Area and Volume

Educator Notes

Learning Objectives

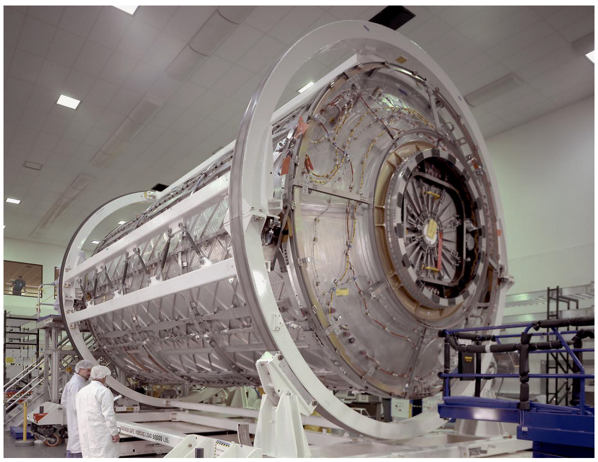
- Students describe how to calculate the floor area and volume of a room.
- Students identify how engineers utilize volume in their designs of the International Space Station modules.

Introduce the Challenge

In this challenge, students calculate the area and volume of their classroom, learn how engineers make the most of interior space aboard the International Space Station, and apply engineering design by redesigning their classroom for a microgravity environment. Students must use a square or rectangular-shaped classroom for this lesson.

The International Space Station, a unique scientific platform, enables researchers from all over the world to put their talents to work on innovative experiments in a unique microgravity setting. Although each space station partner has distinct agency goals for station research, each partner shares a unified goal to extend the resulting knowledge for the betterment of humanity. Through advancing the scientific knowledge of our planet, developing advanced technologies, and providing a space platform, the space station inspires and educates the science and technology leaders of tomorrow. The benefits of the space station drive its legacy as its valuable research strengthens economies and enhances the quality of life for everyone here on Earth.

The U.S. Laboratory Module, Destiny, is the primary research laboratory for U.S. payloads. It supports a wide range of experiments and studies contributing to human health and safety from all over the world. Science conducted on the space station offers researchers an unparalleled opportunity to test physical processes in its unique environment. The results of these experiments allow scientists to better understand our world and prepare us for future missions beyond our planet. Destiny accommodates 24 equipment racks for control of the space station's systems and scientific research. In this lesson, students learn how NASA engineers make the most use of the volume in Destiny, which is a cylinder.



This photograph shows the U.S. Laboratory Module, also called Destiny, in the International Space Station manufacturing facility at the Marshall Space Flight Center.

Grades 5 to 9

Suggested Pacing

2 days (100 min total)

Day 1

- Exploration Activity I – 35 min
- Inquiry Discussion I – 15 min

Day 2

- Exploration Activity II – 15 min
- Inquiry Discussion II – 5 min
- STEMonstration Video – 5 min
- Exploration Activity III – 25 min

Materials

Provide one per group unless otherwise stated.

- ☐ 1 piece of notebook paper (per student)
- ☐ 25-ft tape measure
- ☐ 12-in. ruler
- ☐ 6 pieces of 16 x 20 in. foam board (per class)
- ☐ Scissors
- ☐ Masking tape
- ☐ Graph paper (per student)
- ☐ Equation Sheet
- ☐ 1 square or rectangular room (per class)

Common Core Math Standards

- CCSS.MATH.CONTENT.5.MD.C.3
- CCSS.MATH.CONTENT.5.MD.C.4
- CCSS.MATH.CONTENT.5.MD.C.5

Area and Volume

Destiny Module Facts:

- Length: 28.0 ft
- Diameter: 14.0 ft
- Mass: 14,520 kg
- Weight: 32,010 lb
- Pressurized volume: 3,700 ft^3

International Space Station Facts:

- Habitable volume: 13,696 ft^3, not including visiting vehicles
- Pressurized volume: 32,333 ft^3

NASA astronaut and Expedition 65 Flight Engineer Megan McArthur is at the robotics workstation inside Destiny, the U.S. Laboratory Module, participating in Canadarm2 robotic arm training.

Facilitate the Challenge

Plan (Exploration Activity I)

Students explore by measuring and calculating the area and volume of the classroom.

- Place students into six groups.
- Hand out tape measures to three of the groups and rulers to the other three groups.
- Explain to each group their goal is to figure out the area or square footage of the classroom.
  - The groups with tape measures measure the length and width of the classroom in feet, rounding to the nearest foot. Each group then multiplies the length and width numbers together to calculate the area.
  - The groups with a 12 in. ruler measure, draw, and cut out two 12 x 12 in. squares per group from two pieces of foam board. Next, each of these groups should observe how many times the square fits along the length and width of the room, rounding to the nearest foot with each measurement. Ask the students to multiply the length and width numbers together to calculate the area of the classroom.
  - Next, each student draws a scaled-down version of their results by using the following scale: one square on a sheet of graph paper equals one square foot. Students draw lines to represent the length and width and connect them to create the perimeter of the classroom. Ask students to count the number of squares within the shape to determine the square footage of the room.
- Each group compares their results with those of other groups to determine if all three methods to calculate the area of the classroom generated the same result.

