4 Volume and Surface Area

Overview and Connection to Culminating Project

In this Learning Task, students focus on the safety of their playground. They learn about volume and apply their learning to calculating the volume of the ground cover for their playground. Students finish and present their Culminating Project. Then they complete an Individual Performance Task that assesses their learning in the unit.

Learning Objectives

Students will be able to

- Find the volume of rectangular prisms with fractional lengths.
- Connect academic language to real-life situations involving safety.

Driving Question

- How can you use your knowledge of volume to help you prevent injuries if a person were to fall from the equipment in your playground?

Assessment

Check for Understanding • Volume and Fractions

Timeline

Lesson 1 • Safety and Volume

Lesson 2 • Ground Cover

Lesson 3 • Safety Reports

Lesson 4 • Travelers and Tellers

Check for Understanding • Volume and Fractions (see Handouts and Assessments)

Language Support Strategies

Highlight the academic vocabulary used in this task. Briefly preview the terms orally and have students repeat them aloud and share what they know (definition or real-life connections).

Academic Vocabulary

- centimeter cube
- cube
- cubic unit
- depth
- fractional length
- greatest
- least
- rectangular prism
- volume

Language of Instruction

- cause
- compress
- injury
- least to greatest
- protective surfacing
- revise, revision
- safety
- teller
- traveler
- treehouse

Materials, Supplies, and Technology

- Playground Safety: Applicable Standards, Guidelines and Protective Surfacing
- Centimeter cubes
- Copies of Check for Understanding • Volume and Fractions (see Handouts and Assessments)
- Copies of Group Preview • Garden Boxes (see Handouts and Assessments)
- Copies of Individual Performance Task • Garden Boxes (see Handouts and Assessments)

LESSON 1

SAFETY AND VOLUME

WARM-UP

Safety Reference Information

- Have students work on the warm-up activity in their Student Edition.

Review this safety reference information and then answer the questions that follow.

Safety Reference Information

Six years of school injury data (from a northwest Washington state school cooperative) show that the top five causes of injury on playgrounds are as follows:

Falls from equipment	25%
Athletic participation (in a game)	17%
Slip, trip, or fall	16%
Struck against object	13%
Struck by object	11%
All others	18%

In almost half of the playground injuries, equipment was involved. The types of equipment most frequently involved in school playground injuries are as follows:

Bars	29%
Balls, bats, racquets (tetherballs, baseball bats)	23%
Composite structures (like Big Toys)	14%
Climbing appartatus	10%
Non-play equipment (such as poles and posts)	8%
Swings (including tire swings)	7%
Slides	5%
Other play equipment	3%
Tires and tire climbes	1%

The most severe playground claims involve falls from equipment and being hit with balls.

(*Source*: http://web3.esd112.org/docs/insurance-programs/playgrdgdln1200.pdf)

1. What is the most common cause of injuries while at a playground?
2. How can you reduce the injuries or the severity of an injury if someone were to fall in your playground?
3. What types of materials have you seen under play structures at playgrounds?
4. Which types of material do you think work best?
5. How could you know how much of those materials to use?

STUDENT EDITION

- As students share their answers, tell them to return to the Units of Measurement Graphic Organizer that they started in Learning Task 1.
- Explain that for ground cover, students will need to know how much area to cover and how high to stack the material. They will need to know the volume (how much space the material will occupy) to build a safe amount of ground cover. Have students add to the third column of the graphic organizer.

PROJECT ACTIVITY

Dimension Connections

- Give students centimeter cubes and have them complete the "Dimension Connections" activity according to the instructions in their Student Edition.

Use the centimeter cubes at your table to build different cubes and rectangular prisms. Record data about the dimensions of your figures. Label appropriate units. Record observations and patterns you notice in your data. An example is provided in the first row of the table. **Do not take the figures apart after you build them.**

Figure	Length	Width	Height	Volume	Surface Area
1 cube	1 cm	1 cm	1 cm	1 cm^3	6 cm^2
2					
3					
4					

Observations

Answers will vary.

STUDENT EDITION

Extension

- As a possible extension, introduce the formula for surface area. Some students might already be familiar with the formula for finding the volume of a rectangular prism.
- Probe those students to demonstrate why the formula for volume (and/or the formula for surface area) works.
- Encourage all students to test and record how changing different dimensions will change the volume (and/or surface area) of the figures.

Summary

- At the end of class, ask students to share and compare their strategies and observations.
- Have students **show that volume can be measured by finding how many cubic units are needed to fill a three-dimensional space**. Also have them **show how the formula length x width x height will enable them to predict the number of cubic units needed to fill a rectangular prism**.
- Tell students to complete the volume column of their Units of Measurement Graphic Organizer.

