5-8 Activity #1

Article: Astronauts' Little Helper

In the near future, a day in the life of an astronaut may include being awakened in the morning by a personal assistant that also provides a briefing for the coming day. There may be computer files to check, experiments to monitor, inventories to update, web sites to consult, reports to file…and for each task, the astronaut's assistant keeps track of progress, notes unusual circumstances, and provides feedback.

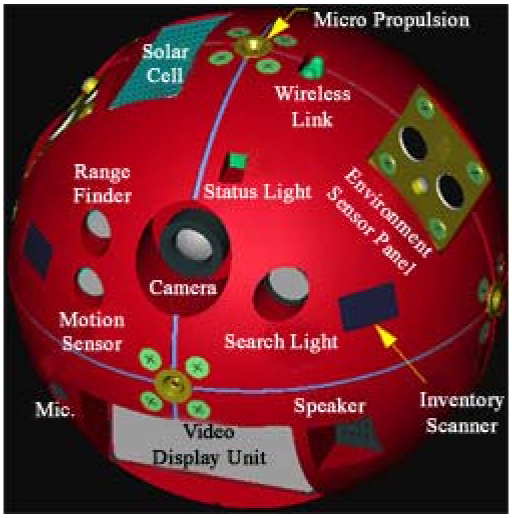
The assistant also keeps a log of conditions on the Space Shuttle or Space Station: if levels of oxygen, hydrogen, or **emissions** reach critical levels, the assistant lets everyone know. When a **videoconference** is needed, the assistant is right there to provide the hookup and transmission needs.

That's a mighty busy assistant! The surprising part is that this assistant isn't a human; it's a robot. To most people, however, this robot doesn't look like anything they might expect. Not at all **humanoid**, this robot looks like…a grapefruit. A large, red, flying grapefruit, to be sure, but still, a grapefruit. It's packed full of sensors, miniaturized video equipment, wireless network equipment, and technology. This allows the robot to understand spoken commands and reply with the same.

"We're developing an intelligent robot that essentially can serve as extra eyes, ears, and nose for the crew and ground-support personnel," says Yuri Gawdiak. He is the principal researcher for the Personal Satellite Assistant (PSA) in development at NASA's Ames Research Center in California. "The PSA will allow scientists to interact naturally with the crew. Because it's not a humanoid shape, it will offer more **dexterity** and enhanced performance because it can travel where people can't." **Prototypes** are being developed; a test flight is planned for mid-2002, and a year later, the PSA could be on the job up in space.

Developing the PSA has presented scientists with enormous challenges. PSA will operate in microgravity conditions, and it's difficult to simulate those settings here on Earth. "There will be lower power requirements up in space for the robot to move," says Gawdiak. "On the Space Station, it takes far less effort and much reduced power requirements."

The PSA is eerily close to the flying bot that taught Luke Skywalker to fight with a light saber in *Star Wars*. It floats in microgravity, and propels itself by using small fans, moving not just up and down and back and forth, but in a full range of motions, darting and zooming like a hummingbird. PSA maneuvers tight corners, records actions on video, and can go where humans can't—to check on a potentially hazardous situation, for instance. Besides alerting astronauts to dangerous situations, the PSA can also take care of **tedious** tasks ranging from inventory control to monitoring experiments to taking the night sentry shift.



Because it's computer based, the PSA can transfer data between the spacecraft's main computers and those on the ground at mission control. PSA can receive programmed instructions and be modified as needed. PSA can serve as a video outlet for communicating between Earth and space. Because it's so personally programmable, PSA will be able to learn how each user wants to be assisted, Gawdiak says. "PSA will learn whether you want it to fly beside you or behind you. It will learn your schedule, get you the updates you want from the ground, and interact with you on a highly personal scale. It won't just be mobile; it will understand much of what you want it to do."

"Operations we take for granted are very hard to program into a robot," Gawdiak says. "Something as basic as deciding where and when to go to a location, and how to react to variables that might come up along the way are enormously complex programs. The technology that has come about to create the PSA is directly transferable to Earth. In any system—a subway or a factory, for instance—robots can be assigned the mundane and dangerous situations, rather than humans. Managing inventory, monitoring hazards, and performing security can be done by robots to spare humans the risk."

