ROVER RACES:
THE SEARCH FOR MINERALS

INTRODUCTION

In this lesson, students will be divided into groups of six and tasked with using input commands to drive a “rover” to find valuable minerals, including iron and titanium, on the moon. This task requires a basic understanding of the challenges involved in rover communications, rover operations (programming), and learning about the importance of mining on the moon.

LESSON OVERVIEW

Subject & Grade Level: Science, Grades 5 – 8

Length: 45 minutes (1 full class session); Prep time, 30 minutes

Objectives

At the conclusion of this lesson students will be able to:

- Describe the challenges of remotely moving/operating a rover on the surface of the moon.
- Apply the engineering design cycle to produce a rover that achieves the mission goals within the defined mission constraints.

Key Questions

- How much is the success of engineering contingent upon the communications and operations design?
- How can various proposed design solutions be compared and improved?

Standards

- NGSS MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- Common Core MP.2: Reason abstractly and quantitatively.

Materials Needed

- ROV Reproducible 1: 2 per 6-student team
- ROV Reproducible 2: 1 per student team
- ROV Reproducible 3: 1 per student
- ROV Reproducible 4: 1 per student
- ROV Reproducible 5: 1 per student
- ROV Reproducible 6: 1 per student
- ROV Reproducible 7
- ROV Reproducible 8
- 3 blindfolds per team of 6 students (if worried about sanitary conditions, simply ask students to close their eyes when they are the rover)

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- 2 clipboards and pencils per team (1 for each Driver and 1 for each Official)
- Flat obstacles to represent surface rocks (See Teacher Tip in Preparation)
- Laminated (8” x 11”) construction paper works well
- Objects to represent titanium and rock samples
- Small traffic cones work well
- 1 stopwatch per team (for use by the team timer)
- 1 set of job cards per team (see Section Preparation, Step A)
- 6 index cards (3x5)
- 1 set of 3 plastic sports cones per team

Facility

- Large flat area to set up obstacle course (classroom, gym, or outside area)

Background Information: Teacher Knowledge

Robots can go places and do tasks that humans cannot. These tasks include things like exploring and mining. Robots do not need air, food or water. However, robots do need step-by-step instructions to perform even the most basic of functions. Robots have been used for space exploration since the inception of the space flight. Today, rovers from multiple nations occupy various planetary bodies throughout the solar system. Rovers are not driven with a joystick or wheel; they are programmed by people on Earth who use cameras on the robots and satellite images to plot out a path for the robot to follow. The act of driving a rover is a laborious process that requires fine programming, planning, and control.

Resources

NASA’s Lunar Rover: Everything you need to know
http://www.armaghplanet.com/blog/nasas-lunar-rover-everything-you-need-to-know.html

How do you drive a $2.5 billion Mars Rover?
http://www.space.com/17220-mars-rover-curiosity-martian-driving.html

LESSON STEPS

Preparation

Constructing the Job Cards and Obstacle Course

1. Prepare a set of Rover Races job cards for each rover team. Use 3” by 5” index cards and write the job titles on each card:
   - 1 “Rover Driver” card
   - 3 “Rover Student” cards
   - 1 “Timer” card
   - 1 “Official” card
2. Use pieces of laminated construction paper (or similar) to create the obstacle course for the rovers. The course design can be anything. See (G) Course Setup.
3. Use small traffic cones (or any appropriate item) to represent titanium and iron samples

Warm-up: Rover Driver’s License

Start the activity by having the students brainstorm about how an unmanned robotic vehicle on the moon might be driven. Create a list of ideas.

Have students imagine they are astronauts living on a permanent base on the moon. Ask them why mining would be useful.

Sample Answer: It lets you build new things, you don’t have to bring your materials with you from Earth, it lets you discover new things.

Tell students about titanium and iron. Both of these materials are strong and useful for building. In addition, they can be found in abundance on the moon. Titanium and Iron will be important elements when they fly the Lunar Quest mission.

Activity 1: Explore

Explain to students that rover drivers do not actually use a joystick to direct the rovers. Instead, the mission team creates a series of commands to direct the rover and sends the commands to the rover. This activity will demonstrate some of the complications humans (engineers) must overcome to allow for accurate communication to rovers on the moon.

Inform students that they are going to be looking for both Iron and Titanium. These are two very important minerals that students will be looking for in the Lunar Quest Mission.

Choose, ask for volunteers, or draw names of students to form rover teams. Six students are needed for each team:

1 Rover Driver
3 Rover Students (Each student represents two wheels on a six wheeled rover)
1 Timer
1 Official

The Rover Driver will walk through the course first, counting the number of steps and listing the turns needed to guide the rover through the course (e.g.; 3 steps forward. Stop. 1 step left. Stop. etc.). The driver will use the ***ROV REPRODUCIBLE 1*** to build the list of commands.

