# 5.6 Scale Drawings

Learning Target: Solve problems involving scale drawings.

Success Criteria:
- I can find an actual distance in a scale drawing.
- I can explain the meaning of scale and scale factor.
- I can use a scale drawing to find the actual lengths and areas of real-life objects.

EXPLORATION 1

Creating a Scale Drawing

Work with a partner. Several sections in a zoo are drawn on 1-centimeter grid paper as shown. Each centimeter in the drawing represents 4 meters.
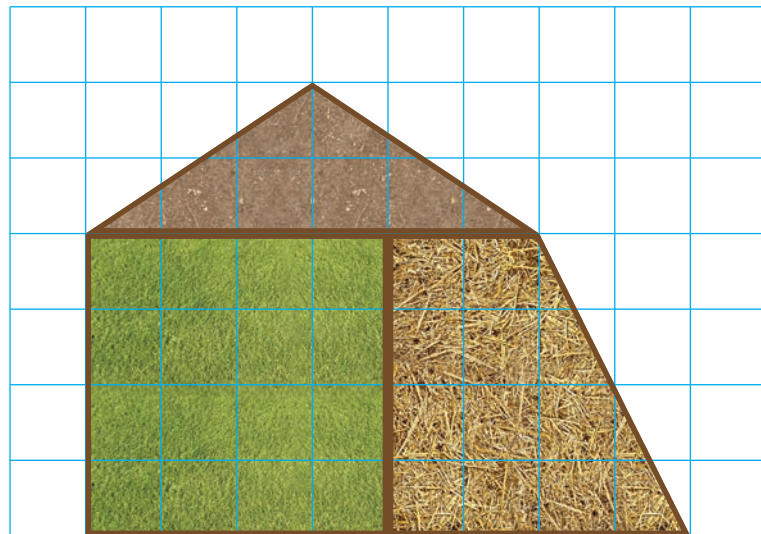
a. Describe the relationship between the lengths of the fences in the drawing and the actual side lengths of the fences.

b. Describe the relationship between the areas of the sections in the drawing and the actual areas of the sections.

c. Are the relationships in parts (a) and (b) the same? Explain your reasoning.

d. Choose a different distance to represent each centimeter on a piece of 1-centimeter grid paper. Then create a new drawing of the sections in the zoo using the distance you chose. Describe any similarities or differences in the drawings.

Math Practice

Analyze Givens
How does the information given about the drawing shown help you create an accurate drawing in part (d)?

5.6 Lesson

Recall that a ratio *a* : *b* is equivalent to $1 : \frac{b}{a}$.

A scale is usually written as a ratio where the first quantity is 1 unit.
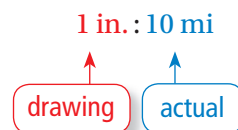
Key Idea

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.
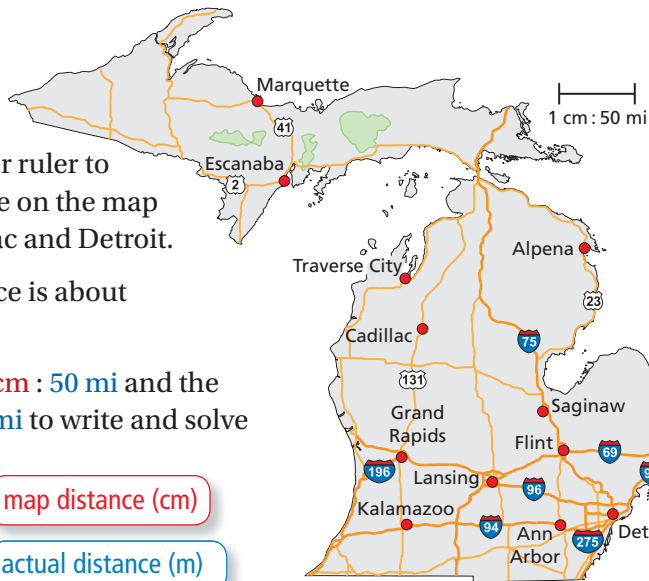
Scale

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.

1 in. : 10 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 1 cm : 50 mi and the ratio 3.5 cm : *d* mi to write and solve a proportion.

$$\frac{1}{50} = \frac{3.5}{d}$$

map distance (cm)
actual distance (m)

$d = 50 \cdot 3.5$ Cross Products Property

$d = 175$ Multiply.

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

Another Method
You can use a ratio table.

× 3.5

Centimeters	1	3.5
Miles	50	175	✓

× 3.5

Try It

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

Multi-Language Glossary at *BigIdeasMath.com*

A scale can be written without units when the units are the same. The value of this ratio is called the **scale factor**. The scale factor describes the multiplicative relationship between the dimensions of a scale drawing or scale model and the dimensions of the actual object.

EXAMPLE 2 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 does 1 inch represent in the model? What is the scale?

The ratio of the model height to the actual height is 10 in. : 100 ft. Divide each quantity by 10 to determine the number of feet represented by 1 inch in the model.

$\div 10$ (10 in. : 100 ft) $\div 10$
1 in. : 10 ft

▶ In the model, 1 inch represents 10 feet. So, 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.

$$10 \text{ ft} = 10 \, \cancel{ft} \times \frac{12 \text{ in.}}{1 \, \cancel{ft}} = 120 \text{ in.}$$

▶ The scale is 1 in. : 120 in., or 1 : 120. So, the scale factor is $\frac{1}{120}$.

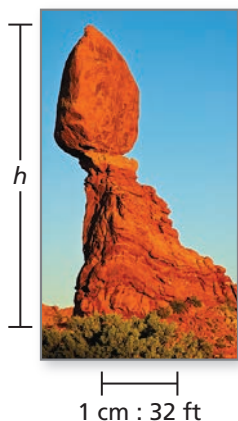## *Try It*

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

Self-Assessment for Concepts & Skills

Solve each exercise. Then rate your understanding of the success criteria in your journal.

3. **VOCABULARY** In your own words, explain the meaning of the scale and scale factor of a drawing or model.

4. **FINDING AN ACTUAL DISTANCE** Consider the scale drawing of Balanced Rock in Arches National Park. What is the actual height of the structure?

5. **FINDING A SCALE FACTOR** A drawing has a scale of 3 in. : 2 ft. What is the scale factor of the drawing?

6. **MP REASONING** Describe the scale factor of a model that is (a) larger than the actual object and (b) smaller than the actual object.

h

1 cm : 32 ft

EXAMPLE 3 | **Modeling Real Life**
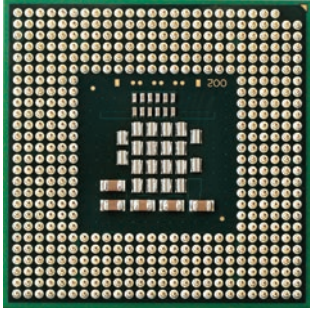
The scale drawing of a square computer chip helps you see the individual components on the chip.

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.**

Multiplying each quantity in the scale by 4 shows that the actual side length of the computer chip is 8 millimeters.

$$\times 4 \left(\begin{array}{c} 1 \text{ cm} : 2 \text{ mm} \\ 4 \text{ cm} : 8 \text{ mm} \end{array} \right) \times 4$$

▶ 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 side lengths of the scale drawing with the actual side lengths of the computer chip.**
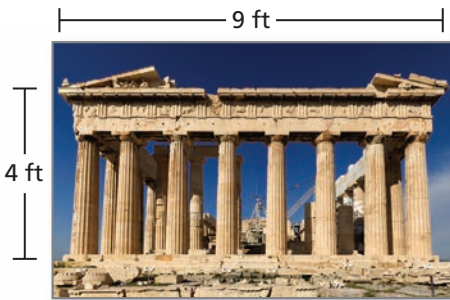
Find the scale factor. Use the fact that 1 cm = 10 mm.

Because the scale can be written as 10 mm : 2 mm, or 10 : 2, the scale factor is $\frac{10}{2} = 5$.

▶ So, the side lengths of the scale drawing are 5 times the actual side lengths of the computer chip.

Self-Assessment for Problem Solving

Solve each exercise. Then rate your understanding of the success criteria in your journal.

Scale: 1 ft : 11.2 ft

7. A scale drawing of the Parthenon is shown. Find the actual perimeter and area of the rectangular face of the Parthenon. Then recreate the scale drawing with a scale factor of 0.2. Find the perimeter and area of the rectangular face in your drawing.

8. **DIG DEEPER!** You are in charge of creating a billboard advertisement that is 16 feet long and 8 feet tall. Choose a product. Create a scale drawing of the billboard using words and a picture. What is the scale factor of your design?

▶ Review & Refresh

Tell whether *x* and *y* are proportional. Explain your reasoning.

1.

x	10	9	8	7
y	5	4	3	2

2.

x	6	12	18	24
y	7	14	21	28

Simplify the expression.

3. $7p + 6p$

4. $8 + 3d - 17$

5. $-2 + \frac{2}{5}b - \frac{1}{4}b + 6$

**Write the word sentence as an inequality.**

6. A number c is less than -3.

7. 7 plus a number z is more than 5.

8. The product of a number m and 6 is no less than 30.

▶ Concepts, Skills, & Problem Solving

CREATING A SCALE DRAWING **Each centimeter on the 1-centimeter grid paper represents 8 inches. Create a proportional drawing of the figure that is larger or smaller than the figure shown.** (See Exploration 1, p. 217.)

9.