Robotic Arm

Teacher Sheet(s)

Objective:	To learn how the end effectors for the robotic arms used on the Space Shuttle and the International Space Station work. Students will design and construct a grapple fixture that will enable the end effector to pick up an object.
Level:	5-8
Subjects(s):	Science, Technology
Prep Time:	Less than 10 minutes
Duration:	One Class Period
Materials Category:	Common Household

Materials:

- Styrofoam coffee cups
- String—12-cm pieces
- Cellophane tape
- Plastic picnic knives (serrated)

Related Links:

NASA Site used for derivation of Lesson Plan
Spacelink - Humans And Robots

Supporting Article(s):

Astronauts' Little Helpers

Pre-Lesson Instructions:

In this activity, students can work singly or in small groups of two or three. Have students use a sawing motion to cut through the cups. It is easier to cut through the outer cup first and then the inner cup. The important part about cutting the two cups is that their cut-off ends lie flush with each other when the cups are nested. Use the knives as scrapers to smooth the cut edges.

Upon completing the end effector, have your students design a grapple fixture. The idea here is to design something that the end effector can grab onto without slipping off. After grapple fixtures are completed, tell students to compare their fixtures to those created by two other students or groups. Ask them to create a table or a chart comparing the strong and weak points of the fixtures they evaluated. They should summarize their results with a statement about how they can improve the fixture they designed.

Background Information:

The International Space Station (ISS), currently under construction in Earth orbit, will have several robots to help astronauts complete their tasks in space. Five of the ISS international partner nations are developing robotic systems for the station. Japan is developing the Japanese Experiment Module (JEM) Remote Manipulator System. The European Space Agency and the Russian Space Agency are developing the European Robotic Arm. Canada and the United States are developing the Mobile Servicing System (MSS). The MSS, pictured on the Student Sheet, has an effector on each end allowing it to inch-worm along the structure of the ISS.

Guidelines:

1. Read the 5-8 article, "Astronauts' Little Helpers."
2. Discuss the other robots that are going to be used on the International Space Station.
3. Go over the procedure on the Student Sheets.

Discussion/Wrap-up:

- Review the tables or charts created by your students. Pay special attention to the ideas students have for improving their grapple fixtures.
- Discuss the strengths and weakness of the improved grapple features. Remember that these fixtures will have to be attached to anything the robotic arm wants to grab.

Extensions:

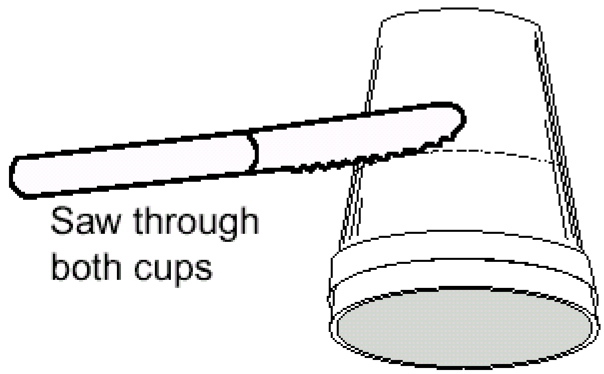
- Search robot sites on the Internet, and review different end effector designs. How does the design of an end effector enable it to pick up and manipulate various objects?

Robotic Arm

Student Sheet(s)

Materials

1. Styrofoam coffee cups (two)
2. String-12-cm pieces (three)
3. Cellophane tape
4. Plastic picnic knives (serrated)



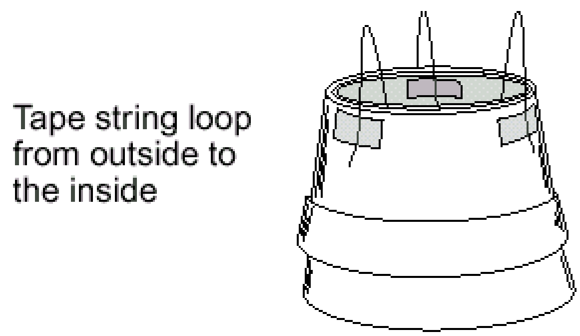
Procedure

Making the End Effector:

1. Nest the two cups together, and cut through both cups where indicated by the dashed line in the diagram.
   Smooth the cut edges by scraping them with the picnic knife edge.

