Lesson 9

Creating Scale Drawings

Goals

- Compare and contrast (orally) different scale drawings of the same object, and describe (orally) how the scale affects the size of the drawing.
- Create a scale drawing, given the actual measurements of the object and the scale.
- Determine the scale used to create a scale drawing and generate multiple ways to express it (in writing).

Learning Targets

- I can determine the scale of a scale drawing when I know lengths on the drawing and corresponding actual lengths.
- I know how different scales affect the lengths in the scale drawing.
- When I know the actual measurements, I can create a scale drawing at a given scale.

Lesson Narrative

In this lesson, students use actual distances to calculate scaled distances and create their own scale drawings. Next, they see how different scale drawings can be created of the same actual thing, using different scales. They also see how the choice of scale influences the drawing. For example, a scale drawing with a scale of 1 cm to 5 m will be smaller than a scale drawing of the same object with a scale of 1 cm to 2 m. (Since each centimeter represents a larger distance, it takes fewer centimeters to represent the object.) This prepares students for future lessons in which they will recreate a given scale drawing at a different scale.

Noticing *how* scale drawings change with the choice of scale develops important structural understanding of scale drawings.

Student Learning Goal

Let's create our own scale drawings.

Access for Students with Diverse Abilities

- Action and Expression (Warm-up)
- Representation (Activity 2)

Access for Multilingual Learners

- MLR3: Critique, Correct, Clarify (Activity 2)
- MLR7: Compare and Connect (Activity 1)
- MLR8: Discussion Supports (Warm-up)

Instructional Routines

- Math Talk
- MLR3: Critique, Correct, Clarify
- MLR7: Compare and Connect
- MLR8: Discussion Supports
- Notice and Wonder

Required Materials

Materials to Gather

- Geometry toolkits: Activity 2

Lesson Timeline

Warm-up	Activity 1	Activity 2	Lesson Synthesis	Assessment
5 min	10 min	20 min	10 min	5 min
				Cool-down

Instructional Routines

Math Talk

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Instructional Routines

MLR8: Discussion Supports

ilclass.com/r/10695617

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Access for Students with Diverse Abilities (Warm-up, Launch)

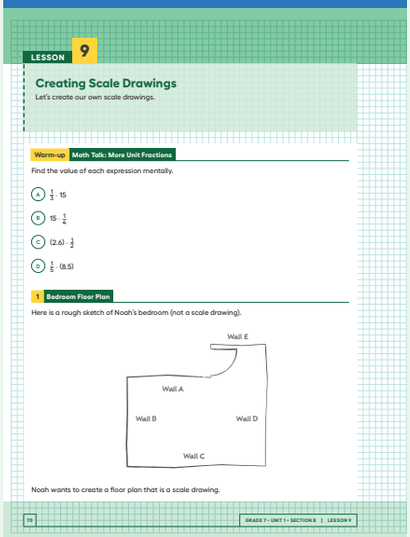
Action and Expression: Internalize Executive Functions.
To support working memory, provide students with access to sticky notes or mini whiteboards.

Supports accessibility for: Memory, Organization

Building on Student Thinking

Students may misinterpret the last question as $15 \cdot \frac{1}{3}$ or $15 \cdot \frac{1}{4}$. Point out that one way to interpret the first expression is "How many one-thirds are there in 15?"

Student Workbook


LESSON 9

Creating Scale Drawings

Let's create our own scale drawings.

Warm-up Math Talk: More Unit Fractions

Find the value of each expression mentally.

A. $\frac{1}{3} \cdot 15$

B. $15 \cdot \frac{1}{4}$

C. $(2.6) \cdot \frac{1}{2}$

D. $\frac{1}{5} \cdot (8.5)$

1 Bedroom Floor Plan

Here is a rough sketch of Noah's bedroom (not a scale drawing).

Wall E

Wall A

Wall B

Wall D

Wall C

Noah wants to create a floor plan that is a scale drawing.

70

GRADE 7 • UNIT 1 • SECTION B | LESSON 9

Warm-up

Math Talk: More Unit Fractions

5 min

Activity Narrative

This *Math Talk* focuses on multiplying a decimal by a unit fraction. It encourages students to think about the relationship between multiplication and division and to rely on properties of operations to mentally solve problems. The strategies elicited here will be helpful later in the lesson when students find equivalent scales involving decimals.

