AUDIENCE WITH AN ASTRONAUT
SPACE FOUNDATION

STEM ACTIVITY LESSON

ENGINEERING DESIGN CHALLENGE - MARS ROVER ARM

Grade Level
6th - 12th

Focus Areas
Engineering and Problem-Solving

Standards
MS-ETS1-1 | HS-ETS1-2

BACKGROUND INFORMATION

Many rovers have been sent to Mars to explore its surface. The latest rover, Perseverance, is specifically designed to collect samples and search for signs of past life. It is equipped with a main robotic arm that includes five electrical motors and five joints. Measuring 7 feet (2.1 meters) long, the arm allows the rover to work as a human geologist does: by holding and using science tools, just like a "hand." The rover's arm also includes high-definition cameras, science instruments, and a percussive drill and coring mechanism. Those tools are used to analyze and collect samples of Martian rock and soil, which are stored on the Martian surface for return to Earth on a future mission.

STUDENT REAL-LIFE CONNECTIONS

- Have you ever tried to tie your shoes without using your thumbs? Or eat with your non-dominant hand? What was difficult about it?
- What kinds of tools do you use that help you grab or hold things? If you didn't have them, how would you still complete the task?

LESSON OBJECTIVES

- Design and build a rover arm prototype so that it can scoop and collect samples.
- Apply the engineering design process to solve a real-world problem inspired by Mars exploration.

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STEM ACTIVITY LESSON

EDC - MARS ROVER ARM

MATERIALS

LIST

- Junk Building Materials: cardboard, plastic straws, string, rubber bands, tape, glue, scissors, small cups, plastic spoons, and possible wheels or levers to help operate scooping mechanism
- Scratch paper and pencils
- Small objects to simulate "samples" (marbles, small rocks, beans)
- 4-6 containers for sample collection
- Engineering Design Challenge Worksheet

ACTIVITY

DIRECTIONS

Prepare

- Gather junk building materials, small objects to act as samples, and containers.
- Print out Engineering Design Handout, one (1) per group of five (5) students.

Excite

- Watch a short clip about Perseverance and how robots on other planets help us collect samples to study soil composition: NASA Mars Perseverance Rover Sample Collection Animation (https://www.youtube.com/watch?v=IAj9tXZyqS8).
- Discuss: What do you think are some challenges engineers face when designing a rover to collect samples in an unknown environment? Why would we want to collect samples on another planet?
- Pose the question: "How would you design a rover arm to scoop up and collect samples?"
- Briefly introduce the Engineering Design Process (Ask, imagine, plan, create, test, improve) .

Explore

- Group students into teams of five (5).
- Present the Engineering Design Challenge and goal to the students: Working in teams of five (5), your challenge goal is to design and build a rover arm that can move and scoop up at least three (3) samples (a rock or small object) and deposit it into a pre-determined collection area.
- Begin the Engineering Design Process together by starting with "Ask" - what questions do students have about the science content, design constraints, and testing conditions to successfully design and build a robotic arm that can fulfill the goal? Spend about 5 minutes answering the questions and writing down key terms for all to see throughout the challenge.
- Provide students one (1) silent minute to individually brainstorm ideas they have for a rover arm design. Provide scratch paper and pencils for students to draw or write down their independent ideas only, no discussions with their team just yet.

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STEM ACTIVITY LESSON

EDC - MARS ROVER ARM

ACTIVITY

DIRECTIONS (CONTINUED)

Explore (Continued)

- Provide teams five (5) minutes to discuss and collaboratively create a design for their team's rover arm. Ensure they label the design drawing, identifying the materials they'll use and how the parts will work together.
- Provide teams twenty (20) minutes to build their prototype using the provided junk engineering materials. The rover arm should be capable of scooping objects and placing them in designated containers. If you want to add in constraints to the design process, such as a limited number of supplies per team, you may do so.
- Conduct the testing session as a whole class, with each team presenting their design process, then performing the test. They can attempt to collect three (3) samples and deposit them into a collection container.

Explain

- After testing, gather the class to discuss the challenges they faced during testing. Ask, "What worked well? What didn't? What did you notice about other teams' designs that you liked?"
- Provide an additional ten (10) minutes for teams to improve their designs based on the test results. Encourage them to think about how engineers improve their prototypes through iteration.
- Conduct a second testing session as a whole class, with each team taking turns to test their improved designs. Identify how each team successfully completed the challenge, whether through a successful design or great collaboration, creativity, and problem-solving. Conclude the lesson with reviewing the Engineering Design Process cycle and how important it is to engineers when solving problems.

