Lesson 19: Designing a Tent

Goals

- Apply understanding of surface area to estimate the amount of fabric 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 use what they learned in this unit to design a tent and determine how much fabric is needed for the tent. The task prompts students to model a situation with the mathematics they know, make assumptions, and plan a path to solve a problem (MP4). It also allows students to choose tools strategically (MP5) and to make a logical argument to support their reasoning (MP3).

The lesson has two parts. In the first part, students learn about the task, gather information, and begin designing. The introduction is important to ensure all students understand the context. Then, after answering some preparatory questions in groups and as a class, students work individually to design and draw their tents. They use their knowledge of area and surface area to calculate and justify an estimate of the amount of fabric needed for their design.

The second part involves reflection and discussion on students' work. Students explain their work to a partner or small group, discuss and compare their designs, and consider the impact of design decisions on the surface areas of their tents.

Depending on instructional choices made, this lesson could take one or more class meetings. The time estimates are intentionally left blank, as the time needed will vary based on instructional decisions made. It may depend on:

- whether students use the provided information about tents and sleeping bags or research this information.
- whether the Tent Design Planning Sheet is provided or students organize their work with more autonomy.
- expectations around drafting, revising, and the final product.

- how student work is ultimately shared with the class (not at all, informally, or with formal presentations).

Note: Students will need to bring in a personal collection of 10–50 small objects ahead of time for the first lesson of the next unit. Examples include rocks, seashells, trading cards, or coins.

Alignments

Addressing

- 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.4: Represent three-dimensional figures using nets made up of rectangles and triangles, and use the nets to find the surface area of these figures. Apply these techniques in the context of solving real-world and mathematical problems.

Instructional Routines

- MLR7: Compare and Connect

Required Materials

Copies of blackline master
Geometry toolkits
For grade 6: tracing paper, graph paper, colored pencils, scissors, and an index card to use as a straightedge or to mark right angles.

For grades 7 and 8: everything in grade 6, plus a ruler and protractor. Clear protractors with no holes and with radial lines printed on them are recommended.

Notes: (1) "Tracing paper" is easiest to use when it's a smaller size. Commercially-available "patty paper" is 5 inches by 5 inches and ideal for this. If using larger sheets of tracing paper, consider cutting them down for student use. (2) When compasses are required in grades 6-8 they are listed as a separate Required Material.

Required Preparation

Prepare one copy of the blackline master for each student.

Student Learning Goals

Let’s design some tents.

19.1 Tent Design - Part 1

This activity has two parts: an introduction to the task and individual work time. In the first part, students read the design problem and ask clarifying questions, and then work with a partner or two to look at tent designs and specifications. Then, they work individually to design a tent, create necessary representations of it, calculate its surface area, and estimate of the amount of fabric needed to construct it.

As students work individually, circulate and focus your observations on two main goals:

1. Notice the strategies and mathematical ideas students use to complete the task. Are students:
    - decomposing or rearranging parts of their tent design to find the area? How?
    - drawing a net of their design?
    - labeling their drawings with measurements?
    - calculating area precisely?
    - using formulas they learned in this unit? How?
    - accounting for the areas of all surfaces of their tent design?
    - using square units for area measures?
2. To record the sizes (in terms of numbers of people accommodated) and shapes of individual tent designs. Use this information to arrange students into groups—by tent size—in the next activity.

Collect student work at the end of the session. Arrange for 2–3 students who have tents that accommodate the same number of people but different designs to work together (e.g., two students design tents for three people, but one designed a triangular prism and the other a pentagonal prism). Put their papers together to begin the second session.

Addressing

- 6.G.A.1
- 6.G.A.4

Instructional Routines

- MLR7: Compare and Connect

Launch

Give students 1–2 minutes to read the task statement individually and ask any clarifying questions. At this point, students only need to understand that the tents need to accommodate same-sized sleeping bags and that there is not one right way to design them.