Launch

Tell students to close their books or devices (or to keep them closed). Reveal one problem at a time. For each problem:

- Give students quiet think time and ask them to give a signal when they have an answer and a strategy.
- Invite students to share their strategies and record and display their responses for all to see.
- Use the questions in the *Activity Synthesis* to involve more students in the conversation before moving to the next problem.

Keep all previous problems and work displayed throughout the talk.

Student Task Statement

Find the value of each expression mentally.

A. $\frac{1}{3} \cdot 15$

5

Sample reasoning: $15 \div 3 = 5$

B. $15 \cdot \frac{1}{4}$

3.25

Sample reasoning: $15 \div 2 = 7.5$ and $7.5 \div 2 = 3.25$

C. $(2.6) \cdot \frac{1}{2}$

1.3

Sample reasoning:

- distributive property: $2 \div 2 = 1$ and $0.6 \div 2 = 0.3$
- place value: $26 \div 2 = 13$ and $13 \div 10 = 1.3$

D. $\frac{1}{5} \cdot (8.5)$

1.7

Sample reasoning:

- distributive property: $5 \div 5 = 1$ and $3.5 \div 5 = 0.7$
- place value: $8.5 \div 10 = 0.85$ and $0.85 \cdot 2 = 1.7$

Activity Synthesis

To involve more students in the conversation, consider asking:

- *"Who can restate _____'s reasoning in a different way?"*
- *"Did anyone use the same strategy but would explain it differently?"*
- *"Did anyone solve the problem in a different way?"*
- *"Does anyone want to add on to _____'s strategy?"*
- *"Do you agree or disagree? Why?"*
- *"What connections to previous problems do you see?"*

The key takeaways are:

- Multiplying a number by a unit fraction is the same as dividing that number by the denominator of the fraction.
- We can use various strategies to reason about division, including place value and the distributive property.

Activity 1
Bedroom Floor Plan

10 min

Activity Narrative

The purpose of this activity is to prepare students to create their own scale drawing. First, they calculate a scale given one actual distance and its corresponding scaled distance. Then, they use the scale to calculate other scaled distances.

The discussion highlights that a scale can be expressed in different ways. Some wordings convey the meaning of the numbers more clearly than others do. Also, different pairs of numbers may be used to express the same relationship.

Monitor for students who:

- Use ratio language in their scale, such as "16 cm to 4 m" or "4 cm for every 1 m."
- Find equivalent scales with smaller numbers, such as "1 cm represents 0.25 m."
- Use words to clarify the meaning of the numbers, such as "4 cm on the drawing represents 1 m in the actual room."
- Oversimplify the relationship between actual and scaled lengths, such as "4 cm = 1 m" or "The scale factor is 4."

If the optional activities "Scaling More Pattern Blocks" and "Biking through Kansas" were not completed in previous lessons, then this is the first time Math Language Routine 7: *Compare and Connect* is suggested in this course. In this routine, students are given a problem that can be approached using multiple strategies or representations, and they record their method for all to see. They then compare and identify correspondences across strategies by means of a teacher-led gallery walk with commentary or teacher think-aloud (such as "I notice … I wonder …"). A typical discussion prompt is "What is the same and what is different?", comparing their own strategy to the others. The purpose of this routine is to allow students to make sense of mathematical strategies and, through constructive conversations, develop awareness of the language used as they compare, contrast, and connect other ways of thinking to their own.

Access for Multilingual Learners (Warm-up, Synthesis)

MLR8: Discussion Supports. Display sentence frames to support students when they explain their strategy. For example, "First, I _____ because …" or "I noticed _____ so I …" Some students may benefit from the opportunity to rehearse what they will say with a partner before they share with the whole class.

Advances: Speaking, Representing

Instructional Routines

MLR7: Compare and Connect

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Access for Multilingual Learners (Activity 1, Narrative)

MLR7: Compare and Connect
This activity uses the *Compare and Connect* math language routine to advance representing and conversing as students use mathematically precise language in discussion.

Building on Student Thinking

Students may see that one value is 4 times the other and write the scale backward, as "1 cm to 4 m." Prompt students to pay attention to the units and the meaning of each number.