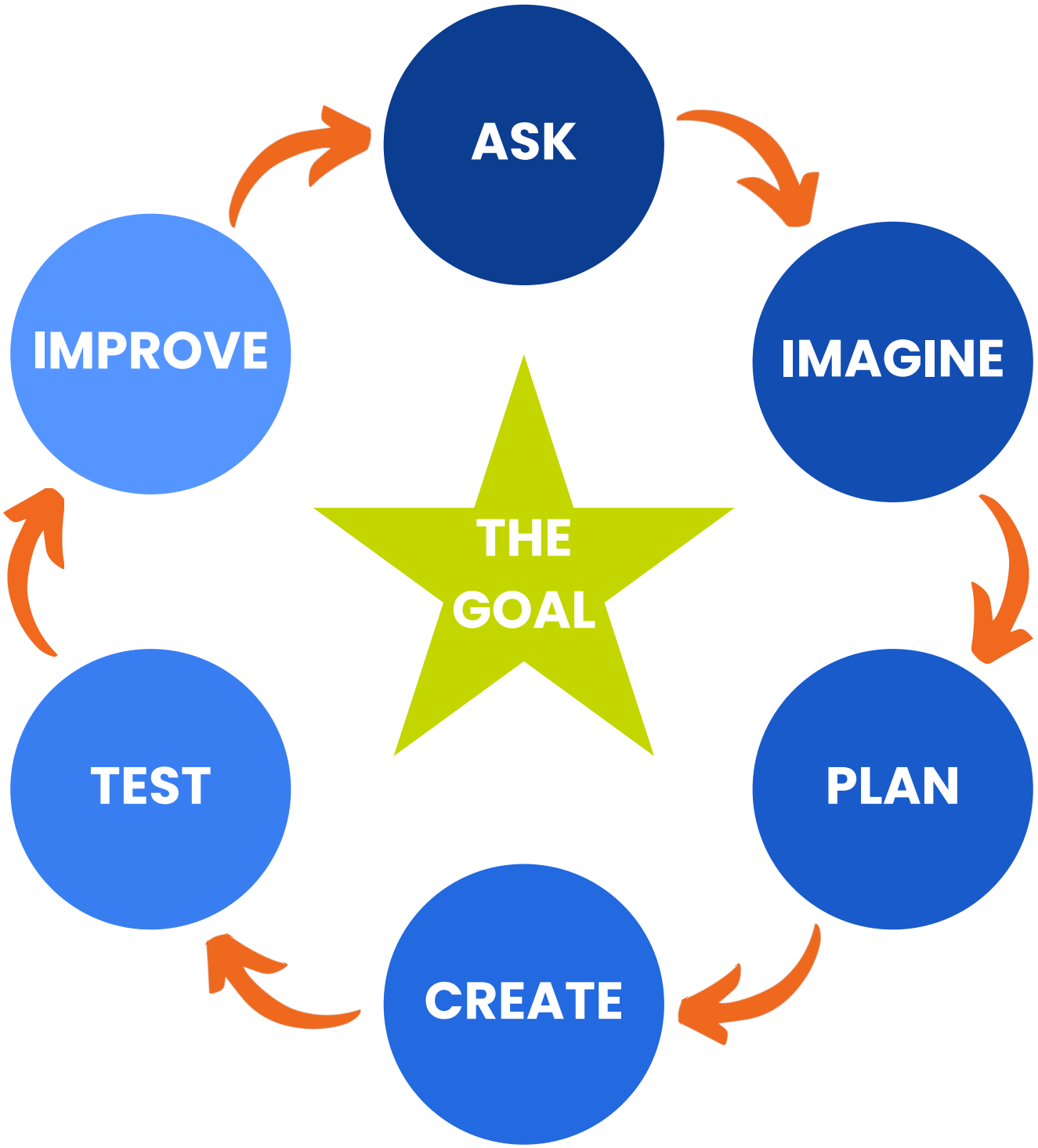
Extend / Expand

- Connect the activity to real-world careers in robotics, space exploration, and mechanical engineering.
- Have students research current NASA rover missions and compare their designs to the real rovers exploring Mars today.

STUDENT WORKSHEET

EDC - MARS ROVER ARM

THE ENGINEERING DESIGN PROCESS



STUDENT WORKSHEET

EDC - MARS ROVER ARM

ENGINEERING DESIGN CHALLENGE WORKSHEET

Team Member Names: _____

Directions:

1. Follow the Engineering Design Process to create a rover with an arm that can successfully scoop up and collect the target 'samples'. Use this sheet to record your notes and observations throughout the process.

Ask: What information do you need to design a rover arm that can scoop and collect samples? Ask questions about science content, design constraints, and testing conditions.
Imagine: Brainstorm possible designs for the rover arm and the scooping mechanism. Sketch different ideas and think about how the arm will operate (e.g., levers, pulleys, or strings).
Plan: Decide on a design you want to build, create a labeled drawing of your rover, identify the materials you'll use and how the parts will work together. **Sketch the final design here:**

STUDENT WORKSHEET

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ENGINEERING DESIGN CHALLENGE WORKSHEET

Create: Work together to build the prototype, using the provided materials. The rover arm should be capable of scooping objects and placing them in designated containers.

What materials did you end up using in your final design?
Write them down here:

Test: Once the rover arm is built, test your design by attempting to collect 3 samples and deposit them into a collection container.

Test #1 Observations:

Improve: What worked well? What didn't? How would you improve your rover arm to be more successful?

Test #2 Observations: