

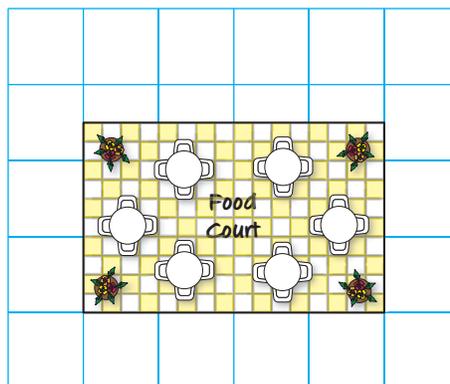
7.5 Scale Drawings

Essential Question How can you enlarge or reduce a drawing proportionally?

1 ACTIVITY: Comparing Measurements

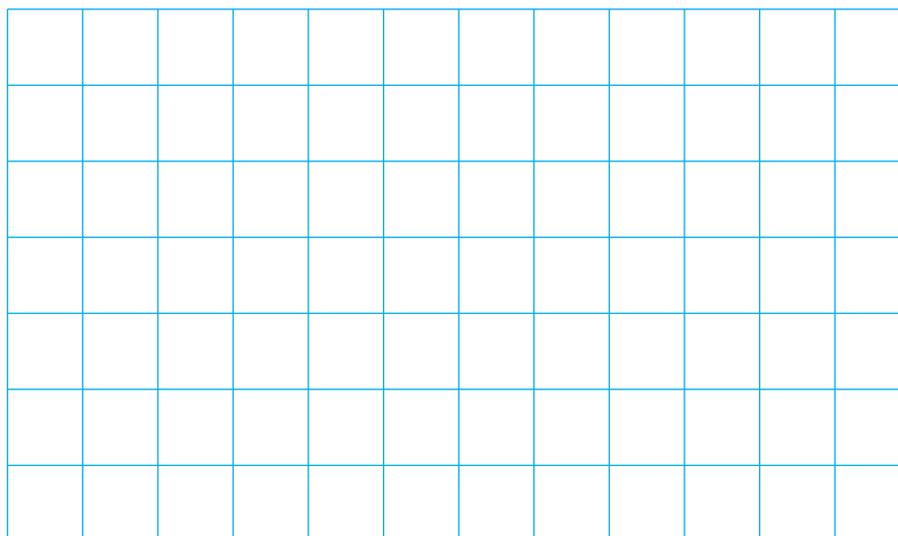
Work with a partner. The diagram shows a food court at a shopping mall. Each centimeter in the diagram represents 40 meters.

- Find the length and the width of the drawing of the food court.
length: cm width: cm
- Find the actual length and width of the food court. Explain how you found your answers.
length: m width: m
- Find the ratios $\frac{\text{drawing length}}{\text{actual length}}$ and $\frac{\text{drawing width}}{\text{actual width}}$. What do you notice?



2 ACTIVITY: Recreating a Drawing

Work with a partner. Draw the food court in Activity 1 on the grid paper so that each centimeter represents 20 meters.



- What happens to the size of the drawing?
- Find the length and the width of your drawing. Compare these dimensions to the dimensions of the original drawing in Activity 1.

Geometry

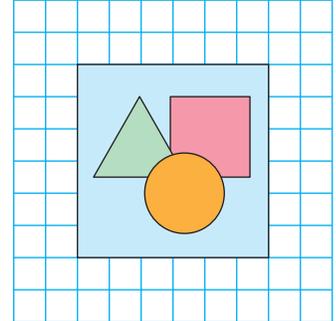
In this lesson, you will

- use scale drawings to find actual distances.
- find scale factors.
- use scale drawings to find actual perimeters and areas.
- recreate scale drawings at a different scale.

3 ACTIVITY: Comparing Measurements

Work with a partner. The diagram shows a sketch of a painting. Each unit in the sketch represents 8 inches.