Next, arrange students in groups of 2. Give groups about 15 minutes to look at and discuss potential tent designs, tent specifications, and sleeping bag information. Tell students that the designs are provided for inspiration and reference, but students are not limited to them.

After partner discussions, give each student a copy of the Tent Design Planning Sheet from the blackline master. Give students quiet think time to sketch out their tent design, create necessary drawings, calculate surface area, and justify their estimate. Provide blank paper for students to use to draw their designs and access to their geometry toolkits. (Note that a scale drawing is not an expectation; scale factor is a grade 7 standard.)

Access for Students with Disabilities

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

Anticipated Misconceptions

Some students may find it challenging to develop and represent a three-dimensional object on paper. Ask them what might help them create or convey their design. Some 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 from paper or other flexible material, or to use a digital drawing tool. Encourage students to consider the tools at their disposal and choose those that would enable them to complete the task (MP5).

Student Task Statement

Have you ever been camping?

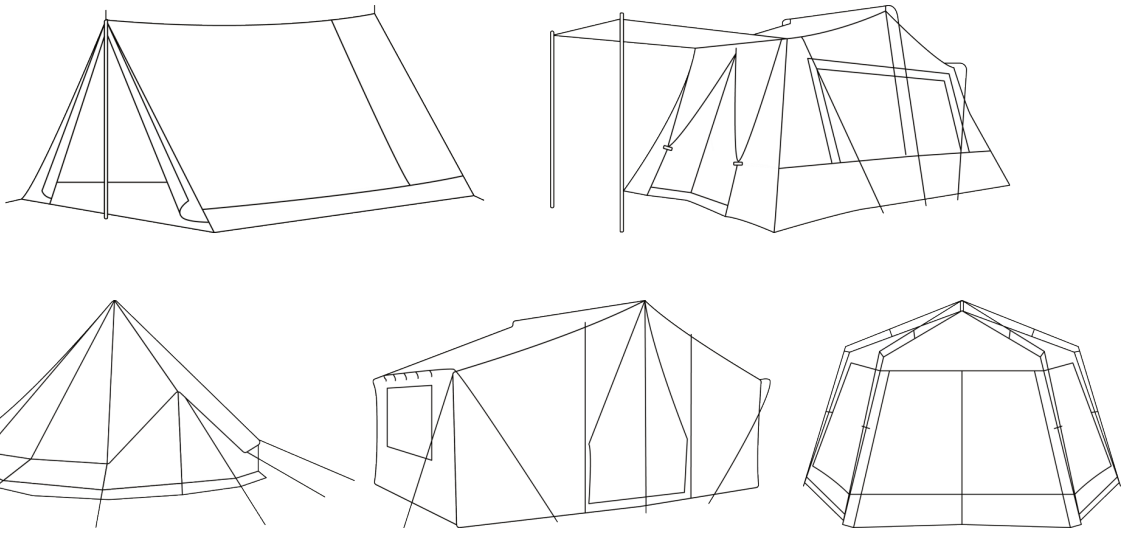
You might know that sleeping bags are all about the same size, but tents come in a variety of shapes and sizes.

Your task is to design a tent to accommodate up to four people, and estimate the amount of fabric needed to make your tent. Your design and estimate must be based on the information given and have mathematical justification.

First, look at these examples of tents, the average specifications of a camping tent, and standard sleeping bag measurements. Talk to a partner about:

- Similarities and differences among the tents
- Information that will be important in your designing process
- The pros and cons of the various designs

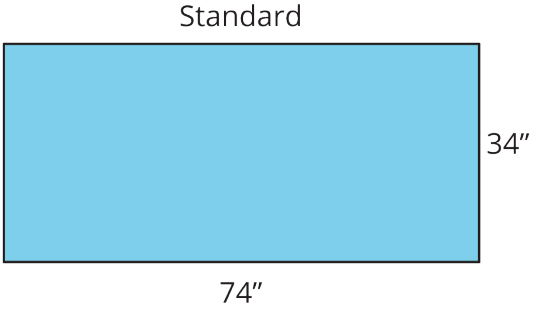
Tent Styles



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.
roaming height	7 feet	Adult campers are able to stand upright and walk around inside tent.

