# NASA CONNECT™

Personal Satellite Assistant

# PSA

# The Astronaut's Helper

**An Educator Guide with Activities in Mathematics, Science, and Technology**

| Volume (cubic inches) | Length (inches) | Width (inches) | Height (inches) | Fits in an 8-inch diameter sphere? (yes or no) |
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NASA CONNECT™

NASA CONNECT™: *PSA: The Astronaut's Helper* is available in electronic format through NASA Spacelink - one of NASA's electronic resources specifically developed for the educational community. This publication and other educational products may be accessed at the following address: **http://spacelink.nasa.gov/products**

A PDF version of the educator guide for NASA CONNECT™ can be found at the NASA CONNECT™ web site: **http://connect.larc.nasa.gov**

NASA CONNECT™ is produced by the NASA Center for Distance Learning, a component of the Office of Education at NASA's Langley Research Center, Hampton, VA, and is a collaborative endeavor of NASA with the organizations below. The NASA Center for Distance Learning is operated under cooperative agreement NCC-1-02039 with Christopher Newport University, Newport News, VA.
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www.aiaa.org

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# NASA CONNECT™

Personal Satellite Assistant

# PSA

## The Astronaut's Helper

An Educator Guide with Activities in Mathematics, Science, and Technology

**AIAA FOUNDATION** Registered users of NASA CONNECT™ may request an American Institute of Aeronautics and Astronautics (AIAA) classroom mentor. For more information or to request a mentor, e-mail **nasaconnect@aiaa.org**.

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# PROGRAM OVERVIEW

## SUMMARY AND OBJECTIVES

In NASA CONNECT™: PSA: The Astronaut's Helper, students will learn about different types of robots and will also be introduced to the Personal Satellite Assistant (PSA), a small, spherical robot that will assist each astronaut with chores on space-based vehicles. Students will learn about the PSA's mechanical systems, which must work together so that it will function properly. In the web activity, students interact with a PSA simulation and learn how forces affect motion in a low-friction, microgravity environment. They discover that scientists need to shrink the PSA, and they engage in a hands-on activity to find the maximum surface area of a computer component that will fit into a smaller PSA. By conducting inquiry-based and web activities, students will make connections between NASA research and the mathematics, science, and technology they learn in their classrooms.

## STUDENT INVOLVEMENT

### Inquiry-Based Questions

Host, Jennifer Pulley, and NASA scientists and engineers pose inquiry-based questions throughout the program. These questions allow students to investigate, discover, and critically think about the concepts being presented. When viewing a videotape or DVD version of NASA CONNECT™, educators should pause the program at designated segments so students can answer and discuss the inquiry-based questions. During the program, Jennifer Pulley and NASA scientists and engineers will indicate the appropriate time to pause the tape or DVD. For more information on inquiry-based learning, visit the NASA CONNECT™ web site, *http://connect.larc.nasa.gov*.

### Hands-On Activity

The hands-on activity is teacher created and is aligned with the National Council of Teachers of Mathematics (NCTM) Standards, National Science Education Standards (NSES), and the International Technology Education Association (ITEA) Standards for Technological Literacy. Students will tackle a problem that NASA scientists face in designing a spherical robot for space-based vehicles. They find the maximum surface area of a rectangular prism with a given volume that fits into a sphere of a specified size. In the extension activity, students will determine whether a tall cylinder or a short cylinder with the same volume will have more surface area.

### Web Activity

The web activity is teacher inspired and is aligned with the National Science Education Standards (NSES) and the American Association for the Advancement of Science (AAAS) Benchmarks for Science Literacy. Students will move the PSA in the simulation by clicking arrows that represent forces and must get the PSA to overheated racks before the batteries on the PSA run out of power. A timer displays the amount of power left in the batteries. Students will change the mass of the PSA and see how increased mass affects the force that must be applied to move the PSA. To access the NASA CONNECT™ web activity, go to the NASA CONNECT™ website *http://connect.larc.nasa.gov.*

## RESOURCES

Teacher and student resources support, enhance, and extend the NASA CONNECT™ program. Books, periodicals, pamphlets, and web sites provide teachers and students with background information and extensions. In addition to the resources listed in this educator guide, the NASA CONNECT™ web site *http://connect.larc.nasa.gov* offers online resources for teachers, students, and parents.

# Hands-on Activity

## BACKGROUND

Scientists at NASA are building a robot called the Personal Satellite Assistant, or PSA. The PSA's mission is to keep astronauts safe and assist them with their chores on space-based vehicles such as the International Space Station (ISS). This small round robot will float in microgravity and move autonomously. It will keep track of an astronaut's schedule, monitor supplies, assist with scientific experiments, communicate with Mission Control, and help keep an astronaut safe by monitoring the air composition and temperature.

NASA engineers have created a model of the PSA that is 12 inches in diameter. The engineers' goal is to build a PSA with an 8-inch diameter.

