Unit 2: Playgrounds Overview

How can we use mathematics to design a playground that is both fun and safe?

Learning Task 1: Get Started on the Culminating Project

Check for Understanding • Area of Use Zones

Learning Task 2: Area of Shapes

Check for Understanding • Areas of Polygons

Learning Task 3: Coordinate Plane

Check for Understanding • Draw Polygons on the Coordinate Plane

Learning Task 4: Volume and Surface Area

Check for Understanding • Volume and Fractions

Culminating Project: Playgrounds

Students will create a fun and safe playground.

Individual Performance Task

Learning Objectives

Students will be able to

- Use precision when selecting, identifying, and converting between units and dimensions of measurement.
- Find the area of rectangles with lengths given in mixed units.
- Calculate the area of triangles and parallelograms.
- Use decomposition, negative space, and/or other strategies to calculate the area of trapezoids and other composite figures.
- Justify why the area formulas for parallelograms and triangles always work.
- Identify and plot points in all four quadrants of a coordinate plane.
- Use the coordinate plane to draw polygons and apply their understanding to solve real-world problems.
- Find the volume of rectangular prisms with fractional lengths.

Standards

Aligned Common Core State Standards for Mathematics

- 6.G.A.1. Find the area of right triangles, other triangles, special quadrilaterals, and polygons by composing into rectangles or decomposing into triangles and other shapes; apply these techniques in the context of solving real-world and mathematical problems.
- 6.G.A.2. Find the volume of a right rectangular prism with fractional edge lengths by packing it with unit cubes of the appropriate unit fraction edge lengths, and show that the volume is the same as would be found by multiplying the edge lengths of the prism. Apply the formulas $V = l\ w\ h$ and $V = b\ h$ to find volumes of right rectangular prisms with fractional edge lengths in the context of solving real-world and mathematical problems.
- 6.G.A.3. Draw polygons in the coordinate plane given coordinates for the vertices; use coordinates to find the length of a side joining points with the same first coordinate or the same second coordinate. Apply these techniques in the context of solving real-world and mathematical problems.
- 6.NS.C.6. Extend number line diagrams and coordinate axes familiar from previous grades to represent points on the line and in the plane with negative number coordinates.
- 6.NC.C.8. Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane. Include use of coordinates and absolute value to find distances between points with the same first coordinate or the same second coordinate.
- 6.NS.B.3. Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation.
- 5.NF.B.6. Solve real world problems involving multiplication of fractions and mixed numbers, e.g., by using visual fraction models or equations to represent the problem.
- 6.RP.A.3d. Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities.

Playgrounds Overview

Learning Task 1: Get Started on the Culminating Project

In Learning Task 1, students learn about the requirements of the Culminating Project and build background knowledge. Students research types of playground systems, features, and activities. They select components to include in their ideal playground by researching types of playground systems, features, and activities. Students practice converting feet to yards and square feet to square yards and review how to calculate the area of a rectangle.

Learning Task 2: Area of Shapes

Students learn how to calculate the area of triangles, trapezoids, parallelograms, and composite shapes. They apply that knowledge in order to calculate the area of their playground.

Learning Task 3: Coordinate Plane

Students learn about plotting points on a four-quadrant coordinate plane. They use that knowledge to place systems, features, and activities within their playground, identifying coordinates for each item within the playground. They convert measurements from feet to yards.

Learning Task 4: Volume and Surface Area

Students focus on the volume of rectangular solids. They use their knowledge to analyze safety requirements as they determine the volume of a ground cover for their playground. Students consider how to calculate the depth given the compression of materials. They convert fall heights from inches to feet.

Culminating Project: Playgrounds

Teams design a playground that is fun, safe, and promotes fitness. Students justify that their selected equipment and activities fit within their playground, and that the ground cover meets the safety requirements for a new playground.

Individual Performance Task

Students individually complete a performance task to display evidence of student mastery of the skills related to this unit.

Playgrounds Culminating Project

In Learning Task 1, you will divide your class into teams and assign each team a playground floor plan. During the unit, the teams will choose equipment to place in their playground, perform calculations about area, determine safety zones, and calculate the volume of ground cover.

After Learning Task 4, you will give your teams time to finish their floor plan and prepare and give a presentation. The teams may present their playground as a website, brochure, book, video, or other some other method (they should check with you if they use a different method). They can use Floorplanner, Tinkercad, or another tool to create models of their playground and structures.

Culminating Project Specifications

Students will be given the following checklist and rubric to prepare for their presentation. You will use the rubric to judge their project.

