STEM IN THE LAB
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# MARS ROVER OBSTACLE COURSE

*How do scientists and engineers control robots that drive around other planets millions of miles away? It is nowhere near as easy as driving a toy remote-control car here on Earth. In this activity you will experience some of the challenges you face when driving a "robot" that you cannot see!*

*Idaho National Laboratory's Space Nuclear Power and Isotope Technologies Division fuels and tests Radioisotope Power Systems at the Materials and Fuels Complex, then delivers the systems for use in remote, harsh environments such as space. INL is working on the Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) for NASA's upcoming Mars 2020 mission that will send a rover to the Red Planet.*

# GRADE LEVELS: K-8

# VOCABULARY

***Isotope-*** *each of two or more forms of the same element that contain equal numbers of protons but different numbers of neutrons in their nuclei, and hence differ in relative atomic mass but not in chemical properties; in particular, a radioactive form of an element.*

***Thermoelectric Generator-*** *a solid state device that converts heat flux (temperature differences) directly into electrical energy through a phenomenon called the Seebeck effect (a form of thermoelectric effect).*

***Navigation-*** *the process or activity of accurately ascertaining one's position and planning and following a route.*

***Programming-*** *the action or process of writing computer programs.*

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# MATERIALS

- *Two volunteers*
- *Two adjacent rooms*
- *Large objects to serve as obstacles, such as furniture or boxes*
- *Paper and pencil*
- *Two smartphones or tablets with video chat capabilities (optional)*

# PROCEDURE

## PREP WORK

1. *One of your volunteers will be walking around with their eyes closed in this activity. Remove any potentially hazardous obstacles from one of the rooms, such as sharp objects or electrical cords they could trip over.*
2. *Plan a path through this room yourself, from a start location to a finish location. For example, if the room has two doors and a table in the middle, plan how to walk from one door, around the table, and to the other door. Write down exact instructions for following this path. Give each command a number. For example, "1) Take one step forward. 2) Turn right. 3) Take two steps forward. 4) Turn left ...."*
3. *You will be the rover "operator." Assign roles to your two volunteers. One of them will be the "rover," and one will be the "messenger."*

## INSTRUCTIONS

1. *Place the "rover" at the start location in the first room. This person now must close their eyes and keep them closed. No peeking!*
2. *Go into the other room with the messenger. Make sure you cannot see the rover.*
3. *Whisper your first command to the messenger. Make sure you are quiet enough that the rover cannot hear you.*
4. *The messenger should now walk (not run) to the other room and tell the command to the rover. The rover should follow the command exactly but have them be careful to walk very slowly (to avoid any stubbed toes or bumped shins). The messenger should stay in the room with the rover while the rover is moving.*
5. *The messenger should then return to you to get the next command and repeat the process. You are not allowed to change the commands—stick to what you wrote down!*
6. *Keep sending commands, one at a time, until the rover reaches the finish location or until it "crashes" (for example, by bumping into a piece of furniture or a wall).*
7. *If your rover made it to the finish, congratulations! Now you can switch roles or try adding more obstacles to make the path longer or more complicated. How complicated can you make the path before your rover crashes?*
8. *If your rover crashed, do not worry! Talk to your volunteers to try and figure out what went wrong. For example, maybe your steps are not the same size. In that case you might need to modify your directions to say, "take big steps" or "take small steps," then try again. How many tries does it take to get your rover from start to finish without crashing?*

## WHAT HAPPENED?

*You might find this activity surprisingly difficult at first! It might be tempting to cheat and modify your commands halfway through, or the rover might want to open their eyes. You might run into problems, such as the rover's steps being bigger or smaller than yours, or the rover not making exactly 90-degree turns. It is important to "calibrate" the rover's motions, so you get the results you expect when you issue commands. The same concept applies to the real Mars rovers: to carefully plan a path, scientists need to know exactly how far they will move or turn when they issue a command. Read the Science Behind It section to learn more about real robots on Mars!*

# THE SCIENCE BEHIND IT

*The U.S. has landed four robotic rovers on Mars: Sojourner in 1997, Spirit and Opportunity in 2004, and Curiosity in 2012. These rovers were given more and more autonomy, meaning they can make some decisions on their own about how to drive around obstacles. They do this by using onboard sensors (such as cameras and lasers) that can detect obstacles and computers to interpret what they see. Scientists on Earth, however, still need to send the rovers commands about where to go. At first you might think this is just like driving a remote-control car, but there's a problem: Mars is very far away from Earth. It's so far away that even the speed of light isn't fast enough for commands to get there without a delay. Depending on where the planets are as they orbit the sun it can take anywhere between eight and 20 minutes for a signal to reach Mars from Earth. That means up to 40 minutes round-trip to send a command to the rover and get a response! Can you imagine playing a video game if you had to wait 40 minutes to see what happened every time you pushed a button on the controller?*

*Because of this delay, when scientists are driving the rover, they need to upload a series of commands all at once to make sure the rover doesn't crash. This requires carefully planning out a path in advance, just like you did in this activity.*

# EXTENSIONS

*If you have two phones or tablets with a video-chat application available, have the rover volunteer hold one so you can see what's in front of them (while still keeping their eyes closed). Now you can see what the rover sees. Instead of writing down all your commands in advance, issue them one at a time based on what you see through the video chat. In addition to movement commands you can also issue commands to control the camera, like "point the camera down." Does this make navigating easier or harder?*

# RESOURCES

- *https://inl.gov/mars-2020/*
- *https://www.sciencebuddies.org/stem-activities/mars-rover-obstacle-course#summary*

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