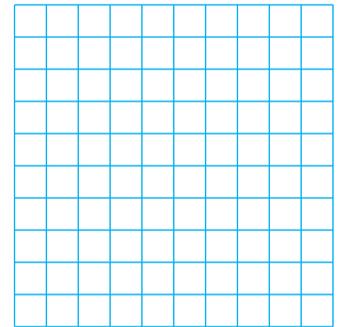
- Find the length and the width of the sketch.
length: units width: units
- Find the actual length and width of the painting. Explain how you found your answers.
length: in. width: in.
- Find the ratios $\frac{\text{sketch length}}{\text{actual length}}$ and $\frac{\text{sketch width}}{\text{actual width}}$.
What do you notice?



4 ACTIVITY: Recreating a Drawing

Work with a partner. Let each unit in the grid paper represent 2 feet. Now sketch the painting in Activity 3 onto the grid paper.

- What happens to the size of the sketch?
- Find the length and the width of your sketch. Compare these dimensions to the dimensions of the original sketch in Activity 3.



Math Practice

Specify Units

How do you know whether to use feet or units for each measurement?

What Is Your Answer?

- IN YOUR OWN WORDS** How can you enlarge or reduce a drawing proportionally?
- Complete the table for both the food court and the painting.

| | Actual Object | Original Drawing | Your Drawing |
|-----------|---------------|------------------|--------------|
| Perimeter | | | |
| Area | | | |

Compare the measurements in each table. What conclusions can you make?

- RESEARCH** Look at some maps in your school library or on the Internet. Make a list of the different scales used on the maps.
- When you view a map on the Internet, how does the scale change when you zoom out? How does the scale change when you zoom in?

Practice

Use what you learned about enlarging or reducing drawings to complete Exercises 4–7 on page 303.

Key Vocabulary

scale drawing, p. 300
scale model, p. 300
scale, p. 300
scale factor, p. 301

Study Tip

Scales are written so that the drawing distance comes first in the ratio.

Key Ideas

Scale Drawings and Models

A **scale drawing** is a proportional, two-dimensional drawing of an object. A **scale model** is a proportional, three-dimensional model of an object.

Scale

The measurements in scale drawings and models are proportional to the measurements of the actual object. The **scale** gives the ratio that compares the measurements of the drawing or model with the actual measurements.

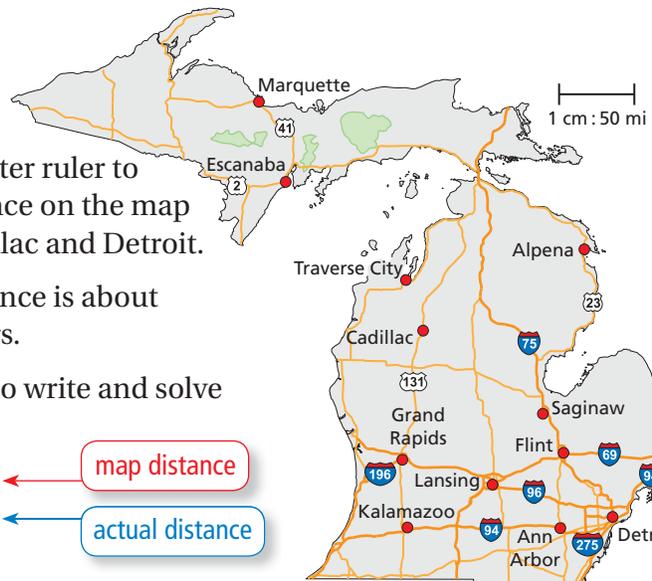
$$\frac{1 \text{ in.}}{10 \text{ mi}} \leftarrow \begin{array}{l} \text{drawing distance} \\ \text{actual distance} \end{array}$$

$$1 \text{ in.} : 10 \text{ mi}$$

drawing actual

EXAMPLE 1 Finding an Actual Distance

What is the actual distance d between Cadillac and Detroit?



Step 1: Use a centimeter ruler to find the distance on the map between Cadillac and Detroit.