Make sure that your playground includes:

- ❑ A detailed design of your playground that is built to scale (show that there is a consistent ratio connecting distances in your design to distances in real life)
- ❑ Labeling on your design (all equipment, ground cover, use zones, dimensions, units, area, and volumes are labeled)
- ❑ A visual and an explanation about how to fit your systems, features, and activities in your playground floor plan using coordinates in all four quadrants
- ❑ Calculations and an explanation about how to find the area of your entire playground floor plan (name which floor plan you have used)
- ❑ Calculations and an explanation about how to find the area of each of your use zones
- ❑ Calculations and an explanation about the amount of each type of ground cover for your playground (including the extra ground cover needed because you are making a new playground)
- ❑ An explanation of any shortcuts, patterns, or formulas and justifications about why these shortcuts, patterns, or formulas always work
- ❑ A report that uses evidence from your analysis to justify why your playground is fun and safe (thoroughly support all of your claims with evidence)

STUDENT EDITION

Playgrounds Culminating Project Rubric

MATHEMATICAL PRACTICE	MASTERS	ACHIEVES	APPROACHES	NOT YET
Model with mathematics (MP4)	Our design is built to scale. We thoroughly show and explain each step of how we found area and volume. We use numbers, words, and other diagrams (tables, pictures, expressions, etc.).	Our design is built to scale. We mostly show and explain each step of how we found area and volume. We use numbers and words.	Our design is built to scale. We partially show and explain each step of how we found area and volume. We only use words or only use numbers.	Our design is not built to scale. We do not show or explain each step of how we found area and volume.
Construct viable arguments (MP3)	Our written report uses evidence from our analysis to justify why our playground is fun and safe. We thoroughly support all of our claims with evidence.	Our written report uses some evidence from our analysis to justify why our playground is fun and safe. We support most claims with evidence.	Our written report uses incomplete or inconsistent evidence from our analysis to justify why our playground is fun and safe. We make claims without support.	We do not make a written report that uses evidence from our analysis.
Look for and make use of structure (MP7)	We clearly show how each area and volume is made of specific dimensions or parts and clearly show how different dimensions or parts can be put together to make different areas and volumes.	We mostly show how each area and volume is made of specific dimensions or parts and clearly show how different dimensions or parts can be put together to make different areas and volumes.	We sometimes show how each area and volume is made of specific dimensions or parts and clearly show how different dimensions or parts can be put together to make different areas and volumes.	We do not show how parts make up the whole.
Look for and express regularity in repeated reasoning (MP8)	We thoroughly show and explain any shortcuts, patterns, or formulas that we used while designing our playground. We justify why these shortcuts, patterns, or formulas work.	We mostly show and explain any shortcuts, patterns, or formulas that we used while designing our playground. We mostly justify why these shortcuts, patterns, or formulas work.	We show and explain some shortcuts, patterns, or formulas that we used while designing our playground.	We do not show or explain any shortcuts, patterns, or formulas in our design.
Attend to precision (MP6)	We make accurate calculations during our analysis. We appropriately label all dimensions and units of measurement.	We mostly make accurate calculations during our analysis. We mostly appropriately label all dimensions and units of measurement.	We have errors in our calculations or we do not use appropriate labels and units of measurement.	We do not use labels and units of measurement.

Playgrounds Assessments

Check for Understanding

At the end of each Learning Task, there is a Check for Understanding that reviews the math content in that Learning Task. Answer keys are provided in this Teacher Edition.

Learning Task 1: Check for Understanding • Area of Use Zones

Learning Task 2: Check for Understanding • Areas of Polygons

Learning Task 3: Check for Understanding • Draw Polygons on the Coordinate Plane

Learning Task 4: Check for Understanding • Volume and Fractions

Individual Performance Task (Including a Group Preview)

You will administer a Group Preview and an Individual Performance Task at the end of the unit.

The Group Preview is an introduction to the Individual Performance Task that has students work in groups. It is meant to make the Individual Performance Task more accessible, but it is not meant to be a summative assessment in and of itself. You will find an answer key on pages 8–10.

The Individual Performance Task should be administered to each student. You will find an answer key and rubric on pages 11–13.

