Human Exploration Telerobotics

For the Teacher

Challenge

Design a robotic device to complete a series of tasks related to Robonaut 2 tasks on board the Space Station.

Materials

- Robotic system such as: LEGO Mindstorm kits, other off-the-shelf programmable robot, remote control cars, and see *More Fun with Engineering* page for other suggestions and alternatives.
- Challenge Area
- Recycled materials to use as obstacles and storage containers for the robots to use in the challenge.

Images and information about the International Space Station modules can be found here:

http://iss.jaxa.jp/en/kibo/about/kibo/jpm/

http://www.isset.org/nasa/tss/aerospacescholars.org/scholars/earthstationmoon/Unit3/ch5/building_blocks.htm

http://www.nasa.gov/pdf/508318main_ISS_ref_guide_nov2010.pdf

Motivate

- Ask students what tasks they complete every day (brushing teeth, taking out the trash, making breakfast, etc.) Ask what tasks they think the astronauts aboard the International Space Station would have to

Pre-Activity Set-up

This challenge provides the story line for a robotics challenge and a template to create a Challenge Area. The teacher can decide which type of robotic product to use to accomplish the challenge. This challenge assumes students already have a basic understanding of programming for the type of robots they will be using.

The teacher can prebuild the obstacles and storage containers (used by the robots to complete the tasks) or students can also design and build the storage containers for the robot to move around the International Space Station.

The dimensions of the storage containers will depend on the type of robot used. Storage containers should be square or rectangular in shape, most storage containers on the International Space Station are white in color and wrapped in fabric to protect the astronauts if they should float into each other.

Additional obstacles can be added to create more directional turns or add difficulty as appropriate for students. The robot will need to maneuver around exercise equipment, an experiment station, a video camera, a sleeping bag, etc. Adjust obstacles as needed for your environment.

accomplish every day (housekeeping chores, resupply of food/water, taking out the trash, recording temperatures and air quality levels). Robots are the perfect way to complete some of these types of repetitive tasks.

- Discuss Robonaut and SPHERES (see Student Section) and how engineers are working to create ways to control the robots on space station from Earth. Telerobotics is a great tool to save time in waiting for the next launch to upload new programs or new robots. It also allows more time on the International Space Station for the astronauts to complete science-related experiments.
- Videos and more information about Telerobotics are available at *http://www.nasa.gov/mission_pages/tdm/telerobotics/index.html* and *http://robonaut.jsc.nasa.gov/default.asp*
- Find more information about robots in general at NASA, see more videos and student interactives at *http://www.nasa.gov/audience/foreducators/robotics/home/index.html* or *http://robotics.nasa.gov/edu/matrix.php*
- Find more information about the International Space Station science and layout at *http://www.nasa.gov/mission_pages/station/main/index.html* and *http://www.nasa.gov/externalflash/ISSRG/*
- Follow the testing of Robonaut 2 on Facebook or Twitter.

Ask

- Clarify the challenge involves moving storage containers around the space station. The students will design, program and test a robot to complete the following tasks:
  1. The robot will travel from docking station to Forward rack.
  2. Pick up/push “used” storage container from Forward rack.
  3. Robot will need to be programmed to navigate around obstacles in its path.
  4. Move “used” storage container for storage on Starboard rack.
  5. Retrieve “new” storage container from Starboard rack and install in Forward rack.
  6. Robot will need to be programmed to navigate around obstacles in its path.
  7. Return to docking station in Aft rack.

Imagine

- Students will decide what features their robot will have and brainstorm ways the robot can complete required tasks.

Plan

- If the storage containers are not pre-built, students will design two small storage containers.

Telerobotics

For the Teacher

Create

- Use materials provided to create the storage containers and robots.
- Create program (or write out detailed steps) to complete the required tasks.

Experiment

- Follow the directions and answer questions on the *Quality Assurance* sheets.
- This challenge does not use an *Experiment and Record* sheet because students will be programming their robot.

Improve

- After completing the first round of testing, students will make modifications to their programs to improve the performance of the robot.

Challenge Closure

Engage the students in a discussion posing the following questions:

