Activity Title: mini Principles of Remote Exploration!

This activity is based on ***Principles of Remote Exploration****, an extensive, technology-based sample-analysis mission simulation for middle school students.* ***learners.gsfc.nasa.gov/PREP/***

Activity Objective(s): In this two-week activity teams will execute a mini-simulation of a robotic mission, to get the flavor of Mission Planning, including mapping, communication, calibration and simple programming. The ultimate goal is to get the human-robot from one end of the course to the other, and the robot should pick something up (A "lunar rock") at the end of the course.

Graphic courtesy NASA.

Grade Levels: 6 - 8

Process Skills: mapping, communication, measuring, graphing, logical thinking

Activity Duration:
Two 60 min sessions

Materials and Tools (per group of three students):

- Rulers
- Graph paper, if available

Club Worksheets: (Make copies for each student to put in binder)

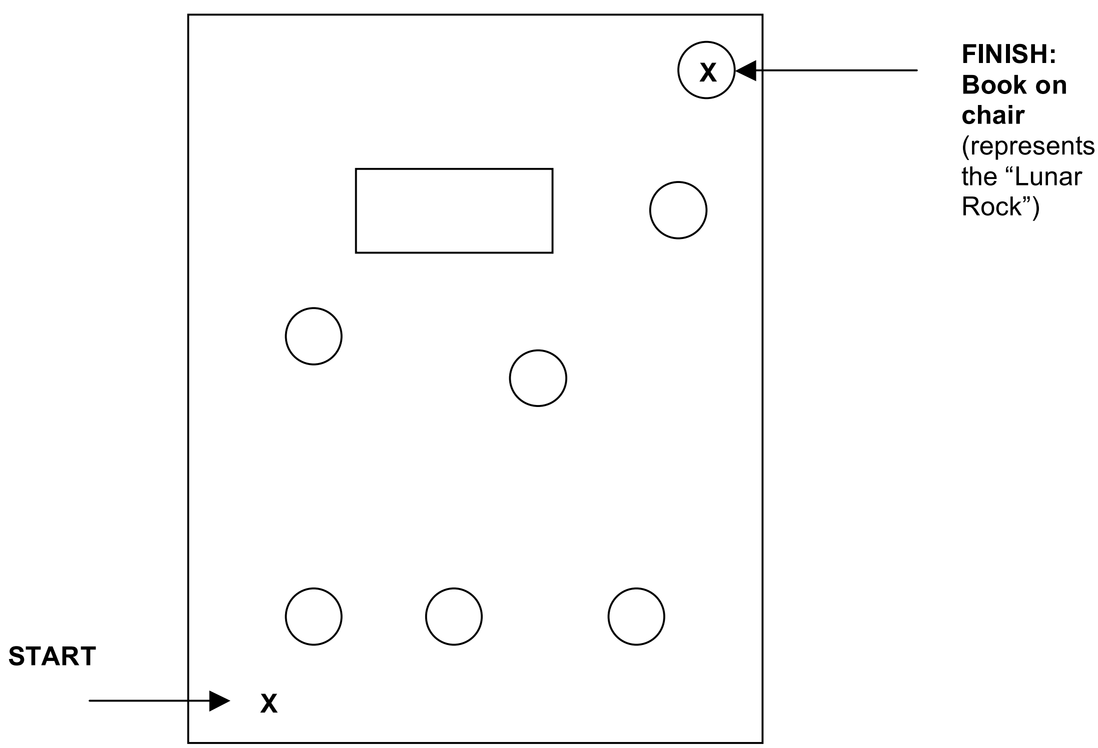
1. Mapping
2. Communications
3. Calibration
4. Mission Plan
5. Summary
6. Fun With Engineering at Home, Part A and Part B

Club Facilitator or Teacher Notes by Stage:
(Based on those running 60-minute Clubs)

Session 1:
SET-UP

Set up a small obstacle course ("landing site") with a few chairs, small table, and/or boxes (any "obstacle" with a fairly well defined "foot print" will do). The course does not have to be too complicated, but you should set it up so that the students must execute at least one right turn and at least one left turn. Also, give the students enough obstacles so that they have a choice of how to get from one end to the other (that is, so there is more than one path). The overall size of the landing site is also arbitrary, needing to fit within a convenient area that is available to the club, but probably an area at least 25 square meters would be best.

An example might look like this (table is rectangle, chairs are circles):



Remember: you will be using this exact same landing site set-up for two consecutive weeks, so you must be able to duplicate the arrangement of tables and chairs next week. This means you have to have your own "map" of the set up to place obstacles in the same place.