Once the Rover Drivers have recorded their command sequences on their ***ROV REPRODUCIBLE 1***, the rover races can begin. The rover teams are lined up at the starting line. Blindfold the three Rover Students to prevent the rovers from aiding the Rover Driver during the command execution. The 3 Rover Students represent the six wheels of a rover and are sequentially in a line (front to back). The blindfolded Rover Students have their hands placed on the student's shoulders in front of them for stability.

Once the Rover Drivers have recorded their uplink sequences on their ***ROV REPRODUCIBLE 1***, the Rover Students will proceed along the course by following the Rover Drivers' verbal commands. The commands cannot be changed from the original commands that the Rover Driver wrote down. They must be followed exactly. During robotic missions, usually the commands are sent up all at once. Any changes have to be made in another uplink of commands later. (If you have additional time and or resources you can utilize technology, like Skype, to have the driver give directions from another classroom out of site.)

The Timers will start their stopwatch as soon as the teacher says "start" and will time until their rover team crosses the finish line. Their time will be recorded on ***ROV REPRODUCIBLE 2/(B) OFFICIAL'S RECORD***.

The Official will use their ***ROV REPRODUCIBLE 2*** to record any time either foot of the first Rover Student touches a Tile on the course (foot faults). The Official will keep a tally of the number of foot faults that their rover team makes. Feel free to remind students that accuracy is always more important than speed.

The cones on the course are titanium and iron samples that can be collected if the Rover Driver has included it on their ***ROV REPRODUCIBLE 1*** sheet. The command would be "Rock Retrieval Right" or "Rock Retrieval Left". At that command, the third Rover Student bends down, and, still blindfolded, sweeps with his or her hand to feel the cone. The student picks the cone up and hands the cone to the second (middle) Rover Student to carry. The second Rover Student then has only one hand on the shoulder of the first Rover Student. The retrieved rock samples give the team extra points upon completing the course.

Activity 2: Explain

Identify Constraints:

Allow time for all the teams to complete the course. Each Rover Team will get together to debrief how the driving went and complete the ROV REPRODUCIBLE 3. This information will include the challenges they faced or observed and their ideas about what might have caused those challenges. They will make a list of the challenges along with the suggested changes for the next drive.

During this time discuss with students how things have gone. Have them describe some of the challenges and successes they found during the first race. What would they do differently?

Activity 3: Elaborate

When teams are finished with their ROV REPRODUCIBLE 3, have students tally the counts on the ROV REPRODUCIBLE 2. The team that has successfully completed the course with the least foot faults, most rock samples returned, and best time is declared to have "mission success."

Repeat the activity as time permits with the second group of students, allowing for the changes the students brainstormed to be included. This iteration will also allow for more students to participate directly. Students will complete their ROV REPRODUCIBLE 4.

At the conclusion of the activity, read the following to explain and tie up all of the Engineering concepts introduced and experienced in this activity:

What you have just experienced is a lesson on engineering and how we communicate with a rover on another planet. Engineering allows us to solve human problems using science and technology. In this case, you found quite a few problems on your first round. Give me a couple of examples.

Examples students might note:

- Our steps were not the same, so we had to adjust.
- Moving three people is harder than moving one.

These are examples of calibration. Calibration means that you need to make adjustments to create a standard. For example, you adjusted the length of your step to a standard length for everyone in your group.

The engineering design cycle includes identifying a problem, specifying constraints (limitations) and criteria for the desired solution, developing a design plan, producing and testing models (physical and/or computer generated), selecting the best option among alternative design features, and redefining the design ideas based on the performance of a prototype or simulation.

(A) Student Worksheet. Rover Driver Command and Information Sheet

Name____ Date_________________

1. Walk through the simulated moon surface obstacle course. Write down the commands the rover should follow. Count your steps and be sure to list where the rover needs to make a turn on the course.
2. When the rover is in the correct position to retrieve a rock, you may ask the last person in the rover to pick up the rock for bonus points. Use the command “Rock Sample Retrieval Left” or “Rock Sample Retrieval Right.”
3. The rover will only be able to follow your set of written commands. The commands to the rover cannot be any different from what you have written.

Rover Commands:

Right (R)	**Left (L)**
Backward (B)	**Forward (F)**
Stop (S)	**Rock Sample Retrieval (RSR)**

Commands: (Example: 1. Forward 3 steps. Stop. 2. Turn left 1 step. Stop…….)

1.	11.
2.	12.
3.	13.
4.	14.
5.	15.
6..	16.
7.	17.
8.	18.
9.	19.
10.	20.

(B) Student Worksheet. Official's Record

Name____ Date________________

Make a counting (tally) mark (example: lll…) every time the first person in your rover team steps on a tile (simulated moon surface). These are called foot faults. Keep track of these foot faults through the entire course, and count the marks to make a total after your rover team crosses the finish line.