Group Preview • Garden Boxes

Name _____ Date _____ Group _____

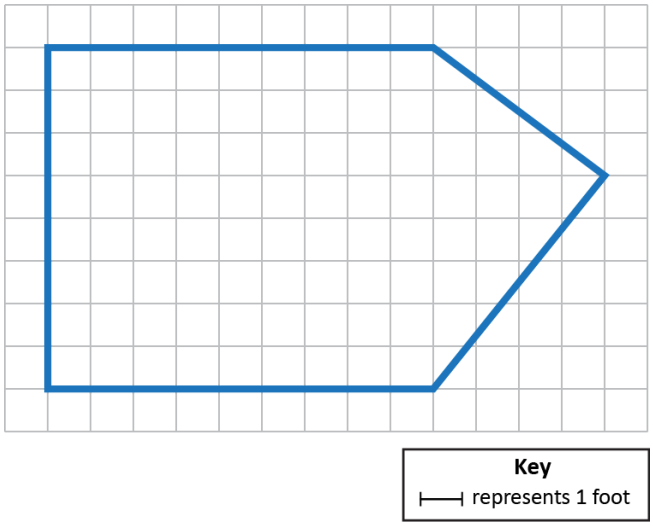
You are designing and building a raised garden box for your school.



Section 1: Area of the Base of a Garden Box

A classmate created a garden box. Figure 1 represents the base of the garden box.

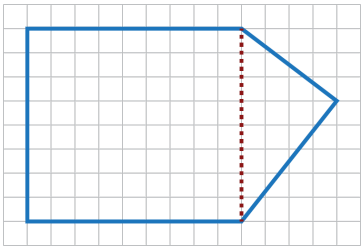
Figure 1. Base of a Garden Box Design



Group Discussion

- What strategies can you use to determine the area of the base of the garden box?

  The most likely response is to divide the base into a rectangle and triangle. However, look for other responses.



- Which formula(s) can you use to calculate the area of the base of the garden box?

  You will need both the formula for the area of a rectangle ($A = b \bullet h$) and the formula for the area of a triangle ($A = \frac{1}{2} \bullet b \bullet h$).

What is the area of the base of the garden box?

Use words and numbers to explain your work.

The rectangle is 9 ft by 8 ft. The area is 72 ft^2.

The triangle has a base of 8 ft and a height of 4 ft. The formula is $A = \frac{1}{2} b \bullet h$, or $A = \frac{1}{2} \bullet 8 \bullet 4$.
The area of the triangle is 16 ft^2.

To find the area of the composite figure, add the two areas together.
$A = 72\ ft^2 + 16\ ft^2 = 88\ ft^2$
The area of the composite figure is 99 ft^2.

Section 2: Amount of Soil

The depth of the soil in the garden needs to be 18 inches. How many cubic **feet** of soil is needed for the raised garden shown in Figure 1?

Use words and numbers to explain your work.

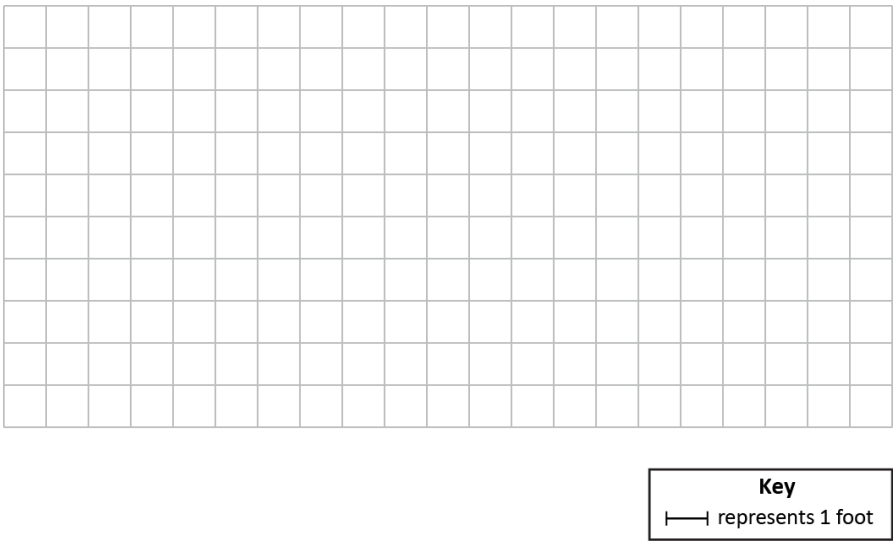
To find the volume, calculate the area of the base (88 ft^2) times the height (18 in., or 1.5 ft).
Volume = 88 • 1.5 = 132
You will need 132 cubic feet of soil.

