1.1 Evaluate Expressions

Before You used whole numbers, fractions, and decimals.

Now You will evaluate algebraic expressions and use exponents.

Why So you can calculate sports statistics, as in Ex. 50.

Key Vocabulary
- **variable**
- **algebraic expression**
- **power**
- **base**
- **exponent**

A **variable** is a letter used to represent one or more numbers. The numbers are the values of the variable. *Expressions* consist of numbers, variables, and operations. An **algebraic expression**, or *variable expression*, is an expression that includes at least one variable.

Algebraic expression	Meaning	Operation
$5(n)$ $5 \cdot n$ $5n$	5 times n	Multiplication
$\frac{14}{y}$ $14 \div y$	14 divided by y	Division
$6 + c$	6 plus c	Addition
$8 - x$	8 minus x	Subtraction

COMMON CORE

CC.9-12.N.Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.*

To **evaluate an algebraic expression**, substitute a number for each variable, perform the operation(s), and simplify the result, if necessary.

EXAMPLE 1 Evaluate algebraic expressions

Evaluate the expression when $n = 3$.

a. $13 \cdot n = 13 \cdot 3$ **Substitute 3 for n.**

$= 39$ **Multiply.**

b. $\frac{9}{n} = \frac{9}{3}$ **Substitute 3 for n.**

$= 3$ **Divide.**

c. $n - 1 = 3 - 1$ **Substitute 3 for n.**

$= 2$ **Subtract.**

d. $n + 8 = 3 + 8$ **Substitute 3 for n.**

$= 11$ **Add.**

USE A PROPERTY

Part (a) of Example 1 illustrates the transitive property of equality: If $a = b$ and $b = c$, then $a = c$. Because $13 \cdot n = 13 \cdot 3$ and $13 \cdot 3 = 39$, $13 \cdot n = 39$. Two other properties of equality are the reflexive property ($a = a$) and the symmetric property (if $a = b$, then $b = a$).

✓ GUIDED PRACTICE for Example 1

Evaluate the expression when $y = 2$.

1. $6y$ **2.** $\frac{8}{y}$ **3.** $y + 4$ **4.** $11 - y$

EXAMPLE 2 Evaluate an expression

MOVIES The total cost of seeing a movie at a theater can be represented by the expression $a + r$ where a is the cost (in dollars) of admission and r is the cost (in dollars) of refreshments. Suppose you pay \$7.50 for admission and \$7.25 for refreshments. Find the total cost.

Solution

$$\begin{aligned} \text{Total cost} &= a + r && \text{Write expression.} \\ &= 7.50 + 7.25 && \text{Substitute 7.50 for } a \text{ and 7.25 for } r. \\ &= 14.75 && \text{Add.} \end{aligned}$$

▸ The total cost is \$14.75.

EXPRESSIONS USING EXPONENTS A **power** is an expression that represents repeated multiplication of the same factor. For example, 81 is a power of 3 because $81 = 3 \cdot 3 \cdot 3 \cdot 3$. A power can be written in a form using two numbers, a **base** and an **exponent**. The exponent represents the number of times the base is used as a factor, so 81 can be written as 3^4.

base, exponent

$$\underbrace{3^4}_{\text{power}} = \underbrace{3 \cdot 3 \cdot 3 \cdot 3}_{\text{4 factors of 3}}$$

EXAMPLE 3 Read and write powers

Write the power in words and as a product.

Power	Words	Product
a. 7^1	seven to the first power	7
b. 5^2	five to the second power, or five *squared*	$5 \cdot 5$
c. $\left(\frac{1}{2}\right)^3$	one half to the third power, or one half *cubed*	$\frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2}$
d. z^5	z to the fifth power	$z \cdot z \cdot z \cdot z \cdot z$

WRITE EXPONENTS
For a number raised to the first power, you usually do not write the exponent 1. For instance, you write 7^1 simply as 7.

✓ GUIDED PRACTICE for Examples 2 and 3

5. WHAT IF? In Example 2, suppose you go back to the theater with a friend to see an afternoon movie. You pay for both admissions. Your total cost (in dollars) can be represented by the expression $2a$. If each admission costs \$4.75, what is your total cost?