The computer components of the PSA are contained in a rectangular prism that sits in the middle of the spherical PSA. These electronic components generate heat. Since the heat is lost through the surface area of the rectangular prism, the goal of this activity is to find the greatest surface area for a rectangular prism that will fit into a smaller PSA. Students can use blocks and card stock, make drawings, or simply use their visualization skills to determine the change in surface area as a rectangular prism gets taller or wider.

## INSTRUCTIONAL OBJECTIVES

The student will

- find the maximum surface area of a rectangular prism that has a volume of 24 cubic inches and fits into a sphere with a diameter of 8 inches.

## NATIONAL STANDARDS

### NCTM Mathematics Standards

Geometry

- Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships

- Use visualization, spatial reasoning, and geometric modeling to solve problems

### NSCS Science Standards

Science and Technology

- Abilities of technological design

### ITEA Standards for Technological Literacy

Standard 8: Students will develop an understanding of the attributes of design.

## NASA RELEVANCE

NASA scientists and engineers working on the PSA project need to reduce the volume and mass of the PSA because of the high cost of transportation to the ISS, limited space in space-based vehicles, and for safety reasons. Even though they use computer programs to design the PSA and its components, a basic understanding of volume and surface area is essential when designing the PSA and the shape of the components that go inside it.

## PREPARING FOR THE ACTIVITY

### Student Materials
• 24 wooden or plastic blocks (of any size)
• card stock cut into circles with a diameter equal to the width of 8 blocks
• rulers
• sheets of plain paper and pencils
• modeling clay
• calculators (optional)
• 1 copy of the student handout sheet

### Teacher Materials
• A copy of the video, NASA CONNECT™: *PSA: The Astronaut's Helper*

### Time for Activity
• 60 minutes (watching the video and discussing the inquiry-based questions)
• 45 minutes (the activity)
• 30 minutes (the extension activity)

### Brief Description

In this lesson, students discover that the surface area of a rectangular prism changes as its length, width, and height change. They find that the surface increases as you flatten the prism, and that the width of the 8-inch sphere that it must fit inside restricts the length, width, and height of the prism. They also discover that there is more than one solution to this problem.

## Lesson Description

### ENGAGE

Have students view the program, NASA CONNECT™: *PSA: The Astronaut's Helper.* Working in groups, have students answer and discuss all inquiry-based questions that are presented in the program.

Ask students why NASA scientists need to make a smaller PSA and a smaller computer inside it. Ask them to explain what surface area is and why the surface area of the computer in the PSA needs to be as large as possible.

*Summarize the three conditions that the rectangular prism must meet:*

1. The total volume of the rectangular prism must be 24 cubic inches.
2. The rectangular prism must fit into a sphere with a diameter of 8 inches.
3. The rectangular prism must have as much surface area as possible.

Volume = 24 cubic inches
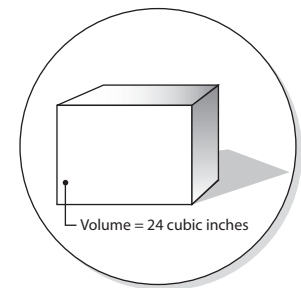
Review with students how to calculate the volume and surface area of a rectangular prism.

### EXPLORE

- Provide each group of 3 or 4 students with 24 cubes and a circle cut out of card stock that has a diameter equal to the length of 8 cubes. Make drawing paper and pencils available.
- Ask students to use the blocks and card-stock circles, to draw or use any other method to figure out the possible dimensions of the cube.
- Distribute the Student Handout sheets. Ask students to write all the possible dimensions of a rectangular prism that has a volume of 24 cubic inches.
- Ask students to indicate in the last column of the table whether the rectangular prism will fit into the 8-inch diameter sphere.

### EXPLAIN

- Ask students: "Why won't your rectangular prism fit into the sphere?"
- Ask students how they know that their rectangular prism will or will not fit into the sphere.
- Ask students what needs to be done to the rectangular prism for it to fit into the sphere.
- Students may realize at this point that if they use decimals, they can get many more dimensions for the rectangular prism.
- Allow students to round the value for the volume of the sphere, so that 23.99 and 24.02 are acceptable values.

**EXPLORE**

- Ask students to calculate the surface area.

- Ask students to try and come up with other numbers that will result in a rectangular prism with more surface area. Permit students to use calculators if they are available.

**EXPLAIN**

- Ask students whether they see a pattern in the numbers for the surface area. Ask students: "What needs to happen to the length, width, and height to create more surface area?"

If students do not see the pattern, that a longer and wider rectangular prism has more surface area, ask them to rewrite their list in order of increasing surface area. Ask them what happens to the length and width as the surface area increases.

**EXTEND**

- Ask students to think about the same problem, except that fans in the shape of cylinders must fit into the PSA. Will a tall cylinder or a short cylinder have more surface area? These fans are being used to propel the PSA.