2. Cut three pieces of string 12 centimeters long each.

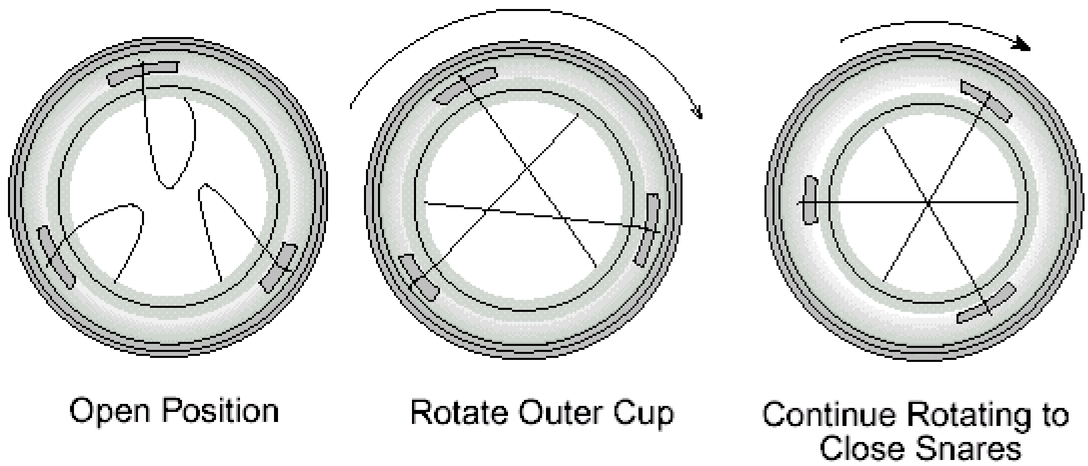
3. Tape the end of the first string to the inside of the inner coffee cup just below the cut edge. Tape the other end of the string to the outside of the cup, but do not press this piece of tape tightly yet.



4. Repeat step 3 twice more, but place the strings about 1/3 of the way (120 degrees) around the cup from the first string.

5. While holding the rim of the inner cup,
   rotate the outer cup until the three strings cross each other. The strings will have some slack. Pull the end of the strings on the outside until they are straight and intersect exactly in the middle of the opening. Press the tape on the outside to hold the strings.