Math Curricular Connection Suggestions

Illuminations: Cubes (volume and surface area manipulative)

Learnzillion: Identify the difference between a square unit and a cubic unit (video)

Khan Academy: Geometry

LESSON 2
GROUND COVER

WARM-UP

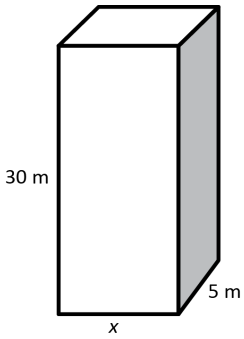
Volume

- Have students work on the warm-up activity in their Student Edition.

What is the volume of the rectangular prism below?

3 in • 6 in • 15 in = 270 in^3

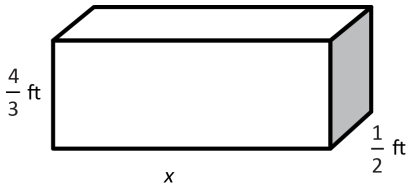
The volume of the rectangular prism below is 1,500 m^3. What is the missing width?



1,500 m^3 = 30 m • 5 m • x

x = 10 m

The volume of the rectangular prism below is $\frac{4}{3}$ ft^3. What is the missing length?



$\frac{4}{3}$ *ft^3* = $\frac{1}{2}$ *ft* • $\frac{4}{3}$ *ft* • *x ft*

x = 2 ft

STUDENT EDITION

PROJECT ACTIVITY

Safety Reports

- Have students read the Playground Safety article.
- Students will use the table from the article and their Playground Information Table from Learning Task 1 to work on completing their safety report.

NOTE

The type and depth of material required is determined by the fall height of the item. The material must cover the entire use or safety zone. Ground-cover materials will compress 25% over time, so students must add extra depth when they design their playground to meet the requirements. Students need to label and convert units of measurement to be successful in this activity.

Read the following:

Playground Protective Surfacing Guidelines

Playgrounds should not be installed or operated without protective surfacing of some type. Concrete, asphalt or other hard surfaces should never be directly under playground equipment. Grass, dirt and compacted clay are not considered protective surfacing.

Pea gravel, sand, shredded/recycled rubber mulch, wood mulch and wood chips along with material (including unitary surfaces) tested to ASTM F1292 standards are appropriate playground surface materials.

CPSC's Handbook Publication 325 Guide to Loose Fill Groundcover Depth

Minimum Compressed Loose Fill Groundcover

Inches of Loose Fill Material		Protects to Fall Height *(feet)*
6*	Shredded/recycled rubber	10
9	Sand	4
9	Pea Gravel	5
9	Wood Mulch	7
9	Wood Chips	10

*Shredded/recycled rubber loose-fill surfacing does not compress in the same manner as other loose-fill materials. However, care should be taken to maintain a constant depth as displacement may still occur.

Loose-fill materials will compress at least 25% over time due to use and weathering. This must be considered when planning the playground. For example, if the playground will require 9" of wood chips, then the initial fill level should be 12".

Safety Report

Use the table below to **show how** you determined how much ground cover your playground will need. Because your playground is brand new, you will need to add extra ground cover. 25% of your ground cover will compress over time. **Remember to label all units of measurement!**

Name of Playground Item	Fall Height	Type of Ground Cover Needed	Area of Use Zone	Depth of Ground Cover Needed (Remember: $\frac{1}{4}$ of it will compress)	Total Amount of Ground Cover Needed for This Item
					Answer will vary.

STUDENT EDITION

Math Curricular Connection Suggestions

Illuminations: Cubes (volume and surface area manipulative)

Learnzillion: Identify the difference between a square unit and a cubic unit (video)

Khan Academy: Geometry

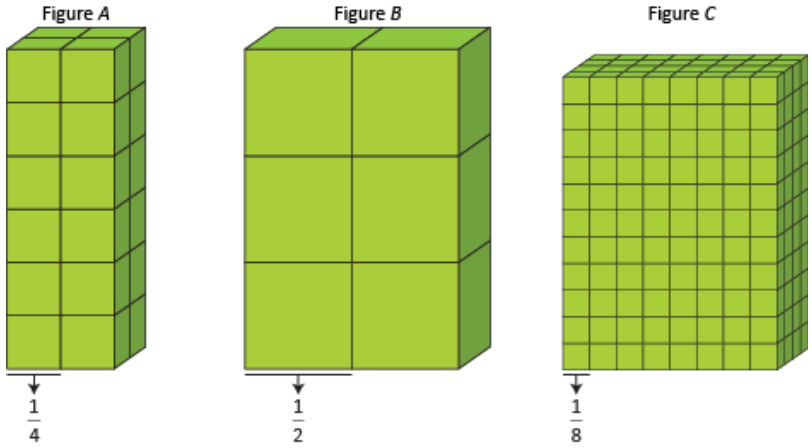
LESSON 3
SAFETY REPORTS

WARM-UP

Volume Word Problem

- Have students work on the warm-up activity in their Student Editions.

Put these rectangular prisms in order from the least to greatest volume. Justify your answer.