- Show students a piece of playdough in the shape of a cylinder. Tell students that the volume of the cylinder will stay the same. How must the shape of the cylinder change for it to have the most surface area? Does a tall, narrow cylinder or a short, wide cylinder have more surface area? How do you calculate the surface area of a cylinder?

- Flatten the playdough cylinder while still maintaining its cylindrical shape. Ask students how they think the volume and surface area have changed.

- Distribute a playdough cylinder to each group and ask group members to figure out whether a tall or a short cylinder has more surface area.

**EVALUATE**

As a class, create an assessment rubric for this activity. Here are suggested criteria for the rubric:

- Appropriate numbers for the length, width, and height of the rectangular prism

- Appropriate drawings and reasoning methods to determine whether the rectangular prism will fit into the 8-inch sphere

- Correct assessment as to whether the rectangular prism will fit into the sphere

- Clear oral reasoning as to why a rectangular prism will or will not fit into the sphere

- Appropriate calculations of surface area

- Clear written presentation of results

- Clear oral presentation of results

# STUDENT HANDOUT

Possible dimensions of a rectangular prism with a volume of 24 cubic inches:

| Volume (cubic inches) | Length (inches) | Width (inches) | Height (inches) | Fits in an 8-inch diameter sphere? (yes or no) |
|---|---|---|---|---|
| 24 | | | | |
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Reasons why a rectangular prism will or will not fit into the sphere:

_____

_____

_____

_____

_____

Surface area of the rectangular prisms that fit into an 8-inch diameter sphere:

| Volume (cubic inches) | Length (inches) | Width (inches) | Height (inches) | Surface area of rectangular prism (square inches) |
|---|---|---|---|---|
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# Teacher Handout

Possible dimensions of a rectangular prism with a volume of 24 cubic inches:

| Volume (cubic inches) | Length (inches) | Width (inches) | Height (inches) | Fits in an 8-inch diameter sphere? (yes or no) |
|---|---|---|---|---|
| 24 | 24 | 1 | 1 | no |
| 24 | 12 | 2 | 1 | no |
| 24 | 8 | 3 | 1 | no |
| 24 | 6 | 4 | 1 | yes |
| 24 | 6 | 2 | 2 | yes |
| 24 | 4 | 3 | 2 | yes |
| 24 | 5.6 | 2.06 | 2.08 | yes |
| 24 | 5.5 | 2.1 | 2.08 | yes |

**Sample Scoring Tool**

2:
Calculations are correct and clearly presented.
Assessments of fit are correct.
Reasoning is logical and clear explanations are provided.
Oral and written presentations are clear.

1:
Most calculations are correct and attempts are made to present data clearly.
Most assessments of fit are correct.
Attempts are made to reason logically and provide clear explanations.
Attempts are made to provide clear oral and written presentations.

0:
All other responses.

**Extension Activity**

The surface area of a cylinder is the sum of the areas of the circles at the top and bottom of the cylinder and the area of the side of the cylinder. The area of the side of the cylinder is a rectangle formed by opening up the cylinder. The width of the rectangle is the circumference of the circle at the top and bottom of the cylinder and the length of the rectangle is the height of the cylinder. The formula for the surface area of a cylinder is

(2 X Pi x Radius x Radius) + (2 x Pi x Radius x Height)

When the volume is the same, a short, wide cylinder will have more surface area than a tall, narrow cylinder.

PSA: The Astronaut's Helper

# RESOURCES

**Personal Satellite Assistant Education**
The PSA Education web site provides information on the PSA and the history of its development, online activities, links to challenges, webcasts and biographies of NASA scientists and engineers, and information for educators.
*http://quest.arc.nasa.gov/projects/psa/index.html*

**Building a Droid for the International Space Station**
Read about and listen to the story of the inspiration behind the development of the Personal Satellite Assistant.
*http://science.nasa.gov/headlines/y2001/ast23jul_1.htm*

**Lesson Plans on Microgravity**
Provides links to activities and lessons on microgravity.
*http://quest.arc.nasa.gov/projects/space/lessons/microgravity.html*

**Microgravity Research Program Office**
Find out about microgravity news and research at this NASA site.
*http://microgravity.msfc.nasa.gov/*

**International Space Station Home Page**
*http://spaceflight.nasa.gov/station/*

**Robotics Education Project Home Page**
Find out about robotics contests and link to robotics games and activities.
*http://robotics.nasa.gov/*

**Assembly of the International Space Station**
*http://spaceflight.nasa.gov/station/assembly/index.html*

**Track the Location of the International Space Station**
*http://microgravity.msfc.nasa.gov/*

**NCTM – National Council of Teachers of Mathematics**
*http://www.nctm.org*

**NSES – National Science Education Standards**
*http://www.nap.edu/readingroom/books/nses/html/*

**NSTA – National Science Teachers Association**
*http://www.nsta.org*

**ITEA – International Technology Education Association**
*http://www.iteawww.org/*