Sleeping Bag Measurements



1. Create and sketch your tent design. The tent must include a floor.

2. What decisions were important when choosing your tent design?
3. How much fabric do you estimate will be necessary to make your tent? Show your reasoning and provide mathematical justification.

Student Response

Answers vary.

Activity Synthesis

After students complete the task, engage students in a whole-class discussion. Ask students: "What were important things you had to think about in your design?"

Collect student work at the end of the session. Tell students they will continue to think about the problem and their proposed solution in the next activity.

Arrange for 2–3 students who have tents that accommodate the same number of people but have different designs to work together (e.g., two students designed tents for three people, but one designed a triangular prism and the other a pentagonal prism). Put their papers together to begin the second session.

Access for English Language Learners

Representing, Conversing: MLR7 Compare and Connect. Use this routine to help students consider audience when preparing to display their work and prepare students for the discussion in the next activity. At the appropriate time, invite students to create a visual display showing their tent design and response to the task questions. Display the list of items that should be included on the display and ask students, "What kinds of details could you include on your display to help a reader understand your tent design, what decisions you made in your design, and how much fabric you will need?" Record ideas and display for all to see. Examples of these types of details or annotations include: the order in which responses are organized on the display, the clarity of any drawn diagrams, written notes or details to clarify diagrams, use of specific vocabulary or phrases, or color or arrows to show connections between representations. If time allows, after the gallery walk, ask students to describe specific examples of additional details that other groups used that helped them to interpret and understand their displays.
Design Principle(s): Maximize meta-awareness; Optimize output

19.2 Tent Design - Part 2

This activity gives students a chance to explain and reflect on their work. In groups of 2–3, they share drawings of their tent design, an estimate of the amount of fabric needed, and the justification. They compare their creations with one or more peers. Students discuss not only the amount of fabric required, but also the effects that different designs have on that amount.

Prior to the session, identify 2–3 students who have tents that accommodate the same number of people but different designs (e.g., two students each design a 3-person tent, but one designed a triangular prism and the other a pentagonal prism). Put their papers from Part 1 together.

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

- provide justification for their measurements and choices?
- explain clearly their process of calculating surface area?
- see how the type of design affects the amount of fabric?
- compare their tents in terms of the differences in the measurements at the base and the height of tent?

Addressing

- 6.G.A.1
- 6.G.A.4

Launch

Tell students that they will now reflect on and discuss their tents with another student who designed a tent for the same number of people but in a different way. Arrange students in the predetermined groups of 2–3 and return the presorted sets of papers to them.

Student Task Statement

1. Explain your tent design and fabric estimate to your partner or partners. Be sure to explain why you chose this design and how you found your fabric estimate.
2. Compare the estimated fabric necessary for each tent in your group. Discuss the following questions:
    - Which tent design used the least fabric? Why?
    - Which tent design used the most fabric? Why?
    - Which change in design most impacted the amount of fabric needed for the tent? Why?

Student Response

Answers vary.

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. One idea would be to display tent designs that used the most and the least amount of fabric. Also consider asking students to reflect on the following prompts:

- What design choices lead to using less fabric?
- What design choices lead to using more fabric?
- What are some ways that tents designed to accommodate the same number of people could use very different amounts of fabric?
- When calculating the surface area of your tent, what kinds of techniques from this unit did you find useful?

Access for Students with Disabilities

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

Lesson Synthesis

This culminating lesson could be wrapped up in a number of ways, depending on the time available and your goals and expectations. You could choose a simple wrap-up discussion, or assign students to develop a more elaborate presentation of their tent design involving posters or three-dimensional models of their tents.