Exploring Space Through ALGEBRA

EDUCATOR EDITION

Algebra I and Geometry

Next Generation Spacecraft – Orion

Instructional Objectives

Students will

- decompose a larger geometric shape into smaller parts;
- apply the proper area formulas for various geometric shapes; and
- estimate the area of a complex geometric shape using decomposition methods.

Prerequisites

Prior to this activity, students should have had experiences decomposing geometric figures (breaking figures into smaller shapes) and applying area formulas. Students should be familiar with using calculators in evaluating formulas.

Background

This problem is part of a series of problems that apply Algebra and Geometry principles to NASA's Vision for Space Exploration.

Exploration provides the foundation of our knowledge, technology, resources, and inspiration. It seeks answers to fundamental questions about our existence, responds to recent discoveries and puts in place revolutionary techniques and capabilities to inspire our nation, the world, and the next generation. Through NASA, we touch the unknown, we learn and we understand. As we take our first steps toward sustaining a human presence in the solar system, we can look forward to far-off visions of the past becoming realities of the future.

The Vision for Space Exploration includes returning the space shuttle safely to flight, completing the International Space Station, developing a new exploration vehicle and all the systems needed for embarking on extended missions to the Moon, Mars, and beyond.

Orion is the vehicle NASA is developing to carry a new generation of explorers back to the Moon and later to Mars. Orion will succeed the space shuttle as NASA's primary vehicle for human space exploration. Figure 1 shows some components of the Orion spacecraft.

Grade Level
8-12

Subject Area
Mathematics: Algebra I, Geometry

Key Concept
Decomposition of a figure into small shapes to estimate area

Teacher Prep Time
5 minutes

Problem Duration
45-60 minutes

Technology
TI-83 Plus family; TI-84 Plus family; TI Explorer; other scientific calculator

Materials
- Student Edition
- Ruler or straight edge
- Colored pencils or Highlighters
- Graph paper

Degree of Difficulty
Basic to Moderate

Skill
Operate with real numbers; solve problems in a geometric context; use formulas to find areas

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NCTM Principles and Standards
- Number and Operations
- Algebra
- Geometry
- Measurement
- Problem Solving
- Communication
- Connections
- Representation

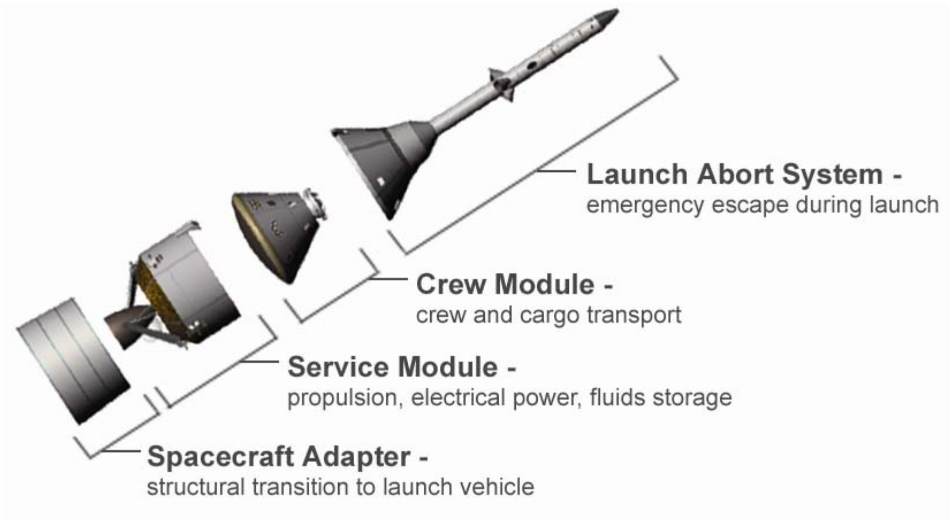

Figure 1: Components of the Orion spacecraft (NASA concept)

Orion will use an improved, larger blunt-body capsule, much like the shape of the Apollo capsule (Figure 2). With an outside diameter of 5 meters, the Orion crew module will have more than two and a half times the volume of an Apollo capsule.

During Orion's planning process, NASA studied several different kinds of entry vehicles and rockets. Although Apollo-era researchers were consulted, NASA did not set out to make the Orion spacecraft identical to the Apollo spacecraft. Ultimately, this design was found to meet the requirements while being the most effective within the safety goals.

For more information about Orion and the Vision for Space Exploration, visit www.nasa.gov.