Student Workbook

1 Bedroom Floor Plan

1. The actual length of Wall C is 4 m. To represent Wall C, Noah draws a segment 16 cm long. What scale is he using? Explain or show your reasoning.
2. Find another way to express the scale.
3. Discuss your thinking with your partner. How do your scales compare?
4. The actual lengths of Wall A and Wall D are 2.5 m and 3.75 m. Determine how long these walls will be on Noah's scale floor plan. Explain or show your reasoning.

GRADE 7 • UNIT 1 • SECTION B | LESSON 9 71

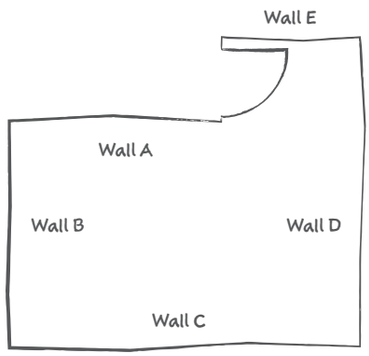
Launch

Tell students that a floor plan is a top-view drawing that shows a layout of a room or a building. Floor plans are usually scale drawings. Explain that sometimes the scale of a drawing is not specified, but we can still tell the scale if we know both the scaled and actual lengths.

Arrange students in groups of 2. Give students 4–5 minutes of quiet work time and partner discussion. Select work from students with different strategies, such as those described in the activity narrative, to share later.

Student Task Statement

Here is a rough sketch of Noah's bedroom (not a scale drawing).



Noah wants to create a floor plan that is a scale drawing.

1. The actual length of Wall C is 4 m. To represent Wall C, Noah draws a segment 16 cm long. What scale is he using? Explain or show your reasoning.

   1 cm to 0.25 m (or equivalent)

   Sample reasoning: Since 16 cm represents an actual length of 4 m, then 1 cm must represent $\frac{1}{16}$ of 4 m, which is 0.25 m.

2. Find another way to express the scale.

   Sample responses: 4 cm to 1 m, 1 cm to 0.25 m, 16 cm to 4 m

3. Discuss your thinking with your partner. How do your scales compare?

   No written response required.

4. The actual lengths of Wall A and Wall D are 2.5 m and 3.75 m. Determine how long these walls will be on Noah's scale floor plan. Explain or show your reasoning.

   Wall A: 10 cm; Wall D: 15 cm

   Sample reasoning:

   - Since every 1 m is shown as 4 cm on the drawing, then the actual lengths, in meters, can be multiplied by 4 to find how many centimeters long the scale drawing should be.
   - Since every 1 cm represents 0.25 m, then actual lengths, in meters, can be divided by 0.25 to find how many centimeters long the scale drawing should be.

Are You Ready for More?

If Noah wanted to draw another floor plan on which Wall C was 20 cm, would 1 cm to 5 m be the right scale to use? Explain your reasoning.

No

Sample reasonings:

- If he used 1 cm to 5 m, Wall C, which is 4 m long, would be less than 1 cm on the drawing—much smaller than what he wanted.
- If he used 1 cm to 5 m, a 20-cm segment would represent a 100-m long wall, which is not the length of Wall C.

Activity Synthesis

The goal of this discussion is to compare different ways to express the same relationship between scaled and actual lengths. Display 3–4 representations from previously selected students for all to see. Use *Compare and Connect* to help students compare, contrast, and connect the different ways to express the scale. Here are some questions for discussion:

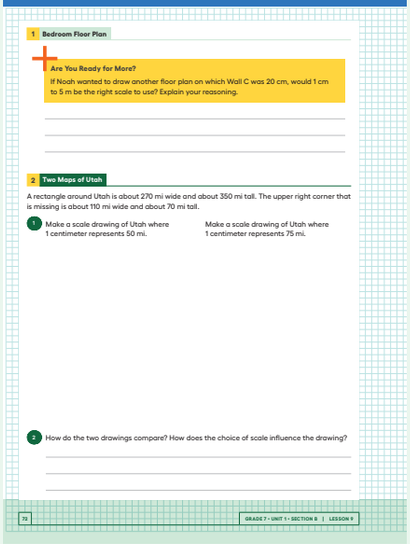
- *"What do the scales have in common? How are they different?"*
- *"How do these different representations show the same information?"*
- *"Are there any benefits or drawbacks to one representation compared to another?"*

The key takeaways are:

- Because of equivalent ratios, there are multiple ways to express the same scale.
- Scales are often simplified to show the actual distance for 1 scaled unit (or a benchmark fraction, such as 0.25, 0.5, 0.75).
- A good scale makes it clear which value refers to the scale drawing and which refers to the actual object.

