Lesson 19

All about Tents (Optional)

Goals

- Apply understanding of surface area to estimate the amount of material in a tent, and explain (orally and in writing) the estimation strategy.
- Compare and contrast (orally) different tent designs.
- Interpret information (presented in writing and through other representations) about tents and sleeping bags.

Learning Targets

- I can apply what I know about the area of polygons to find the surface area of three-dimensional objects.
- I can use surface area to reason about real-world objects.

Lesson Narrative

In this culminating lesson, students apply what they learned in this unit to solve problems about surface area in context.

Students begin by looking at different examples of tents, analyzing two simple tents of different sizes, and reasoning about the amount of material needed to construct these tents. Then, they can create their own tent design and estimate how much material is needed for the tent. They need to ensure that their design meets specified parameters and their estimate is backed by sound reasoning and calculations. Finally, students present, compare, and reflect on their design solutions and estimates. They consider the impact of design decisions on the surface areas of their tents.

The activities in the lesson prompt students to model a situation with the mathematics they know, make assumptions, and plan a path to solve a problem and to make a logical argument to support their reasoning.

Depending on instructional choices made, this lesson could take one or more class meetings. The *Warm-up* activity and the first activity about two camping tents can be completed in a typical class period. The last two activities (designing a tent and presenting the design) are optional and may take another class period or more, depending on the instructional decisions made, such as:

- Whether students use the provided information about tents and sleeping bags or perform additional research.

Lesson Timeline

5 min	35 min	45 min	15 min	10 min
Warm-up	Activity 1	Activity 2	Activity 3	Lesson Synthesis

Access for Students with Diverse Abilities

- Action and Expression (Activity 1, Activity 3)
- Engagement (Activity 2)

Access for Multilingual Learners

- MLR5: Co-Craft Questions (Activity 1)
- MLR8: Discussion Supports (Activity 2, Activity 3)

Instructional Routines

- MLR5: Co-Craft Questions
- MLR8: Discussion Supports
- Notice and Wonder

Required Materials

Materials to Gather

- Geometry toolkits: Activity 2

Lesson 19

All about Tents (Optional)

Lesson Narrative (continued)

- Expectations regarding drafting, revising, and the final product.
- How students' work is ultimately shared with the class (not at all, informally, or with formal presentations).

A note about context:

While experience with camping or tents is not necessary for comparing surface areas in the *Two Tents* activity, it might affect students' readiness to design a tent in the subsequent activity. Consider showing additional images, videos, or an actual camping tent to orient students as needed. If the camping-tent context is anticipated to be challenging or sensitive (such as for students who have experienced housing insecurity or displacement), consider adapting the design task to be about a different structure or object. A tent for a party, a booth for a fair, a birdhouse or house for a pet, and packaging for a toy are some examples.

Student Learning Goal

Let's find out how much material is needed to build some tents.

Warm-up

Notice and Wonder: Structures

5 min

Activity Narrative

The purpose of this *Warm-up* is to familiarize students with the context of tents, which will be useful when students investigate the amount of material needed to construct tents later in the lesson. While students may notice and wonder many things about these images, the important discussion points are that many structures use fabric (or another flexible material) for cover or enclosure. These structures can be designed in different shapes and sizes and to accommodate different purposes or numbers of occupants.

When students articulate what they notice and wonder, they have an opportunity to attend to precision in the language that they use to describe what they see. They might first propose less formal or imprecise language, and then restate their observation with more precise language in order to communicate more clearly.

Launch

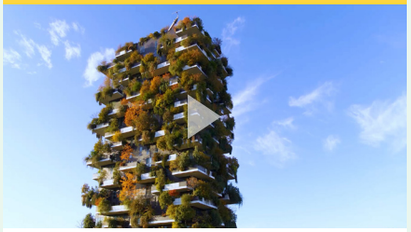
Arrange students in groups of 2. Display the images for all to see. Ask students to think of at least one thing they notice and at least one thing they wonder. Give students 1 minute of quiet think time, and then 1 minute to discuss the things they notice and wonder with their partner.