Stage 1.1: Set the Stage (About 15 minutes)

- Explain to the students that many of NASA's missions are conducted by robots. Although some robots have the ability to make decisions based on data they receive from sensors, the original program given to the robots is written by humans. Humans tell robots what to do and how to execute their missions. Today club members will divide into teams and select primary responsibilities that will enable them to prepare for a simulated robotic Discovery Mission. Next week they will carry out the mission and evaluate its success.

The Discovery Mission Challenge

Your team has been chosen to operate a robotic Discover Mission on the surface of the Moon. You will be given a specific starting location, and your robot must mover from there to the location of the "lunar ice" without bumping into any "lunar boulders" or other obstacles. To successfully complete the Discovery Mission Challenge, your robot must pick up a piece of "lunar ice."

A NASA mission has several parts, and you will be responsible for carrying out each component of the mission. Before your robot begins to traverse the lunar surface, you will have to complete the following activities:

- <u>Map the "landing site"</u> – your team will make a scale map that you will use to determine the path that your robot should take. You will mark out a route for the robot on this map, and then you will translate this path into a program for the robot.
- <u>Learn to communicate with your rover</u> – you will develop a simple language to pass commands to your robot. You will practice these commands until you and the robot are comfortable with them. These will be the commands that you will give the robot to traverse the path you have drawn on the map.
- <u>Calibrate your robot</u> – you must determine how your robots motions translate into standard units. For example, ONE robot step will equal how many centimeters? You will use this information to tell the robot how to traverse the route you have planned on the map.
- <u>Program the robot</u> – you will use the commands that you developed and the calibration to make a command set that will tell the robot how to traverse the path you have drawn on the map.

Next session, your robot will get the opportunity to execute the program you have written at the "landing site." Your mission will be complete when your robot picks up a piece of "lunar ice."

- Break the students into three-person teams (four members are ok if necessary). Each member of the team should choose a primary role for today's preparation phase, though the team members will work together to accomplish all phases of the mission:
  1. **Robot (BOT)**: One of the students in the team should volunteer to be the robot. The BOT will be the person who actually walks through the course, following the instructions of her/his team. The team should give their robot a name.
  2. **Communicator (COM)**: One of the team members will be the person who directly communicates with the robot throughout the BOT's progress in the landing site. COM will read commands to the BOT.
  3. **Mapper (MAP)**: Initially the team will construct a scale map of the landing site. One team member will chart the robot's progress on the map that the team made of the landing site. This is an important job for the *Improve* phase: If the robot has problems on the first attempt, the team will use these notes on the map to determine how to change the robot's course on the second attempt.

Stage 1.2: Pre-Mission Activities (About 45 minutes)

Logistics Note: Mapping, Communication and Calibration can be done at the same time, so that while one group is mapping the "landing site," the other groups can be developing their command language and calibrating their robot.

<u>Mapping</u>

The students should take a ruler and a blank piece of paper (graph paper is realy preferable for this) to the "landing site" and make a map of it. It is more important that the scale of the map be accurate than that it is drawn beautifully. For example, they may use symbols for the chairs, they do not need to try to draw pictures that look like chairs. Remember that the purpose of the map is for the BOT to navigate through the area using only the explicit instructions given to him by the Communicator.

<u>Communication</u>

The teams develop a "language" (a set of commands) that they will use with their BOT. These commands should be one or two words, plus perhaps a number (that indicates the number of steps the BOT moves). The Communicator may not talk in any other way to the BOT except giving him the explicit commands. And the BOT will not be able to talk except to repeat the commands. A few example commands might be:

FORWARD 3	(meaning walk forward 3 steps)
RIGHT	(meaning execute a 90 degree right turn)
LEFT	(meaning execute a 90 degree left turn)

They may come up with other simple commands, but they must remember that the BOT must follow the commands <u>exactly</u>. The team should make a list of their commands. If a command is not in their list, they may not use it once the robot is in the landing site. Remind them that they will need a set of commands for picking up the "lunar rock" at the very end.

COM should practice giving commands to BOT. COM must determine how many commands BOT can reliably execute in each command sequence. COM should keep a log indicating which commands they give to BOT each time, to keep track of what BOT can remember.

A command sequence is delivered as follows:

A. COM touches BOT's shoulder
B. COM: HELLO <BOT's name>
C. BOT: HELLO
D. COM reads the command sequence
E. BOT repeats the sequence exactly
F. Steps D and E are repeated until BOT repeats the sequence correctly
G. COM: CORRECT. GOODBYE.
H. BOT: GOODBYE

The command-response pattern is important to be sure the BOT understands the command. The greetings at the beginning and the end of the sequence serve to tell the BOT when to start listening and when to stop. COM repeats this many times to familiarize the BOT and to determine how many commands the BOT can actually remember. Three or four commands seem to be a reasonable number.