NASA concept of the Orion crew module

Apollo capsule

Figure 2: Shape comparison of the Orion crew module and the Apollo capsule (not to scale)

NCTM Principles and Standards

Number and Operations

- Develop and use strategies to estimate the results of rational number computations and judge the reasonableness of the results.

Algebra
- Model problem situations with objects and use representations such as graphs, tables, and equations to draw conclusions.
- Model and solve contextualized problems using various representations, such as graphs, tables, and equations.

Geometry
- Recognize and apply geometric ideas and relationships in areas outside the mathematics classroom, such as art, science, and everyday life.

Measurement
- Understand both metric and customary systems of measurement.
- Understand relationships among units and convert from one unit to another within the same system.
- Understand, select, and use units of appropriate size and type to measure angles, perimeter, area, surface area, and volume.
- Select and apply techniques and tools to accurately find length, area, volume, and angle measures to appropriate levels of precision.

Problem Solving
- Solve problems that arise in mathematics and in other contexts.
- Apply and adapt a variety of appropriate strategies to solve problems.
- Monitor and reflect on the process of mathematical problem solving.

Communication
- Communicate their mathematical thinking coherently and clearly to peers, teachers, and others.
- Use the language of mathematics to express mathematical ideas precisely.

Connections
- Recognize and apply mathematics in contexts outside of mathematics.

Representation
- Use representations to model and interpret physical, social, and mathematical phenomena.

Problem

The Orion spacecraft will replace the space shuttle as NASA's spacecraft for human space exploration. The vehicle is designed to accommodate four to six astronauts traveling into space. This activity focuses on the Orion crew module, one of four functional modules of the Orion spacecraft. Students will find the areas of the largest vertical and horizontal cross-sections. This information will provide students a sense of the room within the crew module. Students will also be asked how many crew modules could fit in their classroom. This might be extended to larger areas such as the gymnasium or cafeteria.

Lesson Development

Students will work in pairs to find the areas of the largest vertical and horizontal cross-sections using a drawing of the Orion crew module. Students will record their work on the tables provided.

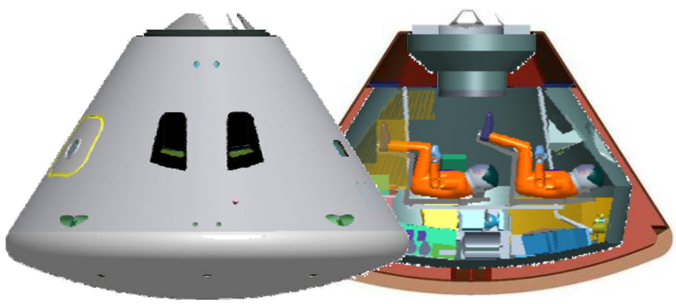

Figure 3: Vertical cross-section of the Orion crew module (NASA Concept)

