Rover Relays

Overview:
Campers will get a sense of the challenges faced by the Mars Rover teams and an introduction to the Engineering Design Process as they simulate programming a rover. The objective is to obtain as many rock samples as possible within the time limit. Some campers will be drivers and will provide the directions to the rover. Other campers will act as the rover and will follow the directions exactly as they receive them.

Counselors are encouraged to adjust each of the elements to the campers' level of understanding and physical ability.

Time Recommended	Locations
40-50 min	inside or outside At least 15' x 15' spaces

Materials:

- Rock samples (5 per team)
- Obstacles
- Rock Sample Storage* (a bag)
- Grabber arms (1 per team, optional but fun!)
- Direction Cards
- Job cards
- Computer with internet access (optional)

Preparation:

- Make and assemble materials:
    - Rock Samples: these are the objects the campers will pick up. Something easy to see is ideal, but anything that's easy to pick up with one hand or a grabber arm works (Large pom pom balls, rocks, balls, or similar)
    - Obstacles: objects that the rovers must go around. They do not need to be real obstacles: hula hoops, mats, etc, would all work.
    - Direction Cards: Print provided cards, or draw the following on squares of paper. You'll want at least 5 arrows, 1 stop, and 1 rock sample card per team. For older campers, consider increasing the number of cards so the drivers can create more complex directions for their rovers.

        - straight arrows (campers can rotate the square papers so the arrows can indicate any direction)
        - stop
        - rock sample
    - Job cards: print or write the jobs on papers.
- Clear as much space as possible in the room if inside, or find areas outside that are at least 15' x 15'. If you would like to have multiple teams go at once, use tape or rope to divide the space into two Exploration Zones (areas where each rover team may collect samples) and place half of the obstacles and rock samples in each zone, keeping in mind the size and skill of the campers and keeping each side roughly the same level of difficulty as the other. Be sure all obstacles are at least 3 child-sized steps away from each other.

Introduction (10-15 Minutes):

- Ask campers what they know about exploration on other planets. How do we know so much about Mars, even though no human has been there yet? Rovers! A rover is a remote-controlled vehicle that explores places that humans cannot get to, and takes photographs and gathers information about the surface. So far, there has been Pathfinder, Spirit, Opportunity, and Curiosity. Perseverance will launch for Mars this summer (launch window is July 17 - August 11).
- If you have access to a computer, show parts or all of these videos, depending on time and interest level. If no computer access, tell them about Spirit (see Wikipedia link below)
    a. Free Spirit- Plotting an Escape http://www.jpl.nasa.gov/video/details.php?id=877 (Follow up information, if students are interested- this video is from 2009- https://en.wikipedia.org/wiki/Spirit_(rover)#Sand_trap - they were not able to free Spirit, but even though this meant the end of the program, it was not a failure, but a huge success. It was only supposed to last 90 days, but ran for 6 years.)
    b. Rover Rocker Rocker-Bogie http://www.jpl.nasa.gov/video/details.php?id=932
- Explain the challenge:
- Campers will be in groups of 4. 3 will work if needed- just have one driver, not two. If you have a group of 5, you can have 3 rover parts by adding a Computer who will read the cards to the Motor.
- They will have 3 - 5 minutes (determine time based on age and amount of time available) to collect as many of the rock samples as possible.
- Explain that NASA rover drivers create a series of commands to direct the rover and then send them to the rover. It takes 8-20 minutes for the signal to travel from Earth to Mars, and once it is received, it cannot be changed, so they send

the directions in small groups to minimize mistakes. This activity will demonstrate some of the complications humans (engineers) must overcome to allow for accurate communication to rovers on another planet.

- Each group will have two drivers (engineers) and two rover parts, the motor and the sample retrieval arm (to choose their role, each camper pulls a job card without looking. If there is extra time after, they can switch roles and try again).
- The drivers will create a set of instructions to direct their rover to one rock sample at a time. They will use the arrow, stop, and rock cards to tell the Rover what to do. Each arrow means one step. Demonstrate one set of instructions. When the rover completes a set of instructions, the Drivers collect the cards and create a new set of instructions.
- The obstacles represent rocks or craters too big for the Rover to travel over safely. The Rover cannot touch them at all. Each time the Rover touches an obstacle, it must immediately stop. The Drivers will need to create new instructions to free the Rover and help it continue to its destination.
- Other Rules: The Drivers can only communicate with the Rover through the cards. They cannot talk to them at all (after all, we can't just call Curiosity for a chat)! The Rover parts stand with the motor in front and the sample retrieval arm behind, with one arm on the motor's shoulders. They cannot separate while in motion. The Drivers must move away from the Rover while it is in motion, but may stay close enough to collect the cards quickly when they finish the instructions. The Rover must do exactly what the cards say, even if it means they walk into an obstacle (if you have trouble with this rule not being followed, you could make the Rover look up while moving to make it harder for them to know if they're going to hit an obstacle). The Sample Retrieval Arm cannot move his/her feet when trying to pick up a rock.