The map distance is about 3.5 centimeters.

Step 2: Use the scale to write and solve a proportion.

$$\frac{1 \text{ cm}}{50 \text{ mi}} = \frac{3.5 \text{ cm}}{d \text{ mi}}$$

map distance actual distance

$$d = 50 \cdot 3.5 \quad \text{Cross Products Property}$$

$$d = 175 \quad \text{Multiply.}$$

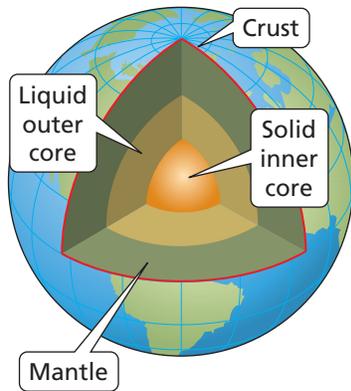
∴ So, the distance between Cadillac and Detroit is about 175 miles.

On Your Own

1. What is the actual distance between Traverse City and Marquette?

EXAMPLE 2 Finding a Distance in a Model

The liquid outer core of Earth is 2300 kilometers thick. A scale model of the layers of Earth has a scale of 1 in. : 500 km. How thick is the liquid outer core of the model?



- (A) 0.2 in. (B) 4.6 in. (C) 0.2 km (D) 4.6 km

$$\frac{1 \text{ in.}}{500 \text{ km}} = \frac{x \text{ in.}}{2300 \text{ km}}$$

← model thickness
← actual thickness

$$\frac{1 \text{ in.}}{500 \text{ km}} \cdot 2300 \text{ km} = \frac{x \text{ in.}}{2300 \text{ km}} \cdot 2300 \text{ km}$$

Multiplication Property of Equality

$$4.6 = x$$

Simplify.

∴ So, the liquid outer core of the model is 4.6 inches thick. The correct answer is (B).

On Your Own

2. The mantle of Earth is 2900 kilometers thick. How thick is the mantle of the model?

A scale can be written without units when the units are the same. A scale without units is called a **scale factor**.

EXAMPLE 3 Finding a Scale Factor



A scale model of the Sergeant Floyd Monument is 10 inches tall. The actual monument is 100 feet tall.

- a. What is the scale of the model?

$$\frac{\text{model height}}{\text{actual height}} = \frac{10 \text{ in.}}{100 \text{ ft}} = \frac{1 \text{ in.}}{10 \text{ ft}}$$

∴ The scale is 1 in. : 10 ft.

- b. What is the scale factor of the model?

Write the scale with the same units. Use the fact that 1 ft = 12 in.

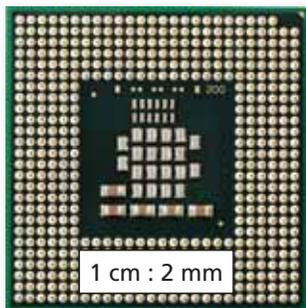
$$\text{scale factor} = \frac{1 \text{ in.}}{10 \text{ ft}} = \frac{1 \text{ in.}}{120 \text{ in.}} = \frac{1}{120}$$

∴ The scale factor is 1 : 120.

On Your Own

3. A drawing has a scale of 1 mm : 20 cm. What is the scale factor of the drawing?

EXAMPLE 4 Finding an Actual Perimeter and Area



The scale drawing of a computer chip helps you see the individual components on the chip.

- a. Find the perimeter and the area of the computer chip in the scale drawing.

When measured using a centimeter ruler, the scale drawing of the computer chip has a side length of 4 centimeters.

- So, the perimeter of the computer chip in the scale drawing is $4(4) = 16$ centimeters, and the area is $4^2 = 16$ square centimeters.

- b. Find the actual perimeter and area of the computer chip.

$$\frac{1 \text{ cm}}{2 \text{ mm}} = \frac{4 \text{ cm}}{s \text{ mm}}$$

drawing distance ←
actual distance ←

$$s = 2 \cdot 4 \quad \text{Cross Products Property}$$

$$s = 8 \quad \text{Multiply.}$$

The side length of the actual computer chip is 8 millimeters.