10.
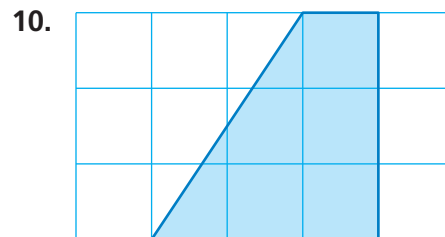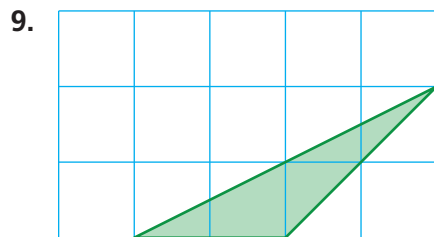
FINDING AN ACTUAL DISTANCE **Use the map in Example 1 to find the actual distance between the cities.**

11. Kalamazoo and Ann Arbor

12. Lansing and Flint

13. Grand Rapids and Escanaba

14. Saginaw and Alpena

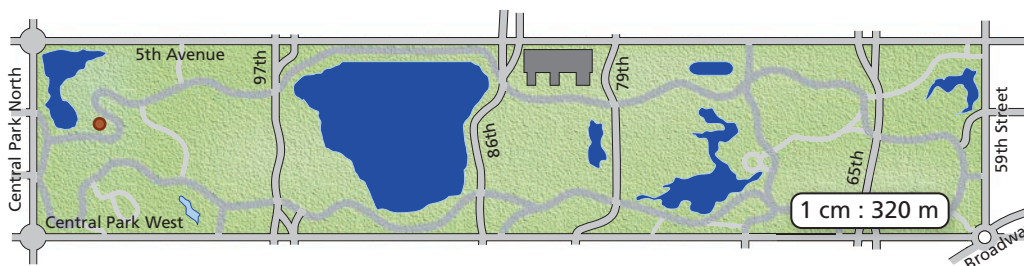**USING A SCALE** **Find the missing dimension. Use the scale 1 : 12.**

	Item	Model	Actual
15.	Mattress	Length: 6.25 in.	Length: ▢ in.
16.	Corvette	Length: ▢ in.	Length: 15 ft
17.	Water tower	Depth: 32 cm	Depth: ▢ m
18.	Wingspan	Width: 5.4 ft	Width: ▢ yd
19.	Football helmet	Diameter: ▢ mm	Diameter: 21 cm

FINDING A SCALE FACTOR Use a centimeter ruler to find the scale and the scale factor of the drawing.

20.

$\vdash$———— 120 m ————$\dashv$

21.

Iris
Cornea
Pupil
Vitreous humor
Lens
24 mm
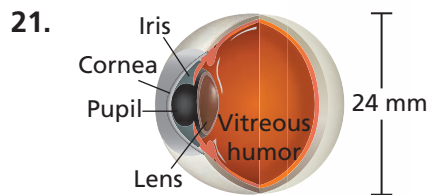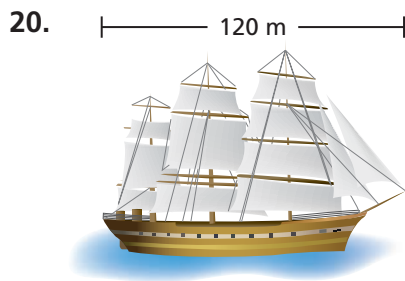
22. **CRITICAL THINKING** You know the length and the width of a scale model. What additional information do you need to know to find the scale of the model? Explain.

**23.** **MP** **MODELING REAL LIFE** Central Park is a rectangular park in New York City.

Central Park North
5th Avenue
97th
86th
79th
65th
59th Street
Central Park West
1 cm : 320 m
Broadway

a. Find the perimeter and the area of the scale drawing of Central Park.

b. Find the actual perimeter and area of Central Park.

Reduced Drawing of Blueprint

24. **MP** **PROBLEM SOLVING** In a blueprint, each square has a side length of $\frac{1}{4}$ inch.

a. Ceramic tile costs $5 per square foot. How much does it cost to tile the bathroom?

b. Carpet costs $18 per square yard. How much does it cost to carpet the bedroom and living room?

Bedroom
Living room
Bathroom
1 in. : 16 ft
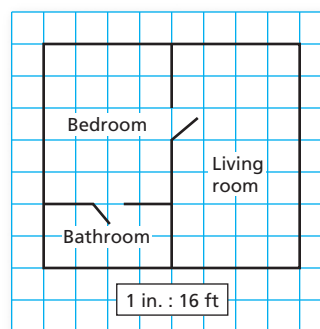
REPRODUCING A SCALE DRAWING Recreate the scale drawing so that it has a scale of 1 cm : 4 m.

25.

1 cm : 8 m

26.

1 cm : 2 m
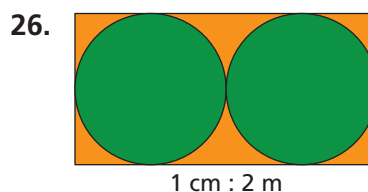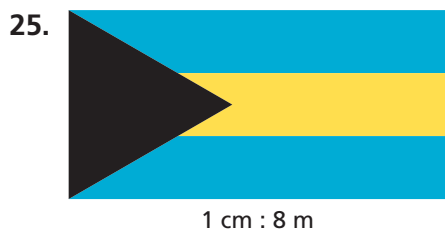
27. **DIG DEEPER!** Make a conjecture about the relationship between the scale factor of a drawing and the quotients $\dfrac{\text{drawing perimeter}}{\text{actual perimeter}}$ and $\dfrac{\text{drawing area}}{\text{actual area}}$. Explain your reasoning.