Answer: Figure A ($\frac{5}{16}$ unit^3), Figure C ($\frac{11}{16}$ unit^3), Figure B ($\frac{3}{4}$ unit^3)

STUDENT EDITION

PROJECT ACTIVITY

Safety Reports (continue working)

- Have students continue to work on their safety reports and on any other unfinished activities. If a team can demonstrate that they are finished (every team member can thoroughly explain what was done) then they can work on finalizing their playground project based on the checklist and rubric in Learning Task 1.

NOTE

The computation will require multiplying by either a mixed number or a decimal. Circulate and provide support as needed with this computation. You may find that once groups get to this point, you will need to pull the class together again and do a mini review on multiplying by mixed numbers or decimals.

Math Curricular Connection Suggestions

Illuminations: Volume and Surface Area Manipulative

Learnzillion: Difference between square and cubic units

Khan Academy: Geometry

LESSON 4

TRAVELERS AND TELLERS

WARM-UP

Volume Word Problem

- Have students work on the warm-up activity in their Student Edition.

For his playground, Alex built a tree house in the shape of a cube. Each of the cube's edges are 3 $\frac{1}{4}$ meters long. He wants to store all of his cube-shaped boxes in the tree house while the rest of the playground is being built. All of the boxes have edges of $\frac{1}{4}$ meter. If he fills the whole tree house, how many boxes could he fit inside?

Alex can fix 13 boxes of $\frac{1}{4}$ meter in a length of 3 $\frac{1}{4}$ meter. Thus, the total number of boxes that can fit in 3 $\frac{1}{4}$ meter cube treehouse is 13 x 13 x 13, or 2,197 boxes.

STUDENT EDITION

PROJECT ACTIVITY

Travelers and Tellers

Have the playground teams split in half. Send one half (the Travelers) to review and interview other teams about their project; the other half (the Tellers) will answer questions from the Travelers. The goal is to cross-pollinate ideas and problem-solving strategies and for the class to self-assess their progress. Set up a large visual timer and give the Travelers 3 minutes at each team to ask questions and share ideas. The Travelers should rotate so that they are able to visit three to four other teams. The Tellers should explain to the Travelers the reasons why they made their play areas the way they did and answer any questions. After the Travelers have rotated through multiple teams, have them return to their original team and share at least one thing they saw when they went to other teams.

Your playground team will divide in half.

- Half of the team (the Travelers) will interview other teams about their project.
- The other half (the Tellers) will explain their project to the visiting Travelers and answer any questions.

Travelers: Rotate through the other playground teams as your teacher directs. Then go back to your team and share at least one thing you learned from the other teams.

Tellers: Briefly present your project to the Travelers and answer questions. When the Travelers have rejoined you, share at least one thing you learned from the Travelers who visited your team.

STUDENT EDITION

Revise

Have the teams make any necessary revisions to their projects based on the Travelers and Tellers activity, and finalize any outstanding information needed for their playground.

> Make any necessary revisions to your playground based on the Travelers and Tellers activity, and finalize any outstanding information needed for your playground.

STUDENT EDITION

Math Curricular Connection Suggestions

Illuminations: Cubes (volume and surface area manipulative)

Learnzillion: Identify the difference between a square unit and a cubic unit

Khan Academy: Geometry

CHECK FOR UNDERSTANDING

Volume and Fractions

- Distribute the Learning Task 4 assessment: Check for Understanding • Volume and Fractions.

> Marina wants to build a giant ball pit for her playground. Her pit will be a right rectangular prism that is 50 ft long, 25 ft wide, and 12.5 ft deep. She will fill the pit up $\frac{3}{4}$ of the way so that her friends have room to breathe at the top.
>
> Will 10,000 ft^3 of balls be enough to fill that space? Why or why not?
>
> *Answer:* $\frac{3}{4} \cdot 12.5 = 9.375$
>
> $50\ ft \cdot 25\ ft \cdot 9.375\ ft = 11{,}718.75\ ft^3$
>
> *No, 10,000 ft^3 of balls will not be enough to fill $\frac{3}{4}$ of the giant ball pit.*

ASSESSMENTS AND HANDOUTS

CULMINATING PROJECT

PLAYGROUNDS

PROJECT ACTIVITY

Work on Culminating Project

- Give student teams time to finish their Playgrounds Culminating Project. Refer them to the rubric and checklist in Learning Task 1. Students should make sure that they have completed all the items on the checklist, and have assessed their project using the rubric. Then have students present their playground to the class either through presentations or a gallery walk.

INDIVIDUAL PERFORMANCE TASK (Including a Group Preview)

- Arrange students in groups and have them work on the Group Preview (see Handouts and Assessments). An answer key for the Group Preview is provided in the Overview section of this Teacher Edition. If you feel it would be helpful, discuss the Group Preview.
- Then, administer the Individual Performance Task (see Handouts and Assessments). A rubric and answer key are provided in the Overview section of this Teacher Edition.