NAME OF ROVER DRIVER:

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NAME OF ROVER TEAM OFFICIAL:

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NAME OF ROVER TEAM TIMER:

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TOTAL FOOT FAULTS (steps on tiles by first person in rover):

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TOTAL TIME FOR ROVER TEAM TO COMPLETE COURSE:

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TOTAL TITANIUM SAMPLES COLLECTED:

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TOTAL IRON SAMPLES COLLECTED:

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(C) Student Worksheet. Rover Team Evaluation – First Race

Name____ Date________________

As a class, complete the following after your Rover Team has completed the first round of Rover Races.

1. Brainstorm some of the challenges you experienced during your first Rover Race and the potential causes of these challenges.

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2. What are the suggested changes for the Rover Team's next drive?

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(D) Student Worksheet. Rover Team Evaluation – Second Race

Name____ Date________________

As a class, answer the following questions after the Rover Team completes the second round of Rover Races.

1. Which changes worked well and why?

2. Which changes did not work well and why?

3. If you could do a third race, what changes would you use to make your Rover move where you want it to go?

Name____ Date________________

Identifying a problem: Name at least 2 problems that needed to be solved for the team to develop successful communication to your rover.

1. ____

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2. ____

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Specifying constraints (limitations) and criteria for the desired solution: What were some of the requirements (constraints and criteria) you needed to consider for your solutions? For example, worked for all 3 student rovers, not just for 1 person.

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How many different options did your group identify to solve this particular problem? Which did your group choose and why?

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Redefine the design ideas based on the performance of a prototype or simulation:

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After your group tried out the new design to solve the problem, did it solve the problem? What new changes would you try to make this solution better?