- So, the actual perimeter of the computer chip is $4(8) = 32$ millimeters, and the actual area is $8^2 = 64$ square millimeters.

- c. Compare the ratios $\frac{\text{drawing perimeter}}{\text{actual perimeter}}$ and $\frac{\text{drawing area}}{\text{actual area}}$ to the scale factor.

Use the fact that $1 \text{ cm} = 10 \text{ mm}$.

$$\text{scale factor} = \frac{1 \text{ cm}}{2 \text{ mm}} = \frac{10 \cancel{\text{ mm}}}{2 \cancel{\text{ mm}}} = \frac{5}{1}$$

$$\frac{\text{drawing perimeter}}{\text{actual perimeter}} = \frac{16 \text{ cm}}{32 \text{ mm}} = \frac{1 \text{ cm}}{2 \text{ mm}} = \frac{5}{1}$$

$$\frac{\text{drawing area}}{\text{actual area}} = \frac{16 \text{ cm}^2}{64 \text{ mm}^2} = \frac{1 \text{ cm}^2}{4 \text{ mm}^2} = \left(\frac{1 \text{ cm}}{2 \text{ mm}}\right)^2 = \left(\frac{5}{1}\right)^2$$

- So, the ratio of the perimeters is equal to the scale factor, and the ratio of the areas is equal to the square of the scale factor.

On Your Own

4. **WHAT IF?** The scale of the drawing of the computer chip is $1 \text{ cm} : 3 \text{ mm}$. How do the answers in parts (a)–(c) change? Justify your answer.

Study Tip

The ratios tell you that the perimeter of the drawing is 5 times the actual perimeter, and the area of the drawing is $5^2 = 25$ times the actual area.

Now You're Ready
Exercises 22 and 23

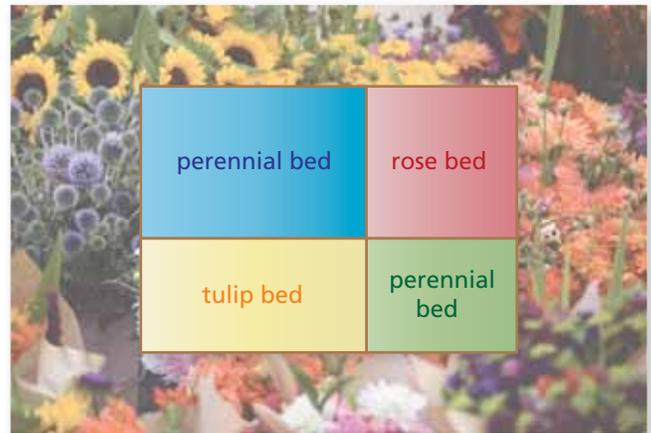
Vocabulary and Concept Check

- VOCABULARY** Compare and contrast the terms *scale* and *scale factor*.
- CRITICAL THINKING** The scale of a drawing is 2 cm : 1 mm. Is the scale drawing *larger* or *smaller* than the actual object? Explain.
- REASONING** How would you find the scale factor of a drawing that shows a length of 4 inches when the actual object is 8 feet long?

Practice and Problem Solving

Use the drawing and a centimeter ruler. Each centimeter in the drawing represents 5 feet.

- What is the actual length of the flower garden?
- What are the actual dimensions of the rose bed?
- What are the actual perimeters of the perennial beds?
- The area of the tulip bed is what percent of the area of the rose bed?



Use the map in Example 1 to find the actual distance between the cities.