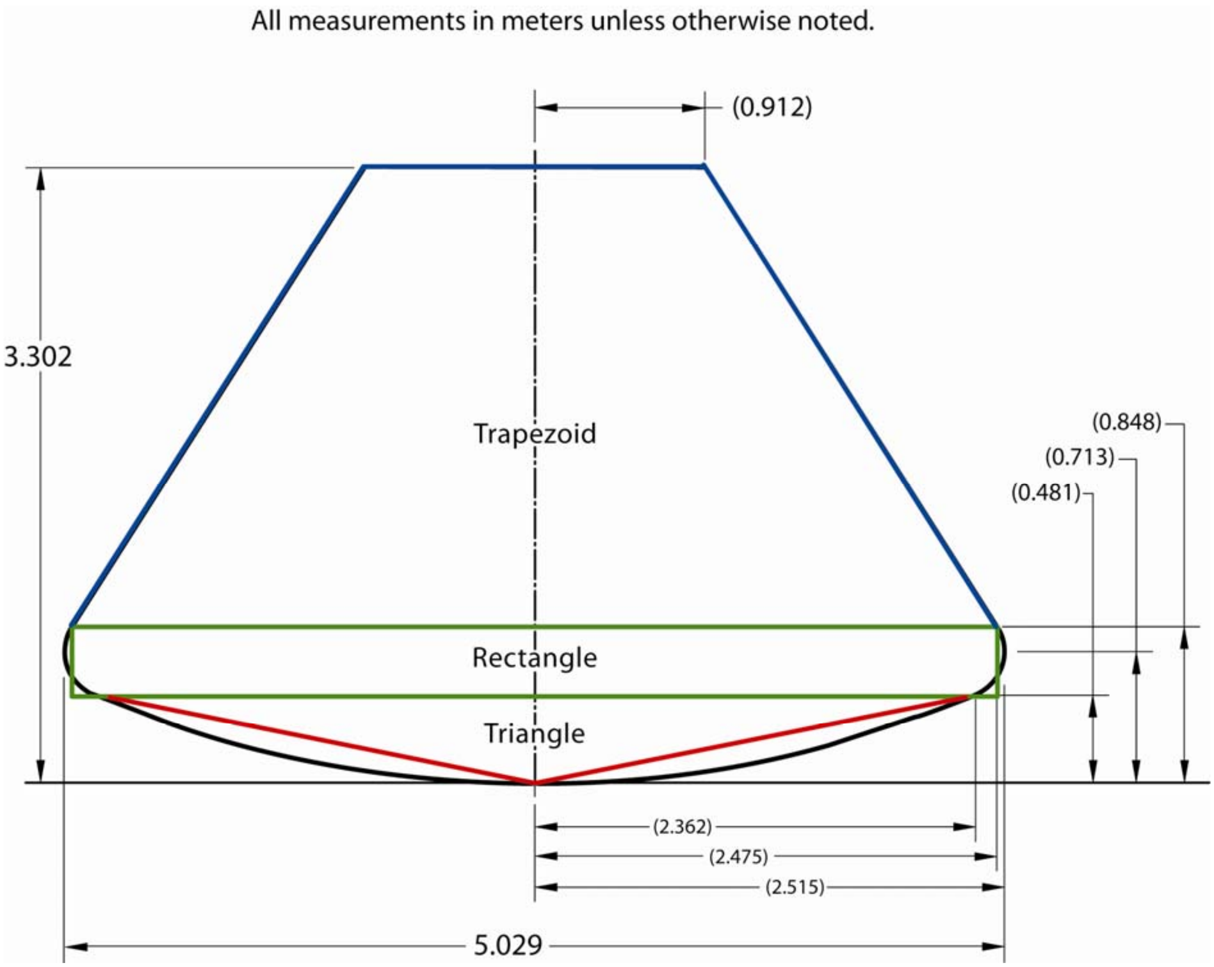

Figure 4: Largest vertical cross-section of the Orion crew module
(This figure shows the student version with decomposition.)

Table 1: Vertical Cross-Section Area Data

Figure	Area Formula	Area Formula with Values	Area (m^2)
Trapezoid	$A=\frac{1}{2}(b_1+b_2)h$	$A=\frac{1}{2}\times[(2\times 2.475)+(2\times 0.912)]\times 2.454$	$A=8.312$
Rectangle	$A=lw$	$A=(2\times 2.475)\times 0.367$	$A=1.817$
Triangle	$A=\frac{1}{2}bh$	$A=\frac{1}{2}\times(2\times 2.362)\times 0.481$	$A=1.136$

Total Area = Area of Trapezoid + Area of Rectangle + Area of Triangle

$A=11.265\text{ m}^2$

2. If the actual largest vertical cross-sectional area of the crew module is 11.665 m^2, how far off was your estimate? Express your answer in terms of a percent (percent error). Please round your answer to the nearest percent.

$$\%\text{ error}=\left|\frac{\text{actual value - estimated value}}{\text{actual value}}\right|\bullet 100$$

$$\%\text{ error}=\left|\frac{11.665-11.265}{11.665}\right|\bullet 100$$

$$\%\text{ error}=3\%\text{ under estimated}$$

3. Find the area, in square meters (m^2), for the largest horizontal cross-section (Figure 5; Figure 6). Show how you would decompose, or break the figure into smaller parts, to estimate the total horizontal area. You may use a calculator to evaluate the formulas. Record your information in the table provided (Table 2). Please round your answer to three decimal places.

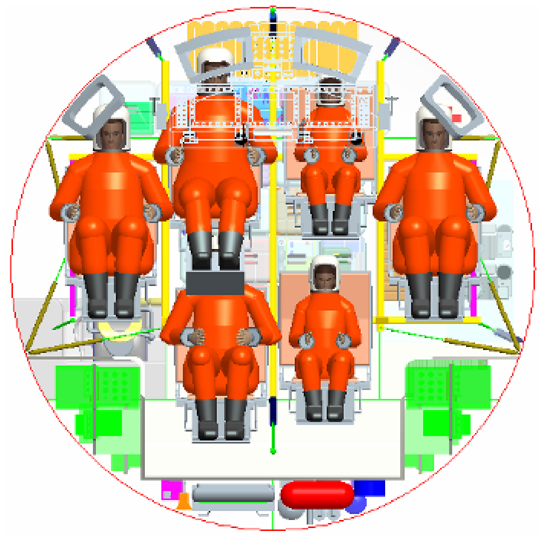

Figure 5: Horizontal cross-section of the Orion crew module (NASA Concept)