Student Task Statement

What do you notice? What do you wonder?

Inspire Math

Greening the City video



Go Online

Before the lesson, show this video to reinforce the real-world connection.

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Instructional Routines

Notice and Wonder

ilclass.com/r/10694948

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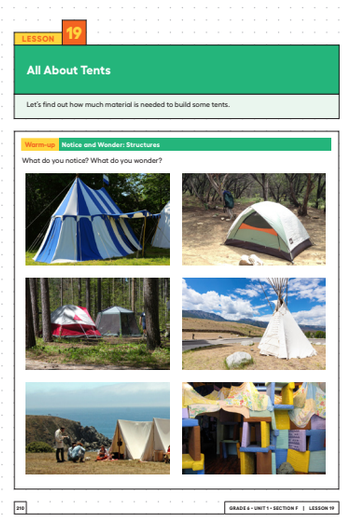
Student Workbook



Students may notice:

- These are all pictures of tents or shelters built with fabric or a flexible material.
- Most images show outdoor tents. One picture shows an indoor tent or a fort.
- The tents are of different kinds, shapes, and sizes.
- Some tents are held up by sticks or posts. Others are held up by frames and strings.

Students may wonder:

- How many people can fit in each tent?
- What are the tents used for? Why are they put up where they are?
- How many blankets are needed to make the indoor fort? What are the strings tied to?
- How is the teepee built? How much fabric does it take?

Activity Synthesis

Record and display their responses for all to see, without editing or commentary. If possible, record the relevant reasoning on or near the images. Next, ask students,

💬 *"Is there anything on this list that you are wondering about now?"*

Encourage students to respectfully disagree, ask for clarification, or point out contradicting information.

If the idea of structures that use a flexible material does not come up during the conversation, invite students to discuss this idea. Relate it to students' experience by asking questions such as:

💬 *"Have you seen a tent?"*

"Have you been inside a tent or a structure that uses fabric or another flexible material for cover?"

"Have you built one?"

Invite students to reflect on the size of the structure, how it was built, the functions it served, and the experience inside or underneath it.

Tell students that they will look at some tent designs and the amount of materials needed to build them.

Activity 1
Two Tents

35 min

Activity Narrative

The purpose of this activity is for students to apply their understanding of area and surface area to solve a problem about tents. It also familiarizes students with some considerations that are important in tent design, preparing students to design their own tent in the next activity.

Students are presented with an image of two tents of the same design but of different sizes. While the problem situation is fairly well defined, students are not initially given a problem to solve or any measurements. Instead, they have an opportunity to think about mathematical questions that could be asked, consider the information necessary to answer one of the questions, and make assumptions or estimates if needed. As students make sense of a situation, consider relevant quantities in context, and think about how to solve a problem with the mathematics that they know, they practice aspects of mathematical modeling.

As students work to solve the chosen problem, monitor for different assumptions students make about the tents (such as whether there is a floor panel inside the tent or whether the tents have an open side). Also monitor for various ways in which students reason about the surface areas (including their choice of units of measurement) and communicate their reasoning.

This is the first time Math Language Routine 5: Co-Craft Questions is suggested in this course. In this routine, students are given a context or situation, often in the form of a problem stem (for example, a story, image, video, or graph) with or without numerical values. Students develop mathematical questions that can be asked about the situation. A typical prompt is: "What mathematical questions could you ask about this situation?" The purpose of this routine is to allow students to make sense of a context before feeling pressure to produce answers, and to develop students' awareness of the language used in mathematics problems.

Launch

Arrange students in groups of 2. Introduce the context of camping tents. Tell students that camping tents come in many shapes and sizes. Tent designs can also vary quite a bit, from simple to elaborate. Use *Co-Craft Questions* to give students an opportunity to familiarize themselves with the context, and to practice producing the language of mathematical questions.