Given their work on scaled copies, students may be inclined to say that the scaled and actual lengths are related by a scale factor of 4. Ask: "Are the actual lengths four times the lengths on the drawing? Why or why not?" Point out that because the units for the two quantities are different, multiplying a scaled length in centimeters (for example, 2.5 cm) by 4 will yield another length in centimeters (10 cm), which is not the actual length. However, it is not essential for students to know that the scale factor here is actually 250. That idea will be explored in an upcoming lesson.

Student Workbook


1 Bedroom Floor Plan

Are You Ready for More?
If Noah wanted to draw another floor plan on which Wall C was 20 cm, would 1 cm to 5 m be the right scale to use? Explain your reasoning.

2 Two Maps of Utah

A rectangle around Utah is about 270 mi wide and about 350 mi tall. The upper right corner that is missing is about 110 mi wide and about 70 mi tall.

1. Make a scale drawing of Utah where 1 centimeter represents 50 mi.
Make a scale drawing of Utah where 1 centimeter represents 75 mi.

2. How do the two drawings compare? How does the choice of scale influence the drawing?

Instructional Routines

MLR3: Critique, Correct, Clarify

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Instructional Routines

Notice and Wonder

ilclass.com/r/10694948

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Access for Multilingual Learners (Activity 2, Narrative)

MLR3: Critique, Correct, Clarify
This activity uses the *Critique, Correct, Clarify* math language routine to advance representing and conversing as students critique and revise mathematical arguments.

Activity 2
Two Maps of Utah

20 min

Activity Narrative

In this activity, students create two different scale drawings of the state of Utah and notice how the scale impacts the size of the drawing. As students notice how the different scales impact the size of the scale drawings, they are making use of structure.

This is the first time Math Language Routine 3: *Critique, Correct, Clarify* is suggested in this course. In this routine, students are given a "first draft" statement or response to a question that is intentionally unclear, incorrect, or incomplete. Students analyze and improve the written work by first identifying what parts of the writing need clarification, correction, or details, and then writing a second draft (individually or with a partner). Finally, the teacher scribes as a selected second draft is read aloud by its author(s), and the whole class is invited to help edit this third draft by clarifying meaning and adding details to make the writing as convincing as possible to everyone in the room. Typical prompts are: "Is anything unclear?" and "Are there any reasoning errors?" The purpose of this routine is to engage students in analyzing mathematical writing and reasoning that is not their own, and to solidify their knowledge and use of language.

Launch

Display the map of Utah. Ask "What do you notice? What do you wonder?"

Students may notice:

- The shape of the state looks like a rectangle with a corner cut out.
- The angles are all right angles.
- There are a lot of green areas in a stripe from the bottom left to the top right.

Students may wonder:

- Where is Utah?
- How long are the side lengths of the state?
- What are the green areas?

If not mentioned by students, highlight that the shape of the state looks like a rectangle with a smaller rectangle removed from the upper right corner.

Give students 7–8 minutes of quiet work time followed by whole-class discussion. If time is limited, consider arranging students in groups of 2 and instructing the partners to each draw one of the two drawings and then share their results with each other.

Student Task Statement

A rectangle around Utah is about 270 mi wide and about 350 mi tall. The upper right corner that is missing is about 110 mi wide and about 70 mi tall.

1. Make a scale drawing of Utah where 1 centimeter represents 50 mi.

   Make a scale drawing of Utah where 1 centimeter represents 75 mi.

   A scale of 1 cm represents 50 mi produces a rectangle approximately 5.4 cm wide and 7 cm tall, missing an upper right corner that is approximately 2.2 cm wide and 1.4 cm tall. A scale of 1 cm represents 75 m produces a rectangle approximately 3.6 cm wide and 4.7 cm tall, missing an upper right corner that is approximately 1.5 cm wide and 1 cm tall.

2. How do the two drawings compare? How does the choice of scale influence the drawing?

   Sample response: The measurements in the 1 cm to 50 mi scale drawings are larger than the measurements in the 1 cm to 75 mi scale drawing. This makes sense because when 1 cm represents 50 mi, it takes 1.5 cm to represent 75 mi.

Activity Synthesis

Ask students what the two scale drawings share in common.