<u>Calibration</u>

- This part of the preparation puts together the map and the behavior of the BOT. If the team wants the BOT to go forward 2.5 meters before turning left, they must be able to tell the BOT exactly how many steps to take. Thus the team has to measure how far the BOT actually moves each step. A simple suggestion here is have the BOT walk a set number of steps, measuring the distance covered. Dividing the total distance by the number of steps provides the distance the BOT walks each step.

- Once the command set is developed, the BOT practices executing the commands, and MAP keeps track of the actual performance of the robot. MAP should keep a log of the measurements. For example, how much distance does the BOT cover when s/he executes each FORWARD 3 command? Is FORWARD 6 really the same as two FORWARD 3 commands?

Programming

Once Mapping, Communication and Calibration are complete, the teams chart the course for their BOT. First, they draw their chosen course on the map. Then they use their calibration data to determine what command sequence they must use to get the BOT through the course. Once they have their full command sequence, they break it into chunks, according to what they determined their BOT could remember. These chunks are then listed, in order, on the Mission Program.

Stage 1.3: Closure for Session 1 (5 minutes)

The Summary Sheets will be handed out next week, at the end of the Discovery Mission. Bring the students into a brief discussion to assess their progress at this point. Ideally, they will have a completed program for their BOT and will be ready to drop the BOT at the starting point to begin their mission next session. If they are not this far along, they can use the first part of the next session to finish programming their BOT. Send them home with "Fun with Engineering at Home, Part A."

Session 2

SET-UP

The landing site (obstacle course) must be reconstructed exactly as it was in Session 1.

Stage 2.1: Mission Readiness review (10 minutes)

Assemble the students in their teams. Ask each team to share their calibration results. They should show the graph they have made of the BOT's movements.

Discussion Questions

Does each BOT have the same calibration factor? (That is, ONE BOT step equals how many centimeters?) Why or Why not?

Why must we convert the BOT's steps into standard units?

If suddenly you were asked to work with a new BOT, would you have to change any of your calculations? If so, what would change? Why?

Stage 2.2: Mission Execution (5 minutes per team per trial)

- Missions should begin as soon as a team is ready to go.
- The BOT is placed at the starting point. COM delivers the first set of commands, using the command protocol. Map keeps track of the BOT's progress. If the BOT successfully executes the commands, the next set is delivered. If BOT makes a mistake or runs into an obstacle they go back to the beginning and get a second chance. If they still cannot execute properly, they get sent back to Mission Control for a tune-up, and the next team gets to go.
- Students **IMPROVE** by examining their maps and making corrections to their command sequence.

Stage 2.3: Challenge Closure

- Hopefully everyone will have gotten to the "lunar ice." Ask them to share with you whether they found this activity easy or hard. Ask them to imagine if they were programming a robot that was a quarter million miles away. Would that be easy? Hand out the Summary Sheets (please collect one per team and save in a folder for NASA).

Stage 2.4: Previewing Next Week (Approx 5 minutes)

- The Moon is a very harsh environment. There is no atmosphere to protect astronauts and their equipment from solar radiation and the extreme temperature swings between night and day. Next week, we will begin to find ways to protect astronauts from those extreme temperature changes. Send them home with "Fun with Engineering at Home, Part B."

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1. Mapping

Goal: Produce to-scale map of "landing site" to plan the robots traverse.

Use graph paper or blank white paper and rulers to map out the "landing site."

What is your measurement strategy? (Hint: are there floor tiles or other ways to scale up one measurement to a larger distance?)

What units are you using for measurement?

How accurate are your measurements?

How accurate do you think they need to be? (Come back to this question after you have calibrated your BOT and see if you give the same answer!)

What is the scale of your map?

Can you identify regions that might be difficult for your BOT to navigate?

What are the most important features in your map for the BOT?

2. Communications

Goal: Develop a communications strategy with the BOT.

The teams develop a "language" (a set of commands) that they will use with their BOT. These commands should be one or two words, plus perhaps a number (that indicates the number of steps the BOT moves). The Communicator may not talk in any other way to the BOT except giving him the explicit commands. And the BOT will not be able to talk except to repeat the commands. A few example commands might be:

FORWARD 3	(meaning walk forward 3 steps)
RIGHT	(meaning execute a 90 degree right turn)
LEFT	(meaning execute a 90 degree left turn)
BEND and GRAB	(meaning grab for the "lunar ice")

Make a list of your commands. If a command is not in the list, you may not use it once the robot has started the discovery process.

COMMANDS

COM should practice giving commands to BOT. COM must determine how many commands BOT can reliably execute in each command sequence. COM should keep a log indicating which commands they give to BOT each time, to keep track of what BOT can remember.