- Display only the image of the two tents. Ask students,

💬 *"What mathematical questions could you ask about this situation?"*

- Give students 1–2 minutes to write a list of mathematical questions that could be asked about the tents before comparing questions with a partner.

  As partners discuss, support students in using conversation and collaboration skills to generate and refine their questions, for instance, by revoicing a question, seeking clarity, or referring to their written notes. Listen for how students talk in context about the characteristics and measurements of the triangular prisms.

Access for Multilingual Learners (Activity 1, Launch)

MLR5: Co-Craft Questions
This activity uses the *Co-Craft Questions* math language routine to advance reading and writing as students make sense of a context and practice generating mathematical questions.

Instructional Routines

MLR5: Co-Craft Questions

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- Invite several partners to share one question with the class, and record responses. Ask the class to make comparisons among the shared questions and their own. Ask,

💬 *"What do these questions have in common? How are they different?"*

Listen for and amplify language related to the learning goal, such as "area of each face of the tent," "floor area inside the tent," "surface area of the tent," and "the amount of material needed to build each tent."

If students asked questions related to the amount of material needed to build both tents, choose or adapt one of those questions for the class to answer. Otherwise, select and pose one of the following questions:

💬 *"About how many square feet of material is needed to build each tent?"*

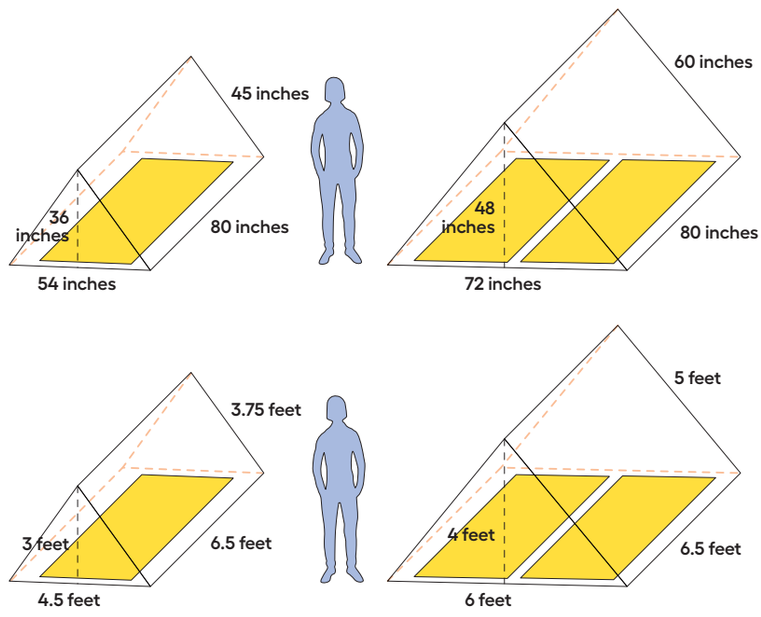
"How much more material is needed to build a two-person tent than a one-person tent?"

"Does it take twice as much material to build a two-person tent than to build a one-person tent? How do you know?"

Give students a minute to record the selected question and 2–3 minutes to discuss with their partner what they need to know to answer the question. Then, ask them to list the information needed.

Next, invite students to ask for information, and then provide the following measurements as requested. For any additional information, ask students to make estimates or assumptions, or to compute what can be computed.

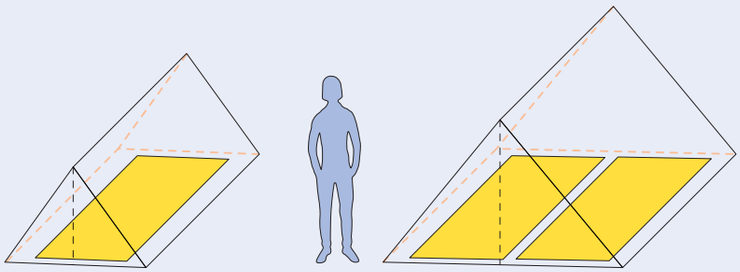
- Each sleeping bag or mat measures 34 inches by 74 inches.
- The person in the image is about 70 inches tall.
- The edge lengths of the tents in inches and in feet are as shown:



Give students 12–15 minutes to complete the activity individually or with their partner. Provide access to calculators.