Activity (20 - 25 Minutes):

- Put all campers into groups. Let them name their Rover team (you can remind them that the Mars rovers are Spirit, Opportunity, Pathfinder, Curiosity, and Perseverance if they need inspiration). Put the Rover team names on the board or easel paper, and add their scores later.
    - Two groups can go at the same time. The counselor will likely need to remind groups of the rules, especially in the first round and will want to engage the campers who are waiting for their turn (encourage them to cheer everyone on, and remind them that by watching closely, they can learn some tips to help them when it's their turn).
- In between rounds, you might choose to rearrange the course slightly so they can't simply repeat what the previous group did, especially if you have a really

clever group. But, take care not to make the course easier or harder when you change it.
- Whichever team gathers the most rocks (or has the most points, if you use the color variation below) wins!

Variations: To increase the challenge, only let the rover hold the grabber in one hand (no switching sides) and add the rule that the rock must be on the same side of the rover as the grabber. You can also make different colored rocks worth more (ex- put a blue pom pom in a trickier spot and make it worth 10 points, while all others are worth 5).

Conclusion (10 minutes)
- What you just did is a lot like how NASA engineers communicate with rovers on Mars. Engineering allows us to solve human problems using science and technology. What were some challenges you had? How did you solve them?
- Engineers have challenges all the time (remind them of the problems Spirit had). They use the Engineering Design Process to problem solve. A simplified explanation of the process is: Identify the problem, figure out a possible solution, make a plan, test the plan, make a new plan based on how the test went (design, build, test, improve). (Younger campers: simply discuss the idea that engineers and scientists don't give up the first time something goes wrong- they use what they've learned to try again and again and again until they succeed). Campers may realize that this is similar to the scientific method. How did the drivers use the Engineering Design Process during the races?
- Talk about what made the teams successful. Who collected more rocks, teams who went quickly and tried to do a lot at once, or teams who tried to be accurate? What would they change if they could do it again? Real planetary rovers have to coordinate using the available power and getting as much done as possible, but have to be careful that the risk to the rover is not too great. A rover isn't useful if it's been driven into a deep crater and can't move anymore!
- Extension: Have campers journal about the activity. They can describe how their rover team did- what was hard, what did they do well, how did they improve? They could draw a map of their course and show how their rover navigated it.

*CHIMRA Device
If you would like to be very fancy and use correct terminology, you can call the rock bag a CHIMRA Device. CHIMRA stands for Collection and Handling for In-situ Martian Rock Analysis and is the device on Curiosity that handles rock samples. It's pronounced like the word chimera (kīˈmirə). In situ means "in place or on site."

-Article about CHIMRA specifically, with an illustration: CHIMRA: Scoops, Sieves and Delivers Samples