- | | |
|---|--|
| <ol style="list-style-type: none"> 8. Kalamazoo and Ann Arbor 10. Grand Rapids and Escanaba | <ol style="list-style-type: none"> 9. Lansing and Flint 11. Saginaw and Alpena |
|---|--|

Find the missing dimension. Use the scale factor 1 : 12.

| | Item | Model | Actual |
|---|---------------------|-----------------------------------|----------------------------------|
| 2 | 12. Mattress | Length: 6.25 in. | Length: <input type="text"/> in. |
| 3 | 13. Corvette | Length: <input type="text"/> in. | Length: 15 ft |
| | 14. Water tower | Depth: 32 cm | Depth: <input type="text"/> m |
| | 15. Wingspan | Width: 5.4 ft | Width: <input type="text"/> yd |
| | 16. Football helmet | Diameter: <input type="text"/> mm | Diameter: 21 cm |

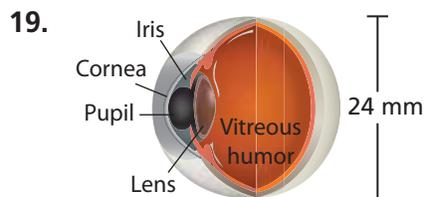
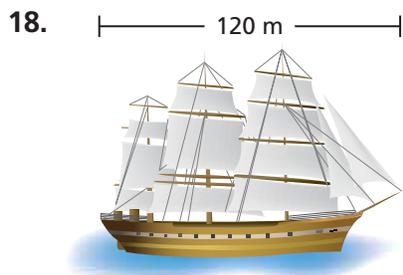
- ERROR ANALYSIS** A scale is 1 cm : 20 m. Describe and correct the error in finding the actual distance that corresponds to 5 centimeters.

X

$$\frac{1 \text{ cm}}{20 \text{ m}} = \frac{x \text{ m}}{5 \text{ cm}}$$

$$x = 0.25 \text{ m}$$

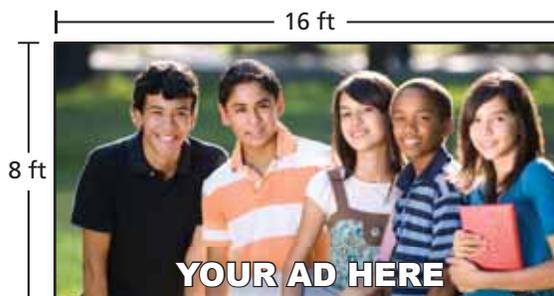
Use a centimeter ruler to measure the segment shown. Find the scale of the drawing.



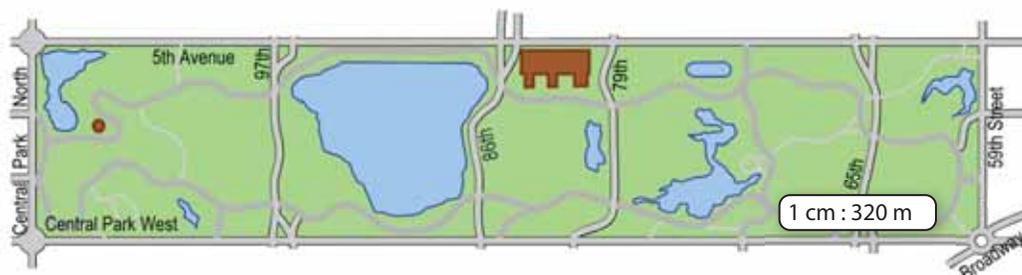
20. **REASONING** You know the length and the width of a scale model. What additional information do you need to know to find the scale of the model?

21. **OPEN-ENDED** You are in charge of creating a billboard advertisement with the dimensions shown.

- Choose a product. Then design the billboard using words and a picture.
- What is the scale factor of your design?



4 22. **CENTRAL PARK** Central Park is a rectangular park in New York City.



- Find the perimeter and the area of Central Park in the scale drawing.
- Find the actual perimeter and area of Central Park.

23. **ICON** You are designing an icon for a mobile app.