They both represent Utah, they both have the same shape, and they both can be used to measure distances in the actual state of Utah.

Ask students how the two scale drawings differ.

The one at a scale of 1 centimeter to 50 mi is larger than the one at a scale of 1 centimeter to 75 mi.

Some students may notice that the scale drawing at a scale of 1 centimeter to 75 mi is actually a scaled copy of the other drawing, with a scale factor of 1.5. If so, ask them to share their observation that links scale drawings with scaled copies.

Use *Critique, Correct, Clarify* to give students an opportunity to improve a sample response for the first scale drawing by correcting errors, clarifying meaning, and adding details.

Building on Student Thinking

Some students may get a shape that is not closed or does not have right angles if they did not measure carefully enough. Prompt them to double-check their measurement for a particular side of the state if you can easily tell which side is drawn incorrectly.

Students may think that a scale of 1 centimeter to 50 mi will produce a smaller scale drawing than a scale of 1 centimeter to 75 mi (because 50 is less than 75). Ask them how many centimeters it takes to represent 75 mi if 1 centimeter represents 50 mi (1.5) and how many centimeters it takes to represent 75 mi if 1 centimeter represents 75 mi (1).

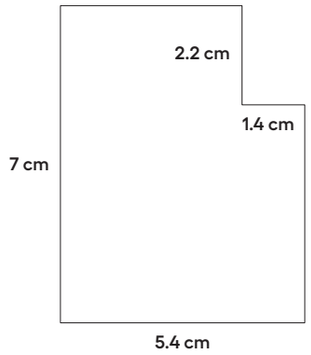
Access for Students with Diverse Abilities (Activity 2, Synthesis)

Representation: Internalize Comprehension.
Use color coding and annotations to highlight connections between representations in a problem. For example, annotate a display of the two scale drawings to make visible what the drawings share in common, and how they differ.

Supports accessibility for: Visual-Spatial Processing

- Display this first draft and image:

💬 *"Since 1 cm represents 50 mi, I divided 110 and 70 each by 50, and got 2.2 and 1.4. The small rectangle that is missing is 2.2 cm tall and 1.4 cm wide."*



- Ask,

💬 *"What parts of this response are unclear, incorrect, or incomplete?"*

- As students respond, annotate the display with 2–3 ideas to indicate the parts of the writing that could use improvement.
- Give students 2–4 minutes to work with a partner to revise the first draft.
- Select 1–2 individuals or groups to read their revised draft aloud slowly enough to record for all to see. Scribe as each student shares, and then invite the whole class to contribute additional language and edits to make the final draft even more clear and more convincing.

Lesson Synthesis

Share with students

💬 *"Today we saw that the size of the scale determines the size of the drawing. There can be different-sized scale drawings of the same actual object, but the size of the actual object doesn't change."*

To review these concepts, consider asking students:

💬 *"Suppose there are two scale drawings of the same house. One uses the scale of 1 cm to 2 m, and the other uses the scale 1 cm to 4 m. Which drawing is larger? Why?"*

The one with the 1 cm to 2 m scale is larger, because it takes 2 cm on the drawing to represent 4 m of actual length.

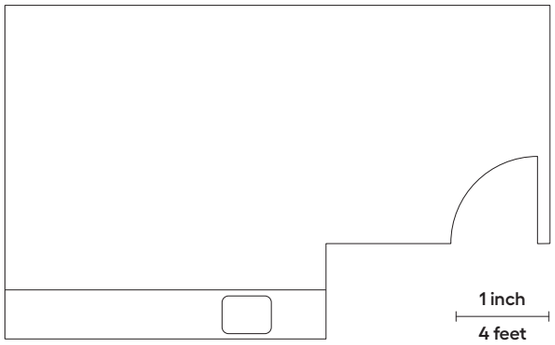
💬 *"Another scale drawing of the house uses the scale of 5 cm to 10 m. How does its size compare to the other two?"*

It is the same size as the drawing with the 1 cm to 2 m scale.

Sometimes two different scales are actually equivalent, such as 5 cm to 10 m and 1 cm to 2 m. It is common to write a scale so that it tells you what one unit on the scale drawing represents (for example, 1 cm to 2 m).

Lesson Summary

If we want to create a scale drawing of a room's floor plan that has the scale "1 inch to 4 feet," we can divide the actual lengths in the room (in feet) by 4 to find the corresponding lengths (in inches) for our drawing.