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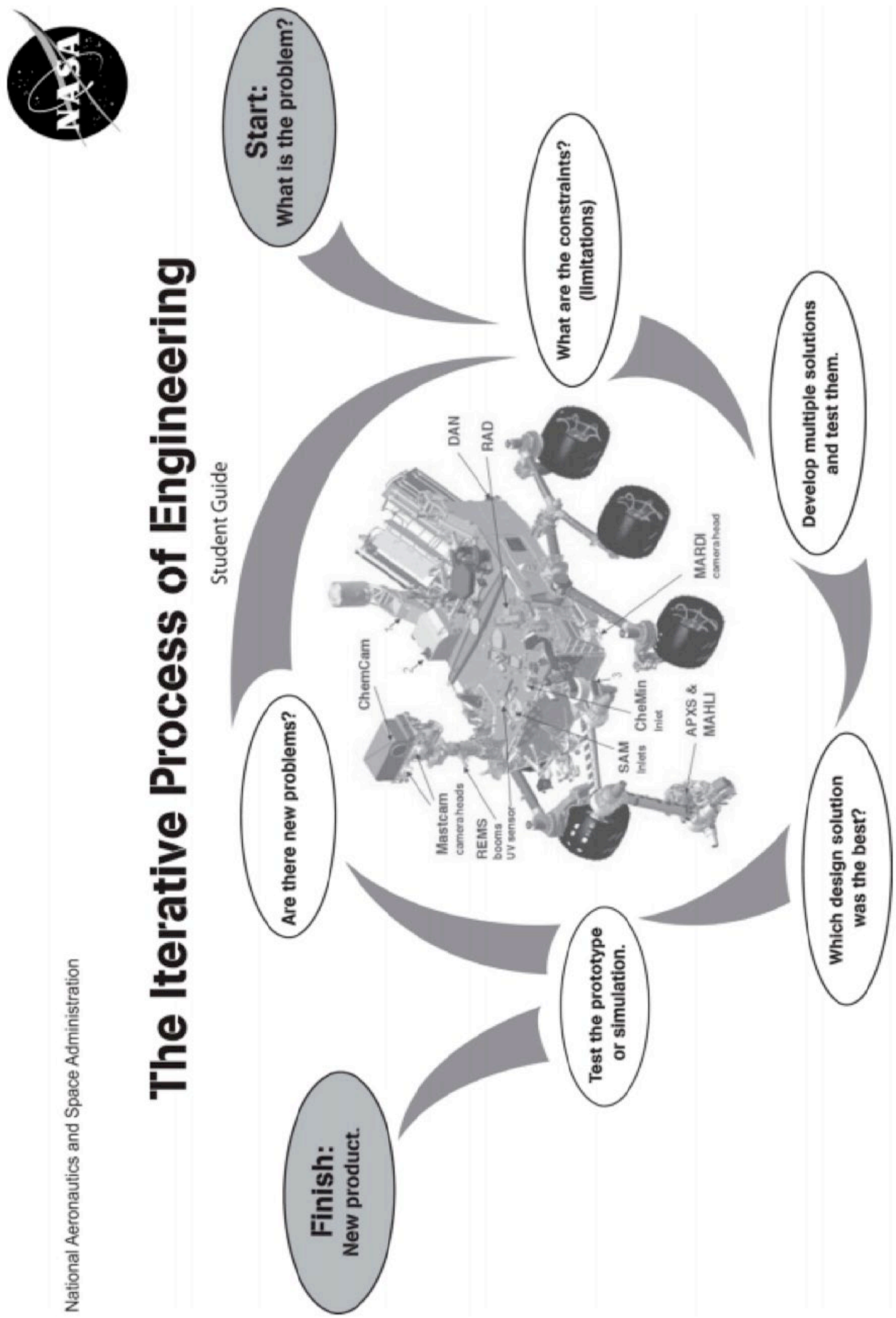
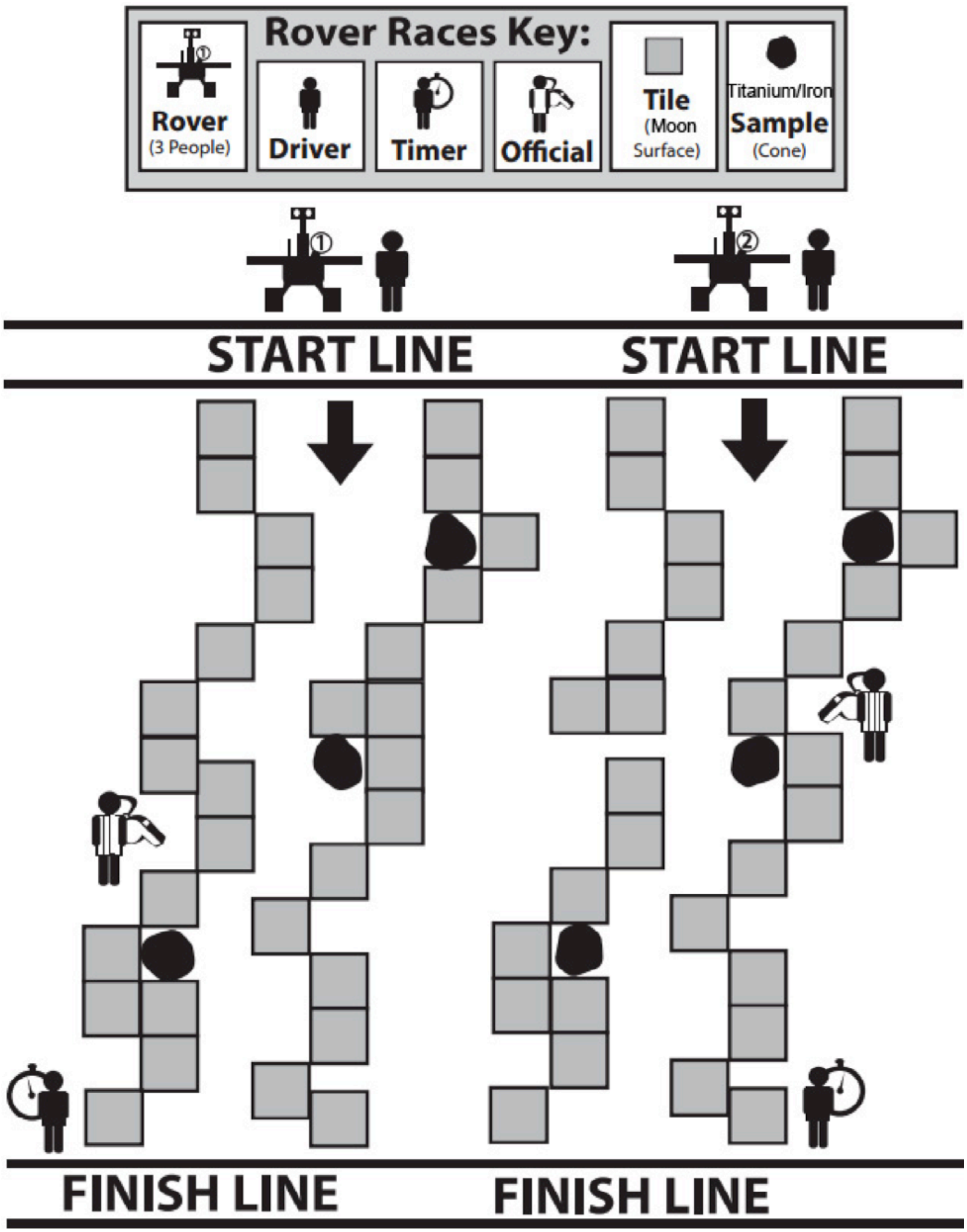
ROV Reproducible 6: Iterative Process of Engineering



FOR TEACHER USE
ROV Reproducible 7: Course Set up Example:



FOR TEACHER USE
ROV Reproducible 8: Iterative Process of Engineering Key:
(OPTIONAL)