Student Task Statement

Here is an image of two tents.



1. Record the question that your class is answering.

   Questions vary based on the teacher's selection.

2. What do you need to know to be able to answer the question? List the information that you need.

   Sample responses:

   - The length and width of the floor of each tent
   - The height of each tent
   - The size of each sleeping bag or mat
   - The size of the gaps between the sleeping bag and the edges of the tent
   - Whether the floor is covered
   - Whether both triangular ends of the tent are covered

3. Use the information that you received to answer the question. Show your reasoning, including any assumptions that you make about the situation. Organize your work so that it can be followed by others.

   All sample responses are based on these assumptions:

   - The tent material covers the floor and both front and back triangular faces.
   - The calculation doesn't include extra material for stitching the pieces together or reinforcing the edges.

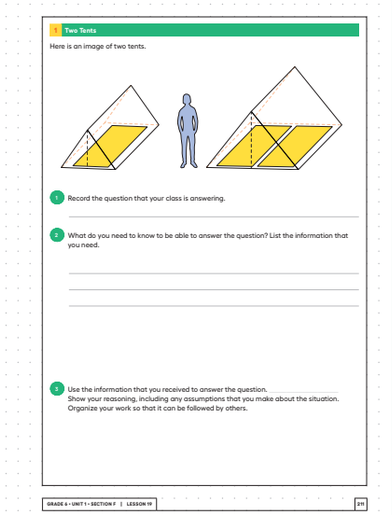
   Sample response for Question A (about how much material is needed for both tents):

   - 259 square feet
   - The surface area of the smaller tent is 91.5 square feet.
     - Left and right panels: $2 \cdot (3.75) \cdot (6.5) = 2 \cdot (24.375) = 48.75$
     - Front and back panels: $2 \cdot \frac{1}{2} \cdot (4.5) \cdot 3 = 2 \cdot (6.75) = 13.5$
     - Floor panel: $(4.5) \cdot (6.5) = 29.25$
     - Total: $48.75 + 13.5 + 29.25 = 91.5$

Access for Students with Diverse Abilities (Activity 1, Student Task)

Action and Expression: Develop Expression and Communication. Invite students to talk about their ideas with a partner before writing them down. Display sentence frames to support students when they explain their ideas. For example, "To find the surface area of each tent I …", "The amount of material needed for both tents is _____ because …"
Supports accessibility for: Language, Organization

Student Workbook


1 Two Tents

Here is an image of two tents.

1. Record the question that your class is answering.

2. What do you need to know to be able to answer the question? List the information that you need.

3. Use the information that you received to answer the question. Show your reasoning, including any assumptions that you make about the situation. Organize your work so that it can be followed by others.

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- The surface area of the larger tent is 128 square feet.
  - It has 3 rectangular faces that make a big rectangle of 11 feet by 6.5 feet, so its area is $11 \cdot (6.5)$ or 104 square feet.
  - Each triangular face has a base of 6 feet and a height of 4 feet, so the area for 2 triangles is $2 \cdot \frac{1}{2} \cdot 6 \cdot 4$ or 24 square feet.
  - $104 + 24 = 128$
- The surface area of both tents: $91.5 + 141 = 232.5$

Sample response for Question B (about how much more material is needed for the two-person tent):

- 76 square feet ($167.5 - 91.5 = 76$).

Sample response for Question C (about whether a two-person tent requires twice as much material):

- No, because twice 91.5 is 183, and a two-person tent requires only 167.5 square feet of material.

Activity Synthesis

Select students or groups who made different assumptions about the two tents to share their thinking. Then, discuss how the differences in assumptions affect their answers to the question.