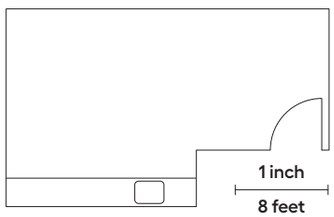
Suppose the longest wall is 23 feet long. We should draw a line 5.75 inches long to represent this wall, because $23 \div 4 = 5.75$.

There is more than one way to express this scale. These three scales are all equivalent, because they represent the same relationship between lengths on a drawing and actual lengths:

- 1 inch to 4 feet
- $\frac{1}{2}$ inch to 2 feet
- $\frac{1}{4}$ inch to 1 foot

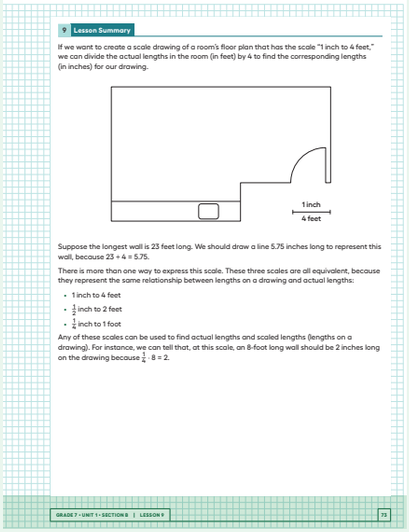
Any of these scales can be used to find actual lengths and scaled lengths (lengths on a drawing). For instance, we can tell that, at this scale, an 8-foot long wall should be 2 inches long on the drawing because $\frac{1}{4} \cdot 8 = 2$.

The size of a scale drawing is influenced by the choice of scale. For example, here is another scale drawing of the same room using the scale 1 inch to 8 feet.



Notice that this drawing is smaller than the previous one. Since one inch on this drawing represents twice as much actual distance, each side length needs to be only half as long as it was in the first scale drawing.

Student Workbook


9 Lesson Summary

If we want to create a scale drawing of a room's floor plan that has the scale "1 inch to 4 feet," we can divide the actual lengths in the room (in feet) by 4 to find the corresponding lengths (in inches) for our drawing.

1 inch
4 feet

Suppose the longest wall is 23 feet long. We should draw a line 5.75 inches long to represent this wall, because $23 \div 4 = 5.75$.

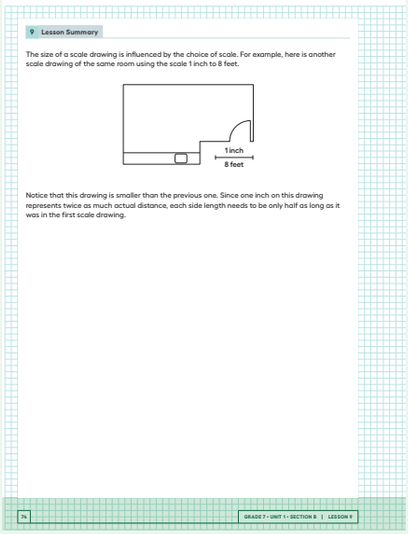
There is more than one way to express this scale. These three scales are all equivalent, because they represent the same relationship between lengths on a drawing and actual lengths:

- 1 inch to 4 feet
- $\frac{1}{2}$ inch to 2 feet
- $\frac{1}{4}$ inch to 1 foot

Any of these scales can be used to find actual lengths and scaled lengths (lengths on a drawing). For instance, we can tell that, at this scale, an 8-foot long wall should be 2 inches long on the drawing because $\frac{1}{4} \cdot 8 = 2$.

GRADE 7 • UNIT 1 • SECTION B | LESSON 9 73

Student Workbook


9 Lesson Summary

The size of a scale drawing is influenced by the choice of scale. For example, here is another scale drawing of the same room using the scale 1 inch to 8 feet.

1 inch
8 feet

Notice that this drawing is smaller than the previous one. Since one inch on this drawing represents twice as much actual distance, each side length needs to be only half as long as it was in the first scale drawing.

