

## Major Project: Engineering Design Challenge Introduction:

### A NASA DESIGN SQUAD CHALLENGE: ON TARGET

I selected the activity "On Target" for the Engineering Design Challenge. This activity is part of both the [PBS Kids Design Squad](#) and the [NASA Jet Propulsion Laboratory](#). The challenge is to modify a paper cup to zip down the zipline and drop the marble into the target. Students will document this activity in the engineering design notebook and am planning to do this activity with students before school ends, if possible.

**Source:** [Build | On Target. DESIGN SQUAD GLOBAL](#)  
NASA JPL -[Educator Guide: On Target](#)

#### 1. Identify the "Big" concept to be covered by the engineering design challenge.

**STEM integration:** Engineering, design process, measurement, trajectory motion and forces, energy transfer of Energy, conservation of energy (6-12)

**Overview:** In this lesson, teams of students will explore the engineering design process by modifying a paper cup to carry a marble down a zip line and drop it precisely on a target. Students will follow the engineering design process to modify a cup to carry a marble down a zip line, attach a string to tip the cup, test their cup by sliding it down the zip line, release the marble, and try to hit a target on the floor. Based on the testing results, they will improve their system and retest. Through this iterative process, they will learn to brainstorm, test, evaluate, and redesign their devices to improve accuracy. Students will be encouraged to be creative and think outside the box while working collaboratively as a team.

**Challenge involves: Brainstorm and Design, Build, Test, Evaluate, and Redesign**

Extension: How was this challenge similar to NASA's LCROSS mission to the moon?

#### 2. Research appropriate learning standards associated with the topic.

**Next Generation Science Standards** HS-ETS1-2, MS-ETS1-2

**Common Core State Standards for Mathematics** : HSN.VM.A.3

**International Technology Education Association Content Standards** (Grades 6 -12)

#### Design

- Standard 8: Students will develop an understanding of the attributes of design
- Standard 9: Students will develop an understanding of engineering design

- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving

### **Abilities for a Technological World**

- Standard 11: Students will develop abilities to apply the design process
- Standard 12: Students will develop abilities to use and maintain technological products and systems
- Standard 13: Students will develop abilities to assess the impact of products and systems

### **The Designed World**

- Standard 16: Students will develop an understanding of, and be able to select and use, energy and power technologies

### **National Council of Teachers of Mathematics Standards (6-12)**

#### **Problem Solving**

- Build new mathematical knowledge through problem solving
- Solve problems that arise in mathematics and in other contexts
- Apply and adapt a variety of appropriate strategies to solve problems

#### **Algebra**

- Represent and analyze mathematical situations and structures using algebraic symbols

#### **Measurement**

- Understand measurable attributes of objects and units, systems, and processes of measurement
- Apply appropriate techniques, tools, and formulas to determine measurement

**ISTE** : Empowered Learner , Innovative Designer, Creative Communication

### **3. Identify and discuss the different types of problem-solving and declarative/procedural knowledge needed.**

As per the principles of teaching problem-solving article by [Kirkley](#), "When teaching problem solving, authentic problems in realistic contents are essential." Both declarative and procedural knowledge must be integrated in the process of problem-solving.

**Declarative knowledge:** Students need to know facts, concepts, and principles with content-specific knowledge. Students will be introduced to the challenge and taught about the NASA Lunar Crater Observation and Sensing satellite LCROSS, which had to hit the crater to look for water. Students must have background knowledge which is vital for problem-solving, including knowledge about Newton's First Law, acceleration, vectors, trajectory, potential and kinetic energy, and measurement.

**Procedural Knowledge:** This challenge comes under moderately structured problems because it requires varying strategies and adaptations to hit the marble on target in the zipline. Students need to gather information and require multiple pieces of declarative knowledge. Learners will invent a plan or system to hit the target, test solutions numerous times, and optimize their solutions.

**Extension for far transfer of knowledge:** Introduce the challenge to students and discuss how NASA sent the Lunar Crater Observation and Sensing satellite LCROSS to search for water on the moon. The satellite had to hit a crater near the moon's south pole, and scientists studied the plume thrown up by collisions for signs of water. Additional pictures and [animations](#) of LCROSS can supplement this learning. )  
[GMS: LRO/LCROSS Launch, Deploy, and Mission Animation](#)

#### **4. Explore objectives and ancillary concepts/content covered by the project.**

##### **Learning objectives:**

Students will use the engineering design notebook and will use the iterative engineering design method for problem-solving.

1. Students will work in cooperative groups to follow the engineering design process by modifying a cup to carry a marble down a zip line, drop it on a target, testing their system, and improve their strategy based on test results.
2. Students will discuss what happened, how they solved problems that arose, and what parts of their design proved vital in getting the marble to hit the target.
3. Students will describe how the marble moved after it was ejected (trajectory).
4. Students will relate their projects to Newton's First Law (an object in motion continues in a straight line unless acted upon by force).
5. Extension: How was this Challenge similar to NASA's LCROSS mission to the moon? Students can view a 4-minute conceptual animation of LCROSS [GMS: LRO/LCROSS Launch, Deploy, and Mission Animation](#), which also involved a remote-controlled system devised to cause something to crash precisely into a surface using trajectory calculations.
6. Students will analyze an object's motion as it follows a trajectory.
7. To show that an object's speed is constant as it follows a trajectory (a curved path), students will record a video of the marble falling from the cup and play it back on a TV or computer one frame at a time. They will tape transparency to the

TV or computer screen and make marks from frame to frame to measure the horizontal distance traveled by the marble each time, which should be a constant distance per frame.

**5. Identify possible activities.: Document everything on the engineering design notebook**

1. Introduce the Challenge—identify the problem, rules, and constraints.
  - a. Students cannot make a door or platform for the marble.
2. Show students the zip line
  - a. Hang the cup on the zipline, using a hook made of a paper clip. Show the students how the cup travels down the zipline, and tell them that just like NASA, their success depends on hitting on the target.
3. Have the students brainstorm possible solutions and sketch designs on the challenge sheet on the EDP notebook.
4. Have students build, test, evaluate, and redesign for optimized solutions by following directions for building from the challenge sheet.
5. Facilitate a discussion with the students about the process.

**6. Select the best activity for your classroom. - “On Target”**

I selected "On Target" as the best activity for my classroom because earth science is in our curriculum, which fits well with this activity because planetary motion, gravity, trajectory, Kepler's Law, and Newton's First Law are already concepts we discuss, and intersecting earth science and engineering design can help reinforce these concepts. Also, this activity incorporates collaboration and teamwork to optimize and troubleshoot solutions, which is essential in the professional world. This activity also fits well with the NASA's Best engineering design model, and the connection to NASA's LCROSS allows for meaningful real-world applications of the concepts.