Next, select those who reasoned about surface area in different ways to briefly present their solutions. Consider asking students:

- *"How did you account for the areas of all the faces of each tent? How did you organize your calculations?"*
- *"What units of measurement did you use? Why did you choose to use that unit?"*
- *"How is working in inches different from working in feet?"*

The goal of the discussion is for students to see that different assumptions about a situation may affect the solutions to problems about that situation, and that different reasoning strategies may affect the problem-solving process. For example, calculating surface area in inches involves working with large numbers and doing so in feet involves working with decimals.

Activity 2: Optional
Tent Design (Part 1)

45 min

Activity Narrative

In this activity, students apply the concepts and skills from this unit to design a camping tent. They learn about the design problem, consider the parameters for the design, and ask clarifying questions. Then, they make decisions about their tent, create a design and necessary representations of it, and estimate the amount of material needed to construct it.

This work prompts students to draw on the reasoning strategies developed in this unit, such as:

- Decomposing polygons and rearranging the parts to find area.
- Drawing and labeling a net to account for all the faces of a polyhedron.
- Using formulas to facilitate area calculation.
- Calculating areas with appropriate degree of precision.
- Including appropriate units of measurement.

In creating their tent design, students may need to estimate lengths that cannot be computed exactly given their current mathematical knowledge. For instance, the length of a slanted edge of a roof panel may be calculated using the Pythagorean Theorem but students are not expected to do so at this point. To support students in making reasonable estimates, encourage them to make comparisons. Consider asking questions such as:

- *"If the horizontal side of this right triangle is 5 feet and the vertical side is 3 feet, would the slanted side be longer or shorter than 5 feet? About how much longer?"*
- *"About how many times as long as this 3-foot-long side is that side?"*

As students make assumptions and decisions for their design and apply the mathematics that they know to solve a problem, they practice aspects of mathematical modeling.

Students also have an opportunity to choose tools strategically as they develop and represent a three-dimensional object. Some students may find it useful to think in two-dimensional terms and start by drawing a net. Others may wish to build a physical model of their design or to use a digital drawing tool. Students should be encouraged to consider the tools at their disposal and choose those that would enable them to complete the task.

Given the open-ended nature and high cognitive demand of a design activity, students may benefit from seeing a sample final product along with the intermediate steps. Consider sharing an example of completed work (such as the provided sample student response) to help students understand the expected outcome.

Launch

Keep students in groups of 2. Read aloud the introduction to the design task or invite a couple of students to do so. Give students 2 minutes to discuss with their partner their understanding of the task. Then, invite students to ask any clarifying questions.

Instructional Routines

MLR8: Discussion Supports

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Access for Multilingual Learners (Activity 2, Student Task)

MLR8: Discussion Supports.
Display sentence frames to support students in stating their assumptions or decisions about their tent, for example:

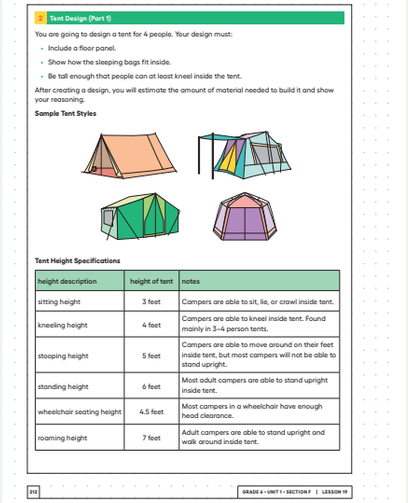
- "My tent will have ... (or will be ...)"
- "I would like my tent to have ... (or to be ...)"
- "I would like the campers to have ... (or to be able to ...)"

Advances: Speaking, Writing

Access for Students with Diverse Abilities (Activity 2, Student Task)

Engagement: Internalize Self-Regulation.
Provide a project checklist that chunks the various steps of the project into a set of manageable tasks.
Supports accessibility for: Organization; Attention

Student Workbook



2 Tent Design (Part 1)

You are going to design a tent for 4 people. Your design must:

- Include a floor panel.
- Show how the sleeping bags fit inside.
- Be tall enough that people can at least kneel inside the tent.

