows a trajectory (a curved path), take a video of the marble falling from the cup. Play it back on a television or computer one frame at a time. Tape a transparency to the television or computer screen, and make marks from frame to frame, measuring the horizontal distance traveled by the marble each time. Kids will see that the distance traveled in each frame is constant. Alternatively, have your kids try the Projectile Motion interactive at www.teachersdomain.org. Type "projectile motion" into the Teachers' Domain "search" box.