74 GRADE 7 • UNIT 1 • SECTION B | LESSON 9

Responding To Student Thinking

Points to Emphasize
If students struggle with creating a scale drawing, discuss this when opportunities arise over the next several lessons. For example, in this activity, make sure to invite multiple students to share their thinking about how they created their scale drawing:

Unit 1, Lesson 10, Activity 2 A New Drawing of the Playground

Cool-down

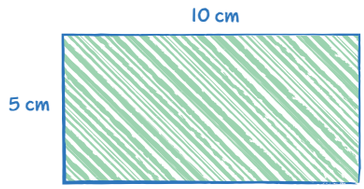
Drawing a Pool

5 min

Student Task Statement

A rectangular swimming pool measures 50 meters in length and 25 meters in width.

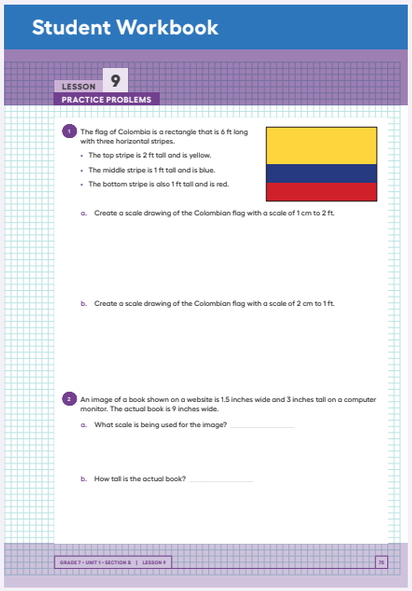
1. Make a scale drawing of the swimming pool where 1 centimeter represents 5 meters.
2. What are the length and width of your scale drawing?



Lesson 9

Practice Problems

4 Problems


Student Workbook

LESSON 9
PRACTICE PROBLEMS

1 The flag of Colombia is a rectangle that is 6 ft long with three horizontal stripes.
- The top stripe is 2 ft tall and is yellow.
- The middle stripe is 1 ft tall and is blue.
- The bottom stripe is also 1 ft tall and is red.

a. Create a scale drawing of the Colombian flag with a scale of 1 cm to 2 ft.

b. Create a scale drawing of the Colombian flag with a scale of 2 cm to 1 ft.

2 An image of a book shown on a website is 1.5 inches wide and 3 inches tall on a computer monitor. The actual book is 9 inches wide.

a. What scale is being used for the image? _____

b. How tall is the actual book? _____

GRADE 7 • UNIT 1 • SECTION B | LESSON 9 75

Problem 1

The flag of Colombia is a rectangle that is 6 ft long with three horizontal stripes.

- The top stripe is 2 ft tall and is yellow.
- The middle stripe is 1 ft tall and is blue.
- The bottom stripe is also 1 ft tall and is red.

a. Create a scale drawing of the Colombian flag with a scale of 1 cm to 2 ft.

The flag will be 3 cm long and 2 cm tall. The yellow rectangle is 1 cm tall and the red and blue rectangles are each 0.5 cm tall.

b. Create a scale drawing of the Colombian flag with a scale of 2 cm to 1 ft.

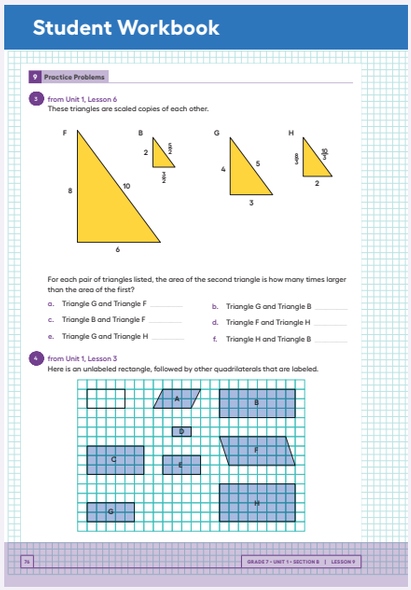
The flag will be 12 cm long and 8 cm tall. The yellow rectangle is 4 cm tall and the red and blue rectangles are each 2 cm tall.

Problem 2

An image of a book shown on a website is 1.5 inches wide and 3 inches tall on a computer monitor. The actual book is 9 inches wide.

a. What scale is being used for the image? 1 inch to 6 inches

b. How tall is the actual book? 18 inches


Student Workbook

9 Practice Problems

3 from Unit 1, Lesson 6
These triangles are scaled copies of each other.