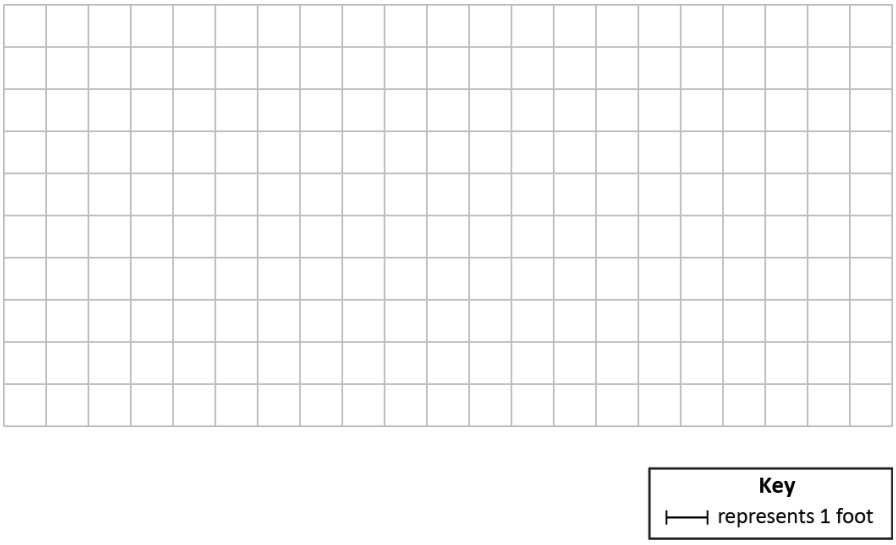
Section 3: Design Your Own Garden Boxes

You now have the opportunity to be creative and design two new garden boxes. Draw on the graph below to sketch two **unique** bases of garden boxes that meet **all** of the following criteria.

1. The base of the garden box can only use straight lines.
2. The base must have four or more sides.
3. The base must have at least two corners that are **not** right angles.
4. Each corner of the base must be at a **lattice point** of the graph paper. *(Your teacher will explain to the class what a lattice point is.)*

   Answers will vary.





Discussion Questions

1. Compare strategies and the work completed for Sections 1 and 2.
2. How do you decide if it is better to decompose a figure or to use negative space to calculate the area?
3. How can you verify that your garden design in Section 3 meets **all** of the criteria?

Individual Performance Task • Garden Boxes

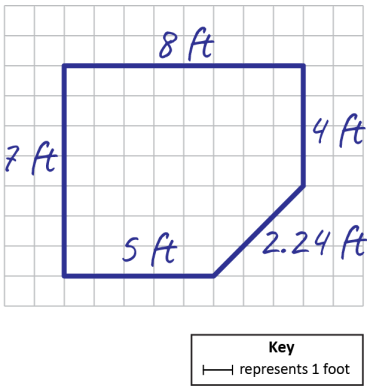
Name _____ Date _____

Section 1: Review Annie's Design

Your friend Annie created this design. She says that her garden box base meets all of the design criteria and has an area of 60.5 square feet.

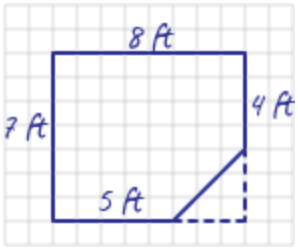
1. The base of the garden box can only use straight lines.
2. The base must have four or more sides.
3. The base must have at least two corners that are **not** right angles.
4. Each corner of the base must be at a **lattice point** of the graph paper.

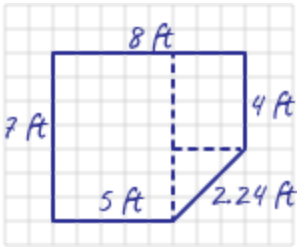
Annie's Design



Do you agree with Annie? Explain below why or why not.

Two ways you could divide the figure are:





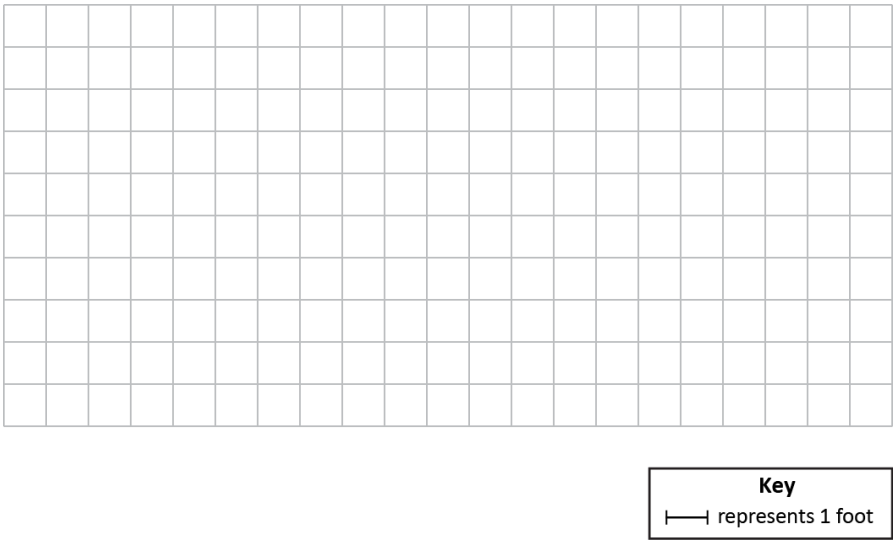
Using the first drawing, the rectangle is 8 × 7, or 56 ft².
The missing triangle has a base of 3 and a height of 3, or