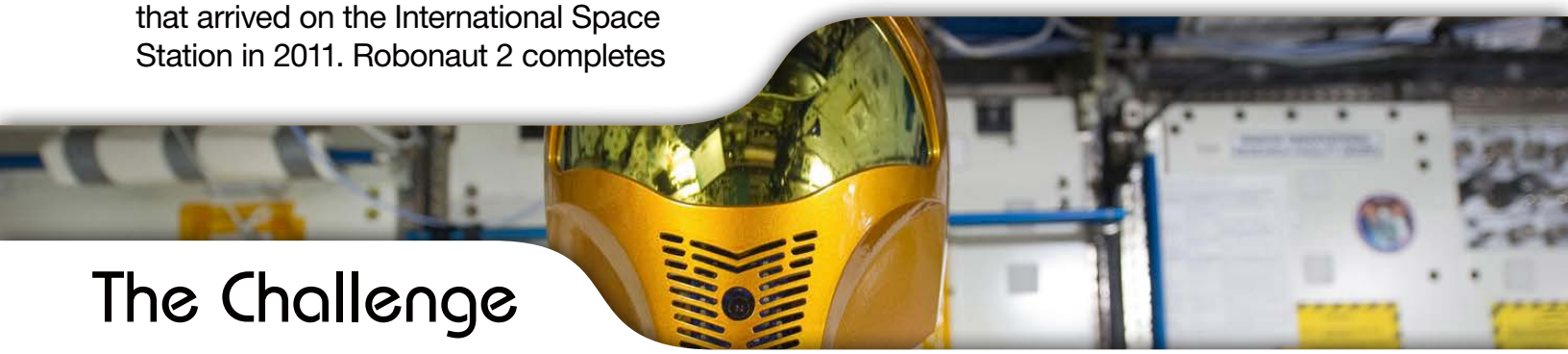
- What other testing could you do before making your recommendations to the engineering team?
- What information could engineers working on this project learn from your team's results?
- What other ISS-related tasks could you also accomplish with this robot design?
- What are some reasons that robots on Earth would not be appropriate for use in space?

Background

Human Exploration Telerobotics

The Human Exploration Telerobotics (HET) mission makes extensive use of open source software to remotely operate robots on the International Space Station. In space exploration, robots often need to work in extreme conditions and must be remotely operated over highly constrained communication networks.

- **SPHERES** is set of three free-flying robots that use an Android "Nexus S" smartphone for data processing. SPHERES acts as another set of eyes and can perform routine inspections of light and sound levels around the station. It can also take pictures and video, freeing up an astronaut to perform other tasks. In future missions, SPHERES may venture outside of the space station.
- **Robonaut 2** is a two-armed, humanoid that arrived on the International Space Station in 2011. Robonaut 2 completes tasks that require dexterity manipulation and are often repetitive tasks done by the astronauts. Robonaut 2 is currently going through various tests to see which tasks it is best suited. Robonaut is learning how to open containers, test ventilation flow, Learn more about Robonaut 2 and learn its latest developments and see videos at *http://robonaut.jsc.nasa.gov/default.asp*, or you can follow Robonaut 2 on Facebook or Twitter.
- **Disruption Tolerant Networking** software is used to compensate for the intermittent network connectivity and the delays that occur when sending data between Earth and space. This technology will help prevent gaps in communication and make SPHERES and Robonaut 2 even better tools for mission control and astronauts.



The Challenge

To design a robotic device to complete a series of tasks related to Robonaut 2 tasks on the International Space Station (ISS).

The design constraints are:

- Use only materials provided to you to create the robot and the storage containers.

Reminder For All Challenges

- Make any necessary design changes to improve your performance.
- Complete all conclusion questions.

Tasks to Complete:

Design and build two storage containers	10 pts
Remove "used" storage container from Forward Rack	25 pts
Install "new" storage container in Forward Rack	25 pts
Store "used" storage container in Starboard Rack	25 pts
Each obstacle navigated	5 pts
Return to home base in Aft Rack	10 pts

Our Team's Plan

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ASK

Today you will design a robot that will replace storage containers on the space station.
What questions do you have about today's challenge?

IMAGINE

What will be the general shape of your robot?

PLAN

Draw and label your robot:

Be sure to include measurements!