A command sequence is delivered as follows:

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E. BOT repeats the sequence exactly
F. Steps D and E are repeated until BOT repeats the sequence correctly
G. COM: CORRECT. GOODBYE.
H. BOT: GOODBYE

Determine the appropriate length for a command sequence. Three or four commands seems to be a reasonable number.

Practice delivering a command sequence so that it becomes easy for your BOT to repeat the commands and execute them. Remember, your BOT may feel under pressure in the "landing site," so you want to help the BOT feel prepared.

How many commands can your BOT remember?

Does it make a difference if you try to do it fast? Why?

Does telling your BOT to move FORWARD 8 get the same results as FORWARD 4 twice? Or FORWARD 2 four times? How close are the results, in both time and distance?

How long does it take you to move the BOT across the room?

Now put a chair in the path of the BOT so you have to move around it. Now how long does it take you to move across the room?

3. Calibration

Goal: Calibrate the* BOT*'s movements.

Listen as COM give commands, then measure the distance traveled by the BOT. Repeat several times and get an average value. Plot the results. Scale up.

Calibration Data Table: what units are you using?

	Trial 1	**Trial 2**	**Trial 3**	**Average**
Forward 1				
Forward 2				
Forward 3				
Forward 4				
Forward 6				
Forward 8				

Graph Your Results

What should the y-axis label be?

# of Steps

What is your measurement strategy?

(from the toe, left foot, right foot, etc)

How accurate are your measurements?

How accurate do you think they need to be?

Look at your graph. What is the relationship between number of steps and distance traveled?

Estimate how far the rover will go in 10 steps.

Now try it out. How close were you?

4 Mission Plan

Goal: Chart your BOT's traverse through the "landing site." Develop a plan that results in a Command Sequence using your command language,

- Use the map you made of the "landing site" to determine the best path for the BOT to take to get from the Starting point to the Finish, where the "lunar rock" awaits.
- Now develop a Command Sequence, using your command language, that will result in your BOT getting from the Starting point, to the Finish, and then picking up the "lunar rock."
- Break the Command Sequence into bite-sized chunks. Recall, you determined how many commands your BOT could remember. Write out the command sequence, with the chunks numbered. You will be required to tell your teacher which chunk you are delivering each time. <u>You may NOT change the chunks in real time.</u>

GOOD LUCK!

Command Sequence	
1.	15.
2.	16.
3.	17.
4.	18.
5.	19.
6.	20.
7.	21.
8.	22.
9.	23.
10.	24.
11.	25.
12.	26.
13.	27.
14.	28.

5. Summary

What was the most challenging aspect of completing this Discovery Mission?

Why was it important to make a good map in the first part of the Mission?

What does NASA do that is like measuring the length of your BOT's footsteps?

What would you do differently the next time?

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Team Name:____

Fun with Engineering at Home – Part A

Activity 8: *mini Principles of Remote Exploration!*

Pre-mission Activities

Today we conducted a simulated, robotic Discovery Mission. We practiced many of the very same activities that NASA scientists and engineers do when planning and executing a mission, such as Mapping, Calibration, Communication and Programming.

Home Challenge: During this week, why not try to do a Discovery Mission at home? You could rearrange some chairs and maybe a table to set up the Landing Site. You could help you family members understand why making a good map is important, and why you must calibrate your BOT. You could even blindfold the BOT to make it more challenging! If you have a big family or are doing this with lots of friends, you could break into teams and race to the end. Maybe the "lunar rock" could be something fun, like a treat!

These are the steps:

- <u>Mapping</u>: make the map of the Landing Site (you'll need a ruler)
- <u>Communication</u>: develop a command language and practice with the BOT
- <u>Calibration</u>: calibrate your BOT's steps (you'll need a ruler)
- <u>Programming</u>: plan a route through the Landing Site and program it using your command language.
- <u>Mission Execution</u>: BOT traverses the Landing Site, following the commands.

HAVE FUN!!

Team Name:____

Fun with Engineering at Home – Part B

Activity 8: *mini Principles of Remote Exploration!*

The Discovery Mission

Today we conducted a simulated, robotic Discovery Mission. Now consider what challenges would face living humans instead of mechanical robots: aside from air and water there are extreme temperature variations on the Moon because the Moon lacks an atmosphere.

Home Challenge: During this week consider the ways in which we deal with this problem on Earth. Research on the web and/or talk with family and friends. List three ways we protect ourselves from extreme cold on Earth. List three ways we protect ourselves from extreme heat.

Protect against Cold:

- ____
- ____
- ____

Protect against Heat:

- ____
- ____
- ____

On the Moon: Which of the ways that you described above as working on Earth will work on the on the Moon, and why?

- ____

HAVE FUN!!