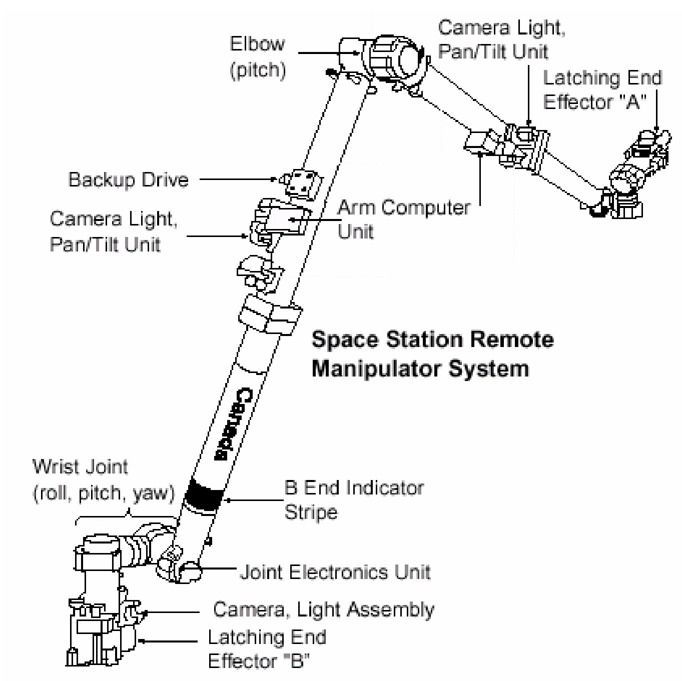
Using the End Effector



1. Use the end effector to pick up an object such as a pencil. Have someone hold a pencil upright. Open your end effector so that the strings are not crossing each other. Slip the end effector over the pencil so that the pencil extends down the center and not through any of the loops. Rotate the outer cup until the strings grasp the pencil. Pick up the pencil.

2. You may find that the pencil is too slippery to be held securely. How might you modify the pencil so that it can be held? Design a standard grapple fixture that can be mounted to other objects so that they can be picked up.

3. Compare your grapple fixture to two other grapple fixtures designed by your classmates. Which one works the best? Why? Create a chart or a table that evaluates the strong and weak points of each grapple fixture you compared. How can you improve you design?



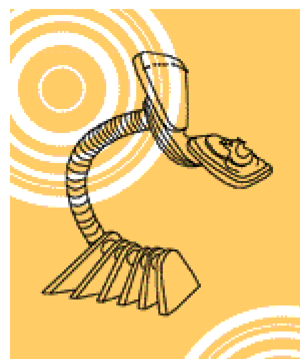
5-8 Activity #2

Can a Robot Tie Your Shoes?

Robots are machines that do specific tasks. Movies are full of robots that can do everything that humans can do and more. However, in reality, there are limits to what robots can do. This activity is designed to help analyze a simple, everyday task from the point of view of a robot. Gloves, blindfolds and pliers are used to limit sensory information, and tongue depressors limit the number of moving joints.

Tying a shoe, an every-day task that seems easy enough for us, is difficult, if not impossible, for a mechanical robot. Robots have limited movement, only a few sensors, and are controlled by computers, which must be programmed with instructions for each step required. It is difficult for two people to work together to tie a shoe. Likewise two robots working together is very difficult to coordinate and only recently has been achieved. (A line of robots working sequentially in an assembly plant is different than two robots working together on the same task.)

It is helpful for participants to discuss their experience after each variation.



Materials Needed

- shoes that tie
- tongue depressor
- masking tape
- heavy gloves
- 2 pairs of pliers
- blind folds

Try tying your shoes blindfolded. Not too hard! Now, repeat the activity but with heavy gloves on your hands. Then, tape tongue depressors onto your thumbs and forefingers and try again.
And if those activities weren't difficult enough, tie your shoes with pliers. First, use pliers in both hands; then with only one hand; finally with two people -- each with one pair of pliers. For fun, these activities can be set up as a race between two people

5-8 Activity #3

Design a Microrover for the Moon

Materials

- paper
- art supplies
- assorted materials (plastic food containers, Styrofoam packaging, spools, broken toys, etc.)
- glue
- tape

Background

NASA has shifted its planetary exploration strategies from complex and expensive "do-everything" spacecraft to simpler and less expensive spacecraft that do only a few jobs. A good example of this operational change is the Sojourner microrover robot spacecraft that explored small areas of the Martian surface in 1997. Microrovers are easier to design and construct than the larger complex craft and several can be constructed for the same price. If a major malfunction should take place in one rover, others can be deployed to replace it. Recent studies of the Moon by the robot Lunar Prospector spacecraft have confirmed that water, in the form of ice, exists at the Moon's South Pole. The water is found in depressions that are forever shielded from the Sun's heat. The discovery of water means that future human explorers of the Moon can use the water for drinking, for production of breathing oxygen, and for production of rocket fuel.

Procedure

Challenge students to design a microrover spacecraft for exploring the Moon's South Pole region. The purpose of the rover is to map the extent of water ice found there. The robot will have to have some sort of transportation system, sensors, power, scientific instruments, and a communication system. Have students sketch their robot design or construct a model of the robot from assorted materials. Have students write a description of how their robot works or present an oral report.