Challenge Area

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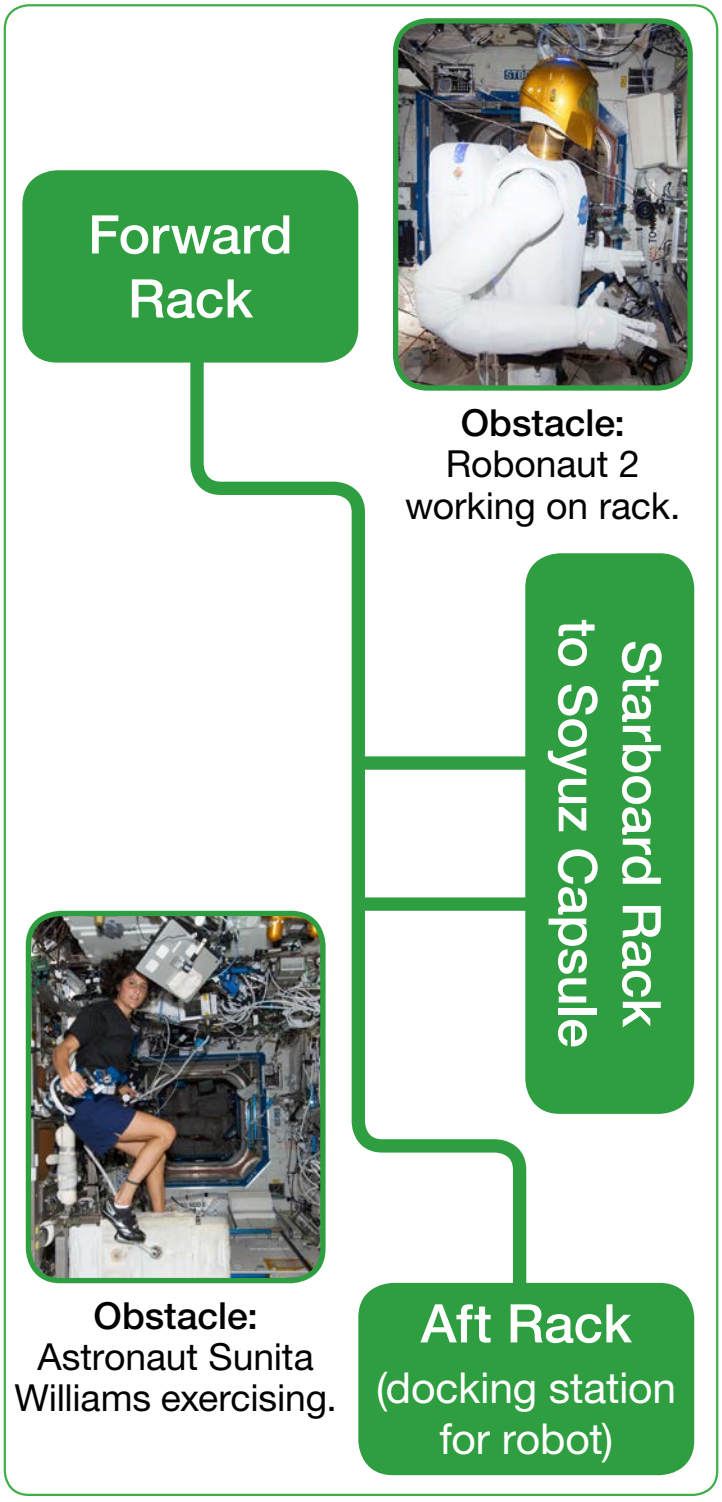
This is a recommendation for the Challenge Area. Make adjustments based on the type of robotics program you are using and the level of difficulty you have set for your students. Mark off the Challenge Area by using tape on the floor or a raised table. Obstacles can either be physical objects or can be marked on the floor.

Recommended size: 44 inches x 92 inches



Quality Assurance

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Each team is to review another team's design and model, then answer the following questions:

Team Name		Yes	No	Points Earned
Did the robot only use the provided materials?				
Tasks the Robot Completed:				
Design and build two storage containers	10 points			
Remove "used" storage container	25 points			
Install "new" storage container	25 points			
Store "used" storage container	25 points			
Each obstacle navigated	5 points			
Return to home base	10 points			

List the specific strengths of the design.

List the specific weaknesses of the design.

Inspected by: _____

Signature: _____

Experiment & Record

Challenge Closure

1 What other testing could you do before making your recommendations to the engineering team?

2 What information could engineers working on this project learn from your team's results?

3 What other ISS-related tasks could you also accomplish with this robot design?

4 What are some reasons that robots on Earth would not be appropriate for use in space?

More Fun With Engineering

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Activity One:

If you do not have access to robotic or remote control vehicles here are some alternatives for this challenge:

Paper and pencil version

- Students will write out step-by-step instructions to get a pre-built object (out of recycled materials) manually moved through the series of tasks. (Move forward 5 cm, turn left 90 degrees, move up 10 cm, etc.)
- Exchange instructions for another team to test through the series of tasks. The template for the Challenge Area can also be used.

Remote controlled vehicle version

- Students can modify a remote controlled vehicle to follow step-by-step instructions to complete the series of tasks. (Move forward 5 cm, turn left 90 degrees, move up 10 cm, etc.)
- Exchange instructions with another group to test. The template for the Challenge Area can be used and/or modified to be appropriate size for the type of remote controlled vehicles.

Activity Two:

The Cellbots website offers a variety of platforms and ways to transform Android-based products to robots. After selecting which platform will work best for you, complete the Teleroboics Challenge again.

http://www.cellbots.com/

Activity Three:

The International Space Apps Challenge is an international mass collaboration focused on space exploration. For 48 hours in multiple cites around the world, people work together to collaborate and problem-solve open source solutions to improve life on Earth and in space. Look through the nearly 50 challenges listed on the website and select one for your group to collaborate to solve. Write or present your group's solution to the class. Be sure to incorporate a time limit to maintain the feel of the original project. This would also work well with partnerships across multiple schools or classrooms.

http://spaceappschallenge.org/about/