Ask (Discussion I)

- Ask students the following questions and discuss their answers:
  - Which method was easier to calculate the area of the classroom?
  - What is the difference between area and volume?
  - How might we calculate the volume or cubic footage of the classroom?

Plan (Exploration Activity II)

- Ask all six groups to work together as a team. Students use their existing six 12 x 12 in. squares to create a cube. Give the students tape to complete this portion of the lesson and encourage teamwork among the groups.
- As a class, students work together to calculate the volume of the room and discuss how their results directly relate to the number of 12 x 12 x 12 in. foam cubes needed to fill the room. Be sure your students are using a safe method of measuring the height of the classroom.

Ask (Discussion II)

- Ask students the following questions and segue into the STEMonstration video.
  - How would the microgravity environment of space affect the way we might use our classroom if it was in space?
  - Why is it important to understand the volume of a room aboard the space station or any other vehicle in space?

STEMonstration Video

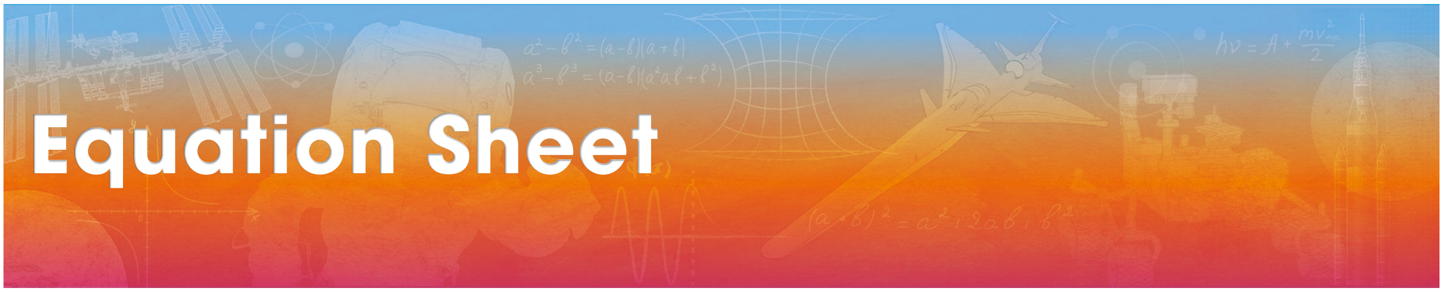
- Watch the Area and Volume STEMonstration video found at https://www.nasa.gov/stemonstrations.
  - Discuss why it is important to understand the volume of rooms in space and how engineers designed Destiny, the U.S. Laboratory Module, to best utilize this space.
  - Discuss why the space station's modules are cylindrical in shape. Use a soda can to model this cylindrical shape.
  - Show students how to calculate the volume of cylinders utilizing the equation sheet provided.

Share (Exploration Activity III)

- Ask all students to redesign their classroom for the microgravity environment of space. Students may use their existing graph paper or notebook paper to draw their designs. Encourage students to utilize the entire space, including the walls and ceiling.
- Students present their designs to the class and discuss the similarities and differences between other student designs and the existing classroom design.
- Discuss the importance of space architects and understanding the volume of rooms.

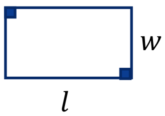
Extensions

- Ask students to take it a step further and create a three-dimensional model of their newly designed microgravity classroom. Give students enough foam board to create their own classroom model and encourage students to create model furniture and decorations to glue inside. Ask each student to present their redesigned classroom model and explain how they utilized the entire volume of the room.
- Ask students to create a model of the Destiny module using a soda can, toilet paper roll, or anything similarly shaped. Students may decorate their model with paint, paper, markers, or other materials available in the classroom. Ask students to measure the diameter and length of the model, calculate the volume in cubic inches, and label the outside of the model with its dimensions.



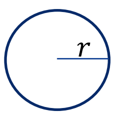
Calculating Area (Square Footage)

Rectangle

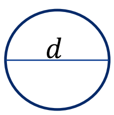


$$\textbf{Area} = \boldsymbol{l} \times \boldsymbol{w}$$

Circle



$$\boldsymbol{r} = \frac{1}{2}\boldsymbol{d}$$

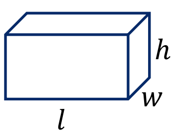


$$\textbf{Area} = \pi \times \boldsymbol{r}^2$$

Symbols:
w = width
l = length
h = height
r = radius
d = diameter
A = area
π = pi ≈ 3.14

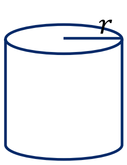
Calculating Volume (Cubic Footage)

Rectangular Solid



$$\textbf{Volume} = \boldsymbol{l} \times \boldsymbol{w} \times \boldsymbol{h}$$

Cylinder



$$\boldsymbol{r} = \frac{1}{2}\boldsymbol{d}$$

$$\textbf{Volume} = \boldsymbol{A} \times \boldsymbol{h}$$

$$\textbf{Volume} = (\pi \times \boldsymbol{r}^2) \times \boldsymbol{h}$$