F B G H

For each pair of triangles listed, the area of the second triangle is how many times larger than the area of the first?

a. Triangle G and Triangle F
b. Triangle G and Triangle B
c. Triangle B and Triangle F
d. Triangle F and Triangle H
e. Triangle G and Triangle H
f. Triangle H and Triangle B

4 from Unit 1, Lesson 3
Here is an unlabeled rectangle, followed by other quadrilaterals that are labeled.

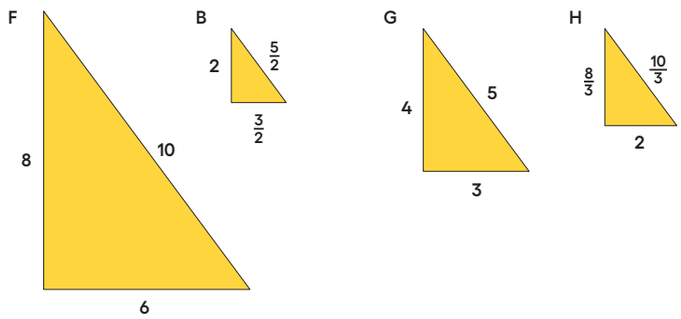
A B C D E F G H

74 GRADE 7 • UNIT 1 • SECTION B | LESSON 9

Problem 3

from Unit 1, Lesson 6

These triangles are scaled copies of each other.



For each pair of triangles listed, the area of the second triangle is how many times larger than the area of the first?

a. Triangle G and Triangle F

4

b. Triangle G and Triangle B

$\frac{1}{4}$

c. Triangle B and Triangle F

16

d. Triangle F and Triangle H

$\frac{1}{9}$

e. Triangle G and Triangle H

$\frac{4}{9}$

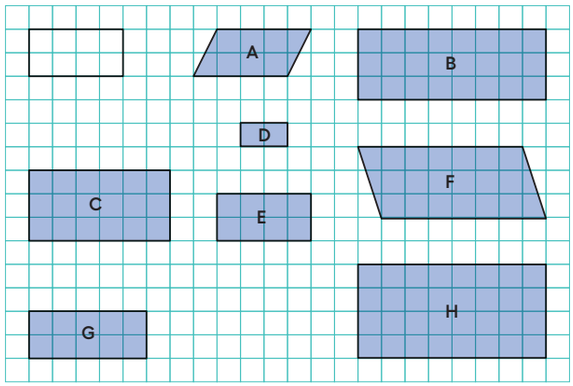
f. Triangle H and Triangle B

$\frac{9}{16}$

Problem 4

from Unit 1, Lesson 3

Here is an unlabeled rectangle, followed by other quadrilaterals that are labeled.



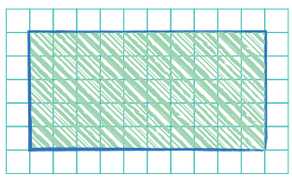
a. Select **all** quadrilaterals that are scaled copies of the unlabeled rectangle. Explain how you know.

C, D, E, and H

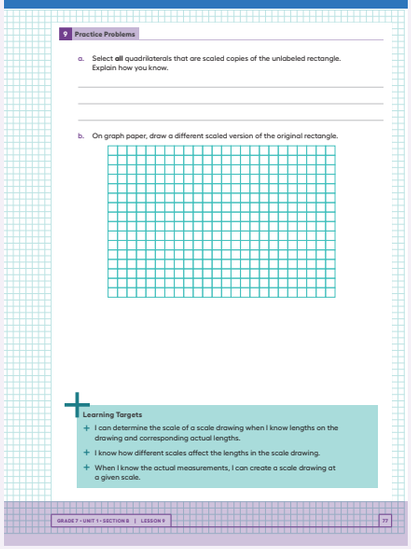
Sample reasoning: The length and width of each copy is related to the length and width of the original by the same factor and the corresponding angles are unchanged.

b. On graph paper, draw a different scaled version of the original rectangle.

Sample response:



Student Workbook


9 Practice Problems

a. Select **all** quadrilaterals that are scaled copies of the unlabeled rectangle. Explain how you know.

b. On graph paper, draw a different scaled version of the original rectangle.

Learning Targets

+ I can determine the scale of a scale drawing when I know lengths on the drawing and corresponding actual lengths.
+ I know how different scales affect the lengths in the scale drawing.
+ When I know the actual measurements, I can create a scale drawing at a given scale.

GRADE 7 • UNIT 1 • SECTION B | LESSON 9 77