After creating a design, you will estimate the amount of material needed to build it and show your reasoning.

Sample Tent Styles

Tent Height Specifications

height description	height of tent	notes
sitting height	3 feet	Campers are able to sit, lie, or crawl inside tent.
kneeling height	4 feet	Campers are able to kneel inside tent. Found mainly in 3–4 person tents.
stooping height	5 feet	Campers are able to move around on their feet inside tent, but most campers will not be able to stand upright.
standing height	6 feet	Most adult campers are able to stand upright inside tent.
wheelchair seating height	4.5 feet	Most campers in a wheelchair have enough head clearance.
roaming height	7 feet	Adult campers are able to stand upright and walk around inside tent.

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Make sure students understand the parameters of the tent design:

- The tent needs to accommodate sleeping bags for 4 people.
- The tent needs to be a minimum height.
- There is not one right design.

Next, give partners 10 minutes to look more closely at the given information (sample tent designs, tent specifications, and sleeping bag information) and to discuss their ideas. The sample tent styles are provided for inspiration and reference, but students are not limited to them. If desired or if needed, allow students to perform additional research on tent styles. Students designing a wheelchair-accessible tent, for instance, may want to account for minimum clearances for the width and height of the tent's opening.

Before students begin working, make sure that they understand that their estimate for the amount of material needed should:

- Be based on given or researched facts.
- Reflect the decisions made about their tent (for example, that it can accommodate standing height).
- Be supported by sketches and calculations.

Provide access to blank paper, geometry toolkits, and calculators. (Note that a scale drawing is not an expectation, because scale factor is a grade 7 standard.)

Student Task Statement

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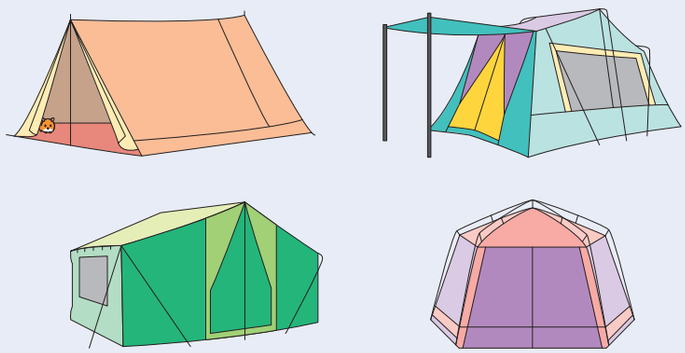

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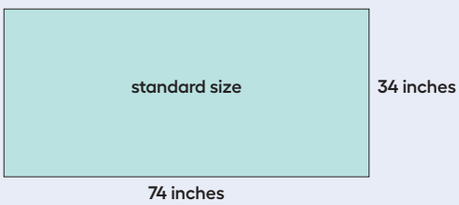
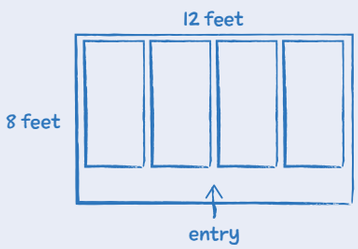
Sleeping Bag Measurements



1. Create your design.

a. Tent floor: Sketch the shape of the floor panel and the placements of sleeping bags. Think about approximate measurements. How large is this floor panel?

Sample response:



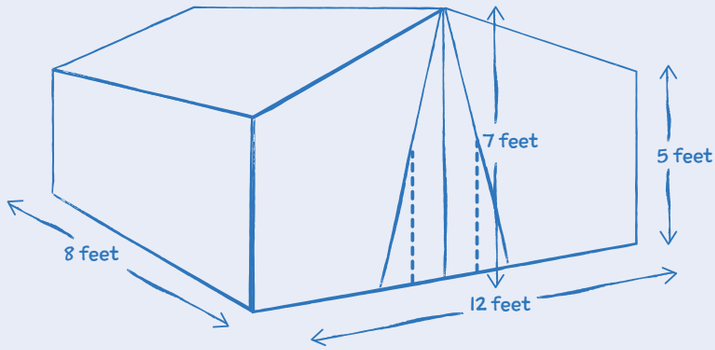
b. Relevant information: What decisions did you make for your tent? What assumptions did you make?