DRIVER

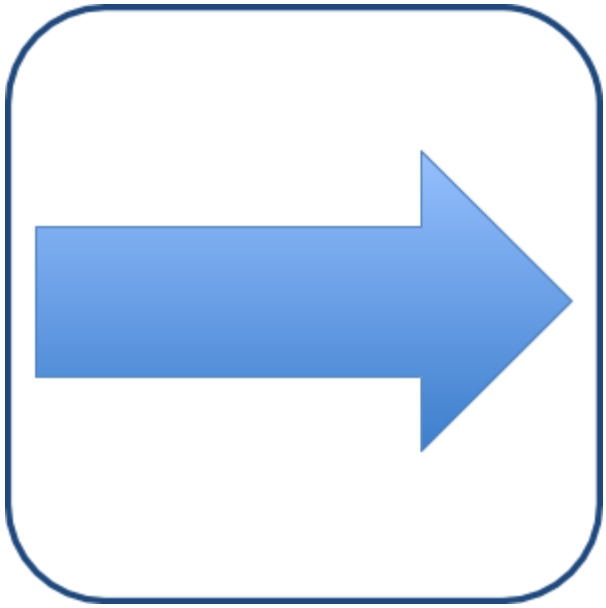
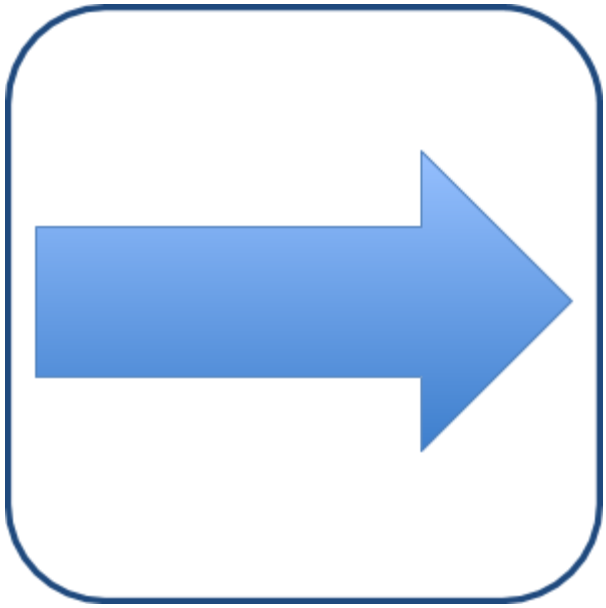
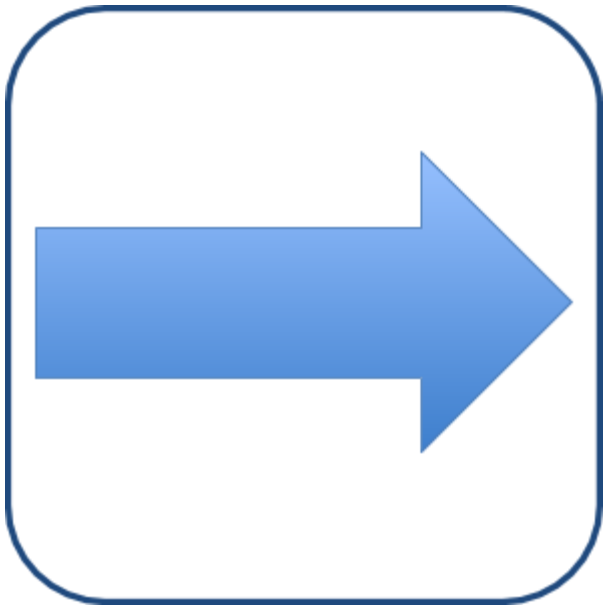
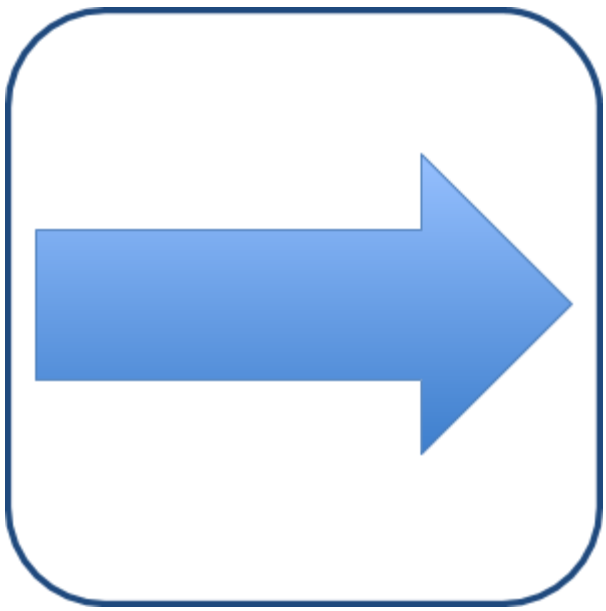
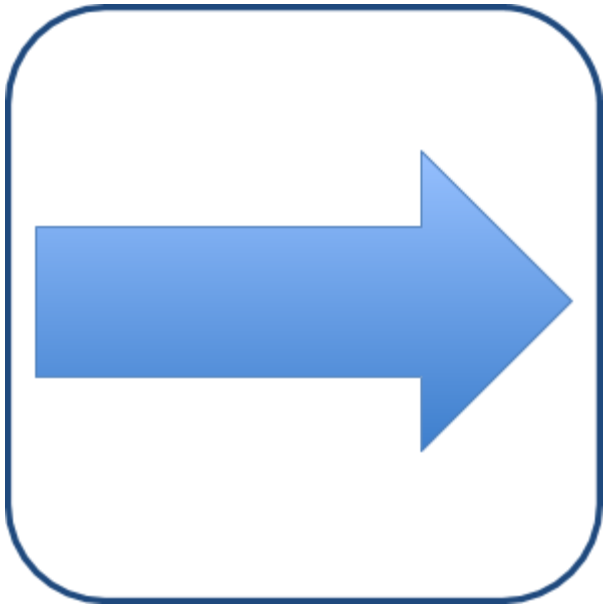
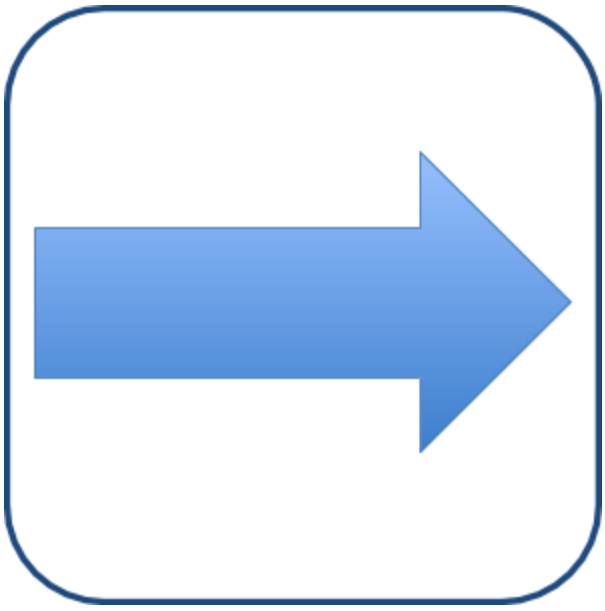
DRIVER

ROVER MOTOR

ROVER MOTOR

ROVER ROCK RETRIEVAL

ROVER ROCK RETRIEVAL


STOP


STOP


STOP


STOP


STOP


STOP