Write the power in words and as a product.

6. 9^5 **7.** 2^8 **8.** n^4

EXAMPLE 4 Evaluate powers

USE A PROPERTY
Example 4 illustrates the substitution property of equality: If $a = b$, then a can be substituted for b in any expression or equation. Because $x = 2$, $x^4 = 2^4$.

Evaluate the expression.

a. x^4 when $x = 2$

b. n^3 when $n = 1.5$

Solution

a. $x^4 = 2^4$
$= 2 \cdot 2 \cdot 2 \cdot 2$
$= 16$

b. $n^3 = 1.5^3$
$= (1.5)(1.5)(1.5)$
$= 3.375$

✓ GUIDED PRACTICE for Example 4

Evaluate the expression.

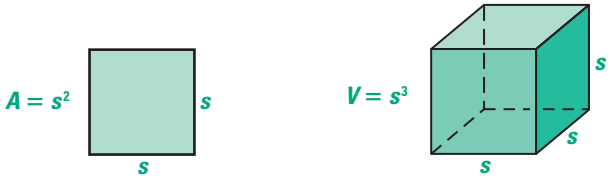
9. x^3 when $x = 8$

10. k^2 when $k = 2.5$

11. d^4 when $d = \frac{1}{3}$

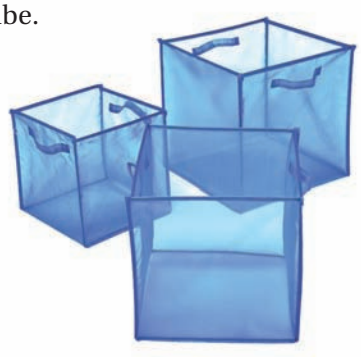
REVIEW AREA AND VOLUME
For help with area and volume, see pp. SR14 and SR17.

AREA AND VOLUME Exponents are used in the formulas for the area of a square and the volume of a cube. In fact, the words *squared* and *cubed* come from the formula for the area of a square and the formula for the volume of a cube.



EXAMPLE 5 Evaluate a power

STORAGE CUBES Each edge of the medium-sized pop-up storage cube shown is 14 inches long. The storage cube is made so that it can be folded flat when not in use. Find the volume of the storage cube.



Solution

$V = s^3$ Write formula for volume.

$= 14^3$ Substitute 14 for s.

$= 2744$ Evaluate power.

▸ The volume of the storage cube is 2744 cubic inches.

✓ GUIDED PRACTICE for Example 5

12. WHAT IF? In Example 5, suppose the storage cube is folded flat to form a square. Find the area of the square.

1.1 EXERCISES

HOMEWORK KEY

◯ = See **WORKED-OUT SOLUTIONS** Exs. 19, 35, and 51

★ = **STANDARDIZED TEST PRACTICE** Exs. 2, 15, 44, 45, 52, and 54

SKILL PRACTICE

1. VOCABULARY Identify the exponent and the base in the expression 6^{12}.

2. ★ WRITING *Describe* the steps you would take to evaluate the expression n^5 when $n = 3$. Then evaluate the expression.

EXAMPLE 1 for Exs. 3–15

EVALUATING EXPRESSIONS **Evaluate the expression.**

3. $15x$ when $x = 4$

4. $0.4r$ when $r = 6$

5. $w - 8$ when $w = 20$

6. $1.6 - g$ when $g = 1.2$

7. $5 + m$ when $m = 7$

8. $0.8 + h$ when $h = 3.7$

9. $\frac{24}{f}$ when $f = 8$

10. $\frac{t}{5}$ when $t = 4.5$

11. $2.5m$ when $m = 4$

12. $\frac{1}{2}k$ when $k = \frac{2}{3}$

13. $y - \frac{1}{2}$ when $y = \frac{5}{6}$

14. $h + \frac{1}{3}$ when $h = 1\frac{1}{3}$

15. ★ MULTIPLE CHOICE What is the value of $2.5m$ when $m = 10$?