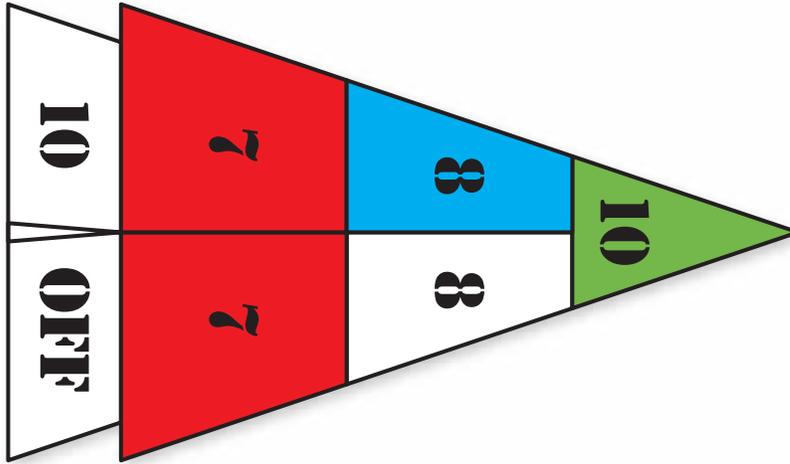
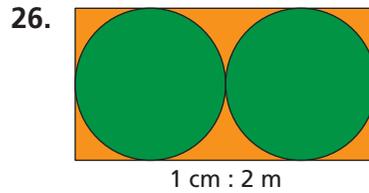
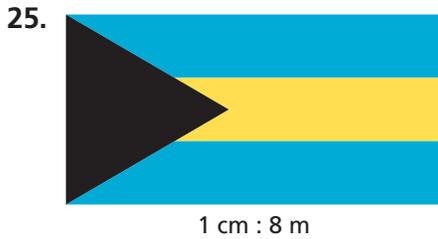
- Find the perimeter and the area of the icon in the scale drawing.
- Find the actual perimeter and area of the icon.



24. **CRITICAL THINKING** Use the results of Exercises 22 and 23 to make a conjecture about the relationship between the scale factor of a drawing and the ratios

$$\frac{\text{drawing perimeter}}{\text{actual perimeter}} \text{ and } \frac{\text{drawing area}}{\text{actual area}}$$

Recreate the scale drawing so that it has a scale of 1 cm : 4 m.

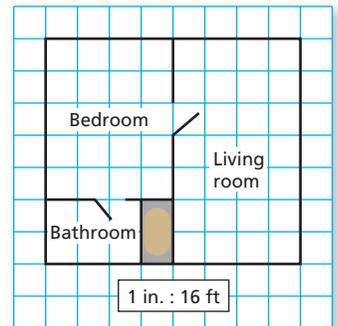


The shuffleboard diagram has a scale of 1 cm : 1 ft. Find the actual area of the region.

- 27. red region
- 28. blue region
- 29. green region

30. **BLUEPRINT** In a blueprint, each square has a side length of $\frac{1}{4}$ inch.
- a. Ceramic tile costs \$5 per square foot. How much would it cost to tile the bathroom?
 - b. Carpet costs \$18 per square yard. How much would it cost to carpet the bedroom and living room?
 - c. Which has a greater unit cost, the tile or the carpet? Explain.

Reduced Drawing of Blueprint



31. **Modeling** You are making a scale model of the solar system. The radius of Earth is 6378 kilometers. The radius of the Sun is 695,500 kilometers. Is it reasonable to choose a baseball as a model of Earth? Explain your reasoning.



Fair Game Review what you learned in previous grades & lessons

Plot and label the ordered pair in a coordinate plane. (*Skills Review Handbook*)

32. $A(-4, 3)$ 33. $B(2, -6)$ 34. $C(5, 1)$ 35. $D(-3, -7)$

36. **MULTIPLE CHOICE** Which set of numbers is ordered from least to greatest?
(*Section 6.2*)

- (A) $\frac{7}{20}$, 32%, 0.45 (B) 17%, 0.21, $\frac{3}{25}$ (C) 0.88, $\frac{7}{8}$, 93% (D) 57%, $\frac{11}{16}$, 5.7