$\frac{1}{2} \bullet 3 \bullet 3 = 4.5$ *ft².*
The total area is 56 ft² – 4.5 ft² = 51.5 ft².

Annie did not calculate the area of the garden box correctly.

Section 2: Design a Garden Box

Use the grid below to draw the base of another garden box. You can either use a design you created in the group activity, or create a new box that meets **all** of the criteria listed in Section 1.



Part A: What is the area of the base of your garden box?

Answers will vary.

Part B: The garden box will have a height of 2 feet. What is the total volume of your garden box?

Answers will vary.

Part C: Experts recommend filling a garden box $\frac{7}{8}$ of its total volume with soil. How many cubic feet of soil will you need for your garden box? Explain how you determined your answer by showing all work using math, words, and a diagram.

Answers will vary.

Playgrounds Individual Performance Task Rubric

MATHEMATICAL PRACTICE	MASTERS	ACHIEVES	APPROACHES	NOT YET
Construct viable arguments (MP3)	Achieves Plus: I provide more than one way to verify that my argument is correct.	I support my arguments and claims with evidence. I evaluate and improve incomplete or flawed arguments.	I provide partial or inconsistent evidence to support my conjectures, arguments, and claims.	I am still working to provide evidence (that someone else will understand) to support my conjectures, arguments, and claims.
Critique the reasoning of others (MP3)	Achieves Plus: I provide more than one way to verify the reasoning of others.	I explain how I tested the reasoning of others. If there is a flaw, I can identify it. I use evidence to support or refute others' arguments and claims.	I provide partial or inconsistent evidence to support or refute others' conjectures, arguments, and claims.	I need assistance to provide evidence to support or refute others' conjectures, arguments, and claims.
Model with mathematics (MP4)	Achieves Plus: I describe the conditions for which my model is valid.	I represent situations, questions, and problems in multiple and effective ways (pictures, diagrams, charts, graphs, expressions, numbers, words, etc.). I adjust, revise, and update my model when I receive new information and document that I did this.	I start to represent situations, questions, and problems, but I am not sure how to use my model to find my answer.	I need assistance showing how to represent the given situation. I am unsure what information I should use in my model.

Materials, Supplies, and Technology

Learning Task 1: Get Started on the Culminating Project

- http://www.bciburke.com/
- "Playgrounds" digital slide presentation
- Kaboom Playground Construction video
- Kaboom.org
- Examples of playgrounds that use "strange" shapes:
    - http://theverybesttop10.com/unusual-playgrounds/
    - http://www.treehugger.com/sustainable-product-design/ruins-of-electric-train-turned-into-terribly-cool-amusement-park-in-lima-photos.html
    - http://www.neatorama.com/2012/07/25/the-12-most-unique-playgrounds-in-the-world/
    - https://www.pinterest.com/pin/10977592818873911/
    - http://www.citymuseum.org/
- Copies of Check for Understanding • Area of Use Zones (see Handouts and Assessments)

Learning Task 2: Area of Shapes

- Bulk foam square color tiles (optional) or sticky notes
- Rulers
- Measuring tape
- Graph paper
- Scissors
- One copy to display of the four Parallelogram Shapes in the Real World images (see Handouts and Assessments)
- One copy to display of the four Triangle Shapes in the Real World images (see Handouts and Assessments)
- Copies of Check for Understanding • Areas of Polygons

Learning Task 3: Coordinate Plane

- Video: How to Set Posts in Concrete (without mixing)
- Blank copies of the playground floor plans (see Handouts and Assessments)
- Blank copy of a coordinate plane for display
- Copies of Check for Understanding • Draw Polygons on the Coordinate Plane (see Handouts and Assessments)

Learning Task 4: Volume and Surface Area

- 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)