Ⓐ 0.25 Ⓑ 2.5 Ⓒ 12.5 Ⓓ 25

EXAMPLE 3 for Exs. 16–25

WRITING POWERS **Write the power in words and as a product.**

16. 12^5

17. 7^3

18. $(3.2)^2$

19. $(0.3)^4$

20. $\left(\frac{1}{2}\right)^8$

21. n^7

22. y^6

23. t^4

ERROR ANALYSIS ***Describe*** **and correct the error in evaluating the power.**

24. $(0.4)^2 = 2(0.4) = 0.8$ ✗

25. $5^4 = 4 \cdot 4 \cdot 4 \cdot 4 = 1024$ ✗

EXAMPLE 4 for Exs. 26–37

EVALUATING POWERS **Evaluate the power.**

26. 3^2

27. 10^2

28. 1^5

29. 11^3

30. 5^3

31. 3^5

32. 2^6

33. 6^4

34. $\left(\frac{1}{4}\right)^2$

35. $\left(\frac{3}{5}\right)^3$

36. $\left(\frac{2}{3}\right)^4$

37. $\left(\frac{1}{6}\right)^3$

EVALUATING EXPRESSIONS **Evaluate the expression.**

38. x^2 when $x = \frac{3}{4}$

39. p^2 when $p = 1.1$

40. $x + y$ when $x = 11$ and $y = 6.4$

41. kn when $k = 9$ and $n = 4.5$

42. $w - z$ when $w = 9.5$ and $z = 2.8$

43. $\frac{b}{c}$ when $b = 24$ and $c = 2.5$

44. ★ MULTIPLE CHOICE Which expression has the greatest value when $x = 10$ and $y = 0.5$?

Ⓐ xy Ⓑ $x - y$ Ⓒ $\frac{x}{y}$ Ⓓ $\frac{y}{x}$

45. ★ **MULTIPLE CHOICE** Let b be the number of tokens you bought at an arcade, and let u be the number you have used. Which expression represents the number of tokens remaining?

Ⓐ $b + u$ Ⓑ $b - u$ Ⓒ bu Ⓓ $\frac{b}{u}$

46. **COMPARING POWERS** Let x and y be whole numbers greater than 0 with $y > x$. Which has the greater value, 3^x or 3^y? *Explain.*

47. **CHALLENGE** For which whole number value(s) of x greater than 0 is the value of x^2 greater than the value of 2^x? *Explain.*

PROBLEM SOLVING

EXAMPLE 2 for Exs. 48–50

48. **GEOMETRY** The perimeter of a square with a side length of s is given by the expression $4s$. What is the perimeter of the square shown?

49. **LEOPARD FROG** You can estimate the distance (in centimeters) that a leopard frog can jump using the expression 13ℓ where ℓ is the frog's length (in centimeters). What distance can a leopard frog that is 12.5 centimeters long jump?

50. **MULTI-STEP PROBLEM** Jen was the leading scorer on her soccer team. She scored 120 goals and had 20 assists in her high school career.

a. The number n of points awarded for goals is given by $2g$ where g is the number of goals scored. How many points did Jen earn for goals?

b. The point total is given by $n + a$ where a is the number of assists. Use your answer from part (a) to find Jen's point total.

EXAMPLE 3 for Exs. 51–52

51. **MULTI-STEP PROBLEM** You are buying a tank for three fish. You have a flame angel that is 3.5 inches long, a yellow sailfin tang that is 5.5 inches long, and a coral beauty that is 3 inches long. The area (in square inches) of water surface the fish need is given by the expression $12f$ where f is the sum of the lengths (in inches) of all the fish in the tank.

a. What is the total length of the three fish?

b. How many square inches of water surface do the fish need?

52. ★ **MULTIPLE CHOICE** For a snow sculpture contest, snow is packed into a cube-shaped box with an edge length of 8 feet. The box is frozen and removed, leaving a cube of snow. One cubic foot of the snow weighs about 30 pounds. You can estimate the weight (in pounds) of the cube using the expression $30V$ where V is the volume (in cubic feet) of the snow. About how much does the uncarved cube weigh?

Ⓐ 240 pounds Ⓑ 1920 pounds

Ⓒ 15,360 pounds Ⓓ 216,000 pounds

◯ = See **WORKED-OUT SOLUTIONS** in Student Resources

★ = **STANDARDIZED TEST PRACTICE**