Sample response:

- Campers will have at least stooping height at the shorter sides of the tent but will be able to stand toward the center of the tent.
- There will be some space to put campers' bags.

c. Overall design: Sketch what the tent would look like. Think about approximate measurements. How high is the tallest point of your tent?

Sample response:

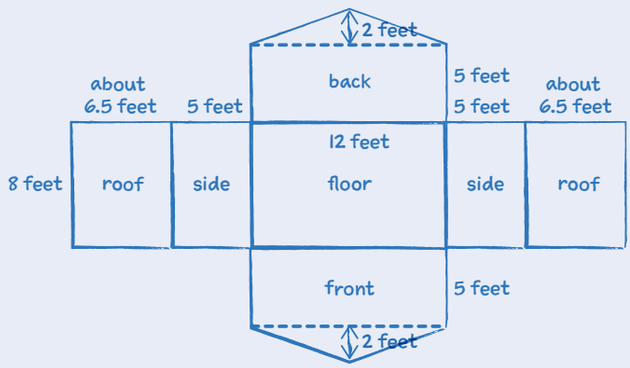


2. Estimate the amount of material needed to build your tent. Your estimate must:

- Be based on measurements you researched or received.
- Include sketches that show the parts of the tent and their measurements.
- Be supported by calculations.

Organize your work so it can be followed by others. You can use additional paper if you need more space.

Sample response: Estimate of material needed: About 424 square feet



- Floor panel: 96 square feet. $12 \cdot 8 = 96$
- Side panels: 80 square feet. The two rectangles are 8 feet by 5 feet or 40 square feet each. $2 \cdot 40 = 80$
- Roof panels: About 104 square feet. The slanted length is about 6.5 feet, so the roof panels are two 6.5-by-8 rectangles with 52 square feet of area in each.
- Front and back panels: 144 square feet. Each panel can be decomposed into a rectangle that is 12 feet by 5 feet (area 60 square feet) and a triangle with a base of 12 and a height of 2 (area 12 square feet), so its area is 72 square feet. The area of both panels are $2 \cdot 72$, which is 144
- Surface area of tent: $96 + 80 + 104 + 144 = 424$

Activity Synthesis

Students will share and reflect on their designs in the next activity. Before moving on, engage them in a brief whole-class discussion. Invite students to share some of the things that they considered and decisions that they made as they were designing their tent. Also invite them to share some challenges that they encountered when trying to estimate the necessary amount of material.

Activity 3: Optional

Tent Design (Part 2)

15 min

Activity Narrative

This activity gives students a chance to explain and reflect on their work. Students share drawings of their tent design, an estimate of the amount of material needed, and the justification. Then, students compare their creations with their peers' creations and discuss not only the amount of material required, but also the effects that different designs have on that amount.

As students discuss in groups, notice how they reason about and communicate their work. Monitor for whether they:

- Provide justification for their measurements and choices.
- Include drawings that reflect their decisions and show relevant measurements and labels.
- Explain clearly their process of calculating surface area.

Also notice how students compare the amounts of material needed for the different designs in their group. Monitor for students who recognize how design decisions (such as tent types, tent measurements, and arrangements of sleeping bags) affect the amount of material needed.

Launch

Arrange students in groups of 4. Tell students that they will now reflect on and discuss their tents with their group. Ask students to take turns sharing their work, allowing 3–4 minutes per person, and then compare the amounts of material needed.

Student Task Statement

1. Explain your tent design and material estimate to your group. Be sure to explain why you chose this design and how you found your material estimate.

   No written response required.

2. Compare the estimated material necessary for each tent in your group. Discuss the following questions:

- Which tent design used the least material? Why?
- Which tent design used the most material? Why?