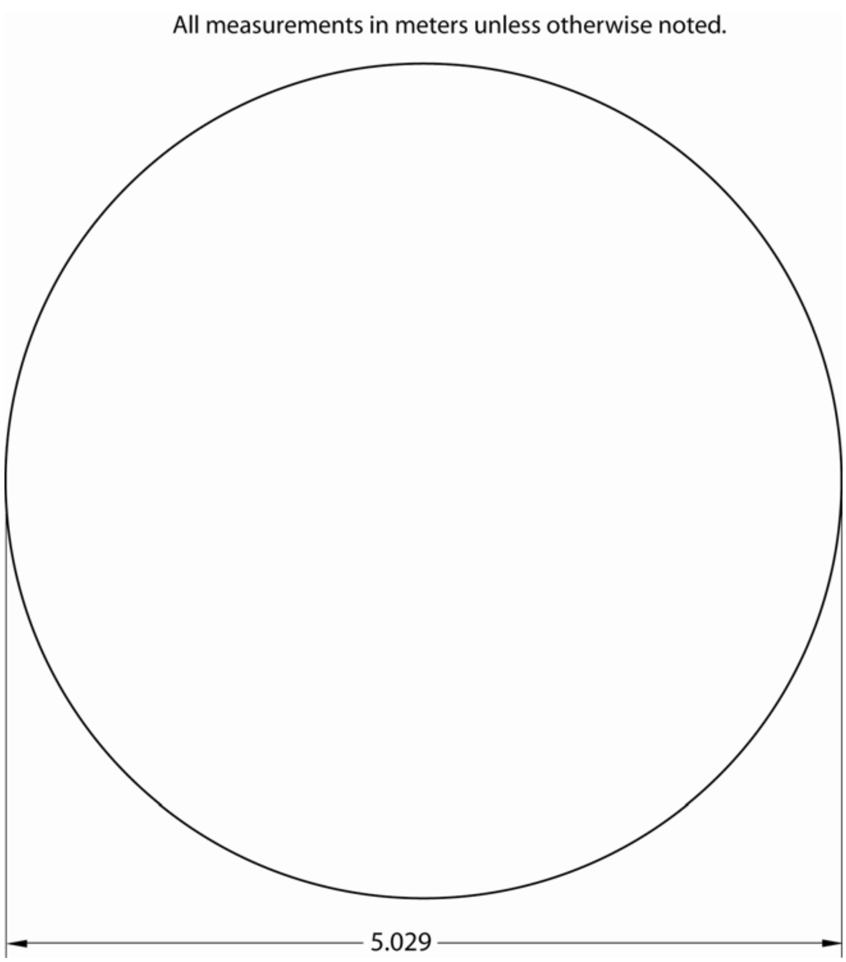

Figure 6: Largest horizontal cross-section of the Orion crew module

Table 2: Horizontal Cross-Section Area Data

Figure	Area Formula	Area Formula with Values	Area (m^2)
Circle	$A = \pi r^2$	$A = \pi \times 2.515^2$	$A = 19.871$

$\pi = 3.142$

Total Area = Area of Circle

$A = 19.871\,\text{m}^2$

4. If lined up side by side, how many of the largest horizontal cross-sections of the Orion crew module (Figure 6) do you think would fit in your classroom? Explain your answer.

   Answers will vary.

5. Would the largest vertical cross-section of the Orion crew module (Figure 4) fit in your classroom? Explain your answer.

   Answers will vary.

Contributors

Thanks to the subject matter experts for their contributions in developing this problem:

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Fax the completed form to: (281) 461-9350 – Attention: Monica Trevathan

Or type your responses in an email and send to: Monica.Trevathan-1@nasa.gov

Please circle the appropriate response.

1. This problem was useful in my classroom. YES NO

2. The problem successfully accomplished the stated Instructional Objectives. YES NO

3. I will use this problem again. YES NO

4. Please provide suggestions for improvement of this problem and associated material:

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5. Please provide suggestions for future Algebra problems, based on NASA topics, that you would like to see developed:

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Thank you for your participation.

Please fax this completed form to Monica Trevathan at (281) 461-9350.