No written response required.

Instructional Routines

MLR8: Discussion Supports

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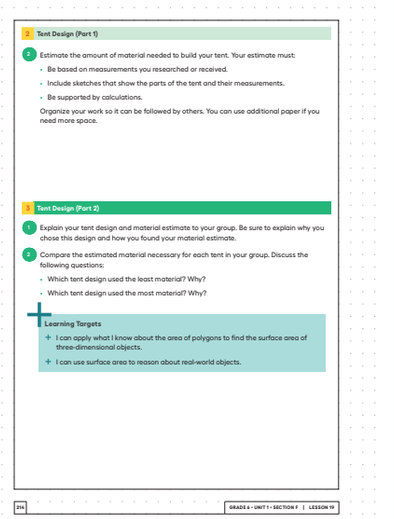
Access for Multilingual Learners (Activity 3, Student Task)

MLR8: Discussion Supports. Encourage students to begin group discussions by reading their written responses aloud. If time allows, invite students to revise or add to their responses based on the conversation that follows.
Advances: Conversing, Speaking

Student Workbook


2 Tent Design (Part 1)

3 Estimate the amount of material needed to build your tent. Your estimate must:

- Be based on measurements you researched or received.
- Include sketches that show the parts of the tent and their measurements.
- Be supported by calculations.

Organize your work so it can be followed by others. You can use additional paper if you need more space.

3 Tent Design (Part 2)

1 Explain your tent design and material estimate to your group. Be sure to explain why you chose this design and how you found your material estimate.

2 Compare the estimated material necessary for each tent in your group. Discuss the following questions:

- Which tent design used the least material? Why?
- Which tent design used the most material? Why?

Learning Targets

- I can apply what I know about the area of polygons to find the surface area of three-dimensional objects.
- I can use surface area to reason about real-world objects.

Access for Students with Diverse Abilities (Activity 3, Synthesis)

Action and Expression: Develop Expression and Communication. Provide sentence frames to support student explanations. Display sentence frames such as: "We chose our tent design because …", "This tent design uses the least/most fabric because …"
Supports accessibility for: Language; Organization

Activity Synthesis

Much of the discussion will take place within the groups. Once groups have had an opportunity to share their designs, reconvene as a class. Consider displaying tent designs that used the most and the least amount of material and discussing with students:

- *"All the tents were designed to accommodate 4 people and a minimum height inside the tent. How did the tents end up using very different amounts of material?"*
- *"What design decisions impact the amount of material needed?"*
- *"Can you give examples of decisions that had a major impact? What about decisions that had a lesser impact?"*
- *"When calculating the surface area of your tent, what reasoning strategies from this unit did you find useful?"*

Lesson Synthesis

This culminating lesson could be wrapped up in a number of ways, depending on which activities students completed, the time available, and your goals and expectations.

Consider inviting students to reflect on their journey through the unit and on the connections between the work in earlier lessons and application problems such as those solved in this lesson. Discuss questions such as:

- *"You started reasoning about area very early in the unit. What reasoning strategies that you used then continued to be useful when working on your tent designs?"*

  decomposing a region and rearranging the parts into shapes whose area we know how to find, adding the areas of individual parts, finding the area of a larger region and subtracting the areas of extra parts

- *"Can you give examples of when you applied something you learned in the unit to make your reasoning more efficient or more reliable?"*

  using formulas to find the areas of parallelograms and triangles, combining several shapes into a larger shape and computing the area once instead of finding the areas of individual pieces and adding them, using a net to make sure that all faces are included in a surface area calculation

- *"We used the math ideas from this unit to find the number of squares to cover a file cabinet, the number of square units in walls or floors, and the amount of material needed to build tents. In what other situations might we apply our knowledge of area and surface area?"*

A note about materials for an upcoming unit:

For the first lesson in the unit on ratios, students will need to bring in a personal collection of 10–50 small objects. Examples include rocks, seashells, trading cards, or coins. Inform or remind students about this.